CHAPTER SIX

Twentieth Century Growth

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Abstract

This paper surveys the experience of economic growth in the 20th century with a focus on technological change at the frontier together with issues related to success and failure in catch-up growth. A detailed account of growth performance based on historical national accounts data is given and is accompanied by a review of growth accounting evidence on the sources of economic growth. The key features of our analysis of divergence in growth outcomes are an emphasis on the importance of "directed" technical change, of institutional quality, and of geography. We provide brief case studies of the experience of individual countries to illustrate these points.

Keywords

Catch-up growth, Divergence, Growth accounting, Technical change

JEL Classification Codes

N10, O33, O43, O47

6.1. INTRODUCTION

This chapter does not pretend to provide a comprehensive survey of the vast literature that has been written on economic growth during the 20th century: for such a task, not even a book would suffice. Rather, it is a brief interpretative essay, which aims to place the 20th century growth experience into a broader historical context, and highlight some of the ways in which the field of economic history can contribute to the study of economic growth.

A theme of the chapter is that the 20th century saw the gradual working out of several long-run implications of the Industrial Revolution: the latter was a massive asymmetric shock to the world economy, which set in train a variety of long-run adjustment processes which are still ongoing, and which seem set to define the economic history of the 21st century as well.

We will be emphasizing two key features of the economic history literature. The first is a focus on institutions, following the insights of North (1990) and others. While institutions have certainly become a central focus of mainstream empirical work on

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economic growth (e.g. Acemoglu et al. 2001), economic historians tend to be quite nuanced in their view of how institutions matter, recognizing that different institutional environments may be appropriate at different points in time and in different countries.

The second is a detailed interest in the mechanics of technological change. The endogenous nature of technological change, and the consequences which this has for economic growth in both leader and follower countries, will be a constant theme of the chapter: while theorists like Acemoglu (2002) have recently brought the issue to the forefront of growth theory, economic historians such as Habakkuk (1962) have been emphasizing such themes for many decades.

6.2. SETTING THE STAGE

In this section, we look at the legacy of the Industrial Revolution and its 19th century aftermath. This period saw the advent of modern economic growth (Kuznets, 1966) in what came to be the advanced economies of the 20th century, along with a big shift in the center of gravity of the world economy away from Asia and toward Europe and North America. The world economy of 1900 was hugely different from that of 1700 in terms of its technological capabilities, the income levels in leading economies, the extent of globalization, and the degree of international specialization in production.

6.2.1 The Beginnings of Modern Economic Growth

Recent research has made considerable progress in quantifying growth in the world economy prior to the Industrial Revolution. Table 6.1 reports estimates of income levels measured in purchasing-power-parity adjusted to 1990 international dollars for selected countries. In this metric, it is generally agreed that a bare-bones subsistence income is about $400 per year. The estimates indicate that European countries had incomes well

Table 6.1 GDP per capita, 1086–1850, adjusted to 1990 international dollars

	England/Great Britain	Holland/ Netherlands	Italy	Spain	China	India	Japan
1086	754				1244		
1348	777	876	1376	1030			
1400	1090	1245	1601	885	948		
1500	1114	1483	1403	889	909		
1600	1123	2372	1244	944	852	682	791
1650	1100	2171	1271	820		638	838
1700	1630/1563	2403	1350	880	843	622	879
1750	1710	2440	1403	910	737	573	818
1800	2080	2617/1752	1244	962	639	569	876
1850	2997	2397	1350	1144	600	556	933

Source: Broadberry (2013).

above this level long before the Industrial Revolution, and the same was true of China in medieval times. The implication is that the pre-industrial era should not be seen as one in which people were in a very low income Malthusian Trap equilibrium.

Nevertheless, the overall picture of Table 6.1 is that growth was at best very slow in these pre-industrial centuries. Growth of real income per person averaged 0.2% per year in England, a relative success story, between 1270 and 1700 (Broadberry et al. 2010) while at the other extreme, Chinese income levels almost halved between 1086 and 1800. These estimates re-assert the traditional story of the "Great Divergence", namely, that the most successful parts of Europe overtook China and pulled significantly ahead in the run-up to the Industrial Revolution. They also reflect a "Little Divergence" within Europe between North and South, with Italy and Spain losing out relative to England and Holland.

What were the underpinnings of this modest pre-industrial growth in England? The answer seems to be a combination of increases in hours worked per person and Smithian growth, rather than any major contribution from technological change. The length of the work year may have roughly doubled between the mid-14th and late-18th century (Allen and Weisdorf, 2011). This largely accounts for the long-run tendency for income per person to grow slowly, despite the fact that the null hypothesis that real wage rates were stationary until 1800 cannot be rejected (Crafts and Mills, 2009). Growth in the successful parts of Europe was also strongly correlated with trade expansion. This improved productivity and sustained wage levels in the face of demographic pressure (Allen, 2009).

The term "Industrial Revolution" is commonly used to characterize the unprecedented experience of the British economy during the later decades of the 18th and early decades of the 19th century. Taken literally, it is a misleading phrase; but carefully deployed, it is a useful metaphor. These years saw a remarkable economic achievement by comparison with earlier times, but it must be recognized that by later standards this was in many ways a modest beginning.

The idea of an industrial revolution conjures up images of spectacular technological breakthroughs; the triumph of the factory system and steam power; the industrialization of an economy hitherto based largely on agriculture, and rapid economic growth. Indeed, these were the directions of travel for the British economy but when they are quantified, the numbers although impressive, once put into context, do not live up to the hyperbole. While the economy withstood formidable demographic pressure much better than could have been imagined in the 17th century, the growth of real income per person was painfully slow for several decades. Not much more than a third of the labor force worked in agriculture even in the mid-18th century. In 1851, more people were employed in domestic service and distribution than in textiles, metals, and machine-making combined. Until around 1830, water power was more important than steam power in British industry.

Nevertheless, the economy of the mid-19th century was established on a different trajectory from that of a hundred years earlier. In particular, sustained labor productivity growth based on steady technological progress and higher levels of investment had become the basis of significant growth in real income per person, notwithstanding rapid population growth. This was modern economic growth, as distinct from real income increases based on Smithian growth and working harder. That said, growth potential was still quite limited by 20th century standards: education and scientific capabilities were still quite primitive, the scope to import technological advances from the rest of the world was modest, and institutions and economic policies suffered from obvious limitations.

Table 6.2 reports that the rate of TFP growth more than doubled from 0.3% per year in 1760–1801 to 0.7% per year in 1831–1873. This can certainly be interpreted as reflecting acceleration in the rate of technological progress but TFP growth captures more than this.

Table 6.2 Growth-accounting estimates (percent per annum)

(a) Output growth

	Capital contribution	Labor contribution	TFP growth	GDP growth
1760–1801	0.4*1.0 = 0.4	0.6*0.8 = 0.5	0.3	1.2
1801–1831	0.4*1.7 = 0.7	0.6*1.4 = 0.8	0.2	1.7
1831–1873	0.4*2.3 = 0.9	0.6*1.3 = 0.8	0.7	2.4

(b) Labor productivity growth

	Capital-deepening contribution	TFP growth	Labor productivity
1760–1801	0.4*0.2 = 0.1	0.3	0.3
1801–1831	0.4*0.3 = 0.1	0.2	0.3
1831–1873	0.4*1.0 = 0.4	0.7	1.1

(c) Contributions to labor productivity growth, 1780–1860

Capital deepening	0.22
Modernized sectors	0.12
Other sectors	0.1
TFP growth	0.42
Modernized sectors	0.34
Other sectors	0.08
Labor productivity growth	0.64
Memorandum items	
Labor force growth	1.22
Capital income share (% of GDP)	40
Modernized sectors	5.9

Notes: Growth accounting imposes the standard neoclassical formula in parts (a) and (b). To allow for embodiment effects in part (c) the standard growth-accounting equation is modified as follows to distinguish between different types of capital and different sectors: $\Delta \ln(Y/L) = \alpha_O \Delta \ln(K_O/L) + \alpha_M \Delta \ln(K_M/L) + \gamma \Delta \ln A_O + \Phi \Delta \ln A_M$, where the subscripts O and M denote capital in the old and modernized sectors, respectively; γ and Φ are the gross output shares of these sectors; and α_O and α_M are the factor shares of the capital used in these sectors.
Sources: Crafts (2004a, 2005) revised to incorporate new output growth estimates from Broadberry et al. (2010).

No explicit allowance has been made for human capital or hours worked in the growth accounting equation. Prior to 1830, it is generally agreed that any contribution from extra schooling or improved literacy was negligible, but in the period 1831–1873 education may have accounted for around 0.3 percentage points per year of the measured TFP growth in Table 6.2 (Mitch, 1999). For 1760–1801 there is good reason to think that average hours worked per worker per year were increasing sufficiently that if the growth in labor inputs were adjusted appropriately TFP growth might be pushed down very close to zero (Voth, 2001). Overall then, a best guess might be that the contribution of technological progress, as reflected in TFP growth, went from about zero to a sustained rate of about 0.4% per year by the time the classic Industrial Revolution period was completed.

Neoclassical growth accounting of this kind is a standard technique and valuable for benchmarking purposes, if nothing else. However, it does potentially underestimate the contribution of new technology to economic growth if technological progress is embodied in new types of capital goods, as was set out in detail by Barro (1999). This was surely the case during the Industrial Revolution; as Feinstein put it, "many forms of technological advance . . . can only take place when "embodied" in new capital goods. The spinning jennies, steam engines, and blast furnaces were the "embodiment" of the Industrial Revolution" (1981, p. 142).

Table 6.2 also shows the results of an exercise that allows for embodiment effects. The "modernized sectors" (cottons, woolens, iron, canals, ships, and railways) are found to have contributed 0.46 out of 0.64% per year growth in labor productivity over the period 1780–1860 with the majority of this, 0.34 compared with 0.12%, coming from TFP growth as opposed to capital deepening. If the contribution of technological change to the growth of labor productivity is taken to be capital deepening in the modernized sectors plus total TFP growth, then this equates to 0.54 out of 0.64% per year. It remains perfectly reasonable, therefore, to regard technological innovation as responsible for the acceleration in labor productivity growth that marked the Industrial Revolution as the historical discontinuity that Kuznets supposed, even though the change was less dramatic than was once thought.

It may seem surprising that the Industrial Revolution delivered such a modest rate of technological progress given the inventions for which it is famous, including most obviously those related to the arrival of steam as a general purpose technology (GPT). It should be noted, however, that the well-known stagnation of real wage rates during this period is strong corroborative evidence that TFP growth, which is equal to the weighted average of growth in factor rewards (Barro, 1999), was modest.

Two points can be made straightaway. First, the impact of technological progress was very uneven as is implied by the estimates in Table 6.2. Most of the service sector other than transport was largely unaffected. Textiles, metals, and machine-making accounted for less than a third of industrial employment—or 13.4% of total employment—even in 1851 and much industrial employment was still in "traditional" sectors. Second, the process of technological advance was characterized by many incremental improvements and learning to realize the potential of the original inventions. This took time in an era where scientific and technological capabilities were still very weak by later standards.

Steam power offers an excellent example. In 1830, only about 165,000 horsepower was in use, the steam engine capital share was 0.4% of GDP and the Domar weight for steam engines was 1.7% (Crafts, 2004b). The cost effectiveness and diffusion of steam power was held back by the high coal consumption of the original low-pressure engines and the move to high pressure—which benefited not only factories but railways and steam ships—was not generally accomplished until the second half of the 19th century. The science of the steam engine was not well understood and the price of steam power fell very slowly, especially before about 1850. The maximum impact of steam power on British productivity growth was delayed until the third quarter of the 19th century—nearly 100 years after James Watt's patent—when it contributed about 0.4% per year to labor productivity growth. It seems reasonable to conclude that subsequently leading economies have become much better at exploiting GPTs. The reasons are likely to be found in a superior level of education and scientific knowledge; improvements in capital markets; government policies that support research and development; and thus a greater volume of and higher expected returns to innovative effort.

Indeed, from an endogenous growth perspective the early 19th century British economy still had many weaknesses. The size of markets was still very small in 1820, when modern globalization was yet to begin (O'Rourke and Williamson, 2002), and real GDP in Britain was only about one twentieth of its size in the United States a century later. The costs of invention were high at a time when scientific knowledge and formal education could still make only a modest contribution. This was clearly not a time of high college enrollment, and the highly educated were to be found in the old professions, not science and engineering. Investment, especially in equipment, was a small proportion of GDP. Intellectual property rights were weak since the legal protection offered by patents was doubtful until the 1830s, and even if Britain had less rent-seeking than France, rent-seeking in the law, the bureaucracy, the church, and the military remained very attractive alternatives to entrepreneurship, as is attested by the evidence on fortunes bequeathed (Rubinstein, 1992). Accordingly, TFP growth was modest, although by the 1830s it was still well ahead of the rate achieved in the United States, which averaged 0.2% per year during 1800–1855 (Abramovitz and David, 2001).

6.2.2 Directed Technical Change and the First Industrial Revolution[1]

If the transition to modern economic growth entails a sustained acceleration in the rate of technological progress, why did this happen first in Britain in the late 18th century? Over time many answers have been suggested, but a recent interpretation by Allen, building

[1] This section draws in part on Crafts (2011).

on Habakkuk (1962) and David (1975), has rapidly gained currency. His conclusion is deceptively simple: "The Industrial Revolution . . . was invented in Britain because it paid to invent it there" (Allen, 2009, p. 2). Allen's argument comes from an endogenous innovation perspective but is based on relative factor prices and market size rather than on the superiority of British institutions and policies, at least compared with its European peer group: that is to say, it focuses on the demand for innovation, rather than on the supply side. In particular, Britain's unique combination of high wages and cheap energy plus a sizeable market for the new technologies, which were profitable to adopt only in these circumstances, is held to be the key.

Allen's analysis emphasizes the importance of expected profitability to justify the substantial fixed costs of the investment required to perfect good ideas and make them commercially viable. The rate of return on adopting inventions in textiles, steam power, and coke smelting was a lot higher in Britain than elsewhere and so the potential market for these inventions was much greater. This is very similar to the model of "directed technical change" proposed by Acemoglu (2002).[2] Allen supports his conclusions by empirical analysis of the profitability of adoption of several famous inventions (Hargreaves' spinning jenny, Arkwright's mill, and coke smelting) at British and French relative factor prices. The conclusion is that in each case, adoption would have been rational at the former but not the latter. Eventually, after several decades, a cumulative process of micro-invention had improved these technologies to the point where adoption became profitable in other countries, and the Industrial Revolution began to spread.

