

1780–1860: a survey

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Introduction

The heart of the matter is twelve. Twelve is the factor by which real income per head nowadays exceeds that around 1780, in Britain and in other countries that have experienced modern economic growth (for the international comparisons Maddison 1991; for Britain itself Feinstein 1978, 1988 and Crafts 1985a).

Such statistics are of course not perfect. What is measured by 'real income per head' does not measure all of human happiness and does not measure what it measures perfectly well. The techniques of national income were not designed for such remote comparisons: goods and services unimaginable in 1780 now crowd our lives, from air conditioning to anaesthesia; and on the other side, less weighty, the forests primaeval and the hosts of golden daffodils are rarer, if more cheaply reached. Nor is the income per head divided out perfectly fairly, then or now. But the factor of increase could be nine or fifteen or thirty, rather than twelve, and the distribution of income now less equal than it actually is, and leave the heart of the matter – the logic of the argument – undisturbed. Most conservatively measured, the average person has about twelve times more bread, books, transport and innocent amusement than the average person had two centuries ago. No previous episode of enrichment approaches modern economic growth – not China or Egypt in their primes, not the glory of Greece or the grandeur of Rome.

Observations and predictions

Britain was of course first. And Britain was also first in the study of economics, from the political arithmeticians of the seventeenth century through David Hume, Adam Smith, T. R. Malthus, David Ricardo, John Stuart Mill to the modern masters, Marshall, Keynes and Hicks. Economics was for long a British, even disproportionately a Scottish, subject. What is odd is that the British economists did not recognise the

factor of twelve as it was happening. The economists' theories took useful account of little changes – a 5 per cent rise of income when cotton textiles grew or a 10 per cent fall when Napoleon ruled the Continent. But they did not notice that the change to be explained, 1780 to 1860, was not 10 per cent but 100 per cent, on its way to 1,100 per cent. Only recently has the enquiry into the nature and causes of the wealth of nations begun to recognise this astonishing oversight.

Between 1780 and 1860, dates covering the classic 'industrial revolution' (a dispute breaks out from time to time about the drama in the term, but it survives in use), British national income per head doubled – this even though population also more than doubled. A much larger nation was much richer per head, the beginning of the factor of twelve.

In his *Essay on the Principle of Population* (1798) the economist T. Robert (as he preferred to be called) Malthus predicted the opposite. Malthus told a great truth about earlier history. In medieval England a rising population had become poorer and in Shakespearean England the impoverishment happened again. But in late Georgian and early Victorian England a rising population became richer, much richer. The fact was contrary to every prediction of the economists, those 'dismal scientists', in Carlyle's phrase, who saw nothing in prospect c. 1830 but misery for the working man and riches for the rentier.

The economists, in other words, did not notice that something entirely new was happening 1780–1860. As the demographer Wrigley put it recently to the economic historian Cameron, 'the classical economists were not merely unconscious of changes going on about them that many now term an industrial revolution: they were in effect committed to a view of the nature of economics development that ruled it out as a possibility' (personal correspondence, quoted in Cameron forthcoming). At the moment that Adam Smith and John Stuart Mill came to understand an economy in equilibrium the economy grew away from their equilibrium. It was as though an engineer had satisfied himself of the statics that kept a jumbo jet from collapsing as it sat humming on the tarmac, but did not notice when the whole thing proceeded to launch into dynamic flight.

An historian like Thomas Babington Macaulay, respectful of the economics of his day but with a longer view, could see the event better than could most of the economists. He wrote in 1830:

If we were to prophesy that in the year 1930 a population of fifty million, better fed, clad, and lodged than the English of our time, will cover these islands, that Sussex and Huntingdonshire will be wealthier than the wealthiest parts of the West Riding of Yorkshire now are, ... that machines constructed on principles yet undiscovered will be in every house, ... many people would think us insane. (1830: I, ii, 185)

It has been customary to deprecate such optimism, and to characterise Macaulay in particular as hopelessly Whiggish and pro-capitalist in his sentiments. That he was, a bourgeois to the core. But Whiggish and pro-capitalist or not he was correct, down to his estimate of British population in 1930 (if one includes the recently separated Irish Republic, he was off by less than 2 per cent). The pessimists of his times – both economists and anti-economists – were wrong.

In the suggestive jargon of statistics, the startling rise of income 1780 to the present can be called the 'first moment', the *average* change. There is little historical disagreement about the first moment, at least in its order of magnitude. Macaulay was correct in prospect and so are the dozens of economic statisticians who have confirmed it in retrospect. Few doubt that by the third decade of Victoria's rule the ordinary subject was better off than eighty years before, and was about to become still better off (Lindert and Williamson 1983a).

The *second* moment is the variability of the change, its pattern of acceleration and deceleration. Second moments are more difficult to measure. You can know the average height of British women more exactly than you can know its variability. As Kuznets, the economist who pioneered the historical study of national income, once said, perhaps too gloomily, during our period 'the data are not adequate for testing hypotheses concerning the time patterns of growth rates' (1971: 41–2). An error of plus or minus 20 per cent in measuring income *c.* 1800 may not matter much for the 1,100 percentage points of change down to the present, but will matter a great deal in deciding whether working people paid for the French Wars (see ch. 13).

The second moment, in other words, is the detail of the factor of twelve, and around it the debates of British economic history gather. Has Britain done well since 1800? Did mass unemployment during the 1920s and 1930s check its growth? Did late Victorian Britain fail? And for present purposes, when exactly did the factor of twelve begin? Kuznets wrote early in the research, and we have found new sources and methods since he wrote, but the violence of controversy about such second-moment questions tends to confirm his view.

In the growth of British industry there was at least a before and after, if not a sharp discontinuity. Various emblematic dates have been proposed, down to the famous day and year: 9 March 1776, when Adam Smith's *The Nature and Causes of the Wealth of Nations* provided an ideology for the age; the five months in 1769 when Watt took out a patent on the separate condenser in his steam engine and Arkwright took out a patent on the water frame for spinning cotton; or 1 January 1760, when the furnaces at Carron Ironworks, Stirlingshire, were lit.

It sometimes seems that each economic historian has a favourite date, and a story to correspond. Carus-Wilson spoke of 'an industrial revolution of the thirteenth century': she found that the fulling mill was 'due to scientific discoveries and changes in technique' and 'was destined to alter the face of medieval England' (1941: 41). Bridbury found in the late middle ages 'a country travelling slowly along the road ... that [it] travelled so very much more quickly in Adam Smith's day' (1975: xix–xx). In the eyes of Marxist writers the sixteenth was the century of discontinuity, when capitalism set off into the world to seek its fortune. Nef, no Marxist, believed he saw an industrial revolution in the same century, depending on coal (1932), though admittedly it slowed in the seventeenth century. A student of the seventeenth century itself, such as Coleman (1977), finds glimmerings of economic growth even in that disordered age.

Wider perspectives are possible, encouraging the observer to see continuity instead. Looking at the matter from 1907, the American historian Adams could see a 'movement from unity into multiplicity, between 1200 and 1900, ... unbroken in sequence, and rapid in acceleration' (1907: 498). Jones and Mokyr have taken a similar long view of European exceptionalism (Jones 1981, 1988; Mokyr 1990a). The principal modern student of the age of industrialisation, Hartwell, appealed against the jostling throng of dates (1965: 78): 'Do we need an *explanation* of the industrial revolution? Could it not be the culmination of a most unspectacular process, the consequence of a long period of economic growth?' Cameron has thrown up his hands in the face of such confusion, arguing that the very idea of an industrial revolution – so named early in the nineteenth century in explicit imitation of the upheavals of the French Revolution – is an obstacle to thought (1990 and forthcoming).

