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Macroinventions, economic growth, and 'industrial revolution' in Britain and France

By N. F. R. CRAFTS

In his 1993 Tawney Lecture, Landes returned to the issues raised by an article of mine published in 1977.¹ In that article I argued that Britain's primacy in achieving the decisive inventions in cotton textiles which precipitated the 'industrial revolution' did not of itself show that there was a higher *ex ante* probability of these events occurring in Britain rather than in France and that it was important to recognize the stochastic elements in technological progress. I also suggested that the literature of the time was in danger of making unwarranted inferences concerning a laundry list of alleged advantages of the British over the French eighteenth-century economy supposed to have been the origins of the first industrial revolution. Landes disagrees. His view is that 'Given the composition and growth of the British industrial sector, it is not an accident that Britain produced the inventions and innovations it did; that France did not; and that even after the British had given the good example, the French . . . had trouble keeping pace.' . . . 'If Britain was first, if France was slower . . . these things have their reasons.'²

I am more than happy to accept that the arguments which I put forward nearly 20 years ago are in need of updating and some modification. Indeed, although Landes does not say so, my position has been refined and revised in a large number of subsequent publications.³ Nevertheless, I believe the central thrust of my old argument, properly stated, is still valid and has indeed been strengthened by further research. The central issues hinge on the concept of 'industrial revolution' and, before turning to a detailed reply to Landes, it is necessary to explore this point.

The definition of 'industrial revolution' adopted in the article to which Landes objects was

a period of accelerated structural change in the economy, involving a rapid rise in industrial output, and in factory-based activity . . . based on major technological innovations. The focus will be on the transformation of the already existing industrial sector of the economy, not on the overall growth of the economy. . . . Then for our purposes we can follow Landes in giving the cotton textiles industry the leading role in precipitating the Industrial Revolution.⁴

¹ Landes, 'What room for accident?'; Crafts, 'Industrial revolution in England and France'.

² Landes, 'What room for accident?', pp. 648, 653.

³ e.g. Crafts, *British economic growth*; *idem*, 'Economic growth in France and Britain'; *idem*, 'British industrialization'; *idem*, 'Industrial revolution'.

⁴ Crafts, 'Industrial revolution in England and France', p. 431.

This approach is central to many accounts of the British industrial revolution, although for some purposes it is less useful than a definition such as that of Mathias based on 'the fundamental redeployment of resources away from agriculture'.⁵ Most of my more recent work has been concerned to explore this latter kind of macrostructural change.

On later occasions I amplified the significance of this distinction in an attempt to head off misdirected criticisms. Thus in my book I stated:

it is unlikely that the question 'why was England first?' in terms of the establishment of the factory system in cotton textiles can ever be satisfactorily answered. On the other hand, economic theory can, at least to some extent, illuminate the experience of the industrial revolution in terms of structural change and the sources of economic growth . . . and perhaps provide at least some clues as to why Britain in the mid-nineteenth century was the richest country in Europe and by far the most industrialized.⁶

In other words, there is a big difference between, on the one hand, trying to predict *ex ante* the timing and locations of particular macroinventions and, on the other hand, accounting *ex post* for overall growth potential and structural change in the sense of Mathias—a point which is elaborated in what follows.⁷ Section I compares growth potential in late eighteenth-century Britain and France; section II reconsiders the decisive inventions in cotton; section III then proceeds to draw some inferences about patterns of economic development; and my reasons for disputing Landes's arguments are pulled together in section IV.

I

Landes suggests that quantitative views of French eighteenth-century capabilities were and are distorted by misleading estimates of French growth. He takes the opportunity to pour scorn on old data and to indulge his anti-cliometric prejudices while characteristically failing to offer estimates of his own.⁸ I think he is right to point out that the growth comparisons I made were erroneous, but wrong to suggest that these were central to my case.⁹ It is also important to recognize that cliometric research on both countries has proceeded in a spirit of genuine enquiry and certainly does not continue complacently to repeat discredited figures.

Careful reviews of the evidence on eighteenth-century French economic growth have recently been provided by Crouzet, Goldstone, and Weir.¹⁰ Crouzet and Goldstone suggest respectively that industrial output growth was about 0.1 per cent per year above or 0.1 per cent per year below the

⁵ Mathias, *First industrial nation*, p. 2.