Allen's hypothesis is prima facie plausible and theoretically defensible although more research is required to establish that it stands on really solid empirical foundations. For example, Crafts (2011) presents evidence suggesting that it may have been high machinery costs, rather than low wages, which impeded the adoption of the spinning jenny in France. Strikingly, it also appears that it would have been very profitable to invent and adopt the jenny in the high-wage United States.[3] Perhaps the key disincentive there was small market size relative to the fixed development costs of the invention. There are also a number of other detailed issues about the robustness of Allen's calculations that have arisen in the debate prompted by his book.[4] Allen himself recognizes that the supply side of the market for innovation mattered as well as the demand side: to claim that relative factor prices alone were the key to the Industrial Revolution would be a bit too

[2] Acemoglu (2010) extended this analysis to consider the impact of labor scarcity on the rate, rather than the bias, of technological progress and showed that this is positive if technological change is strongly labor saving, i.e. reduces the marginal product of labor. This might be when machines replace tasks previously undertaken by workers, as in Zeira (1998).

[3] This also seems to be true of the Arkwright mill where the prospective rate of return to adoption was 32.5% (Crafts, 2011).

[4] See the further discussion in Crafts (2011) and the interchanges between Gragnolati et al. (2011) and Allen (2011); and between Humphries (2013) and Allen (2013).

bold. Even so, Allen's contribution has been extremely valuable in focusing attention on the incentives facing innovators. In the context of subsequent British relative economic decline and, especially, American overtaking, his suggestion that the key to getting ahead in the Industrial Revolution was relative factor prices together with large market size has the clear implication that British leadership would be highly vulnerable. Insofar as high wages, cheap energy, and a market sufficient to allow fixed costs of research and development continued to be conducive to faster technological progress, the United States would be a more favored location later in the 19th century, as has become abundantly clear in the literature on the Habakkuk (1962) hypothesis.

6.2.3 Catch-Up and Overtaking: The Transition to American Leadership

By the late 19th century, as Table 6.3 reports, modern economic growth had spread to most of Western Europe. Rates of growth of real GDP per person, although modest by later standards, were generally well above those achieved by Britain during the Industrial Revolution (0.4% per year) and during the second and third quarters of the 19th century (1% per year). Faster growth often went hand in hand with industrialization, and there was a clear but not perfect correlation in 1913 between industrial output and GDP per head. The United Kingdom remained the European leader in 1913 but the rest of Europe was slowly catching up, and by the end of the 19th century Britain had been overtaken by the United States. The hypothesis of unconditional convergence across Europe during 1870–1913 is rejected, however (Crafts and Toniolo, 2008). Southern Europe clearly lagged behind northern Europe while nevertheless opening up a substantial gap with China.

Table 6.4 shows that crude TFP growth remained quite slow until it increased appreciably in several countries at the end of the 19th century, around the time of the so-called Second Industrial Revolution. Even so, nowhere in Europe was there a growth experience that resembled the picture famously drawn by Solow (1957) for the United States in the first half of the 20th century in which the residual accounted for seven eighths of labor productivity growth. For almost all countries, technical change came primarily from the diffusion of advances made elsewhere, but technological diffusion was still relatively slow.[5]

It is not possible to implement a full analysis of conditional convergence given data limitations but Table 6.5 offers some clues. Years of schooling increased everywhere but were generally much higher in northern Europe and, by 1913, were way ahead of the 2.3 years of the cohort born before 1805 in England and Wales (Matthews et al. 1982). In the period before World War I, industry was attracted to market potential and cheap

[5] Germany and the UK together accounted for 53% of all foreign patents taken out in the United States in 1883 and 57% in 1913 (Pavitt and Soete, 1982). The diffusion rate of inventions made before 1925 was less than a third of those made subsequently (Comin et al. 2006).

Table 6.3 Growth in late nineteenth-century Western Europe

	1870 GDP/capita ($1990GK)	1913 GDP/capita ($1990GK)	Growth, 1870–1913 (% p.a.)	Industrialization level, 1870	Industrialization level, 1913
Austria	1863	3465	1.46	13	32
Belgium	2692	4220	1.05	36	88
Denmark	2003	3912	1.58	11	33
Finland	1140	2111	1.45	13	21
France	1876	3485	1.46	24	59
Germany	1839	3648	1.61	20	85
Greece	880	1592	1.39	6	10
Ireland	1775	2736	1.01		
Italy	1499	2564	1.26	11	26
Netherlands	2757	4049	0.91	12	28
Norway	1360	2447	1.38	14	31
Portugal	975	1250	0.59	9	14
Spain	1207	2056	1.25	12	22
Sweden	1359	3073	1.92	20	67
Switzerland	2102	4266	1.67	32	87
UK	3190	4921	1.01	76	115
Europe	1971	3437	1.31	20	45
Aide Memoire					
United States	2445	5301	1.83	30	126
China	530	552	0.1	4	3

Note: Industrialization level is defined as an index of the volume of industrial output/person relative to a base of UK in 1900 = 100.
Sources: Maddison (2010) and Bairoch (1982).

coal (Crafts and Mulatu, 2006; Klein and Crafts, 2012) which again favored the north over the south. Institutions improved with regard to underpinning the appropriability of returns to investment, especially in northern Europe, as reflected in the Political Constraint Index which Henisz (2002) shows was positively related to private sector investment in infrastructure. There was a widespread improvement in legislation enabling capital markets to function (Bogart et al. 2010). Even so, a recent study (Kishtainy, 2011) suggests that only Switzerland (after 1848) and Norway (after 1899) could be classified as "open-access" societies with the political and economic competition that is regarded as essential to becoming an advanced economy by North et al. (2009). Nevertheless, much of Europe was on the verge of attaining that open-access status and this contrasts starkly with the continuation of a closed-access society dominated by a coalition of rent-seekers that stifled innovation in China (Brandt et al. forthcoming).

In growth accounting terms, as Table 6.4 shows, American overtaking was associated with a late 19th century acceleration in the rate of TFP growth to a pace far in excess

Table 6.4 Accounting for labor productivity growth (percent per annum)

	Labor productivity growth	Capital deepening contribution	TFP growth
Austria			
1870–1890	0.9	0.64	0.26
1890–1910	1.69	0.66	1.03
Germany			
1871–1891	1.1	0.39	0.71
1891–1911	1.76	0.58	1.18
Netherlands			
1850–1870	1.02	0.5	0.52
1870–1890	0.94	0.61	0.33
1890–1913	1.35	0.46	0.89
Spain			
1850–1883	1.2	1	0.2
1884–1920	1	0.7	0.3
Sweden			
1850–1890	1.18	1.12	0.06
1890–1913	2.77	0.94	1.83
United Kingdom			
1873–1899	1.2	0.4	0.8
1899–1913	0.5	0.4	0.1
United States			
1855–1890	1.1	0.7	0.4
1890–1905	1.9	0.5	1.4
1905–1927	2	0.5	1.3

Note: All estimates impose a standard neoclassical growth accounting equation based on $Y = AK^{\alpha}L^{1-\alpha}$, calibrated with $\alpha = 0.35$.
Sources: Derived from data presented in the following original growth accounting studies: Austria: Schulze (2007); Germany: Broadberry (1998); Netherlands: Albers and Groote (1996); Spain: Prados de la Escosura and Roses (2009); Sweden: Krantz and Schön (2007); United Kingdom: Feinstein et al. (1982); United States: Abramovitz and David (2001).

of that achieved during the Industrial Revolution.[6] The United Kingdom did not match this acceleration. The origins of faster technological change in the United States may well be along the lines of Habakkuk (1962). He famously claimed that land abundance and labor scarcity in the United States promoted rapid, labor-saving technological change. New economic historians spent quite a long time trying to pin down these arguments. Eventually, it was found that the US was able to exploit complementarities between capital and natural resources to economize on the use of skilled labor in an important

[6] These estimates take no account of education but this would not make much difference according to Abramovitz and David (2001) who found that adjusting TFP growth on this account would reduce TFP growth by 0.0%, 0.1%, and 0.2% per annum in 1855–1890, 1890–1905 and 1905–1927, respectively.

Table 6.5 Variables relating to conditional convergence

	I/Y, 1870	I/Y, 1913	Years of schooling, 1870	Years of schooling, 1913	Polcon, 1870	Polcon, 1913	Market potential, 1910
Austria			3.48	5.58		0.07	55
Belgium			4.45	5.39	0.4	0.48	28
Denmark	8	12.5	4.74	6.08		0.45	20
Finland	12.4	12	0.51	1.12			
France	10.3	12.2	4.04	7.35		0.56	59
Germany	20.8	23.2	5.25	6.92		0.11	62
Greece			1.45	2.79			7
Ireland			2.15	5.5			
Italy	8.8	17.7	0.88	3.06		0.27	40
Netherlands	12.4	21.2	5.33	6.07	0.45	0.55	30
Norway	12.2	20.7	5.67	6.06		0.39	15
Portugal			0.79	2.03	0	0	11
Spain	5.2	12.2	2.43	4.93	0.17	0	26
Sweden	7.7	12	4.86	6.7		0.45	22
Switzerland			6.17	7.65	0.34	0.45	22
UK	7.7	7.5	4.13	6.35	0.33	0.47	89
United States	16.9	19.7	5.57	7.45	0.28	0.39	100

Notes: I/Y is the investment to GDP ratio in percent. "Polcon" is a measure of constraints on the executive; the United States in recent times has scored a little over 0.40. "Market potential" is a measure of proximity to markets which reflects trade costs and the spatial distribution of GDP.
Sources: Investment ratios: Carreras and Josephson (2010) and Rhode (2002); Years of schooling: Morrisson and Murtin (2009); Polcon: database for Henisz (2002); Market potential: Liu and Meissner (2013).

subset of American manufacturing (James and Skinner, 1985), and that scale economies and technological change biased in favor of capital and materials-using were pervasive in manufacturing (Cain and Paterson, 1986). This may partly have been based on localized learning as suggested by David (1975), and partly on directed technical change as in Acemoglu (2010).

Either way, looking at late Victorian Britain, the flip side of this story is that innovations that were made in the United States were frequently "inappropriate" on the other side of the Atlantic because they were not cost-effective at British relative factor prices and/or market size; had they been profit-maximizing, competition in product markets would have ensured rapid adoption (Crafts, 2012). The implication is that lower TFP in British industry was largely unavoidable. Unlike the inappropriate technology literature in development economics, however, this episode concerns the development of north-north rather than north-south technological differences.

Although American overtaking has usually been thought of as centering on industry, this is only part of the story. During the years 1871–1911, the gap between British and

American labor productivity growth was a bit larger in services than in industry, while at the same time employment in both economies shifted strongly toward services. In the services sector, American technological advance was founded on new hierarchical forms of organization based on large volumes and reduced costs of monitoring workers due to falling communication costs (Broadberry, 2006). More generally, US productivity across much of the economy during this period was driven by the organizational innovations that permitted the development of the modern business enterprise and moves toward mass production and mass distribution (Chandler, 1977).

6.2.4 Divergence, Big Time

The fact that the transition to modern economic growth happened first in Britain, and then in Continental Europe and North America, had obvious implications for the international distribution of income. True, buoyant markets in the industrial economies offered new export opportunities for the rest of the world, but this was not sufficient to prevent a large increase in the gap between the industrial rich and the non-industrial poor.

Table 6.6 provides data on per capita incomes in the major regions of the world. The data are mostly taken from Bolt and Van Zanden's (2013) revision of Maddison (2010), although in the case of Africa we have preferred Maddison's original data.[7] We distinguish between Western Europe and Eastern Europe, since industrialization first took hold in the former region, while the English-speaking settler economies of North America and Oceania are considered jointly under the heading "British offshoots." What stands out from the table is the explosive growth in incomes in the British offshoots, where they quadrupled between 1820 and 1913. As a result, this was by far the richest region in the world on the eve of the Great War. Incomes increased by two-and-a-half times in Eastern Europe and Latin America, another European offshoot, during the period, and by slightly less in Western Europe, the richest region in 1820. They increased by much less in Asia and, especially, Africa. Since these two regions had already been the poorest in the world in 1820, and since the British offshoots had been one of the richest, the result was a substantial divergence in living standards—"divergence, big time," as Pritchett (1997) has termed it.

This divergence was due to the rapid growth of the leaders, not the decline of the followers. Incomes rose everywhere over the course of the century, although in Asia, the data show a slight decline in average incomes between 1820 and 1870, perhaps as a result of deindustrialization (Williamson, 2011). From 1870 onwards all regions were growing,

[7] Bolt and Van Zanden present a weighted average of the available data, but since the only available data are for countries in North Africa, as well as Ghana and South Africa, this almost certainly leads to an overstatement of average African incomes. We prefer Maddison's data, which involved making ad hoc judgments about incomes in the rest of the continent, and have adjusted the world per capita figures accordingly.

Table 6.6 GDP per capita, 1820–1913, 1990 international dollars

	1820	1870	1913
Western Europe	1455	2006	3488
Eastern Europe	683	953	1726
British offshoots	1302	2419	5233
Latin America	628	776	1552
Asia	591	548	691
Africa	420	500	637
World	707	874	1524

Sources: Bolt and Van Zanden (2013) and Maddison (2010).

and ended the century more prosperously than they had begun it. Between 1820 and 1913, average incomes rose by 52% in Africa, but by just 17% in Asia.

The net effect was a dramatic increase in international income differentials. In 1820, the then richest region, Western Europe, had an average income twice the world average, and three and a half times the African average. By 1913, Western European incomes were 129% higher than the world average, a small increase, but five and a half times the African average, a sizeable one. Over the same period incomes in the British offshoots rose from being 84% higher than the world average to being 243% higher. By 1913, they were more than eight times those in Africa. Bourguignon and Morrisson (2002, p.734) found that the Theil between-country inequality coefficient almost quintupled between 1820 and 1910.[8]

It is clear, then, that the 19th century saw a large increase in global inequality, driven above all by the rapid income growth of some countries but not others. It is also clear that the primary cause of this rapid income growth was industrialization in Europe and North America. Strikingly, however, some countries, such as Australia and Argentina, had among the highest incomes in the world while remaining largely specialized in primary production. To explain this apparent paradox, we would follow Arthur Lewis (1978), and point to the immigration policies of these resource-abundant countries. While countries such as Burma saw the large-scale immigration of workers from China or India, the temperate settler economies restricted immigration to Europeans only. Racism was undoubtedly a factor here, but the policy also helped maintain living standards. As Lewis (1978, p. 188) put it, "The temperate settlements could attract and hold European emigrants, in competition with the United States, only by offering income levels higher than prevailed in north-west Europe." By appropriately regulating immigration flows, and by absorbing the capital and new technologies of the core, resource-abundant settler economies could thus import rising British living standards.

[8] Based on the data in Maddison (1995).

6.2.5 The Great Specialization

The fact that the Industrial Revolution reduced manufacturing costs so substantially during the 19th century, but only in a small portion of the world, created the potential for a stark international division of labor. Falling transportation costs and relatively liberal trade policy allowed this potential to be realized. North-west Europe and, especially, the United Kingdom exported manufactured goods and imported primary products, while the exports of Oceania, Latin America, and Africa consisted almost entirely of primary products. North America was an intermediary case: its vast natural resources implied net exports of primary products, but rapid industrialization meant that the United States switched to being a net exporter of manufactures just before World War I. Asia was another intermediary case: while it conformed to the peripheral pattern of net primary exports and net manufactured imports, its manufactured exports were non-negligible.