The most widely accepted period for it, whatever exactly it was that led to the factor of twelve, is the late eighteenth century, within which some emphasise the 1760s and 1770s (Mantoux 1928; Landes 1969), others later. Rostow (1960) placed the 'takeoff into self-sustained growth' in the last two decades of the eighteenth century. The dating held through the great work of Deane and Cole (1962; and the parallel project, Mitchell and Deane 1962), which first undertook comprehensive measurement. Deane and Cole, however, for all their excellences, had to build on existing evidence, especially the evidence on foreign trade and on Hoffmann's pioneering index of industrial output. The main statistical finding after their work, in the 1980s, was that the sharpness of the take-off in Britain was exaggerated by the pioneering generation of quantifiers. True, growth could be faster for the late comers. Italy and Switzerland could adopt what Britain and Belgium had invented. But the first industrial nation, rather unsurprisingly, was slow in coming. A hard coming we had of it.

The slowness is documented in the important work of Crafts (1985a) and Harley (1982). They discovered that the indexes of industrial growth put too much weight on the fastest-growing sectors. In particular, Harley noted that in Hoffmann's index the cotton textile industry, growing explosively in the 1780s and 1790s, is given more weight than its size warrants. The overweighting of cotton, Harley argues, makes an interesting sector into an important sector before its time. The bias imparted to the figures is similar to the bias from non-quantitative sources. Without some way of measuring the importance of an industry a qualitative narrative will naturally focus on its early heroes, overweighting the importance of the industry because of its later prominence. The heroism of the cotton industry came when it was devoted chiefly to producing muslin shawls for ladies of fashion. Similarly, an index like Hoffmann's overweights the early years of cotton, during which the cotton grew heroically fast, but when, after all, the industry was nothing like as important in the life of the nation as it later became.

Still, the larger change must start somewhere, and the individual industry is the place to start. As the great student of European industrialisation, Alexander Gerschenkron, once remarked,

If the seat of the great spurt lies in the area of manufacturing, it would be inept to try to locate the discontinuity by scrutinizing data on large aggregate magnitudes such as national income ... By the time industry has become bulky enough to affect the larger aggregate, the exciting period of the great spurt may well be over. (1962b: 34-5)

In a footnote he remarks that 'Walt Rostow's failure to appreciate this point has detracted greatly from his concept of the take-off.'

In other words, small beginnings (exciting as they are, perhaps over-exciting) will be hidden by the mass until well after they have become routine. Mokyr has put it as a matter of arithmetic: if the older sector of an economy is growing at a slow 1 per cent per annum, and starts with 90 per cent of output, then by mere arithmetic the modern sector, growing at 4 per cent per annum, will take three-quarters of a century to account for as much as half of output (1985c: 5). We may call it the Weighting Theorem (or the Waiting Theorem, for the wait is long when the weight is small to begin with).

Gerschenkron was hoist by his own petard. For Italian industrial output he placed his 'big spurt' in the period 1896-1908, and wished to explain it with big banks founded in the 1890s. Stefano Fenoaltea, briefly his student, applied the Weighting Theorem to the case. Surely, Fenoaltea reasoned, the components of the industrial index - the steel output and the chemical output - are the 'real' units of economic analysis. If the components

started accelerating *before* the new banks appeared, becoming bulky only later, then the new banks could not have been the initiating force. The components did just this, spoiling Gerschenkron's bank-led story: the components accelerated not in the 90s but in the 80s, not after but before the banks.

Crafts (1977b) has pointed out that the detailed timing of the beginnings of modern economic growth should not anyway be the thing to be studied, because small beginnings do not come labelled with their probabilities of developing into factors of twelve. He is identifying a pitfall in storytelling. If the onset of modern economic growth fed on itself, then its start could be a trivial accident. Yet one might wonder why then it did not happen before. 'Sensitive dependence on initial conditions' is the technical term for some 'nonlinear' models - a piece of so-called 'chaos theory'. But history under such circumstances becomes untellable (McCloskey 1991).

Mokyr identifies another pitfall in storytelling (1985c: 44): rummaging among the possible acorns from which the great oak of the industrial revolution grew 'is a bit like studying the history of Jewish dissenters between 50 BC and 50 AD. What we are looking at is the inception of something which was at first insignificant and even bizarre', though 'destined to change the life of every man and woman in the West'. What is destined or not destined to change our lives will look rather different to each of us. Mokyr pointed out later (1993) that the destiny was not unified, and is therefore not well explained by a dice throw: the industrial revolution was not one event but a set of loosely related events, a trick in steam engines here, a new dock there. Something more widespread than mere chance was going on.

The slow-growth findings from Harley and Crafts do not mean that British income was low absolutely, or in any way disgraceful, merely that it grew at a stately pace. British economic development - like British population growth in the recent revisions (ch. 4) above - is therefore spread back into the early eighteenth century. The revision, again, affects the second moment, the pattern of industrial development over time, not its size in total. The factor of twelve remains; what is in dispute is whether much of it happened in a few decades in the late eighteenth century, as once believed. Again we see the difficulties with getting exact measures of the second as distinct from the first moment.

Economic and industrial structure

In any case the historians have long known that Britain was no factory in 1860. Mokyr's Weighting Theorem asserts itself: even cotton textiles, growing apace, could not absorb all the many workers in agriculture and

other trades less immediately affected by the machine age. Clapham made the point in 1926, observing that still in 1850 half the population was in employment untouched by 'the first industrial revolution'. Musson's figures imply, as Cameron notes (forthcoming), that steam power in Britain increased by a factor of fully ten from 1870 to 1907, long after the dark satanic mills first enter British consciousness (Musson 1978: 8, 61, 167–8). Clapham, indeed, eschewed the very phrase 'industrial revolution', although he would not have denied that something portentous happened 1780–1860. The statistical revisionists of the 1980s, Harley and Crafts, constitute so to speak a Claphamite sect.

The Claphamite view, in summary, is that industrial change was a slow turning, no revolution if that means short and sharp. Perhaps, to get back to the puzzle, that is why it was largely invisible to economists and some others watching it – though not to many possessed of common sense and eyes to see. Macaulay wrote in 1830, 'A single breaker may recede; but the tide is evidently coming in' (1830: 185). It was not 'evident' to many classical economists, who were predicting when Macaulay wrote that landlords would take all the increase, leaving the workers in precisely the condition they began. The first edition of this book (1981) called it 'The Quiet Revolution'. By now in the thinking of economic historians the revolution is still quieter, but longer and more impressive:

For while the tired waves, vainly breaking,
Seem here no painful inch to gain,
Far back, through creeks and inlets making,
Comes silent, flooding in, the main.

The new estimates by Feinstein and Pollard (1988), Crafts and Harley imply a growth in what people got for their effort of a trifle over half a per cent per year, a little faster in the late eighteenth century, a little slower in the early nineteenth. (The deceleration after 1800 – the second moment again – is not surprising, considering the acceleration of population growth and an expensive war against the French.) The British people also saved and added to their equipment. All told their income per head rose at about 1 per cent per year. It takes something growing at 1 per cent a year seventy-two years to double.

It took a long time, then, at the slow rates of growth that characterised British industrialisation, to transform the economy. The fact does not make the old and new sectors into what is known in development economics as a 'dual economy'. Though Britain did come at last to have many factories, there is nothing intrinsically unprogressive about non-manufacturing sectors. For example, Karl Marx sneered at the 'idiocy of rural life,' but Britain's rural life at the time was notably unidiotic,

economically speaking, at least by comparison with agriculture on the Continent. In later Victorian times it was to become technologically sophisticated, by any standard (vol. 2, ch. 6). Similarly the French physiocrats, a century before Marx, had asserted that services are somehow less genuinely productive than the making of things in factories (and that factories after all merely transform the Fundamental Goods: agricultural goods). The notion that agriculture for one reason and services for another are by nature less progressive or important has had a long life, surviving into present politics. But it is false economically, and false when applied to western European industrialisation (vol. 2, ch. 5). Danish industrialisation was led by butter, for example, Norway's by shipping services, Sweden's by timber. It just happened that Britain's was led by manufacturing.