⁶ Crafts, *British economic growth*, p. 8.

⁷ The term 'macroinventions' is that of Mokyr and is discussed at some length in his well-known *Lever of riches*. Further elaboration is left until section II.

⁸ Landes, 'What room for accident?', pp. 645-8.

⁹ Crafts, 'Industrial revolution in England and France', p. 439.

¹⁰ Crouzet, *Britain ascendant*, chs. 1-2; Goldstone, *Revolution and rebellion*, pp. 180-203; Weir, 'Les crises économiques'.

rate I have estimated for Britain in the years 1700-80.¹¹ Weir estimates that agricultural output growth was about 0.1 per cent per year below that of Britain in 1740-80.¹² These authors review a wide range of material and are not open to the charge of relying on the old sources to which Landes objects so much.¹³ Their conclusions are really quite similar to those of Nef 50 years ago that 'what is striking about eighteenth century economic history is less the contrasts than the resemblances between Great Britain and the Continent . . . in the rate of economic development'.¹⁴ Goldstone notes that the relatively large weight of French agriculture held down overall growth, but Crouzet continues to believe that the growth of aggregate demand in the two economies in the decades prior to the industrial revolution was similar.¹⁵

It is not, then, unreasonable to claim that in terms of realized growth rates of output there was less to choose between Britain and France during much of the eighteenth century than Landes seems to believe and that in this regard overwhelming British superiority is unproven. Nevertheless, it does now seem clear that both French growth potential and the level of income per head were lower than the equivalent for Britain and I readily accept that this is an important correction to my 1977 article.

Table 1. *Growth promoting characteristics and income levels in Britain and France, c. 1788*

	<i>Britain</i>	<i>France</i>
GDP (£ m.)	134.8	290.7
GDP/head (£)	14.4	10.9
Male literacy rate (%)	60.0	47.0
Urbanization (%)	18.6	8.1
Bank money/GDP (%)	11.2	1.4
Direct taxes/GDP (%)	1.0	3.3

Sources: GDP and GDP per head are comparable in terms of purchasing power parity and are taken from Weir, 'Tontines', p. 98; literacy is based on ability to sign name from Cressy, *Literacy*, p. 179; urbanization is defined on population in cities with more than 10,000 inhabitants and is the average of 1750 and 1800 from de Vries, *European urbanization*, p. 30; bank money is derived using Cameron, 'England', p. 42 and *idem*, 'France', p. 116; direct taxes are based on Weir, 'Tontines', p. 98; Mathias and O'Brien, 'Taxation', p. 622; and O'Brien, 'Political economy', p. 11.

Weir's careful review of the available data gives us the best currently available estimate of relative income levels in the late eighteenth century; this shows a British lead in GDP per head in 1788 of about 32 per cent, as reported in table 1. This primarily reflects the much greater weight of low productivity agriculture in the French economy; output per worker in French industry may well have exceeded that of Britain.¹⁶

¹¹ Crouzet, *Britain ascendant*, p. 21; Goldstone, *Revolution and rebellion*, p. 189. Their estimates can be compared with those in Crafts, *British economic growth*, p. 32 as modified by Crafts and Harley, 'Output growth', p. 715.

¹² Weir, 'Les crises économiques', p. 937 can be compared with Crafts, *British economic growth*, p. 42.

¹³ Landes, 'What room for accident?', pp. 647-8.

¹⁴ Nef, 'Industrial revolution reconsidered', p. 5; Crouzet, *Britain ascendant*, ch. 2.

¹⁵ Goldstone, *Revolution and rebellion*, p. 203.

¹⁶ On the clear long-term divergence in agricultural productivity and employment in the two countries, 1500-1800, see Wrigley, 'Urban growth'. Comparisons of industrial productivity have proved highly

Recent research into the theory and empirics of economic growth emphasizes the importance of investment in both human and physical capital for growth, together with the existence of incentives and institutional structures that promote high rates of productive capital accumulation.¹⁷ This literature provides some generalizations on which assessments of comparative growth potential can draw, and strong emphasis has been placed in recent work on the investment/growth enhancing effects of low direct taxes and well-articulated financial intermediation.¹⁸