The "great specialization", as Dennis Robertson (1938) called it, between an industrial north and a primary-exporting south, thus dates from the 19th century. Its causes were straightforward enough: geographically unbalanced technological change, and a dramatic reduction in transport costs. Its consequences, especially for the south, were less so. On the one hand, booming northern markets and falling transport costs implied rising terms of trade, especially prior to the 1870s (Williamson, 2011), and this benefited commodity exporters. On the other hand, insofar as this further hastened deindustrialization, it potentially imposed dynamic costs on southern economies, by depriving them of the growth-enhancing externalities associated with manufacturing, by leading to rent-seeking behavior associated with an over-reliance on resource-based production, or by exposing them to greater terms of trade volatility (*ibid*.). Many of the great policy debates of the 20th century thus have their roots in this period. Should developing countries rely on exports of primary commodities to generate growth (a strategy which worked for several countries in the late 19th century [Lewis, 1969, 1970])? Or did such an outward-oriented strategy give rise to Dutch disease problems, suggesting (on the assumption that there are growth-promoting externalities in industry) the need for policy interventions (such as import-substitution strategies) to increase industrial production? The way in which these debates influenced policy decisions would have a major impact on regional growth experiences once the developing world regained policy independence in the 20th century.

It should be noted, however, that by the end of this period several parts of the periphery were reindustrializing. The best-known example is Japan, but there was also rapid industrial growth, albeit from a low base, in several Asian economies, e.g. in Korea, the Philippines, Taiwan, and parts of China. There was also rapid industrial growth in Mexico, Brazil, and the Latin American Southern Cone (Gómez Galvarriato and Williamson, 2009). The spread of industrialization across the developing world would become one of the main features of 20th century economic growth.

Table 6.7 GDP per capita, 1870–2007, 1990 international dollars

	1870	1913	1950	1973	1990	2007
Western Europe	2006	3488	4517	11,346	15,905	21,607
British offshoots	2419	5233	9268	16,179	22,346	30,548
Japan	737	1387	1921	11,434	18,789	22,410
"West"	**1914**	**3690**	**5614**	**13,044**	**18,748**	**25,338**
Asia minus Japan	539	652	639	1223	2120	4830
Latin America	776	1552	2505	4517	5065	6842
Eastern Europe and former USSR		1519	2594	5741	6458	7731
Africa	500	637	889	1387	1425	1872
"Rest"		**853**	**1091**	**2068**	**2711**	**4744**
World	**874**	**1524**	**2104**	**4081**	**5149**	**7504**

Sources: Bolt and Van Zanden (2013), Maddison (2010). This is a revised version of Table 4 in Maddison (2005).

6.3. TWENTIETH CENTURY GROWTH: WHAT HAPPENED?

In this section we briefly set out some of the major facts concerning aggregate growth in the major regions of the world.

6.3.1 World Growth and Its Decomposition

Table 6.7 presents data on the level of per capita GDP between 1870 and 2007, based on Bolt and Van Zanden's (2013) updating of Maddison (2010). As before, we have preferred Maddison's original figures for Africa up to and including 1913, and have revised the world figures accordingly. We follow Maddison in distinguishing Japan from the rest of Asia (which we will, for the sake of brevity, refer to henceforth as "Asia"), since Japan was a precocious industrializer.[9] We also follow Maddison in grouping Western Europe, Japan, and the British offshoots (the United States, Canada, Australia, and New Zealand) together (the "West"), and in considering separately the other four regions (the "Rest"), which we will refer to jointly as the developing world.

Table 6.8 gives per capita GDP growth rates in five successive periods; the late 19th century (1870–1913); the turbulent years between 1913 and 1950; the "Golden Age" which lasted from 1950 to 1973; the period following the first oil crisis, from 1973 to 1990; and the period since 1990.[10] Whereas Maddison treated the entire period since 1973 as one, we have preferred to split it into two, since the years after 1990 were marked

[9] We use Maddison's population data to derive the average figures for the West, the Rest, Asia minus Japan, and Eastern Europe and the former USSR.

[10] The figure for Eastern Europe and the former USSR is a population-weighted average of the growth rates of the two regions, where the latter growth rate is (in the case of 1870–1913) calculated for the period 1885–1913 only, since data for 1870 are lacking.

Table 6.8 Per capita GDP growth, 1870–2007 (percent per annum)

	1870–1913	1913–1950	1950–1973	1973–1990	1990–2007	1913–2007
Western Europe	1.29	0.70	4.09	2.01	1.82	1.96
British offshoots	1.81	1.56	2.45	1.92	1.86	1.89
Japan	1.48	0.88	8.06	2.96	1.04	3.00
"West"	**1.54**	**1.14**	**3.73**	**2.16**	**1.79**	**2.07**
Asia minus Japan	0.45	−0.06	2.87	3.29	4.96	2.15
Latin America	1.63	1.30	2.60	0.68	1.78	1.59
Eastern Europe and former USSR	1.64	1.46	3.51	0.69	1.06	1.75
Africa	0.57	0.90	1.95	0.16	1.62	1.15
"Rest"	**0.73**	**0.67**	**2.82**	**1.61**	**3.35**	**1.84**
World	**1.30**	**0.87**	**2.92**	**1.38**	**2.24**	**1.71**

Sources: Based on Bolt and Van Zanden (2013), Maddison (2010). This is a revised version of Table 6 in Maddison (2005).

by the collapse of the Soviet Union, the rapid spread of globalization, and a succession of international financial crises.

Table 6.8 shows that world economic growth was higher in the 20th century (1913–2007) than in the late 19th (1870–1913), at 1.7% per annum as opposed to 1.3%. Latin America is the only exception to the rule that 20th century growth was faster, and even there growth rates in the two periods were very similar. Growth was also very similar in the two periods in the British offshoots, reflecting the relative constancy of the long-run United States growth rate (Jones, 1995).

These aggregate 20th century figures disguise a considerable amount of variation between periods. The period between 1913 and 1950, marked by two world wars and the Great Depression, saw world growth fall to just 0.9%. It declined everywhere with the exception of Africa, although it fell by less in the British offshoots, which saw strong wartime growth (helping to offset an especially severe depression after 1929), and in Eastern Europe and the former USSR, where Stalin embarked on a major industrialization drive during the interwar period. The period between 1950 and 1973 clearly deserves the "Golden Age" label, with world growth rates higher than at any other time in history. All regions saw their highest ever growth rates during this quarter century, with just one exception: Asian growth accelerated after 1973, and again after 1990.

With the aforementioned exception of Asia, growth rates declined everywhere after 1973. After 1990, they continued to decline in the "West," but they increased in all four developing regions. The result was that, for the first time since 1870, per capita growth rates after 1990 were higher in the "Rest" than in the "West."

Table 6.9 World shares of GDP, 1870–2007 (percent)

	1913	1950	1973	1990	2007
Western Europe	33.3	26.0	25.5	22.2	17.4
British offshoots	21.3	30.8	25.4	24.6	22.1
Japan	2.6	3.0	7.8	8.6	5.8
"West"	**57.3**	**59.7**	**58.6**	**55.4**	**45.2**
Asia minus Japan	22.1	15.6	16.4	23.3	37.0
Latin America	4.6	7.8	8.7	8.3	7.9
Eastern Europe and former USSR	13.1	13.0	12.9	9.8	6.3
Africa	2.9	3.8	3.4	3.3	3.6
"Rest"	**42.7**	**40.3**	**41.4**	**44.6**	**54.8**
World	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Sources: Bolt and Van Zanden (2013), Maddison (2010).

Table 6.9 presents data on regional shares of world GDP. This requires information on not only per capita GDP levels, but population sizes, the latter being taken from Maddison (2010). As can be seen, the West's share of world GDP peaked in 1950, at almost 60%, before declining slowly before 1990, and more rapidly thereafter: in 2007 it was just 45%. This overall trend masks considerable variation within the "West". The share of the British offshoots was slightly higher in 2007 than in 1913, at 22%, although it was over 30% in the immediate aftermath of World War II, declining slowly thereafter. In contrast, Western Europe's share fell by almost a half, from 33% to 17%; while Japan's share rose from 2.6% in 1913 to 8.6% in 1990, before falling sharply afterward. Within the developing world Asia's share fell substantially between 1913 and 1950, had recovered by 1990, and increased rapidly since then. It was over a third in 2007. The Latin American share rose in the early 20th century, and has held steady since 1950; while Africa's share rose between 1913 and 1950 and has been stable since then. One of the most striking features of the table is the share of Eastern Europe and the former USSR, which was steady until 1973 and then collapsed, falling not just during the last two decades of communism, but after 1990 as well. The share was just 6% in 2007, less than half the 1973 level.

6.3.2 Catching Up, Forging Ahead, and Falling Behind

Since the publication of Moses Abramovitz's (1986) presidential address to the Economic History Association, it has become commonplace to distinguish between economic growth in the leading economy or economies, at the frontier of technological knowledge, and in follower countries which may or may not be catching up on that frontier. Growth in the leading economy is determined by those forces pushing back the frontier; growth in the followers is determined by the extent to which they can import technologies from the leading economies, and embody them in their own capital stock.

Abramovitz pointed out that such catching up is inherently self-limiting, an insight that has been subsequently formalized by growth theorists such as Robert Lucas (2000, 2009). His argument that catching-up was dependent on adequate "social capability" anticipated the enormous literature on conditional convergence. Abramovitz also argued that, given social capability, circumstances had to be conducive to the international diffusion of knowledge. Subsequent research has followed Abramovitz's lead, focusing both on the diffusion of technologies (Comin et al. 2006; Comin and Hobijn, 2010) and on the role of trade in stimulating or hindering the process. While there are disagreements on many details of the international growth process, the broad distinction between growth in the leaders and in the followers tends to be taken as given.

A common theme in economic history is the story of how economic leadership has passed from nation to nation over the course of the last millennium. How to explain this remains unclear (for one attempt to do so, see Brezis et al. 1993). Fortunately, for our purposes the issue is moot, since it is commonly accepted that the economic leader throughout the 20th century was the United States, although it was not until after World War II that the US was willing to translate its technological superiority into economic policy leadership. Figure 6.1 shows the evolution of per capita GDP in the United States between 1800 and 2007, allowing the 20th century performance to be compared with what came before. As is well known (Jones, 1995), and has already been noted, per capita growth rates have been remarkably stable in the United States over time. The heavy straight line is a linear projection backwards and forwards in time of trend growth during the late 19th century (1870–1913). The shaded areas represent the US Civil War (1861–1865), World War I (1917–1918), and World War II (1941–1945), while the dashed vertical lines represent the onset of the Great Depression (1929) and the first oil crisis (1973).

As can be seen, per capita growth accelerated in the United States after 1870. It averaged 1.8% per annum between 1870 and 1913, as opposed to 1.2% between 1820 and 1870.[11] As can also be seen, the long-run trend was very similar in the 20th century, despite the remarkable collapse in incomes during the Great Depression, and the equally remarkable increase in per capita output during World War II. Growth averaged 2.1% per annum between 1913 and 2007, with a slight acceleration evident from the early 1980s. Consistent with Lucas (2000, 2009), per capita growth in the frontier economy has been around 2% per annum for a very long time.

For variety and drama, we need to turn to the followers. There, the 20th century has thrown up growth miracles, reversals of fortune, and sorry tales of steady decline (Pritchett, 2000). Figure 6.2 plots per capita GDPs in the major economies and regions of the world, as a percentage of US GDP, thus indicating whether or not these countries were converging on the technological frontier, keeping pace, or falling further behind. For

11 Here and elsewhere, reported growth rates are based on regressions of the log of per capita output on time.

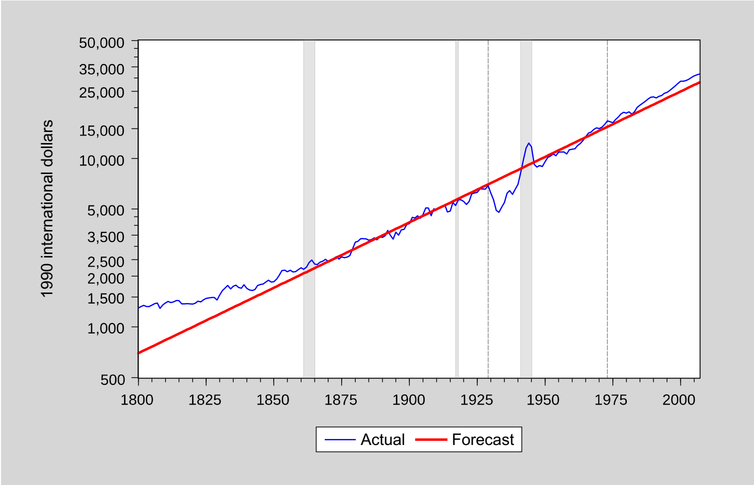

Figure 6.1 US GDP per capita, 1800–2007 (1990 international dollars). *Sources: Bolt and Van Zanden (2013).*

the sake of brevity we will henceforth refer to these percentages as countries' or regions' relative GDP, or relative income. While our interest is in the 20th century experience, we also provide the backstory by plotting the trends beginning in 1870. The figures are, for the most part, regional averages, and therefore average out individual country experiences.

The major point that emerges from the late 19th century data is that as US growth accelerated after the Civil War, other regions, with three exceptions, saw their relative incomes decline. For the purposes of Figure 6.2 we have dated the two world wars, in Eurocentric fashion, between 1914–1918 and 1939–1945.

The first exception is Japan, which managed to keep pace with the United States after 1870. Like all regions it saw its relative GDP increase during the catastrophic interwar period, and then decline during the Second World War. It then caught up on the technological frontier in impressive fashion, experiencing per capita growth of 8% per annum during the Golden Age (Table 6.8), and overtaking Western Europe in the late 1970s. Its subsequent relative decline has been quite astonishing: Japan's relative GDP peaked at almost 85% in 1991, but it was only around 70% in 2007, back to the level of 1979.