As Berg (ch. 6 and 1985) and Hudson (1986, 1989) have noted, some technologically stagnant sectors (building, say) saw large expansion, some progressive sectors little or none (paper); some industries working in large-scale units did little to change their techniques (naval shipyards early in the period), some in tiny firms were brilliant innovators (the metal trades). Big factories in the famous sectors were not the whole of the factor of twelve.

Productivity change

The wider point notwithstanding, productivity change was fast in sectors like cotton textiles, 1780–1860. We do not have industrial censuses in Britain until well after the event (1907), and so it would appear impossible to measure productivity industry-by-industry. We can know roughly what the aggregate equipment of the nation was and how it grew (vol. 3, ch. 4; Feinstein 1978; Feinstein and Pollard, 1988). But we do not know for most industries – coal mining, for example, or pottery – how output or employment grew until well into the nineteenth century. Knowing productivity change by industry therefore would appear to be out of reach. It appears that Kuznets' gloom is justified: 'the data are not adequate for testing hypotheses concerning the time patterns of growth rates'.

But wait. We can some day, if not at present, know the details of productivity change sector-by-sector during the period, though the knowledge will require more archival research. We do not know annual quantities of china plates and steam coal, admittedly, and probably never can. On the other hand, we know practically anything we choose about the *price*. Britain was in 1800 (as in truth it had been since the danegeld) a thoroughly monetised society, with prices for everything, many of which have survived in the records of Eton, All Souls College and a hundred other archives. The technique is to measure physical productivity change

Table 10.1. *The fall in the real cost of cotton cloth, 1780–1860*

	Real cost index	Annual percentage growth of productivity
c. 1780	100	
c. 1812–15	32	3.4
c. 1860	13	2.0

by the changes in prices. The two measures, physical and price-based, are connected by definition, because the value of output must be the same as the value of inputs. Productivity can therefore be measured either on the physical side (output per unit of physical input) or on the value side (real costs).

To illustrate: a piece of cotton cloth that was sold in the 1780s for 70 or 80s was by the 1850s selling for around 5s. In the process cotton cloth moved from fashionable to commonplace, in the manner a century and a half later of nylon (first called 'artificial silk') and other synthetics. A little of the decline in the price of finished cotton cloth was attributable to declines in the prices of raw cotton itself after the introduction of the cotton gin (invented in 1793) and the resulting expansion of cotton plantations in America. But in other ways the price of inputs rose: by 1860, for example, wages of cotton workers had risen markedly. Why then did the price of manufactured cloth fall? It fell because organisation and machinery were massively improved in cotton textiles, 1780 to 1860. The degree to which the price of the cloth fell relative to the price of the inputs is therefore a measure of productivity change. *Quod erat demonstrandum*.

The real costs of cotton cloth, after allowing for the changing prices of inputs, are shown in Table 10.1. In other words, cotton cloth was made with 13 per cent of the real resources in 1860 that it had been made with in 1780. Or, to put it in physical terms, productivity had increased by a factor of $100/13 = 7.7$ times. (The expression and the idea of 'real cost' are the invention of the first modern historical economist, a student of Clapham's named G. T. Jones. Jones invented what is now known as 'total factor productivity measurement' a quarter century before it was reinvented, in ignorance of Jones, by Moses Abramowitz and Robert Solow. For a demonstration that Jones' measures are precisely the 'price dual' of the measures of productivity change see McCloskey 1973: 103n.)

The case is typical in showing more about the second moment than one might at first think knowable. It shows for example that productivity growth slowed in cotton, because power weaving – which came late – was

apparently less important than power carding of the raw wool and power spinning of the wool into yarn. And it shows that invention is not the same thing as innovation (ch. eleven; cf. Chapman and Butt 1988). The heroic age of invention ended by the late 1780s, by which time Hargreaves, Arkwright, Kay, Crompton and Cartwright had flourished. But the inventions saw steady improvement later – one of the main findings of quantitative economic history is that the pattern is typical, invention being only the first step (the same is true, for example, of railways, which improved in scores of small ways down to the twentieth century, with large falls in real costs). The real cost of cotton textiles had halved by the end of the eighteenth century. But it was to halve twice more down to 1860.

Few sectors were as progressive as cotton textiles. Productivity in iron grew a half to a third as fast. Productivity is not the same as production. The production of iron increased enormously in Britain 1780 to 1860 – by a factor of 56, in fact, or at 5.5 per cent per year (Davies and Pollard 1988; 'small' growth rates, as you might think 5.5 is, make for big factors if allowed to run on: 5.5 per cent is explosive industrial growth by historical standards, a doubling every $72/5.5 = 13.2$ years). The expanding British industry crowded out the iron imported from Sweden and proceeded to make Britain the world's forge. But the point is that it did so mainly by applying a somewhat improved technology (puddling) to a much wider field, not by the spectacular and continuous falls in cost that cotton witnessed. The cost of inputs to iron (mainly coal) changed little from 1780 to 1860; during the same span the price of the output (wrought-iron) fell from £20 a ton to £8 a ton. The fall in real costs, again, is a measure of productivity change. So productivity in wrought-iron making increased by a factor of about 2.5, an admirable factor of change. Yet over the same years the productivity in cotton textiles, we have seen, increased by a factor of 7.7.

Other textiles imitated the innovations in cotton (Hudson 1986), significantly cheapening their products, though less rapidly than the master industry of the age: as against cotton's 2.6 per cent productivity growth per year, worsteds (wool cloth spun into a thin yarn and woven flat, with no nap to the cloth) experienced 1.8 per cent and woollens 0.9 per cent (McCloskey 1981b: 114). Coastal and foreign shipping experienced rates of productivity growth similar to those in cotton textiles (some 2.3 per cent per year as compared with 2.6 in cotton). The figure is derived from North's estimates for transatlantic shipping during the period, rising to 3.3 per cent per year 1814–60 (1968). Again the 'low' percentage is in fact large in its cumulative effects: freights and passenger fares fell like a stone, from an index of around 200 after the Napoleonic Wars to 40 in the 1850s. Canals and railways experienced productivity growth of about 1.3 per cent

(Hawke 1970). Transportation was therefore among the more notably progressive parts of the economy.

But many other sectors, like iron as we have seen, experienced slower productivity growth. In agriculture the productivity change was slower still (ch. 5), dragging down the productivity of the economy as a whole; taking one year with another 1780–1860, agriculture was still nearly a third of national income. Productivity change varied radically from one part of the economy to the other, as it has continued to do down to the present, one sector taking the lead in driving up the national productivity while another settles into a routine of fixed technique. Agriculture itself, for example, came to have rapid productivity change in the age of the reaper and the steam tractor (vol. 2, ch. 5), and still more in the age of genetic engineering in the twentieth century. But from 1780 to 1860 textiles and transport were the leaders.

Such methods of analysis might be applied more widely, and would discipline thinking about when and where the quickening of industrial growth happened. For instance: iron machinery doubtless made possible the faster running speeds of the second and third generations of textile machines, and so iron was important in the nineteenth century as an input (ch. 11); but the industry producing the iron was not especially important. The value of iron's output relative to national income 1780–1860 was only 2 per cent.

The archival materials for seeing how productivity grew industry-by-industry are ample: prices are among the most abundant of historical statistics; an historian of ancient Mesopotamia will complain to his colleague in economic history that the cuneiform tablets are '90 per cent prices'. The collection of price statistics has been a low priority, mainly because economic historians think of the prices as useful only for calculating the standard of living. The price measure of productivity allows the prices to be used to see how the living was obtained in detail. Lindert and Williamson have done well in exploiting governmental sources (ch. 14; Lindert and Williamson 1983a; Williamson 1985), finding the wages for a range of service workers from porters to doctors (though again in aid of calculations of the standard of living). They 'urge other scholars to harvest additional wage series from the archives' (Mokyr 1985b: 183), a suggestion which can be seconded. It is a trifle scandalous that the wage estimates marching and countermarching in impossible intellectual campaigns are as old as Gilboy's (1934) for the eighteenth century and Wood's (1910) and Bowley's (1900) for the nineteenth. The price statistics are almost as old. Again Lindert and Williamson have recently improved them, by adding rents (from which one could calculate productivity change in housing per year; Jones in 1933 calculated it for housing construction) – although, as

they remark, the evidential basis is slim. The collection of prices should be a high priority, in Tycho Brahean quantities. To write the history of the period without detailed prices of inputs and outputs is like studying astronomy without detailed descriptions of stars.