Table 1 shows that on the available data, which are inevitably crude, Britain appears to have had arrangements which were more conducive to productive investment. Investment in plant and equipment was never particularly high in eighteenth-century Britain but probably exceeded that in France, and certainly did so in the early nineteenth century when comparable data are available.¹⁹ Similarly, as table 1 suggests, it seems to be generally agreed that educational standards in Britain, though modest, were better than those in France. As Bairoch has argued, urbanization appears to have aided investment in the acquisition and development of knowledge, and in this, too, Britain has the edge.²⁰

Another recent theme both in economic history and development economics is the importance for growth of the use of talent to promote productive investment rather to concentrate on redistributive activities. As Jones put it so well, 'economic history may be thought of as a struggle between a propensity for growth and one for rent-seeking'.²¹ In this respect quantitative data are not feasible but there is little doubt that rent-seeking was much more prevalent and damaging in eighteenth-century France than Britain and that this also went along with a greater ability to resist technological change and create barriers to entry.²²

On a wide range of standard considerations Britain appears, then, to have had a better growth potential even though growth rates in the two countries in the mid eighteenth century were probably similar. On this point I agree with Landes. This does not, however, equate to being the more likely to make the decisive inventions in cotton—the nub of the issue for the 'industrial revolution' as I approached it in 1977.

controversial and O'Brien and Keyder's pioneering figures in *Economic growth*, p. 91 are not now generally accepted. Nevertheless, the most recent attempt at further estimates still finds French industrial labour productivity to be about 10% above that of Britain in the 1820s: see Dormois, 'Des machiens ou des hommes?', p. 284.

¹⁷ A good introduction to basic ideas can be found in Romer, 'Origins' and an overview of empirical results is in Levine and Renelt, 'Sensitivity analysis'.

¹⁸ For the argument on taxes see Rebelo, 'Long-run policy' and on financial intermediation see King and Levine, 'Finance and growth'.

¹⁹ This category of investment has been stressed as particularly important for growth by De Long and Summers, 'Equipment investment'. In 1811–30 equipment investment was 1.6% of GDP in Britain compared with 1.0% in France: Feinstein, 'National statistics'; Lévy-Leboyer, 'Capital investment'.

²⁰ Bairoch, 'City', finds a strong tendency for innovation to take place disproportionately in cities in eighteenth- and nineteenth-century Europe.

²¹ Jones, *Growth recurring*, p. 1.

²² On rent-seeking comparisons in general see Root, 'Redistributive role'; on implications for technological change in particular see Mokyr, 'Technological inertia', pp. 331–2.

II

One of the most influential papers on comparisons of technological change in eighteenth-century England and France was that of Crouzet, originally published in 1966.²³ In that paper Crouzet favoured a factor-shortage explanation for Britain's advantage over France: 'The inventions were designed to make possible the replacement of relatively scarce and expensive resources, such as wood, water-power and labour. . . . The contention is that these shortages and bottlenecks, which in England exerted strong pressure in favour of innovation, did not exist in France.'²⁴

This was certainly an example of an argument of the kind to which I objected. Crouzet himself has recognized the difficulties associated with this claim and has withdrawn it. He makes the important distinction between overall economic performance and the achievement of the decisive inventions in cotton, and in his 1985 review of the debate concludes that 'research into the origins of the Industrial Revolution still seems somehow akin to the quest for the Holy Grail . . . we lack, in particular, an adequate explanation of . . . the invention of cotton-spinning machinery, since it is there that, in the last analysis, the Gordian knot lies . . . Hargreaves' and Arkwright's inventions could have been fortuitous.'²⁵

This is entirely consistent with the position set out by Mokyr, who describes mechanical spinning as a 'macroinvention of enormous economic importance'.²⁶ He defines macroinventions as 'those inventions in which a radical new idea, without clear precedent, emerges more or less *ab nihilo*' and distinguishes them from microinventions which are 'the small, incremental steps that improve, adapt, and streamline existing techniques already in use, reducing costs'.²⁷ Microinventions account for most productivity gains and are generally explained by economic variables but the process of microinvention with a given technology is subject to diminishing returns.²⁸ By contrast, 'Macroinventions . . . do not seem to obey obvious laws, do not necessarily respond to incentives, and defy most attempts to relate them to exogenous economic variables. Many of them resulted from strokes of genius, luck, or serendipity.'²⁹

Given this distinction, it seems clear that the attributes of British economy and society which are frequently cited as favourable to economic growth and technological progress are factors which would indicate a high capability for microinventions—a strength which would, however, require macroinventions to be activated.³⁰ Indeed, Mokyr himself argues that 'Britain seems to have had no particular advantage in generating macroinventions; a large number of them were generated overseas, especially in France. . . . The

²³ Crouzet, *Britain ascendant*, ch. I.