The second exception is Latin America, whose relative GDP, like that of Japan, remained constant at just under 30% between 1870 and 1913. Unlike Japan, it stayed at this level until 1940, avoiding both the catch-up of the Depression years and the collapse that followed during World War II: one interpretation might be that the continent's economies were closely linked with that of the US during this period. Indeed, Latin America's relative income remained fairly constant during the next four decades, dipping to around 25–26% during the 1950s and 1960s, and recovering its 19th century level of

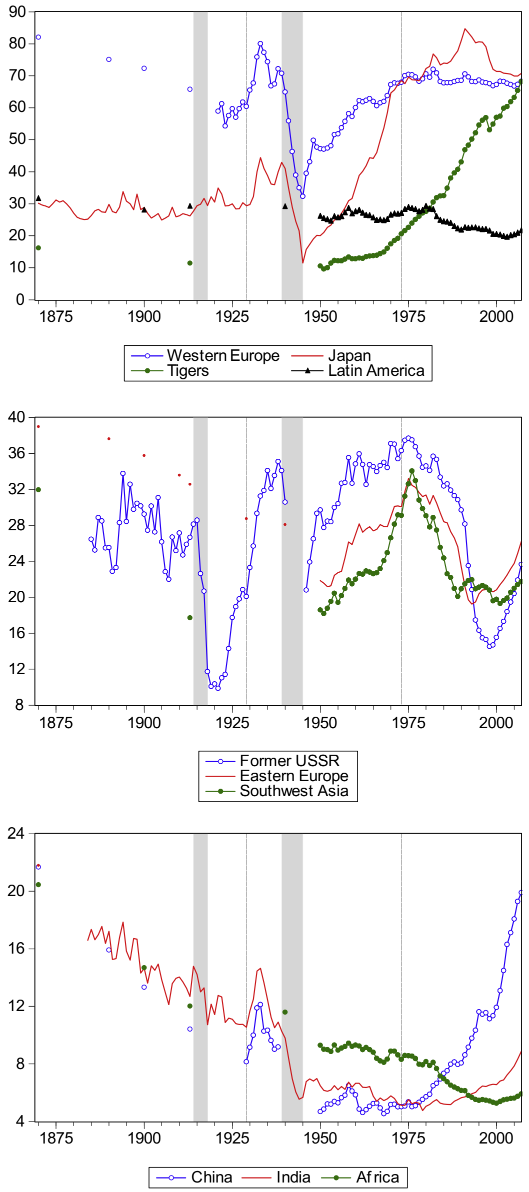

Figure 6.2 Regional GDP per capita, 1870–2007 (percentage of US level). *Sources:* *Bolt and Van Zanden (2013)* and *Maddison (2010)*.

29% in 1980. The next three decades saw Latin America's relative income steadily decline, and it stood at just 20% at the end of the 20th century.

The East Asian Tigers (Hong Kong, South Korea, Singapore, and Taiwan) are, with Japan, the main success story emerging from Figure 6.2. Their relative GDP fell from 16% in 1870 to around 11% by 1913, and there it stood until 1950. It then started to rise, accelerating dramatically in the late 1960s, until by 2007 it stood at just under 70%, on a par with both Western Europe and Japan.

The European growth miracle of the Golden Age was real enough, with growth rates of 4% per annum, but in a longer run perspective this quarter century episode stands out as an exception to what was a generally disappointing performance. Like most other regions, Western Europe's relative GDP fell between 1870 and 1913, from 82% to 66%, and it collapsed during World War II to a low point of 32% in 1945. The Golden Age saw the region's relative GDP recover to its 1913 level, and even surpass it slightly, so that it stood at around 70% in the early to mid-1970s. Since then there has been absolutely no convergence on the technological frontier.

The most dramatic experience, in this catching-up perspective, was probably that of the former USSR. This region was the third to keep pace with the United States during the late 19th century (although we only have data from 1885), but its relative GDP was highly volatile during the period. It then collapsed during the First World War, recovered dramatically during the interwar period to the point where it surpassed its previous peak, reaching 35% in 1938. It collapsed again during the Second World War, and recovered in equally dramatic fashion, peaking at 38% in 1975. There followed a spectacular decline, to a nadir of 14.5% in 1998. It then rose sharply, reaching 24% in 2007.

Given the extent to which the Soviet and Eastern European economies were connected after 1945, it is not surprising to see Eastern Europe's relative GDP tracing out the same rise and fall as its imperial master before and after 1975. It arrested its decline earlier than the former USSR, in 1993, and has been richer ever since. More surprising is the fact that Southwest Asia, which essentially comprises oil rich states in the Middle East and the Gulf, along with Israel, Lebanon, and Turkey, followed a very similar trajectory as well, with its post-1976 decline extending all the way to 2001.

Finally, Africa, China, and India all saw their relative incomes decline steadily until the late 20th century. China's relative GDP fell more sharply early on, and then stagnated at a very low level from 1950 onwards, about 5%, before starting a remarkable rise in the late 1970s. It stood at 20% in 2007. India's relative decline was slower, and its catch-up began around a decade after China's, again from a level of around 5%. Africa's relative decline was the slowest of all, with its relative GDP only hitting 5% in the mid-1990s. From 2000 onwards it started to slowly recover, reaching 6% in 2007.

6.4. THE PROXIMATE SOURCES OF GROWTH

This section explores the proximate sources of growth, as revealed by growth accounting techniques. We provide a broad overview of results relating to 20th century economic growth. We also review a number of issues relating to the use of these methods and, in particular, the interpretation of results obtained by using them. Handled with care, we believe that growth accounting can provide an important benchmarking or diagnostic tool but there is also considerable scope to make misleading comparisons or inferences.

6.4.1 Conventional Growth Accounting Results

The conventional growth accounting approach assumes that GDP is given by:

$$Y = AK^{\alpha}L^{1-\alpha},$$

where Y is output, K is capital, L is labor, and A is TFP, while α and $(1-\alpha)$ are the elasticities of output with respect to capital and labor, respectively. The level of TFP is usually measured as a residual after the other items in the expression have been measured.

This can be converted into the basic growth-accounting formula:

$$\Delta\ln(Y/L) = \alpha\,\Delta\ln(K/L) + \Delta\ln A,$$

which gives a decomposition of the percentage rate of growth of labor productivity into a contribution from the percentage rate of growth of capital per unit of labor input (capital deepening) and a term based on the percentage growth rate of TFP. For benchmarking purposes, it is convenient to adopt a standardized value for α.[12]

It is tempting but misleading to assume that residual TFP growth in this formula captures the contribution of technological progress to labor productivity growth. Technological change may be less than TFP growth if there are scale economies or improvements in the efficiency with which factor inputs are used. On the other hand, if technological progress is partly embodied in new forms of capital (rather than "manna from heaven") then some of its contribution will seem to accrue to capital when this approach is used.

A more general approach seeks to take account of human capital and modifies the production function to be:

$$Y = AK^{\alpha}(L^{*}(HK/L))^{1-\alpha},$$

where HK/L is the average educational quality of the labor force, typically approximated by years of schooling. The growth-accounting formula then becomes:

$$\Delta\ln(Y/L) = \alpha\,\Delta\ln(K/L) + (1-\alpha)\Delta\ln(HK/L) + \Delta\ln A,$$

so that the decomposition now includes a contribution from the rate of growth of the quality of the labor force, which in practice is based on the additional earnings from years

[12] It is common to use $\alpha = 0.35$ which is similar to the share of profits in GDP for many countries. The profits share is potentially a misleading estimate of the output elasticity of capital, for example in the presence of significant externalities or market power, but in practice it is probably acceptable (Aiyar and Dalgaard, 2005; Bosworth and Collins, 2003).

Table 6.10 Accounting for labor productivity growth in OECD Countries, 1913–1950 (percent per annum)

	K/L	HK/L	TFP	Y/L
France	0.59	0.36	1.06	2.01
Germany	0.19	0.22	0.74	1.05
Japan	0.62	0.61	0.49	1.72
Netherlands	0.43	0.27	0.88	1.58
UK	0.42	0.32	0.83	1.57

Source: Maddison (1987).

of schooling. The estimates of the TFP growth contribution are less crude and, of course, tend to be smaller once education is taken into account.

Tables 6.10 and 6.11 report growth-accounting estimates on this basis where the methods used allow international comparisons to be made. Taken at face value, several interesting points stand out from these estimates. First, even after allowing for education, TFP growth in the advanced economies compares very favorably with the 19th century until the end of the Golden Age in the 1970s. Second, the rise of East Asian countries after 1960 is notable for a very strong capital deepening contribution to labor productivity growth, which was much greater than had been observed in the European transition to modern economic growth in the 19th century. Third, TFP growth in sub-Saharan Africa was disastrous in the last 30 years of the 20th century and most disappointing in Latin America post-1980, and for both these regions there was virtually no capital deepening contribution after 1980.

Table 6.12 provides an account of productivity gaps based on an application of growth accounting to levels pioneered in a classic article by Hall and Jones (1999). Its results are quite similar to those given in that paper although for a later study that took place in 2005. The results are striking: by far the most important reason for differences in labor productivity (and income per head) is differences across countries in levels of TFP.[13] This is a striking rejection of the basic set-up of the pure Solow growth model which assumes that technology is the basis of TFP and is both exogenous and universal—an assumption which underpins the neoclassical predictions of β- and σ-convergence.

In principle, there are two reasons why TFP levels may differ, namely technology and efficiency. The most obvious reason why technology might differ is that technological progress has been uneven and has improved the production function at some factor intensities (high capital-labor or human capital-labor ratios) but not others. The evidence

[13] There are alternative ways to specify the "development accounting" equation and measurement issues, in particular with regard to human capital. Nevertheless, there seems to be general agreement that residual TFP is the biggest part of the story, accounting for 50–70% of cross-country income differences (Hsieh and Klenow, 2010).

Table 6.11 Proximate sources of labor productivity growth, 1960–2003 (percent per annum)

	K/L	HK/L	TFP	Y/L
Industrial countries				
1960–1970	1.4	0.3	2.3	4
1970–1980	1	0.5	0.4	1.9
1980–1990	0.6	0.2	0.9	1.7
1990–2003	0.8	0.2	0.6	1.6
East Asia				
1960–1970	1.7	0.4	1.6	3.7
1970–1980	2.7	0.6	1	4.3
1980–1990	2.5	0.6	1.3	4.4
1990–2003	2	0.5	0.6	3.1
Latin America				
1960–1970	0.8	0.3	1.7	2.8
1970–1980	1.3	0.3	1.1	2.7
1980–1990	0	0.5	−2.3	−1.8
1990–2000	0.1	0.3	−0.1	0.3
Sub-Saharan Africa				
1960–1970	0.8	0.2	1.9	2.9
1970–1980	1.3	0.1	−0.4	1
1980–1990	−0.1	0.4	−1.5	−1.2
1990–2000	0	0.4	−0.5	−0.1

Sources: Bosworth and Collins (2003) and website update.

Table 6.12 Decomposition of cross-country differences in GDP per capita, 2005 (USA = 100)

	Y/P	K/Y	HK/L	L/P	TFP
United States	100	100	100	100	100
Japan	72.6	130.7	100.4	105.1	52.6
EU27 + EFTA	64.7	114.1	91.2	91.3	67.8
Russia	28.6	97.4	84.9	99.3	31.5
Brazil	20.5	103.1	70.1	96.8	29.3
China	9.8	105.2	57.3	119.5	13.6
India	5.2	98.3	47.7	87.1	12.7
World	22.8	104.2	64.2	95.8	27.9

Notes: GDP per capita (Y/P) is measured at PPP. Estimates derived by imposing the production function $Y = K^{\alpha}(AhL)^{1-\alpha}$ where h is human capital per worker (HK/L). This can be re-written as $Y/L = (K/Y)^{\alpha/(1-\alpha)}\,Ah$ so that $Y/P = (K/Y)^{\alpha/(1-\alpha)}\,Ah(L/P)$ which is the formula used for the decomposition.
Source: Duval and De la Maisonneuve (2010).

suggests that this was the case during the 20th century (Allen, 2012), as might be expected, in a world of directed technical change where research and development is oriented primarily to the incentives provided by the economic environment of advanced economies. In other words, there could be an "inappropriate technology" explanation for the TFP gap. An inefficiency explanation for TFP gaps might relate to differences in institutional quality which impact on allocative and/or productive inefficiency. Again, there is evidence that points in this direction, notably the finding by Hsieh and Klenow (2009) that if capital and labor were used as efficiently in Chinese and Indian manufacturing as in the United States, TFP would increase by 30–50% and 40–60%, respectively.

Table 6.13 reports results from one attempt to discriminate between these two hypotheses. The overall conclusion in Jerzmanowski (2007) is that in 1995 (1960) factor inputs accounted for 31 (45)% of the variation in output per worker while of the 69 (55)% attributable to TFP, 43 (28)% came from efficiency and 26 (27)% from technology differences. These estimates imply that, while both efficiency and technology are important in explaining TFP gaps, on average, efficiency matters more, and increasingly so over time. These results suggest that episodes of rapid catch-up growth are likely to be based

Table 6.13 Decomposing TFP levels relative to the United States (USA = 1.00)

	1960			1995		
	TFP	**E**	**T**	**TFP**	**E**	**T**
France	0.72	0.71	1.01	0.77	0.87	0.89
Greece	0.49	0.57	0.86	0.56	0.58	0.97
Spain	0.64	0.74	0.86	0.76	0.85	0.9
Italy	0.67	0.71	0.94	0.84	0.88	0.96
UK	0.85	0.89	0.95	0.82	0.85	0.97
India	0.3	0.41	0.74	0.29	0.44	0.67
Indonesia	0.31	0.55	0.57	0.37	0.54	0.69
Japan	0.48	0.56	0.86	0.68	0.79	0.86
Korea	0.33	0.37	0.88	0.49	0.49	0.99
Singapore	0.47	0.54	0.87	0.85	1	0.85
Argentina	0.76	0.79	0.96	0.57	0.65	0.88
Brazil	0.42	0.49	0.86	0.5	0.6	0.84
Chile	0.51	0.57	0.89	0.58	0.73	0.8
Mexico	0.65	0.72	0.9	0.49	0.58	0.84
DR Congo	0.38	0.58	0.65	0.23	0.35	0.67
Malawi	0.23	0.39	0.6	0.16	0.27	0.61
Mauritius	0.62	0.71	0.88	0.8	1	0.8
Tanzania	0.15	0.22	0.69	0.11	0.17	0.64

Note: $TFP_i = Efficiency_i * Technology_i = E_i T_i$ where E_i is obtained by estimating an efficient production frontier, TFP is obtained by growth accounting in levels and T is then inferred.
Source: Jerzmanowski (2007).

on major improvements in both efficiency and technology. They also suggest that the lengthy period of negative TFP growth in Africa reported in Table 6.11 is a sign of deteriorating efficiency of factor use, rather than of technological retrogression.

6.4.2 Some Issues of Measurement and Interpretation[14]

There are a number of important issues that have to be addressed when trying to compare growth-accounting exercises for the late 19th and early 20th centuries with similar exercises for the late 20th century. For example, to obtain estimates of real GDP an accurate GDP price deflator is required. Boskin et al. (1996) thought that, for a variety of reasons, inflation had been overestimated (and thus real GDP growth and TFP growth had been underestimated by a similar amount) in the national accounts during the period of the productivity slowdown in the 1970s and 1980s, and that the correction required was of the order of 0.6% per year. On the other hand, the Boskin bias in inflation measurement does not appear to generalize to other periods (Costa, 2001).