Some economic historians, incidentally, have formed the impression that using prices to measure productivity requires additional, and dubious, assumptions. The impression is mistaken. Physical productivity change can come from economies of scale or from monopoly. So can change in the price measure. If the price measure is misleading, so is the physical measure, and for the same reasons. In accounting the two are not merely correlated with each other; they are identical. The stars can be observed with a refracting telescope or a reflecting telescope, but are the same stars.

For the edification of the mathematical reader, a simple demonstration can be given for the case of one output and one input. (It can be generalised easily.) With one input, I , costing P_i per unit the total cost is just IP_i . The revenue from output Q at the price P_q is, similarly, QP_q . The two are equal if the accounting for inputs and outputs is complete. And so $IP_i = QP_q$. So of course $P_i/P_q = Q/I$. So the rate of change of physical productivity (which is the rate of change of Q/I) will be the same as the rate of change of the price-measured productivity (which is the rate of change of P_i/P_q). It is no chancy theorem. It is an accounting identity.

The causes of growth

Even without the requisite star maps, though, we now know enough about the second moments of growth to say some things about its causes, 1780–1860. We have learned in the past twenty years of research into the era, to put the findings in a nutshell, that reallocation was not the cause. To put the findings another way, we have learned many Nots: that industrialisation was not a matter of foreign trade, not a matter of internal reallocation, not of transport innovation, not investment in factories, not education, not science. The task of the next twenty years will be to untie the Nots.

Foreign trade

Consider foreign trade. An old tradition carried forward by Rostow and by Deane and Cole puts much emphasis on Britain's foreign and colonial trade as an engine of growth. What the recent research has discovered is that the existence of the rest of the world mattered for the British economy, but not in the way suggested by the metaphor of an 'engine of growth' (O'Brien and Engerman 1991 demur).

What has become increasingly clear from the work of Williamson and Neal (ch. 7; Williamson 1985, 1987, 1990b; Neal 1990) among others is that Britain functioned in an international market for many goods and for investment funds. More exactly, the fact has been rediscovered – it was a commonplace of economic discussion by Ricardo and the rest at the time (it became obscured in economics by the barriers to trade erected during the European Civil War, 1914–45, and aftermath just ended).

By 1780 the capital market of Europe, for example, centred in Holland and England, was sophisticated and integrated, capital flowing with ease from French to Scottish projects. True, the market dealt mainly in government debt. The old finding of Pollard (1964) and others survives: industrial growth was financed locally, out of retained earnings, out of commercial credit for inventories and out of investors marshalled by the local solicitor (Richardson 1989; ch. 7). But ‘the’ interest rate relevant to local projects was determined by what was happening in wider capital markets, as is plain for example in the sharp rises and falls of enclosure in the countryside with each fall and rise in the rate on Consols (ch. 5). The interest rate in the late eighteenth century also determined booms and busts in canal building. And the interest rate in turn was determined as much by Amsterdam as by London.

The same had long been true of the market in grain and other goods, as David Ricardo assumed in his models of trade *c.* 1817 as though it were obvious. The disruptions of war and blockade masked the convergence from time to time, and regulations – such as the Corn Law (ch. 12) – could sometimes stop it from working. But the European world had a unified market in wheat by the eighteenth century, as is becoming clear. Already in 1967 Braudel and Spooner had shown in their astonishing charts of prices that the percentage by which the European minimum was exceeded by the maximum price fell from 570 per cent in 1440 to a mere 88 per cent in 1760 (1967: 470). Prices continued to converge, a benefit of the rapid growth of productivity already noted in shipping and railways. The same could be said of prices of iron, cloth, wood, coal, skins and the rest of the materials useful to life around 1800. They were beginning to cost roughly the same in St Petersburg as in New York.

The reason the convergence is important is this: an economic history that imagines the British economy in isolation is wrong. If the economy of Europe is determining the price of food, for example, it makes little sense to treat the British food market as though it could set its own prices (except, of course, by protective tariffs: which until the 1840s it imposed). Purely domestic assumptions, such as those around which the controversy over agriculture’s role in industrialisation have raged (Ippolito 1975), will stop making sense. The supply and demand for grain in Europe, or indeed

the world, not the supply and demand in the British portion of Europe, was setting the prices faced by British farmers in 1780. Likewise for interest rates or the wages of seamen. Centuries earlier the price of gold and silver had become international.

The intrusion of the world market can become so strong that the domestic story breaks down entirely. One can tell a domestic story in the eighteenth century of how much was saved, but not a domestic story of what interest rate it was saved at. One can tell a domestic story in the early nineteenth century of the supply of labour from a slowly growing agricultural sector, but not a domestic story of the entire supply of labour to Liverpool, Glasgow and Manchester, if Ireland is not included. *Nots.*

Pollard, again, has argued persuasively that for many questions what is needed is a European approach, or at least a north-western European regional approach (Pollard 1973, 1981a; within Britain cf. Hudson 1989 and Crafts 1989a). He wrote in 1973 (Mokyr 1985b: 175), ‘the study of industrialization in any given European country will remain incomplete unless it incorporates a European dimension: any model of a closed economy would lack some of its basic and essential characteristics’. The political analogue is that it would be bootless to write a history of political developments in Britain or Italy or Ireland 1789 to 1815 without reference to the French Revolution. Politics became international – not merely because French armies conquered most of Europe but because French political ideas became part of political thinking, whether in sympathy or in reaction. Likewise in economic matters. The world economy from the eighteenth century (and probably before) provided Britain with its framework of relative values, wheat against iron, interest rates against wages.

The point is crucial, to return again to the puzzle, for understanding why the classical economists were so wrong in their dismal predictions. Landlords, they said, would engorge the national product, because land was the limiting factor of production. But the limits on land seen by the classical economists proved unimportant, because north-west Europe gained in the nineteenth century an immense hinterland, from Chicago and Melbourne to Cape Town and Odessa. The remarkable improvement of ocean shipping tied Britain to the world like Gulliver to the ground, by a hundred tiny threads. Grain production in Ukraine and in the American Midwest could by the 1850s begin to feed the cities of an industrial Britain; but the price of wheat in Britain was constrained even earlier.

Trade, then, was important as a context for British growth. Yet it was not an engine of growth (chs. 8 and 12). For the period in question Mokyr makes the clearest case (Mokyr 1985b: 22–3 and works cited there). The underlying argument is that domestic demand could have taken the place

of foreign demand (Mokyr earlier (1977) had shown likewise that the shuffling of domestic demand was no more promising). To be sure, Britons could not have worn the amount of cotton textiles produced by Lancashire at its most productive: cotton dhotis for the working people of Calcutta would not have become fashionable at the High Street Marks and Spencer. But in that case the Lancastrians would have done something else. The exporting of cotton cloth is not sheer gain. It comes at the cost of something else that its makers could have done, such as building more houses in Cheshire or making more wool cloth in Yorkshire.

In other words, the primitive conviction most people have that foreign trade is the source of wealth is wrong. Nations, or villages, do not have to trade to live. (The power of the conviction is shown nowadays by the role of fish exports in the political economy of Iceland or of exports generally in that of Japan.) Exports are not the same thing as new income. They are new markets, not new income. They are a shift of attention, not consciousness itself. Not.

The trade, of course, benefits the traders. Although not all the income earned in trade is a net gain, nonetheless there is such a gain. But – here is the nub – the gain can be shown in static terms to be small. One of the chief findings of the ‘new’ economic history, with its conspicuous use of economic models, is that static gains are small. Fogel’s calculation of the social savings from American railways is the leading case (1984, replicated by Hawke in 1970 for Britain with broadly similar results). However essential one may be inclined to think railways were, or how crucial foreign trade to British prosperity, or how necessary the cotton mill to industrial change, the calculations lead to small figures, far below the factor of twelve.