²⁴ *Ibid.*, p. 38.

²⁵ *Ibid.*, pp. 100, 102-3.

²⁶ Mokyr, 'Introduction', p. 21.

²⁷ *Idem*, *Lever of riches*, p. 13.

²⁸ *Ibid.*

²⁹ *Ibid.*

³⁰ This clearly seems to include Landes's own preferred reasons for British superiority related to Smithian gains from putting out: 'What room for accident?', p. 25.

key to British technological success was that it had a *comparative* advantage in *microinventions*.³¹

Once set in motion, the process of microinvention in British cotton textiles was obviously very fast, based on rapid learning and a marked change in the trajectory of improvements towards factor-saving as opposed to product innovations.³² Nevertheless, had the French happened on the key macroinvention first and obtained a lead, the learning advantages of primacy might have precluded nineteenth-century British domination of the world market and allowed the establishment of a much larger French cotton industry.

In sum, we do not currently have a convincing explanation for the timing and location of the decisive inventions in cotton textiles. Landes certainly does not provide one. Technological history suggests that seeking socio-economic explanations for macroinventions is likely to be a fruitless pursuit. The subsequent rapid development of the British cotton industry does not demonstrate a greater *ex ante* probability of British primacy.

III

A major theme of my research on the British industrial revolution has been that the pattern of economic development which resulted was highly atypical of that in Europe as a whole. In particular, Britain was most unusual in the extent of industrialization of the labour force and exports at a relatively low income level and also in its high agricultural labour productivity.³³ In that sense writers such as O'Brien and Keyder are quite right to stress that Britain is not a paradigmatic case and that France's path to the modern world was a very different one.³⁴

Britain's idiosyncratic experience was deeply embedded in its external relations and reflected its comparative advantage in international trade. By 1831 cottons accounted for 50 per cent of British merchandise exports. I have developed in detail elsewhere the implications of Britain's domination of world trade in cotton textiles for the emergence of agriculture as an importable despite very high domestic productivity.³⁵ Yet this was certainly not the trajectory which was apparent in the mid eighteenth century when Britain had been a net exporter of wheat and when the productivity growth potential of British agriculture was tending to promote a quite different pattern of comparative advantage.³⁶

This suggests that the macroeconomic invention in cotton deserves a good deal of credit for promoting industrialization through trade and that the rapid and unusual structural change of the industrial revolution in the sense of Mathias was not readily predictable in the mid eighteenth century.

³¹ Mokyr, 'Introduction', p. 33.

³² Griffiths et al., 'Inventive activity', p. 893.

³³ Crafts, *British economic growth*, esp. chs. 3, 6.

³⁴ O'Brien and Keyder, *Economic growth*.

³⁵ Crafts, 'British industrialization'.

³⁶ Harley, 'Reassessing', develops this point quantitatively using a computable general equilibrium model which demonstrates that, had industrial exportables productivity growth not been enhanced by faster technological progress, agricultural improvement was tending to push Britain towards substantial agricultural exporting.

IV

Unlike Landes, then, I am still prepared to contemplate a role for accident in economic history or, in terminology that I would prefer, to think in terms of economic models which both permit a role for exogenous technological shocks and also allow on occasions for wide ramifications of those shocks.

It is important to make a sharp distinction between the predictability of macroinventions and the assessment of overall growth potential. I now believe Landes is right to question the comparative achievements and potential of the eighteenth-century French economy but is wrong to suggest that this requires us to believe that Britain would necessarily be first to the decisive inventions in cotton spinning. Crouzet and Mokyr both appear to share my point of view.

In terms of a definition of 'industrial revolution' based on the establishment of the factory system in cotton it still seems unlikely that we can answer the question 'why was England first?'. Even if we prefer to focus on macrostructural change we should allow a greater role for stochastic aspects of invention than did the literature of the 1960s, once we recognize the power of international trade to amplify the effects of unbalanced productivity growth.

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