Perhaps a more serious concern in many cases is a potential index number problem regarding the measurement of capital inputs. The standard approach, used in virtually all historical studies, relies on estimates of the perpetual inventory capital stock that are weighted using asset prices. A theoretically more appropriate (but much more data demanding) method is to estimate flows of capital services using rental prices as weights. This requires estimates of the user cost of capital for different assets. The difference between the two methods will be especially important when investment switches toward short-lived assets (like computers) and away from long-lived assets (like structures), since the user cost of the former is much higher relative to the asset price. Not surprisingly, this issue has come to prominence since the ICT revolution.[15] Generally speaking, using the capital services methodology raises the growth contribution of capital and lowers that of TFP. However, this probably makes relatively little difference, even in the United States, before the second half of the 20th century, as Table 6.14 reports; it is, however, very important for analyses of recent growth.[16]

It has long been recognized that research and development is an intangible investment and that the R & D knowledge stock could be introduced as an input in growth-accounting estimates. More recently, it has been argued that intangible investments generally (including design and product development; investments in branding; firm-specific human and organizational capital formation including training and consultancy; and computerized information, especially software) should be treated in this way.

[14] This section draws in part on Crafts (2009a, 2010).

[15] Estimates for the UK show that the volume of capital inputs for the period 1950–2006 grew by 3.1% per annum measured by the traditional capital stock data but by 3.5% when measured by the capital services method. The difference relates entirely to the post-1980 and, in particular, the post-1990 period (Wallis, 2009).

[16] The EUKLEMS database which covers recent decades and permits international comparisons is constructed using a capital services methodology: see O'Mahony and Timmer (2009).

Table 6.14 Sources of labor productivity growth in the United States (percent per annum)

	K/L	Crude TFP	Labor quality	Capital quality	Refined TFP	Y/L
1800–1855	0.19	0.2	0	0	0.2	0.39
1855–1871	0.53	−0.39	0	0	−0.39	0.14
1871–1890	0.84	1	0	0	1	1.84
1890–1905	0.55	1.38	0.1	0	1.28	1.93
1905–1927	0.48	1.57	0.19	0	1.38	2.05
1929–1948	0.07	1.89	0.38	0.08	1.43	1.96
1948–1966	0.81	2.3	0.43	0.4	1.47	3.11
1966–1989	0.57	0.66	0.31	0.31	0.04	1.23

Note: capital quality reflects the adjustment required to move from a capital stock to a capital services basis.
Source: Abramovitz and David (2001, Table 1: IVA).

Expenditure on these items has been growing rapidly in the context of the "knowledge economy" and in both the UK and the USA, is of similar magnitude to investment in tangible capital. If these expenditures are treated as final investment rather than intermediates in growth-accounting exercises, this will imply that there is more output, more input, and revised factor-share weights.

In principle, the impact of switching to accounting with intangibles on TFP growth is ambiguous. In practice, at least in the ICT era, the impact is to increase estimated labor productivity growth a bit, to raise the contribution of capital deepening considerably, and to reduce measured TFP growth appreciably, as Table 6.15 reports. Growth accounting with intangibles for earlier periods has not yet been attempted but the impact would surely be much less dramatic since, in the 1950s, intangible investment added only about 4% to US GDP compared with about three times that amount 50 years later.

Neoclassical growth accounting is normally carried out by imposing a Cobb-Douglas production function. In some circumstances, it may be that a CES specification is more appropriate with the elasticity of substitution between capital and labor, σ, being set to a value less than 1. In that case, especially when the capital-labor ratio is growing rapidly and technical change exhibits capital-using bias, TFP growth will be underestimated by the conventional method. For example, taken at face value, the estimates in Table 6.14 (which assume that $\sigma = 1$) invite the conclusion that technical change was insignificant in the American economy for much of the 19th century, and only became significant with the rise of the science-based industries and R & D in the so-called Second Industrial Revolution. This runs counter to standard historical discussions, however, and is certainly not the interpretation in Abramovitz and David (2001). If, as they argue, the 19th century US economy was characterized by a low elasticity of substitution between factors and capital-using technical change, then TFP growth was considerably stronger than shown in Table 6.14. If estimates are obtained assuming $\sigma = 0.3$, as Abramovitz and David believe is appropriate, then TFP growth turns out to have been 0.9% per year between

Table 6.15 Sources of labor productivity growth, United States non-farm business sector, 1973–2003 (percent per annum)

	1973–1995	1995–2003
Traditional growth accounting		
Labor productivity growth	1.36	2.78
Capital deepening	0.6	0.98
IT capital	0.33	0.7
Other tangible capital	0.27	0.28
Labor quality	0.28	0.38
TFP	0.48	1.42
Accounting with intangibles		
Labor productivity growth	1.63	3.09
Capital deepening	0.97	1.68
Tangible capital deepening	0.55	0.85
IT capital	0.3	0.6
Other tangible capital	0.25	0.24
Intangible capital deepening	0.43	0.84
Software	0.12	0.27
Other intangible capital	0.31	0.57
Labor quality	0.25	0.33
TFP	0.41	1.08

Note: accounting with intangibles is based on the formula $\Delta\ln(Y^*/L) = s^*_{TK}\Delta\ln(TK/L) + s^*_{IK}\Delta\ln(IK/L) + \Delta A/A$, where Y^* includes expenditure on intangible investments and s^*_{TK} and s^*_{IK} are the factor shares of tangible and intangible capital in Y^*.
Source: Corrado et al. (2009).

1835 and 1890, much higher than a crude estimate of 0.24% per year, assuming $\sigma = 1$.[17] Other cases where a similar issue arises, and which are discussed below, include the "East Asian Miracle" (Rodrik, 1997) and the 1970s growth slowdown in the USSR (Allen, 2003).

A further problem with conventional growth accounting that matters in some circumstances is that it assumes no costs of adjustment, fixed factors of production, or economies of scale. Morrison (1993) proposed an econometric procedure to address these problems and her results indicated that the 1970s slowdown in TFP growth in American manufacturing was very largely a weakening of economies of scale rather than of technological progress. Using Morrison's methodology, Crafts and Mills (2005) found that adjustment costs meant that technological progress was about 2 percentage points faster than conventional TFP growth in both British and German manufacturing during 1950–1973

[17] This calculation applies the correction to TFP growth in Rodrik (1997). The correction is given by $0.5\,\alpha((1-\sigma)/\sigma)(1-\alpha)(\Delta K/K - \Delta L/L)(\Delta A_L/A_L - \Delta A_K/A_K)$ where the last term captures the degree of factor-saving bias in technological progress measured as the difference between the rate of labor augmentation and the rate of capital augmentation.

but not much different thereafter. Once again, as with the previous examples, the point is that intertemporal comparisons of conventional TFP growth may be hazardous because the degree of measurement bias appears to have varied considerably over time.

Underpinning growth accounting in the neoclassical tradition is, of course, the neoclassical growth model.[18] The later development of endogenous growth models could potentially call for alternative growth-accounting formulae or a different interpretation of the standard results (Barro, 1999). The most obvious implication might be to recognize the importance of the embodiment of technical change in new varieties of capital, as in the voluminous literature that has applied growth accounting to the impact of ICT (e.g. Oliner et al. 2007). The growth-accounting formula that has been applied in the ICT literature is:

$$\Delta\ln(Y/L) = \alpha_{KO}\Delta\ln(KO/L) + \alpha_{KICT}\Delta\ln(KICT/L) + \phi\,\Delta\ln A_{ICT} + \eta\,\Delta\ln A_{O},$$

where ϕ and η are gross output weights, KICT is capital used in ICT production, KO is the rest of the capital stock, A_{ICT} is TFP in ICT production, and A_O is TFP in the rest of the economy. The contribution of the new ICT technology to labor productivity growth is taken to be the sum of the second and third terms. Given that ϕ and α_{KICT} are very small initially, it is easy to see why a new GPT initially adds very little to overall labor productivity growth. By including the ICT capital deepening term, however, the implication is that TFP growth underestimates the contribution of technological progress to growth.

It should be noted that this approach seeks only to benchmark the direct ex-post ICT component of productivity growth. It does not answer the (much harder) question, "How much faster was productivity growth as a result of ICT?" This hinges on the counterfactual rate of growth of other capital in the absence of ICT, estimation of which would be a complex modeling exercise taking account of both crowding out and crowding in effects. Fogel (1964) took the view that no capital deepening component should be included because in the absence of the new technology similar returns would have been earned on alternative investments. However, this is not a position that everyone would accept, especially in the case of GPTs.[19]

This links to a deeper concern regarding the use of growth accounting to identify the sources of growth, which was very clearly articulated by Abramovitz (1993). The issue is two-way interdependence between the trajectories of technological change on the one hand, and physical and human capital formation on the other. While some endogenous growth models stress the latter interdependence, it is actually the former

[18] As Griliches (1996) underlined, the big contribution of Solow (1957) was to put the economics into growth accounting by making this connection.

[19] Fogel (1964) measured the contribution of railways to American economic growth in terms of "social savings," essentially a measure of user benefits arising from the impact of technical change on the transport supply curve. It is easy to show that this is equivalent to $\phi\,\Delta\ln A_{ICT}$ (Foreman-Peck, 1991).

which is highlighted by a comparison of the American growth process in the 19th and 20th centuries.[20]

Three key points should be noted. First, using conventional growth accounting to estimate TFP growth is not always a good guide to underlying technological change. As we have seen, TFP growth can be either an under- or an overestimate of the contribution of technological progress to economic growth. Second, the size and direction of the bias in neoclassical growth accounting varies considerably in different periods or types of economy; this can make historical comparisons quite difficult. Third, while growth accounting invites its users to treat the growth of capital and technological change as independent and additive, this assumption is potentially quite misleading and may detract from a deeper understanding of the sources of growth.

6.4.3 Economic Miracles are Not All the Same[21]

All of that having been said, an interesting application of growth accounting is to compare episodes of rapid catch-up growth, which exhibit some striking differences when viewed through this lens.[22] Table 6.16 reports estimates relating to the Golden Age of Western European growth, the East Asian Miracle, the Celtic Tiger, the rise of the BRICs, and the Soviet Union. This last case ended in failure but back in the 1960s it was conventional wisdom that the USSR was on track to overtake the United States before the beginning of the 21st century (Levy and Peart, 2011).

The European Golden Age saw strong contributions to labor productivity growth from both capital deepening and TFP growth, but it is the latter that was typically larger in the poorer countries which exhibited the fastest growth. This was not based to any significant extent on domestic R & D, but rather on a combination of technology transfer, structural shift away from agriculture, economies of scale, and more efficient utilization of factors of production. The transfer of "surplus labor" from small-scale family farms was an important part of the process (Crafts and Toniolo, 2008). External trade liberalization and the increased integration of the European market were factors that speeded up technology transfer and helped Europe to reduce the technology gap with the United States (Badinger, 2005; Madsen, 2007). Nelson and Wright (1992) also stressed the increased cost-effectiveness of American technology in Europe, the greater codification of

[20] Of course, in the neoclassical growth model an increase in exogenous TFP growth raises the growth rate of the capital stock; some implications of this point for growth accounting are explored by Hulten (1979). However, Abramovitz has in mind a richer story about 19th century American growth in which, *inter alia*, the great expansion of the domestic market resulting from technological change in transport leads to larger-scale and more capital-intensive methods of production.

[21] This section draws in part on Crafts and Toniolo (2008).

[22] Our examples are all taken from the late 20th century, so hopefully, the problems of inter-temporal comparability highlighted earlier will not be too severe. See however the caveats in the succeeding two footnotes.

Table 6.16 Accounting for growth during "economic miracles" (percent per annum)

(a) Sources of labor productivity growth

	K/L	HK/L	TFP	Y/L
Western Europe 1960–1970				
France	2.02	0.29	2.62	4.93
Germany	2.1	0.23	2.03	4.36
Italy	2.39	0.36	3.5	6.25
Spain	2.45	0.38	3.73	6.56
East Asia 1960–2003				
Korea	2.7	0.7	1.28	4.68
Singapore	2.86	0.46	1.2	4.52
Taiwan	3.04	0.54	2.16	5.74
Ireland				
1990–2003	0.49	0.26	2.24	2.99
USSR				
1928–1940	2		0.5	2.5
1940–1950	−0.1		1.6	1.5
1950–1970	2.6		1.4	4
1970–1985	2		-0.4	1.6
China				
1978–1993	2.1	0.4	3.9	6.4
1993–2004	3.7	0.3	4.5	8.5
India				
1978–1993	0.8	0.3	1.3	2.4
1993–2004	1.6	0.4	2.6	4.6

(b) Sources of output growth

	K	L = Employment + Education	TFP	Y
Western Europe 1960–1970				
France	2.24	0.42 + 0.29	2.62	5.57
Germany	2.13	0.06 + 0.23	2.03	4.45
Italy	2.2	−0.35 + 0.36	3.5	5.71
Spain	2.74	0.55 + 0.38	3.73	7.4
East Asia 1960–2003				
Korea	3.64	1.75 + 0.70	1.28	7.37
Singapore	4.03	2.18 + 0.46	1.2	7.87
Taiwan	3.97	1.74 + 0.54	2.16	8.41
Ireland				
1990–2003	1.7	2.24 + 0.26	2.24	6.44
USSR				
1928–1940	3.2	2.1	0.5	5.8
1940–1950	0.1	0.5	1.6	2.2
1950–1970	3.1	0.9	1.4	5.4
1970–1985	2.4	0.8	−0.4	2.8

(*Continued*)

Table 6.16 (*Continued*)

China				
1978–1993	3	1.6 + 0.4	3.9	8.9
1993–2004	4.1	0.8 + 0.3	4.5	9.7
India				
1978–1993	1.5	1.4 + 0.3	1.3	4.5
1993–2004	2.3	1.2 + 0.4	2.6	6.5

Notes: Ireland and USSR are GNP not GDP. Education is included in TFP growth for USSR.
Sources: Bosworth and Collins (2003, and web update); for USSR derived from Ofer (1987); and for China and India derived from Bosworth and Collins (2008), in each case assuming $\alpha = 0.35$.

technological knowledge, and increases in European technological competence based on increased investments in human capital and R & D. Overall though, this is clearly a case where TFP growth involved much more than technological progress.