The finding that foreign trade is a case in point, with small static gains, can stand up to a good deal of shaking of the details. Its robustness is a consequence of what is known informally among economists as Harberger’s Law (after A. C. Harberger, an economist famous for such calculations). That is, if one calculates a gain amounting to some fraction from a sector that amounts to again a fraction of the national economy one is in effect multiplying a fraction by a fraction. Suppose X per cent of gain comes from a sector with Y per cent of national income. The resulting fraction, X times Y , is smaller than either of its terms. For most sectors and most events – here is the crucial point – the outcome is a small fraction when set beside the 1,100 percentage points of growth to be explained 1780 to the present, or even beside the 100 percentage points of growth to be explained 1780 to 1860.

To take foreign trade as the example, in 1841 the United Kingdom exported some 13 per cent of its national product. From 1698 to 1803 the

range up and down of the three-year moving averages of the gross barter terms of trade is a ratio of 1.96, highest divided by lowest (Deane and Cole 1962; Mitchell and Deane 1962: 330); Imlah’s net barter terms range over a ratio of 2.32, highest divided by lowest (1958). So the variation of the terms on which Britain traded was about 100 per cent over century-long spans like these. Only 13 per cent of any change in income, then, can be explained by foreign trade, statically speaking: $100 \times 0.13 = 13$. Another Not.

Faced with such an argument the non-economists, and some of the economists, are likely to claim that ‘dynamic’ effects will retrieve trade as an engine of growth. The word ‘dynamic’ has a magical quality. Waving it about, however, does not in itself suffice to prove one’s economic and historical wisdom. One has to show that the proffered ‘dynamic’ effect is quantitatively strong.

For example, one might claim that the industries like cotton textiles encouraged by British trade were able to exploit economies of scale, in perhaps the making of textile machinery or the training of master designers. There: a dynamic effect that makes trade have a larger effect than the mere static gain of efficiency. Not Not.

It may be true. And in fact a smaller cotton textile industry would have been less able to take advantage of technological change nationally. After all, cotton was unusually progressive. But is the dynamic effect large?

One can answer the question by a thought experiment. If the cotton textile industry were cut in half by an absence of foreign markets 1780–1860 the importance of cotton in national productivity would have fallen from 0.07 to 0.035. Resources would have had to find other employment. Suppose that the released resources would have experienced productivity growth of 0.5 per cent per year (on the low end of the available possibilities) instead of the princely 2.6 per cent they in fact experienced in cotton. The cotton industry in the actual event contributed a large amount – namely, $(0.07) (2.6 \text{ per cent}) = 0.18 \text{ per cent per year}$ – to the growth of national income; this one giant contributed some 18 per cent of the total growth of income per person nationally 1780–1860. With the hypothetical cut-off of trade the resources would contribute instead $(0.035) (2.6 \text{ per cent}) + (0.035) (0.5 \text{ per cent}) = 0.11 \text{ percentage points a year}$. The fall in national productivity change can be inferred from the difference between the actual 0.18 per cent attributable to cotton and the hypothetical 0.11 per cent attributable to a half-sized cotton industry and the industries its resources went to. The difference is about a 7 per cent fall in the national rate of productivity change, that is, a fall from (notionally) 1.00 per cent a year to 0.93 per cent a year. In the eighty years 1780–1860 such a lag would cumulate, however, to merely 9 per cent of national income. Remember

that a 100 per cent change is to be explained. The dynamic effect sounds promising, but in quantitative terms does not amount to much. Another Not.

A 'dynamic' argument has a problem as an all-purpose intellectual strategy. If someone claims that foreign trade made possible, say, unique economies of scale in cotton textiles or shipping services, she owes it to her readers to tell why the gains on the swings were not lost on the roundabouts. Why do not the industries made *smaller* by the large extension of British foreign trade end up on the losing side? The domestic roads in Shropshire and the factories unbuilt in Greater London because of Britain's increasing specialisation in cotton textiles may themselves have had economies of scale, untapped. (The argument applies later to the worries over 'excessive' British specialisation in foreign investment, insurance and shipping; see vol. 2, chs. 7 and 8).

All this Not-saying is not to say that foreign trade was literally a nullity. Trivially, of course, some goods – the banana for the Englishman's breakfast table was the popular instance late in the nineteenth century, raw cotton the most important instance throughout – simply cannot be had in England's clime. Trade is a conduit of ideas and competitive pressures, as is best shown by the opening of Japan after 1868. And trade insures against famine, as the Raj knew in building the railways of India. A literal closing of trade is not what is contemplated: the question is, was trade a stimulus to growth in the simple, mercantilist way usually contemplated in the literature? Not.

To put the wider Not finding in a sentence: we have not discovered any single factor essential to British industrialisation. Gerschenkron a long time ago argued that the notion of essential prerequisites for economic growth is a poor one (1962a). He gave examples from industrialisation in Russia, Italy, Germany and Bulgaria that showed substitutes for the alleged prerequisites. Big banks in Germany and state enterprises in Russia, for instance, substituted for entrepreneurial ability. The British case provided the backdrop for comparison with other industrialisations. But Gerschenkron's economic metaphor that one thing can 'substitute' for another applies to Britain itself as much as to the other countries. Economists believe, with good reason, that there is more than one way to skin a cat. If foreign trade or entrepreneurship or saving had been lacking, the economist's argument goes, other impulses to growth – with some loss – could conceivably have taken their place. A vigorous domestic trade or a single-minded government or a forced saving from the taxation of agriculture could take the place of the British ideal of merchant-adventurers left alone by government to reinvest their profits in a cotton factory.

Transport

Transportation, for example, is often cast in the hero's role. The static drama is most easily criticised. Canals carrying coal and wheat at a lower price than cartage, better public roads bringing coaching times down to a mere day from London to York, and then the railway steaming into every market town were of course Good Things. But land transportation is never more than 10 per cent of national income – it was something like 6 per cent 1780–1860. Britain was well supplied with coastwise transportation and its rivers flowed gently like sweet Afton when large enough for traffic at all. Even unimproved by river dredging and stone-built harbours, Mother Nature had given Britain a low cost of transportation. The further lowering of cost by canals and railways would be, say, 50 per cent (a figure easily justified by looking at freight rates and price differentials) on the half of traffic not carried on unimproved water – say another 50 per cent. By Harberger's Law, 50 per cent of 50 per cent of 10 per cent will save a mere 2.5 per cent of national income. One would welcome 2.5 per cent of national income as one's personal income; and even spread among the population it is not to be sneezed at. But it is not by itself the stuff of 'revolution'.

Yet did not transportation above all have 'dynamic' effects? It seems not, though historians and economists have quarrelled over the matter and it would be premature to claim that the case is settled (for the pro-transport side see Szostak 1991). A number of points can be made against the dynamic effects. For one thing the attribution of dynamism sometimes turns out to be double counting of the static effect. Historians will sometimes observe with an air of showing the great effects of transport that the canals or the railways increased the value of coal lands or that they made possible larger factories – dynamic effects (the word is protean). But the coal lands and factories are more valuable simply because the cost of transporting their outputs is lower. The higher rents or the larger markets are alternative means of measuring what is the same thing, the fall in the cost of transporting coal or pottery or beer.

For another, some of the dynamic effects would themselves depend on the size of the static, 2.5 per cent effect. For example, if the 'dynamic' effect is that new income is saved, to be reinvested, pushing incomes up still further, the trouble is that the additional income in the first round is small.

For still another, as has already been stressed, the truly dynamic effects may arise from expensive as much as from cheap transportation. Forcing more industry into London in the early nineteenth century, for example, might have achieved economies of scale which were in the event dissipated by the country locations chosen under the regime of low transport costs.

The balance of swings and roundabouts has to be calculated, not merely asserted.

Enclosure

Sector by sector the older heroes have fallen before the march of Notting economists and historians. Marx put great emphasis for instance on the enclosure of open fields, which he claimed enriched the propertied classes and drove workers into the hands of industrialists. By now several generations of agricultural historians have argued, contrary to a Fabian theme first articulated eighty years ago, that eighteenth-century enclosures were equitable and did not drive people out of the villages. True, Parliament became in the eighteenth century an executive committee of the landed classes, and proceeded to make the overturning of the old forms of agriculture easier than it had been. Oliver Goldsmith lamenting *The Deserted Village* wrote in 1770 that 'Those fenceless fields the sons of wealth divide,/ And even the bare-worn common is denied.' But contrary to the romance of the poem, which reflects poetic traditions back to Horace more than evidence from the English countryside, the commons was usually purchased rather than stolen from the goose.

The result of enclosure was a somewhat more efficient agriculture. But was enclosure therefore the hero of the new industrial age? By no means. The productivity changes were small (McCloskey 1972; Allen 1992; ch. 5), perhaps a 10 per cent advantage of an enclosed village over an open village. Agriculture was a large fraction of national income (shrunk perhaps to a third by 1800), but the share of land to be enclosed was only half (McCloskey 1975; Wordie 1983). Harberger's Law asserts itself again: $(1/3)(1/2)(10 \text{ per cent}) = 1.6 \text{ per cent}$ of national income was to be gained from the enclosure of open fields. Improved road surfaces around and about the enclosing villages (straightening and resurfacing of roads went along with enclosure, but is seldom stressed) might have been more important than the enclosure itself.

Specialisation and the division of labour

Nor was Adam Smith correct that the wealth of the nation depended on the division of labour. To be sure, the economy specialised. Kussmaul's work on rural specialisation shows it happening from the sixteenth century onward (ch. 1). Berg and Hudson (ch. 6; Hudson 1989) have emphasised that modern factories need not have been large, yet the factories nonetheless were closely divided in their labour. Most enterprises were tiny, and accomplished the division of labour through the market, as Smith

averred. It has long been known that metal working in Birmingham and the Black Country was broken down into hundreds of tiny firms, anticipating by two centuries the 'Japanese' techniques of just-in-time inventory and thorough sub-contracting. Division of labour certainly did happen, widely.

That is to say, the proper dividing of labour was, like transport and enclosure, efficient. Gains were to be had, which suggests why they were seized. But a new technique of specialisation can be profitable to adopt yet lead to only a small effect on productivity nationally – look again at the modest, if by no means unimportant, productivity changes from the puddling and rolling of iron. The gains were modest in the absence of dynamic effects, because the static gains from more complete specialisation are limited by Harberger's Law.

A similar thought experiment shows the force of the argument. Specialisation in the absence of technological change can be viewed as the undoing of bad locations for production. Some of the heavy clay soil of the midlands was put down to grazing, which suited it better than wheat. Or the labour of the Highlands was ripped off the land, to find better employment – higher wages, if less Gaelic spoken – in Glasgow or New York. The size of the reallocation effect can be calculated. Suppose a quarter of the labour of the country were misallocated. And suppose the misallocation were bad enough to leave, say, a 50 per cent wage gap between the old sector and the new. This would be a large misallocation. Now imagine the labour moves to its proper industry, closing the gap. As the gap in wages closes the gain shrinks, finally to zero. So the gain from closing it is so to speak a triangle (called in economics, naturally, a Harberger Triangle), whose area is half the rectangle of the wage gap multiplied by the amount of labour involved. So again: $(1/2)(1/4)(50 \text{ per cent}) = 6.25 \text{ per cent}$ of labour's share of national income, which might be half, leaving a 3 per cent gain to the whole. The gain, as usual, is worth having, but is not itself the stuff of revolutions. The division of labour: Not.

Natural resources

Geography is still another Not. Some economic historians (e.g. Wrigley 1988) continue to put weight on Britain's unusual gifts from Nature. It must be admitted that coal correlates with early industrialisation: the coal-bearing swath of Europe from Midlothian to the Ruhr started early on industrial growth. But economically speaking the coal theory, or any other geographical theory, has an appointment with Harberger. Coal is important, blackening the Black Country, running the engines, heating the

homes. But it does not seem, at least on static grounds, to be important enough for the factor of twelve. The calculations would be worth doing, but one suspects they would turn out like the others.

Classical models of economic growth

The claim is that the economists' static model does not explain the factor of twelve. It can tell why it did *Not* happen, a series of Nots, useful Nots, correctives to popular fable and sharpeners of serious hypotheses. But the kind of growth contemplated in the classical models, embedded now deep within modern economics as a system of thought, was not the kind of growth that overtook Britain and the world in the late eighteenth and nineteenth centuries.

One might reply that many small effects, static and dynamic, could add up to the doubling of income per head to be explained: trade, coal, education, canals, peace, investment, reallocation. No, Not. One trouble is that doubling – 100 per cent – is not enough, since in time modern economic growth was not a factor of two but a factor of twelve – not 100 per cent but 1,100 per cent. Another is that many of the effects, whether in the first or the second century of modern economic growth, were available for the taking in earlier centuries. If canals, say, are to explain part of the growth of income it must be explained why a technology available since ancient times was suddenly so useful. If teaching many more people to read was good for the economy it must be explained why Greek potters signing their amphora c. 600 BC did not come to use water power to run their wheels and thence to ride on railways to Delphi behind puffing locomotives. If coal is the key it must be explained why north China, rich in coal, had until the twentieth century no industrial growth. The mystery inside the enigma of modern economic growth is why it is modern.

The classical model from Smith to Mill was one of reaching existing standards of efficiency and equipment. To put it in a name: of reaching Holland. Holland was to the eighteenth century what America is to the twentieth, a standard for the wealth of nations.

The province of Holland [wrote Adam Smith in 1776] ... in proportion to the extent of its territory and the number of its people, is a richer country than England. The government there borrows at two per cent., and private people of good credit at three. The wages of labour are said to be higher in Holland than in England, and the Dutch ... trade upon lower profit than any people in Europe. (1776: I.ix.10: 108)

The emphasis on profit at the margin is characteristic of the classical school. The classical economists thought of economic growth as a set of investments, which would, of course, decline in profit as the limit was

reached. Smith speaks a few pages later of 'a country which had acquired that full complement of riches which the nature of its soil and climate, and its situation with respect to other countries allowed it to acquire' (1776: I.ix.14: 111). He opines that China 'neglects or despises foreign commerce' and 'the owners of large capitals [there] enjoy a good deal of security, [but] the poor or the owners of small capitals ... are liable, under the pretense of justice, to be pillaged and plundered at any time by the inferior mandarines' (1776: I.ix.15: 112; cf. 1776: I.viii.24: 89). In consequence the rate of interest in China, he claims, is 12 rather than 2 per cent (Smith, incidentally, was off in his facts here). Not all the undertakings profitable in a better ordered country are in fact undertaken, says Smith, which explains why China is poor. Smith and his followers sought to explain why China and Russia were poorer than Britain and Holland, not why Britain and Holland were to become in the century after Smith so very much more rich. The revolution of spinning machines and locomotive machines and sewing machines and reaping machines that was about to overtake north-west Europe was not what Smith had in mind. He had in mind that every country, backward China and Russia, say, and the Highlands of Scotland might soon achieve what the thrifty and orderly Dutch had achieved. He did not have in mind the factor of twelve that was about to occur even in the places in 1776 with a 'full complement of riches'.

Smith, of course, does mention machinery, in his famous discussion of the division of labour: 'Men are much more likely to discover easier and readier methods of attaining any object, when the whole attention of their minds is directed towards the single object' (1776: I.i.8: 20). But what is striking in his and subsequent discussions is how much weight is placed on mere reallocations. The reallocations, mere efficiencies, we have found, are too small to explain what is to be explained.