The East Asian Miracle was quite different. Table 6.16 shows that TFP growth contributed relatively less, and capital deepening more, than in Golden Age Europe. Rapid growth of the capital stock was underpinned by increasingly high investment rates which reached around 35% of GDP in Korea and Singapore, around 10 percentage points higher than the average in 1960s Europe. East Asian growth was also notable for a very strong growth of labor inputs, underpinned by a "bonus" from the age structure effects of the demographic transition which (unlike in Western Europe) coincided with the growth spurt. Although East Asian countries were successful in importing technology, overall the developmental states of the region were better at mobilizing factor inputs than at achieving outstanding TFP growth (Young, 1995; Crafts, 1999).[23]

The Celtic Tiger was a very different animal from its Asian counterpart and contrasts quite strongly with Golden Age European growth (Crafts, 2009). Ireland's labor productivity growth was a good deal lower, mainly because of a small capital deepening component in an economy where investment was about 20% of GDP. TFP growth was strong but relied on ICT production which accounted for nearly two thirds of TFP growth during the 1990s (van Ark et al. 2003). In turn, this was based on Ireland's exceptional ability to attract FDI, especially from the United States: domestic R & D was only about 1.4% of GNP. Apart from ICT production, as Table 6.16 reports, the other outstanding feature of the Celtic Tiger was employment growth which far outstripped population growth. As unemployment fell, female participation rose, and emigration turned into immigration. Irish growth thus benefited from a very elastic labor supply (Barry, 2002).

The striking feature of catch-up growth in the Soviet Union is that, if standard growth accounting assumptions are adopted, it relied much more on "extensive growth." While

[23] Rodrik (1997) argues that TFP growth may be underestimated by standard techniques because σ was less than 1, given biased technical change and strong capital deepening. It is unclear how big this effect may have been.

the capital deepening contribution to growth in the Golden Age was similar to that in Western Europe, or a bit lower, TFP growth was decidedly inferior. Its contribution was very weak compared with countries like Italy with similar catch-up potential.[24] The problem with the Soviet growth model is that it ran into a rapidly rising marginal capital to output ratio, implying that the rate of capital stock growth delivered by a constant investment/GDP ratio fell steadily over time. The problem became acute when TFP growth ceased in the 1970s and further increases in the investment rate (which had doubled between 1950 and 1970 to 30%) became infeasible given the commitment to high defense spending.

Finally, we consider the "growth miracles" in two of the BRICs with rather different growth trajectories. China has experienced very rapid growth of real GDP per person since reforms began at the end of the 1970s. This has been based on impressive contributions from both capital deepening and TFP growth. The former has resulted from investment rates which are massive by historical standards, reaching well over 40% of GDP by the early 2000s. The latter has two components, technology transfer linked closely to FDI (Whalley and Xin, 2010), and increases in efficiency starting from the very low base of the Maoist economy. Here, de-collectivization of agriculture which led to a surge in TFP in the 1980s (McMillan et al. 1989) played a big part, initially. The rapid reduction in the state-owned enterprise share of GDP has also been a key component, and it is TFP growth in industry which has been most impressive. India experienced a productivity surge after the disappointing period of the so-called Hindu growth rate (Rodrik and Subramanian, 2005). Even so, capital deepening and investment rates have been well below those in China. So has TFP growth, although this strengthened appreciably after the Indian reforms of the early 1990s. The detailed comparisons in Bosworth and Collins (2008) show that TFP growth in the industrial sector in India has been very disappointing (averaging 0.6% per annum from 1978–2004 compared with 4.3% in China), while TFP growth in services has been strong—in 1993–2004 averaging 3.9% per annum compared with 0.9% in China.

6.5. GROWTH IN THE LEADER: THE UNITED STATES

The United States overtook Britain at the start of the 20th century in terms of real GDP per person and maintained its leading position throughout the "American century." By mid-century, the United States had become the clear technological leader

24 It has been suggested that this may be an artifact of the methodology and that the USSR is better described in terms of a production function with a very low elasticity of substitution between capital and labor and thus severely diminishing returns to capital (Weitzman, 1970). Allen (2003) provides a convincing rebuttal of this claim, noting that the technological possibilities were similar in West and East and that there is clear evidence of massive waste of capital in the Soviet system, which implies that standard benchmarking is appropriate.

and had developed a very different "national innovation system" from that which had prevailed in 1900. Although other OECD countries, notably Japan, reduced the gap from the 1960s to the 1980s, the United States reasserted its leadership in the context of the ICT revolution. This section examines the foundations of this exceptional performance and considers American technological prowess using an endogenous innovation lens.

6.5.1 Technological Leadership

During the 20th century, the United States was in the forefront of the development of the most important new technologies, including: the internal combustion engine, electricity, petrochemicals, aviation, and ICT. In this era, technological progress increasingly became the result of systematic research and development based on formal science and engineering, and was associated much more with corporate research laboratories and public investment than with independent invention.

That said, there is a clear difference between the pre- and post-World War II eras (Mowery and Rosenberg, 2000). In the former period, the United States developed a formidable record in the commercial development of technologies which had typically originated from Europe. Already, by the interwar period, revealed comparative advantage in American exports was strongly correlated with research intensity (Crafts, 1989). In the latter period, United States' science and invention played a much bigger role as American universities became world leaders in academic research and federal funding for research soared in the context of the Cold War. These points are epitomized by the automobile, where the American contribution was the development of mass production, and the computer, where the transistor and integrated circuit were American inventions. Federal funding accounted for less than 20% of R & D in the 1930s but well over half on average from the 1950s through the 1970s. Germany had 41 (44) Nobel Prize winners prior to 1950 (1950 to present) compared with 27 (229) for the United States (excluding Economics and Peace).

American industrial research was built up during the first half of the 20th century by corporate investment in laboratories. Although independent inventors still accounted for 50% of patents in the late 1920s, down from about 80% at the start of the century, their share had fallen to only 25% by the 1950s (Nicholas, 2010). About three-quarters of industry-funded R & D was performed by firms with more than 10,000 employees in the early 1980s, when defense-related expenditure still accounted for about a quarter of all R & D. This picture had changed quite significantly by 2001 when the large firms' share had fallen to just over a half, the defense-related share was below 15%, and R & D was increasingly outsourced to specialist, smaller firms resembling—to some extent—an early 20th century landscape rather than the classic post-war American national innovation system (Mowery, 2009).

The transition to an economy with substantial investments in R & D and higher education is reflected in Table 6.17. This was clearly a very different technological leader than

Table 6.17 The knowledge economy in the United States

	R & D expenditure/ GDP (%)		R & D stock/ GDP (%)		Tertiary education/ person (years)
1920	0.2	1900–1910	0.03	1913	0.200
1935	1.8	1929	4.5		
1953	1.4	1948	13.0	1950	0.420
1964	2.9	1973	38.2	1970	0.674
1990	2.7	1990	47.7	1995	1.474
2007	2.7			2005	1.682

Sources: R & D expenditure: Edgerton and Horrocks (1994), Nelson and Wright (1992), and National Science Board (2012) R & D stock: Abramovitz and David (2001) Tertiary education: Barro and Lee (2012) and Maddison (1987).

Table 6.18 Productivity growth arising from US research, 1980s (percent of total in each country)

France	42
Germany	42
Japan	36
UK	33
USA	60

Source: Eaton and Kortum (1999, p. 558).

Industrial Revolution Britain. The size of these investments also marks the United States out from the rest of the OECD, especially in the third quarter of the century. Not only was R & D spending relative to GDP higher than anywhere else, but its absolute size loomed very large: as late as 1969, US R & D expenditure was more than twice the combined total of France, Germany, Japan, and the UK (Nelson and Wright, 1992). Similarly, the educational attainment of the American population far outstripped OECD rivals. In 1970, the next highest country (Denmark) had only about half the American tertiary education years per person. The dominant role of American (relative to all other countries') R & D as a source of productivity growth across the OECD is clearly shown in Table 6.18.

6.5.2 Explaining Technological Progress

There is a rich analytical narrative literature on the underpinnings of 20th century American technological progress, seeking to explain both its strength and its factor-saving bias. It is generally agreed that the geography of the United States in terms of the scale of the domestic market, the distances between major population centers, and the natural resource endowment, was an important influence, especially in the early part of the century. These features of American geography are seen as favorable to key

Table 6.19 Resource abundance

(a) US share of world totals (%)

	1913 output	1989 reserves	1989 + cumulative 1913–1989 production
Petroleum	65	3.0	19.8
Copper	56	16.4	19.9
Phosphate	43	9.8	36.3
Coal	39	23.0	23.3
Bauxite	37	0.2	0.5
Zinc	37	13.9	14.0
Iron Ore	36	10.5	11.6
Lead	34	15.7	18.1
Gold	20	11.5	8.6
Silver	30	11.7	16.3

Source: David and Wright (1997).

(b) Ratio of labor cost/hour to electricity cost/hour

	United Kingdom	United States
1909		8.8
1919		31.8
1929	14.8	44.6
1938	20.3	57.0
1950	35.6	157.5

Source: Melman (1956).

technological clusters such as those based on the internal combustion engine and the chemical industry (Mowery and Rosenberg, 2000). The rise of mass production in the later railroad era can be seen as "the confluence of two technological streams: the ongoing advance of mechanical and metal-working skills ... focused on high-volume production of standardized commodities"; and the exploration and utilization of the mineral resource base (Nelson and Wright, 1992, p. 1938). Table 6.19 reports the concentration of world minerals output in the United States in 1913. It also implies that the country had been very efficient in discovering and developing minerals relatively early on. A relatively low price of electricity (Table 6.19) was conducive to the electrification of factories, which led to a surge in manufacturing productivity growth in the 1920s (David and Wright, 1999).

Over time, these influences became somewhat less important and the accumulation of human capital mattered more. The United States led the way in the expansion both of secondary and tertiary education. High school enrollment among 14–17 year olds rose from 10.6% in 1900 to 51.1% in 1930 and 86.9% in 1960, a time when only 17.5% of British 15–18 year olds were enrolled (Goldin and Katz, 2008). While about 5% of Americans born in 1880 went to college, nearly 60% of the cohort born in the 1960s did so. Throughout the third quarter of the century, average years of college education in the American adult population were a long way ahead of leading European countries (Barro and Lee, 2012). Even so, the rate of return to a year of college education in 1990 was only slightly below what it had been in 1915. This is symptomatic of the change in factor-using bias, from tangible-capital to intangible-capital using, between the 19th and the 20th centuries that Abramovitz and David (2001) detected.[25] Notable also, is that American leadership in electronics technology after World War II owed a great deal to the abundance of scientific and engineering human capital and federal research funding, rather than to the natural resource endowment.

Before World War II, relatively rapid American technological progress primarily reflected the capabilities of firms and thus the incentive structures that they faced. Endogenous innovation models point to several features of the American economy which were more favorable than in Europe at the time, and much more favorable than in Industrial Revolution Britain. These include a better system of intellectual property rights (Nicholas, 2010), a stricter anti-trust policy (Mowery and Rosenberg, 2000), a larger market potential (Liu and Meissner, 2013), and a significant fall in the costs of research as experimental science improved and the supply of specialized human capital expanded rapidly (Abramovitz and David, 2001).

This may be sufficient to explain the acceleration in technological progress but there is more to be said in terms of its direction. The experience of the American economy during the 20th century has been described as a "race" between education and technology (Goldin and Katz, 2008). Goldin and Katz highlight the development of a complementarity between advances in technology and the use of human capital that is visible from the early 20th century. The outcome of the race between increased demand for human capital as technology evolved, and increasing supply as the education system expanded, is captured in the behavior of the college wage premium (Table 6.20). Over the long-run the outcome was a photo-finish, but relative demand grew more strongly after 1960 and eventually outstripped supply after 1980.

The "directed technical change" model proposed by Acemoglu (2002) might be a suitable framework within which to analyze these trends. The key element of this model is its incorporation of a market size effect, as well as a relative price effect in the incentives that inform innovative effort. If the market size effect dominates, technological progress will be biased toward complementarity with a factor whose relative supply expands, rather than the opposite as would be expected on the basis of the ceteris paribus fall in its relative price. This induced innovation will in turn underpin the factor's rate of return through outward shifts in its demand curve.

[25] Abramovitz and David use a composite notion of intangible capital which includes both R & D and human capital; this is different from the definition in the recent growth accounting with intangibles literature reviewed in Section 6.4.

Table 6.20 Supply and demand for college educated workers and changes in the college wage premium, 1915–2005 (100 × annual log changes)

	Relative wage	Relative supply	Relative demand
1915–1940	−0.56	3.19	2.41
1940–1960	−0.51	2.63	1.92
1960–1980	−0.02	3.77	3.74
1980–2005	0.90	2.00	3.27
1915–2005	−0.02	2.87	2.83

Note: estimates assume the elasticity of substitution between college and high school graduates = 1.64.
Source: Goldin and Katz (2008).

6.5.3 Lessons from the ICT Revolution[26]

The Solow Productivity Paradox was announced in 1987 with the comment that "You can see the computer age everywhere except in the productivity statistics." A great deal of effort was subsequently devoted to explaining this (Triplett, 1999) and it was an important trigger for the literature on General Purpose Technologies. This developed models that had negligible or even negative impacts on productivity performance in their first phase but substantial positive effects later on. Indeed, a GPT can be defined as "a technology that initially has much scope for improvement and eventually comes to be widely used, to have many uses and to have many Hicksian and technological complementarities" (Lipsey et al. 1998, p. 43).

Table 6.21 compares ICT with the two other GPTs, electricity and steam, which are commonly placed in the pantheon on account of their impact on productivity growth in the leading economy of the time. The comparison reveals that the impact of ICT has been relatively big, and that it has come through very quickly. This new GPT is unprecedented in its rate of technological progress, reflected in the speed and magnitude of the price falls in ICT equipment reported in Table 6.21. The impact of ICT on the rate of productivity growth throughout 1973–2006 exceeded that of steam in any period and was already close to twice the maximum impact of steam by the late 1980s. Indeed, these estimates suggest that the cumulative impact of ICT on labor productivity by 2006 was about the same as that of steam over the whole 150-year period, 1760–1910.

A plausible inference seems to be that society is getting better at exploiting the opportunities presented by new GPTs. This may reflect a number of factors including more investment in human capital, superior scientific knowledge, improved capital markets, and greater support for R & D by public policy. Taking an historical perspective, the true paradox is that Solow's ICT paradox was regarded as such, given that by earlier standards the contribution of ICT to productivity performance in the American economy in the late 1980s was already stunning.

[26] This section draws in part on Crafts (2013a).

Table 6.21 GPTs: contributions to labor productivity growth (percent per annum)

Steam (UK)	
1760–1830	0.01
1830–1870	0.30
Electricity (USA)	
1899–1919	0.40
1919–1929	0.98
ICT (USA)	
1973–1995	0.74
1995–2006	1.45
Memorandum item: real price falls (%)	
Steam horsepower	
1760–1830	39.1
1830–1870	60.8
Electric motors (Sweden)	
1901–1925	38.5
ICT equipment	
1970–1989	80.6
1989–2007	77.5

Notes: Growth-accounting contributions include both capital deepening from use and TFP from production. Price fall for ICT equipment includes computer, software, and telecoms; the price of computers alone fell much faster (22.2% per year in the first period and 18.3% per year in the second period).
Sources: Growth accounting: Crafts (2002, 2004b) and Oliner et al. (2007). Price falls: Crafts (2004b), Edquist (2010), and Oulton (2012).