In a deep sense the economist's model of allocation does not explain the factor of twelve. If allocation were all that was at stake then previous centuries and other places would have experienced what Britain experienced 1780–1860. Macaulay says, in a Smithian way, 'We know of no country which, at the end of fifty years of peace, and tolerably good government, has been less prosperous than at the beginning of that period' (1830: 183). Yes. But 100 per cent better off, on the way to 1,100 per cent better off? Not.

To put it another way, economics in the style of Adam Smith, which is the mainstream of economic thinking, is about scarcity and saving and other puritanical notions. In the sweat of thy face shalt thou eat bread. We cannot have more of everything. We must abstain puritanically from consumption today if we are to eat adequately tomorrow. Or in the modern catch-phrase: there's no such thing as a free lunch.

The chief fact of the quickening of industrial growth 1780–1860 and its aftermath, however, is that scarcity was relaxed – relaxed, not banished or overcome by an ‘affluent society’, since whatever the size of income at any one time more of it is scarce. Modern economic growth is a massive free lunch.

In 1871, a century after Smith and at the other end of the period (but not the end of modern economic growth) John Stuart Mill’s last edition of *Principles of Political Economy* marks the perfection of classical economics. Listen to Mill:

Much as the collective industry of the earth is likely to be increased in efficiency by the extension of science and of the industrial arts, a still more active source of increased cheapness of production will be found, probably, for some time to come, in the gradual unfolding consequences of Free Trade, and in the increasing scale on which Emigration and Colonization will be carried on. (1871: Bk IV, ch. ii.1: 62)

Mill was wrong. The gains from trade, though statically commendable, were trivial beside the extension of industrial arts (‘science’ means here ‘systematic thinking’, not, as it came to mean shortly afterwards, the natural sciences alone). The passage exhibits Mill’s classical obsession with the principle of population, namely, that the only way to prevent impoverishment of the working people is to restrict population. His anxieties on this score find modern echo in the environmental and family-limitation movements. Whatever their wisdom today, the Malthusian ideas told next to nothing about the century to follow 1871. British population doubled again, yet income per head increased by nearly a factor of four. Nor did Mill’s classical model, as we have seen, give a reasonable account of the century before 1871.

Mill again: ‘It is only in the backward countries of the world that increased production is still an important object: in those most advanced, what is economically needed is a better distribution, of which one indispensable means is a stricter restraint on population’ (1871: Bk IV, ch. vi.2: 114). Still more wrong, in light of what in fact happened during the century before and the century after. Mill is unaware of the larger pie to come – unaware, so strong was the grip of classical economic ideas on his mind, even in 1871, after a lifetime watching it grow larger. He says elsewhere, ‘Hitherto it is questionable if all the mechanical inventions yet made have lightened the day’s toil of any human being’ (1871: Bk IV, ch. vi.2: 116), a strange assertion to carry into the 1871 edition, with child labour falling, education increasing, the harvest mechanising and even the work week reducing.

Mill was too good a classical economist, in short, to recognise a phenomenon inconsistent with classical economics. That the national

income per head might quadruple in a century in the teeth of rising population is not a classical possibility, and so the classicals from Smith to Mill put their faith in greater efficiency by way of Harberger Triangles and a more equitable distribution of income by way of improvements in the Poor Law. It should be noted that Mill anticipated social democracy in many of his later opinions, that is, the view that the pie is after all relatively fixed and that we must therefore attend especially to distribution. That the growth of the pie would dwarf the Harberger Triangles available from efficiency, or the Tawney Slices available for redistribution, did not comport with a classical theory of political economy. Macaulay’s optimism of 1830 turned out to be the correct historical point: ‘We cannot absolutely prove that those are in error who tell us that society has reached a turning point, that we have seen our best days. But so said all who came before us, and with just as much apparent reason’ (1830: 186). The pessimistic and puritanical classical economists, with the pessimistic and puritanical romantic opponents of industrialisation, were wrong.

Expanding the models

To account for the startling growth of income before 1860 and the still more startling growth to come it would seem that we must let our economic models expand. That economists have not explained modern economic growth is indeed something of a scientific scandal, although economists are not the only ones to blame: a hundred times more funds, perhaps a thousand times more, are spent on mapping distant galaxies or mapping the genes of *E. coli* than explaining the economic event that made the telescopes and the microscopes for the mappings possible. Some economists have recently turned back to questions of economic growth, questions neglected for some decades by most non-historical economists. They have tried on the blackboard to modify the economic models to fit what is by now two centuries of growth, building especially on the speculations in the 1920s by the American economist Allyn Young about economies of scale. But the new growth economists have not read more than a page or two of economic history or the history of economic thought, and so repeat the mistakes of earlier generations of economists, though exhibiting greater mathematical imagination.

Science

Turn then to less material causes, looking for some way of supplementing a materialist but unsuccessful theory in economics. Pure thought, perhaps: Science, in sense 5b in the Oxford English Dictionary, now ‘the dominant sense in ordinary use’, lab-coated and concerned with distant galaxies and

E. coli. Science by this modern definition, however, is another Not (Musson and Robinson 1969; Musson 1972). A powerful myth of moderns is that Science Did It, making us rich. Scientists believe it themselves, and have managed to convince the public. The finding of Not is again relatively recent. Simon Kuznets (1966) and Walt Rostow (1960) both believed that science had much to do with modern economic growth, but it is increasingly plain that they were mistaken (chs. 2 and 11). The Victorians when in an optimistic mood tended to combine technology and science together in a vision of Progress. They were mistaken as well. Workshop ingenuity, not academic science, made better machines. Chemistry made no contribution to the making of steel until the twentieth century, the reactions of a blast furnace being too complex in their details. Sciences mechanical and otherwise had little or nothing to do with inventions in textiles, which depended instead on a craft tradition of machine makers. The same could be said for the other mechanical inventions of the nineteenth century. Steam might be thought to have had a theoretical base, for it was necessary to know that an atmosphere existed before an atmospheric engine would have seemed plausible. But it is notorious among historians of physics that the steam engine affected thermodynamics, not (until very much later) the other way around (von Tunzelmann 1978). Few parts of the economy used much in the way of applied science in other than an ornamental fashion until well into the twentieth century. In short, most of the industrial change was accomplished with no help from academic science.

Literacy

Literacy, too, is a Not, though more of a Not-But than is science. Literacy was not essential for modern industry, as is apparent in its *fall* during periods of intense industrialisation (Mitch 1992; West 1978). But a mute, inglorious Watt would lie undiscovered in an illiterate nation, and doubtless did in Russia and Spain. Britain, especially north Britain, with northern Europe (and the United States), was more literate than other countries in the eighteenth century (Japan, with a more difficult form of writing, had at the time similar attainments in literacy; it appeared ready for economic growth, which was only with difficulty killed by its government).

Culture

So we have more Nots in the world of the mind. 'Cultural factors' more or less mental are promising and much studied. We have learned from Richard Roehl and Patrick O'Brien a good deal about the French/British comparison, learning for example that French agriculture was not

backward, despite an old British presumption that Frenchmen simply cannot get it right. On the technological front it is notable that Frenchmen invented in the eighteenth century what Englishmen applied (ch. 2). Something was different in England that encouraged more application. Yet looked at from a distance it seems wrong to separate France from England. It was north-west Europe as a whole that developed fast, as Pollard points out. Southern France lagged, but so, after all, did southern England: Macaulay promised in 1830 that backward Sussex could some day hope to equal the West Riding. Belgian industrialisation was almost as early and vigorous as Yorkshire's and Lancashire's.

Technology and invention

Suppose then we look at the problem from a chronological distance. 'Give me a lever and a place to stand on', said boasting Archimedes, 'and I shall move the world.' What is odd about his world of the classical Mediterranean is that for all its genius it did not apply the lever, or anything much else, to practical uses. Applied technology, argue Jones (1981) and Mokyr (1990a), was a northern European accomplishment. The 'Dark Ages' contributed more to our physical well being than did the glittering ages of Pericles or Augustus. From classical times we got toy steam engines and erroneous principles of motion. From the ninth and tenth centuries alone we got the horse collar, the stirrup, and the mould-board plough.