Table 6.22 Sources of labor productivity growth in the market sector, 1995–2005 (percent per annum)

	Labor quality	ICT K/hour worked	Non-ICT K/hour worked	TFP	Labor productivity growth
EU	0.2	0.5	0.4	0.4	1.5
France	0.4	0.4	0.4	0.9	2.1
Germany	0.1	0.5	0.6	0.4	1.6
UK	0.5	0.9	0.4	0.8	2.6
USA	0.3	1.0	0.3	1.3	2.9

Source: Timmer et al. (2010).

A very noticeable feature of the ICT revolution is that the United States exploited the opportunities much better than did European countries, generally speaking (Oulton, 2012). Table 6.22 shows that the ICT capital deepening contribution in the United States was about twice that in the European Union between 1995 and 2005. Indeed, this episode saw an ending of the long period of productivity catch-up achieved by Western Europe since the early 1950s.

A lens through which to examine this experience is to think about varieties of capitalism (Hall and Soskice, 2001). The core of this approach is based on a comparison between two ideal types, the co-ordinated market economy (CME) and the liberal market economy (LME), which comprise different environments in which firms operate. The purest cases of the CME and the LME are Germany and the United States, respectively (Schneider and Paunescu, 2012). Each of these economies can be thought of as having a different set of complementary institutions and, as a corollary of this, different comparative advantages in production, trade, human capital formation, and crucially, innovation. The LME is characterized by extensive equity markets and flexible labor markets, while the CME offers high employment protection and corporate governance that is based on monitoring by banks and an absence of hostile takeovers. LMEs place more emphasis on university education and less on vocational training, and are also more lightly regulated in terms of the standard indices calculated by the OECD.

Hall and Soskice (2001, pp. 38–39) argued that CMEs would be relatively strong at "incremental innovation, marked by continuous but small-scale improvements to existing product lines and production processes," while LMEs would be more successful at "radical innovation, which entails substantial shifts in product lines, the development of entirely new goods, or major changes to the production process." Empirical testing of claims about radical and incremental innovation poses considerable problems, but Akkermans et al. (2009) developed an approach based on patent citations, basically taking radical innovations to be those which are more highly cited. They found that the United States is indeed strongly specialized in radical innovation.

With regard to ICT, CMEs and LMEs might also be expected to differ in their abilities to exploit its opportunities since investment in ICT capital is much more profitable and has a much bigger productivity payoff if it is accompanied by organizational change in working and management practices and is therefore encouraged by low adjustment costs (Brynjolfsson and Hitt, 2003). The empirical evidence is that the diffusion of ICT has been aided by complementary investments in intangible capital and high-quality human capital, but weakened by relatively strong regulation in terms of employment protection and regulations that restrict competition, especially in the distribution sector (Conway et al. 2006).

ICT is a technology that is very well suited both to management practices in American-owned companies (Bloom et al. 2012) and the economic environment in the United States. Perhaps the more general message is that, when a disruptive GPT appears, American institutions are at an advantage.

6.6. THE ECONOMIC HISTORIAN'S VIEW OF CATCH-UP

In Section 6.3 we saw that while some regions—notably Japan and the East Asian Tigers—caught up on the world technological frontier in spectacular fashion after 1945, others—notably Latin America and Africa—did not. The growth miracles of the 20th century, including not only the Japanese and Tiger experiences, but Western Europe during the Golden Age, China from the late 1970s onwards, or Ireland during the 1990s, were above all convergence miracles. Economic historians have known, since the work of Gerschenkron (1962) and even before, that backwardness can sometimes lead to rapid growth. The further behind the technological frontier a country is, the faster is its potential growth, since by importing the latest technologies and machinery it can improve its total factor productivity much more rapidly than an economy closer to the frontier. As Gerschenkron (1962, p. 8) put it, "Borrowed technology, so much and so rightly stressed by Veblen, was one of the primary factors assuring a high speed of development in a backward country entering the stage of industrialization." And indeed, industrialization, or the modernization of existing industries, was at the heart of the best-known 20th century growth miracles.

The problem is that while being economically backward implied a potential for rapid catch-up growth, it also implied obstacles to realizing that growth—since otherwise the country or region concerned would not have been backward in the first place. Economic historians have thus also always stressed that there is nothing inevitable or automatic about catch-up. This section will present some general insights from economic history relating to the question of whether countries are able to exploit catch-up opportunities or not. Sections 6.7–6.9 will then go on to apply these insights to well-known episodes of success followed by disappointment, success up to now, and failure, respectively.

6.6.1 Catch-Up is Not Automatic

The logic that backward countries should be able to grow more rapidly than the rich, by importing best-practice technologies, is powerful, but we know that in practice poor countries do not always grow more rapidly than the rich. If they did, then we would not regard those instances where convergence has most visibly been at work as growth miracles. We have seen that some groups of countries have managed to converge on the US technological frontier, while others have not. We have also seen that convergence was widespread in some periods, particularly the 1950–1973 Golden Age, while in other periods there was little or no convergence. Indeed in some periods divergence was more the rule, for example, during the late 19th century when the United States pulled further ahead of most of the rest of the world. Looking at variations in growth among those countries chasing the United States frontier, there have been contrasting experiences of convergence and divergence, depending on the groups of countries and time periods being considered. Absolute convergence characterized the rich economies as a group in the four decades since World War II, but there was no worldwide tendency during these years for poorer countries to grow more rapidly than the rich (Abramovitz, 1986; De Long, 1988; Barro, 1991).

Why does convergence happen sometimes but not always, and in some countries but not others? And why does it sometimes cease altogether, after promising beginnings? The logic of convergence suggests that it should be self-limiting: as countries catch up on the technological frontier, the scope for further catching up diminishes. As workers leave low-productivity agriculture for high-productivity service and manufacturing jobs, the pool of workers who can be similarly redeployed diminishes. One would thus expect converging economies to continue catching up on the lead economy, but at a diminishing rate over time, as in Lucas (2000, 2009). Yet, Western European convergence ceased after the first oil crisis, at a relative GDP level of only 70%, while in the former Soviet empire, and Southwest Asia, convergence not only halted at the same time, but was replaced by two decades or more of sharp divergence. Japan's convergence was also succeeded by divergence, beginning in the 1990s. More generally, there is evidence that countries often experience growth slowdowns after phases of rapid growth that are much sharper than would be expected on the basis of convergence logic alone. Eichengreen et al. (2012) found that the probability of such rapid slowdowns peaks at per capita GDP levels of about $17,000 in 2005 international prices, and that the probability is higher after periods of rapid economic growth.

Many economic historians have written about why convergence may not take place, the advantages of backwardness notwithstanding. Gerschenkron (1962, p. 8), whose major focus was Europe, argued that the major obstacles were "formidable institutional obstacles (such as the serfdom of the peasantry or the far-reaching absence of political unification," as well as (in some countries) a lack of natural resources. True, backward countries also lacked the prerequisites for growth that had been built up in Britain over the course of many decades and even centuries, but for Gerschenkron this handicap could be surmounted by means of institutional substitutes such as universal banks or a developmental state.

Gerschenkron was writing in the early 1960s, at a time when the Soviet Union and its allies were still converging rapidly on the United States, and decolonization with its ensuing policy experimentation was still in its infancy. By the 1980s, greater scepticism regarding the ability of backward states to engineer convergence seemed in order. Abramovitz (1986, pp. 387, 390, 393, 397) lists several reasons why convergence may not take place. Countries may lack the "social capability" required to realize their catch-up potential; the global economy may not be operating in a way that facilitates technological transfer; there may be obstacles to structural change within the backward economies; short-run macroeconomic policies may not encourage investment, with long-run consequences; best-practice technologies may not be appropriate for developing economies' size or factor endowments; and major shocks such as war may disrupt the convergence process. We briefly review each of these arguments in subsequent sections.

6.6.2 The Consequences of Directed Technological Change

Technological change is not exogenous, but an endogenous response to economic conditions. This can make it difficult for countries to catch up on the technological frontier, irrespective of whatever institutions they may have or which policies they adopt. Frontier technologies may have been invented with conditions in the leading economy in mind, and may therefore not be easy or profitable to adopt in poorer countries.

This possibility has been raised by growth economists such as Basu and Weil (1998), and Acemoglu and Zilibotti (2001), in debates about appropriate technology, but it is also a long-standing theme of economic historians. The argument that technologies are invented so as to take advantage of local factor endowments is most often associated with Habakkuk (1962), who as we have seen, argued that it was high American wages, due to an extensive land endowment, that explained the relatively labor-saving nature of US mass production technology. The evidence suggests that since the late 19th century, improvements in the production function have been concentrated at the capital to labor ratios at which rich countries operate. For example, there was a big increase in output per worker at capital to labor ratios between \$15,000 and \$20,000 (1985 prices) between 1939 and 1965, but no further improvement in recent decades. Indeed, at very low capital to labor ratios, output per worker in 1990 appears to have been no higher than in 1820 (Allen, 2012). This is symptomatic of a pattern of directed technical change where advances are made in accordance with the incentives provided by market conditions in rich countries, especially the United States.

The possibility then arises that relative factor prices in less developed economies made the new technologies unprofitable. Gerschenkron (1962, pp. 8–9) raised the issue, noting that "The industrialization prospects of an underdeveloped country are frequently . . . judged aversely, in terms of cheapness of labor as against capital goods and of the resultant difficulty in substituting scarce capital for abundant labor." He also noted that this argument flies in the face of the opposite argument that low wages give developing countries a powerful competitive advantage. But he went on to dismiss the argument in the context of 19th century Europe, on the grounds that "a stable, reliable and disciplined" labor force was scarce, rather than abundant, in backward economies where people were still close to the land. Indeed, he claimed that this fact gave entrepreneurs in countries like Russia an incentive to import technologies that were as modern, efficient, and labor-saving as possible.

In contrast, as we have seen, Allen (2009) argued that it was rational for other countries to not immediately adopt the new technologies of the British Industrial Revolution, implying that Britain initially forged ahead while others fell behind. It was only with time, as the new technologies became more productive, that they became profitable to adopt elsewhere. By the late 19th century, however, Britain was no longer the leading innovator, and the question was whether American inventions were suitable for British conditions or not. British entrepreneurs have often been criticized for failing to adopt the latest technologies—for example, cotton manufacturers were slow to adopt ring spinning, preferring to stick with mule spinning, while soda manufacturers were slow to abandon the Leblanc process for the superior Solvay process. Magee (2004) surveys an abundant literature that argues that British entrepreneurs were in fact responding rationally, not only to British relative factor prices (skilled workmen were cheaper than in America, and natural resources were dearer), but also to different (and in particular less homogenous) demand conditions. If Lancashire cotton manufacturers used mules, this was because they produced more fine yarns, and more yarn for export, than their American counterparts, and mule spinning was superior on both counts (Leunig, 2001). More generally, fragmented demand and skilled labor made it rational for British manufacturers to eschew resource-intensive and labor-saving mass production techniques, and adopt "a more flexible form of production, based on general purpose machinery, skilled labor and customized demand" (Magee, 2004, p. 95). Similar considerations can explain why British firms did not adopt Chandlerian organizational forms during the same period (Harley, 1991).

We will consider the British case in more detail below, merely noting that if frontier technologies do not correspond to the needs of developing countries, then those countries may fall further behind the leaders for perfectly rational reasons, with no "failure" being necessarily involved. What might reverse such a trend? Educational policies are one obvious candidate. Another is late 20th century globalization, which Wright (1990) argues was a major turning point, in that it transformed mineral resources from being endowments to commodities, available to all countries at roughly equal prices. The implication is that resource-intensive American technologies now became potentially easier to implement around the world. Similarly, the opening of the rest of the OECD to international trade meant that American mass production techniques could more easily be adopted elsewhere, and the process of convergence itself strengthened this tendency by further increasing the size of overseas markets. Finally, postwar US technological strength in sectors like semiconductors were based on the expansion of scientific education and research; and research and development, which could be replicated abroad, especially given the inherently international nature of scientific activity (Nelson and Wright, 1992; Abramovitz and David, 1996). As Alice Amsden (1989, p. 7) put it, "Although technology remained … idiosyncratic even in basic industries, higher scientific content increased its codifiedness or explicitness, making it more of a commodity and hence more technically and commercially accessible and diffusible from country to country." Multinational corporations made technology even more diffusible. For all these reasons, US frontier technologies could now in principle be more easily implemented abroad, at least in the relatively advanced economies of Europe and Japan, than had been the case before. The extent to which they were actually implemented presumably depended on a variety of other factors, some of which will be considered below.

6.6.3 Catch-Up and Social Capability

According to Abramovitz (1986), tenacious social characteristics could inhibit countries from importing best-practice technology, and one would therefore only expect poorer countries to grow more rapidly than richer ones if these social characteristics, which he termed "social capability," were roughly similar. Rapid growth was thus most likely when countries were "technologically backward but socially advanced" (p. 388). Abramovitz (1989, pp. 200–201) considered both these conditions to have been present in Europe and Japan after World War II. Both regions had generally well-educated populations, and were well endowed with scientists and engineers, who were increasingly influential within industry. This helped in implementing new technologies invented abroad. Both firms and governments promoted research and development. Large corporations were becoming increasingly well managed. The resumption of international trade, air travel, the press, and American cooperation facilitated the importation of technical knowledge. Such attributes of backwardness as a large agricultural population could be turned into an advantage, since agricultural productivity growth facilitated the release of labor to new and growing sectors of the economy. Other aspects of social capability included openness to change and competition, which were necessary as rapid structural change was part and parcel of the catch-up process. Abramovitz cites Olson's (1982) view that the war itself, by sweeping aside existing vested interests, helped create a *tabula rasa* that facilitated such change.

Social capability can be thought of as being equivalent to the parameter μ_m in Schumpeterian growth theory (Aghion and Howitt, 2006). This refers to the extent to which countries' growth rates are boosted by virtue of their distance from the technological frontier. Abramovitz largely discusses education when referring to social capability, but he also mentions institutions, and these have been a major focus of economic historians seeking to understand different countries' growth experiences. A standard list of institutions that might matter for growth includes "the security of property rights, prevalence of corruption, structures of the financial sector, investment in public infrastructure and social capital, and the inclination to work hard or be entrepreneurial" (Sokoloff and Engerman, 2000, p. 218). The degree and nature of unionization; attitudes toward cartels and competition; social welfare and taxation systems; and the general nature of government involvement in the economy, could also be added to this list. What matters from the perspective of convergence is the incentive structures shaped by policy and institutions which influence the diffusion and assimilation of new technology in follower countries by, for example, determining the expected profitability of innovation, or by mitigating or exacerbating agency problems in the firms which have to invest in the new technologies. Economic historians emphasize that we do not inhabit a "one-size-fits-all" world, and that optimal institutional design may therefore vary according to the degree of backwardness, the technological era, etc.[27]

[27] This is a key point made in Aghion and Howitt (2006).