Then from an explosion of ingenuity down to 1500 we got in addition the blast furnace, cake of soap, cam, canal lock, carrack ship, cast-iron pot, chimney, coal-fuelled fire, cog boat, compass, crank, cross-staff, eyeglass, flywheel, glass window, grindstone, hops in beer, marine chart, nailed horseshoe, overshoot water wheel, printing press, ribbed ship, shingle, ski, spinning wheel, suction pump, spring watch, treadle loom, water-driven bellows, weight-driven clock, whisky, wheelbarrow, whippetree (see 'The Wonderful One-Hoss Shay') and the windmill. Down to 1750 the pace merely slackened, without stopping: note that the pace of invention *decelerated* on the eve of the sharpest industrial change. And then came 'The Years of Miracles', as Mokyr (1990a) calls them, from 1750 to 1900.

Why? Can one give an economic account that does not run afoul of the Nots and the Harbergers?

The economist, Kirzner, has argued recently that profit is a reward for what he calls 'alertness' (1989). Sheer – or as we say 'dumb' – luck is one extreme. Hard work is the other. Alertness falls in between, being neither luck nor routine work. Pure profit, says Kirzner, earned by pure entrepreneurs, is justified by alertness.

The story of European, and British, ingenuity can be told in Kirzner's

metaphors, improving both the story and the metaphor. As many economists have emphasised – relying once again on their conviction that there is No Free Lunch – the systematic search for inventions can be expected in the end to earn only as much as its cost. The routine inventor is an honest workman, but is worthy therefore only of his hire, not worthy of supernormal profit. The cost of routine improvements in the steam engine eats up the profit. It had better, or else the improvement is not routine. Routine invention is not the free lunch experienced since the eighteenth century. Rationalisation of invention has limits, as Joseph Schumpeter and Max Weber did not appreciate. The great research laboratories can produce inventions, but in equilibrium they must spend in proportion to the value invented – or else more research laboratories will be opened until, in the way of routine investment (see Smith on Holland above), the cost rises to exhaust the value.

If hard work in invention was not the cause of the factor of twelve, is the explanation to be found at the other extreme of Kirzner's spectrum, sheer, dumb luck? No, it would seem not. After all, it happened in more than one place (in Belgium and New England as well as in Britain, for instance; in cotton as well as in pottery) but spread selectively (to northern but not southern Italy; to Japan and then Korea but not China – though time will tell). Modern economic growth seems to select countries and sectors by some characteristic.

Well, then, is it Kirzner's metaphor of 'alertness' that explains the European peculiarity? Perhaps it is. Mokyr makes a distinction between micro-inventions (such as the telephone and the light bulb), which responded to the routine forces of research and development (both the telephone and the light bulb were sought methodically by competing inventors), and macro-inventions (such as the printing press and the gravity-driven clock), which did not (Mokyr 1990a). He stresses that both play a part in the story. Yet he is more intrigued by the macro-inventions, which seem less methodical and, one might say, less economic, less subject to the grim necessities of paying for lunch. Guttenberg just did it, says Mokyr, and created a galaxy. Macro-inventions such as these come to the alert, not to the lucky or the hard working, and macro-inventions seem to lie at the heart of the modern miracle. In short, as Mokyr says, from the technological point of view the quickening of industrial change was 'a cluster of macroinventions': the steam engine, the spinning jenny, and so to a factor of twelve.

But there is something missing in the metaphor and the story, needed to complete the theory. From an economic point of view, alertness by itself is highly academic, in both the good and the bad sense. It is both intellectual and ineffectual, the occupation of the spectator, as Addison put it, who is

'very well versed in the theory of a husband or a father, and can discern the errors of the economy, business, and diversion of others better than those engaged in them'.

Persuasion

If his alert observation of error is to be effectual the spectator has to persuade a banker. Even if he is himself the banker he has to persuade himself, in the councils of his mind. What is missing, then, from the theory of technological change is power. (Those outside the mainstream of bourgeois economic thinking will here find something to agree with.) Between the conception and the creation, between the invention and the innovation, falls the shadow. Power runs between the two. An idea without financing is just an idea. In order for an invention to become an innovation the inventor must persuade someone with the financial means or some other ability to put it into effect.

What matters, to put the point another way, are the conditions of persuasion. Europe's fragmented polity, perhaps, made for pluralistic audiences, by contrast with intelligent but stagnant China. An inventor persecuted by the Inquisition in Naples could move to Holland. The Jews of Spain, expelled in 1492, invigorated the economic life of hundreds of towns on the Mediterranean, such as far Salonika in northern Greece.

Early in his book Mokyr asserts that there is no necessary connection between capitalism and technology: 'Technological progress predated capitalism and credit by many centuries, and may well outlive capitalism by at least as long' (1990a). In the era of the factor of twelve one doubts it, and even before one might wonder, so close bound are gain, persuasion, and ingenuity. Capitalism was not, contrary to Marx's story – which still dominates the modern mind – a modern invention. As the medieval historian Herlihy put it long ago, 'research has all but wiped from the ledgers the supposed gulf, once thought fundamental, between a medieval manorial economy and the capitalism of the modern period'. And any idea requires capitalism and credit in order to become an innovation. The Yorkshireman who invested in a windmill c. 1185 was putting his money where his mouth was, or else putting someone else's money. In either case he had to persuade.

What makes alertness work, and gets it power, is persuasion. At the root of technological progress, one might argue, is a rhetorical environment that makes it possible for inventors to be heard. If such a hypothesis were true – and its truth is untried, and may at last end up itself on the pile of weary Nots – it would also be pleasing, for it would suggest that free speech and an openness to persuasion leads to riches. Europeans tortured,

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beheaded and burnt people they disagreed with in alarming numbers, to be sure, but it may be argued that their fragmented polity let new thinkers escape more often than in China or the Islamic world at about the same time. And when the Europeans, or at any rate some of them, stopped torturing, beheading and burning each other, the economy grew. No wonder that the nations where speech was free by contemporary standards were the first to grow rich: Holland, Scotland, England, Belgium and the United States.

Conclusion

The conclusion, then, is that Harberger Triangles – which is to say the gains from efficiency at the margin – cannot explain the factor of twelve. This is lamentable, because economics is much more confident about static arguments than about dynamic arguments. And yet the conclusion is not that static arguments have no role. On the contrary, they give us the means to measure what needs to be explained on other grounds. A static model of costs and revenues, for example, allows one to measure productivity change with the abundant material on prices. One can find out with static models how widespread was the ingenuity set to work in the eighteenth and nineteenth centuries. A static model of international trade allows one to see the wider context for the British economy, to see that political boundaries do not cut economies at their joints.

But going beyond the usual models, static or dynamic, appears to be necessary. In particular we need to consider the role of persuasive talk in the economy (in modern economies it is a quarter of national income). Adam Smith wrote at the beginning of the period that '[The division of labour is a] consequence of a certain propensity ... to truck, barter, and exchange ... [He could not pause to discuss] whether this propensity be one of those original principles in human nature ... or whether, as seems more probable, it be the necessary consequence of the faculties of reason and speech' (1776: 17). 'The faculty of reason' has been much studied by economists since then, resulting in their splendid, useful static models. But they have not taken up his phrase, 'and speech'. In his other book, *The Theory of Moral Sentiments*, he gave it prominence: 'The desire of being believed, the desire of persuading, of leading and directing other people, seems to be one of the strongest of all our natural desires. It is, perhaps, the instinct on which is founded the faculty of speech, the characteristic faculty of human nature' (1790: VII.iv.25: 336). We need an account of the age of industrialisation that admits into the tale the characteristic faculty of human nature, which is to say a combination of reason and of speech, the economic historian's calculations and the social historian's sensibilities.

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