Gerschenkron believed that the institutional mix could adapt to meet the needs of the backward country seeking to catch-up. Where capital markets were not as well functioning as in the mature British economy, and where entrepreneurship was scarce, universal banks mobilizing large amounts of saving and providing not only capital but also entrepreneurial guidance for heavy industries, could fill the void. Where the economy was so backward that this was not an option, as in Russia, the state could step in instead. Gerschenkron believed that in the boom years immediately prior to World War I, universal banks played a more important role in Russia than they had done during the boom of the 1890s, reflecting the fact that Russia was no longer as backward as she had been a quarter of a century earlier.[28] If institutions can adapt in this manner, then although they may be crucial for economic performance, they are also endogenous; and endogenous variables do not make convincing explanatory variables. The view that historical institutions were efficient solutions to economic problems characterized much early cliometric work on the subject, including that of Douglass North (e.g. North and Thomas, 1973). However, institutions can arise for other reasons as well: for example, they could be the result of accident, followed by path dependence; or of cultural belief systems; or of distributional conflicts (Ogilvie, 2007). A frequent theme in modern economic history is that particular institutions may have originated as efficient solutions to context-specific problems, but that they can also be politically hard to reform and subject to path dependence (North 1990). Thus, when the context changed, the institutions stayed the same, and turned from being a help to a hindrance. We will see examples of this kind of logic at work in the case studies below.

Of particular interest is the possibility that institutions which help countries catch-up on the technological frontier may no longer be appropriate once countries have converged. For example, Rosenstein-Rodan (1943) argued that intersectoral complementarities could mean that modern industrialization might only get going if it happened across a broad front. For Gerschenkron (1962, pp. 10–11) this was one explanation for why, in his view, the transition to industrialization tended to happen in a dramatic and even discontinuous fashion (a claim which subsequent quantitative research has however cast doubt on—see Sylla and Toniolo, 1991). Such "big push" arguments naturally suggest a potentially important coordinating role for the state (Murphy et al. 1989) in the early phases of industrialization, but it is far from clear that such state involvement would make sense when countries have reached the frontier, and the question is no longer how to import and implement existing technologies, but to develop new ones. More radically, Baldwin (forthcoming) argues that modern multinational-led globalization and what he refers to as the "second unbundling" has destroyed big push arguments for state-led

[28] Gerschenkron's account is controversial. Sylla (1991, pp. 52–53) reviews evidence which suggests that banks played a larger role in the 1890s industrialization than Gerschenkron had allowed, while Gregory (1991) argues strongly that state involvement was by no means as beneficial as Gerschenkron had believed it to be.

industrialization that were valid not so long ago: small developing countries can now begin to industrialize by colonizing individual niches in global supply chains. Of course, this argument relies on globalization being sustained in the future, which is something that can never be taken for granted (Findlay and O'Rourke, 2007).

Such arguments suggest that institutional reform may be needed as countries progress economically. Unfortunately, if institutions are path dependent then such reform may not always proceed as smoothly as Gerschenkron believed had been the case in pre-1914 Russia.

6.6.4 Geography

It is striking that income levels around the world are highly spatially correlated. Since these income levels are the result of long-standing historical processes, it is not surprising that there was a degree of regional clustering in the timing of the shift to modern industrialization. Signs of rapid industrialization can be found in Eastern Europe and Latin America from the 1870s onwards, and in parts of Asia by the end of the 19th century (Bénétrix et al. 2013). Why do we observe such geographical correlations in the data, and what do they imply for convergence?

One possibility is that countries with similar resource endowments tend to be located close to each other, and thus end up with similar growth experiences and incomes in the long run. This may be because geographical conditions and resource endowments matter directly for growth (Sachs and Warner, 1997), or because they matter indirectly via their impact on institutions (Easterly and Levine, 2003). Economic historians have long argued that institutions may respond to endowments: for example, Domar (1970) argued that forced labor systems such as serfdom and slavery were a predictable outcome in labor-scarce and land-abundant societies, since in the absence of such exploitation the return to owning land was zero, which was not in the interests of would-be aristocrats. Domar is cited by Engerman and Sokoloff (1997), who argue that institutional differences based on underlying differences in geography, rather than superior culture, were the main reason why the United States and Canada eventually became so much richer than other countries in the Americas.[29] Brazil and the Caribbean were ideally suited to producing crops such as sugar, and thus developed slave-based economies, societies, and political institutions, irrespective of what European powers colonized them. British, French, Dutch, Portuguese, and Scandinavian sugar colonies all developed highly unequal, slave-based societies, and remained highly unequal even after the suppression of slavery. Spanish American colonies developed by exploiting Native American workforces in both agriculture and mining, and were also highly unequal. The result was political institutions and economic policies designed to maintain elite privileges: restricted franchise, barriers

[29] Acemoglu et al. (2001) suggest an alternative mechanism through which geography may have influenced development via its impact on institutions. For a discussion, see Albouy (2012).

to European immigration, limited investment in education, conservative taxation systems, and expensive access to patent protection, to name but a few (Sokoloff and Engerman, 2000; Sokoloff and Zolt, 2007).

It is important not to romanticize the US or Canadian experiences, to ignore the treatment meted out to their own native American populations, or to forget that universal suffrage was only attained in the United States as late as the 1960s. This last fact is a shocking reminder of the corrosive effect of inequality and racial segregation on the quality of political institutions. But inequality was relatively low among US and Canadian whites, and because whites made up a relatively large share of those two countries' populations (since sugar was not an important crop even in the US, and since native Americans were so few in number by the 19th century), the net result was societies that were relatively egalitarian in the aggregate. This in turn encouraged not only inclusive institutions for whites, but directly stimulated economic growth by encouraging commercial activity and the development of mass marketing. Canada and the US also invested heavily in public education, funded out of local taxes on income and wealth, made the patent system cheaply accessible to a broad range of people, and promoted economic growth in a variety of other ways. Engerman and Sokoloff (1997) sketch a story in which a rapidly growing and relatively equal population boosted 19th century US growth, by promoting a Smithian process of division of labor and exploitation of scale economies, and by encouraging market-oriented innovation. This route to prosperity was barred to Latin American economies whose institutions perpetuated historical patterns of inequality.

Such arguments explain geographical correlations in GDP by pointing to geographical correlations in resource endowments. They would work even if each country were isolated from its neighbors. But it is also possible that geographical correlations in economic outcomes are shaped by interactions between countries located closer or further together. One possibility, emphasized by the new economic geography, is that market access matters for income levels and, in particular, for the location of industry across the world (Krugman and Venables, 1995). Redding and Venables (2004) find that GDP per capita is strongly related to market access and proximity to suppliers, and argue that this can retard convergence in per capita incomes and wages. Another possibility is that the diffusion of technology itself is a decreasing function of distance (Comin et al. 2013). Economic historians have increasingly been adopting such a geographical perspective in recent years (Crafts and Venables, 2003).

6.6.5 Events, Dear Boy

Easterly et al. (1993) show that shocks are as important as fundamentals in explaining countries' decadal growth performances. Nor can we ignore the impact of shocks over the longer run, as the disastrous performance of the interwar period shows.

Economic theorists such as Lucas (2009) understandably tend to construct models in which certain patterns—such as the gradual diffusion of economic growth across the globe—can be expected to apply in the absence of such non-economic forces as "wars, breakdowns of internal order, and misguided ventures into centralized economic planning" (p. 23).

Economic history, by contrast, focuses heavily on such events, for a number of reasons. First, while economic historians seek general explanations, like other economists, they also want to understand what happened in specific countries and at specific times, like other historians. For example, while the relative decline of the Caribbean may have been in part due to the institutional legacies mentioned above, it was also surely due to the British-led suppression of slavery and the development of beet sugar production in Europe. This tension between the specific and the general is one of the defining features of the field. Second, economic historians are trained to think in terms of path dependence (David, 1985), and sufficiently major crises can have very long-term effects, for example because of their impact on subsequent policy choices (Buera et al. 2011). Third, economic history is an inherently interdisciplinary subject: as Hicks (1969, p. 2) put it, "A major function of economic history ... is to be a forum where economists and political scientists, lawyers, sociologists, and historians—historians of events and of ideas and of technologies—can meet and talk to one another." As such, economic historians are more likely than other economists to try to understand the causes of non-economic shocks, and to integrate them into their analyses.

Although it is beyond the scope of a chapter such as this, it would be impossible to tell a convincing story of 20th century growth without describing the major shocks that defined the century, and tracing out their consequences. The two world wars, the Great Depression, decolonization, the oil shocks of the 1970s, and the Cold War and its ending, all had major effects on regional growth patterns during our period. This is evident from Figure 6.2, which shows major breaks in regional performance relative to the United States coinciding with the world wars, the onset of the Depression in 1929, and the first oil crisis of 1973.

World War I not only brought to an end the period of globalization that preceded it, but changed the economic and geopolitical landscape in ways that defined the rest of the 20th century. It led to the collapse of the German, Austro-Hungarian, and Russian empires, spawning a host of new nation states in Europe; it led to the Russian revolution of 1917, which had an enormous impact on the economies of not only the USSR, but (after 1945) of Eastern Europe and China as well; it permanently weakened the British economy, leaving the interwar world without a hegemon able and willing to provide global public goods (Kindleberger, 1973); it led to major imbalances in the structure of international trade, and to war debts and reparations, which would cast a dark shadow over the interwar period's flawed attempt to recreate a globalized world based on the gold standard. Most accounts of the Great Depression begin with these and other legacies of the conflict (Eichengreen, 1992), while the Depression and German post-war resentments combined to produce the election of Hitler, and ultimately the outbreak of World War II.

That conflict in turn cemented the relative decline of Europe, and paved the way for both the Soviet-US duopoly which lasted until the end of the 1980s, and decolonization throughout Asia and Africa. The historical association between globalization and European imperialism, the distrust of markets which naturally flowed from the disastrous experience of the interwar period, and the spread of communism, all predisposed the leaders of newly independent countries to pursue state-led growth policies, often based on import-substituting industrialization. Western Europe and North America developed a variety of more or less social democratic economies and societies, by and large (but by no means exclusively) using markets to generate wealth, and using the state to redistribute it, provide safety nets, and correct market failures. Elsewhere, the reaction against markets was far more severe. It was only reversed after the poor economic performance of the 1970s, which in turn had at least something to do with the oil shock which followed the Yom Kippur War of 1973—yet another event with important long-term consequences. The policy transition accelerated after the collapse of the Soviet Union, and is still ongoing. As historians, we would not want to bet that there will not be another policy reversal in the future, as a result of further unexpected shocks to the system.

The reason for dwelling on such major events and their consequences is to make the point that economic historians do not just focus on deep historical legacies and institutional path dependence. If these were all that mattered, then one would not expect to see more or less simultaneous reversals in both economic policy regimes and growth experiences across countries with very different histories and institutional legacies. The interwar growth experience was bad across all major regions of the world, while the Golden Age was good. This had a lot to do with the specific historical circumstances at work in both periods, and circumstances change. Change as well as continuity has always concerned historians, since both matter in the real world.

6.6.6 Openness and Other Economic Policies

Previous subsections have looked at some of the difficulties that countries can face in their attempts to join the convergence club—difficulties which may be difficult to overcome, since individual countries cannot easily change the appropriateness of foreign technology, or their geography, or the international geopolitical environment, or even (perhaps) their own institutions. However, countries can change their economic policies for better or worse. The question is whether such policy transitions can produce better growth performances, and if so, which policies are good for growth.

Most attention in the literature has focused on the impact of market-friendly economic policies in general, and trade policy in particular. A key reference is Sachs and Warner (1995), who produce an index of trade openness (subsequently updated in Wacziarg and Welch, 2008). Sachs and Warner used this index to study the impact of trade policy between 1970 and 1989. They found that openness was associated with higher growth, and that unconditional convergence characterized the experience of open economies but not of closed economies. Following discussion of the way in which this index was constructed (e.g. Rodríguez and Rodrik, 2001), several subsequent researchers (e.g. Buera et al. 2011) have preferred to interpret this index as indicating whether a country has adopted generally market-friendly policies or not.

This is how the index is used by Hausmann et al. (2005), who study the characteristics and determinants of growth accelerations from the 1950s to the 1990s. They find that while market-friendly economic reforms are a statistically significant predictor of sustained growth accelerations, they are not a quantitatively reliable predictor. Most pro-market reforms do not lead to such accelerations, and most accelerations are not preceded by such reforms. While their study finds that growth accelerations are difficult to predict, it also finds that they tend to have certain characteristics in common. In particular, growth accelerations are associated with higher investment rates, increases in trade, and real exchange rate depreciations. We will see examples of this below. We also note that the two growth accelerations that have mattered most for human welfare in recent decades—those in China and India—clearly seem to be related to market-friendly policy reforms.

There has been a vigorous debate about whether openness to trade is associated with faster growth or not, with Rodríguez and Rodrik (2001) among others strongly questioning the Sachs and Warner result. A recent contribution (Estevadeordal and Taylor, forthcoming) finds that lower tariffs on imported capital goods were associated with higher growth between 1975 and 2004, and it is probably fair to say that most economists assume that openness and growth go hand in hand today. Economic historians, however, tend to emphasize that the "right" policies may be context-specific, and may have varied over time. Clemens and Williamson (2004) find that tariffs were positively correlated with economic growth during the interwar period: perhaps the benefits to individual countries of maintaining open trade policies were lower in an environment where demand was depressed, and other countries had closed their own markets. Policies that were collectively costly may have been individually rational in such a context.

O'Rourke (2000) finds that tariffs and growth were positively correlated in the late 19th century as well, controlling for country fixed effects, in a sample of 10 relatively well-developed economies. A lack of aggregate demand was not a problem in this period, so unless the correlation is spurious we need another explanation. The growth-promoting externalities associated with industry would seem to offer one such explanation: as is well known, the United States industrialized behind very high tariff barriers during this period, and Germany and other continental European countries similarly protected their heavy industry. The fact that it was industrial tariffs that were associated with high growth, rather than agricultural tariffs, adds weight to this interpretation (Lehmann and O'Rourke, 2011). But even if the argument is correct, it does not follow that such policies would have worked in even less developed countries at the same time, or in the same countries in later periods. There is thus an important potential role for country histories in elucidating the impact of economic policies on growth, since panel growth regressions which estimate effects that are consistent across countries or over time may be seriously misleading.

6.7. CASE STUDIES I: INITIAL SUCCESS, SUBSEQUENT DISAPPOINTMENT

In the following three sections we explore several case studies that illustrate some of the themes of this chapter in slightly greater depth. We begin by looking at two cases where initial growth successes were succeeded by disappointment. The first is Western Europe, which converged strongly on the US during the Golden Age. Since the 1970s, however, convergence in GDP per capita has come to a halt. The second is the United Kingdom, which pioneered the transition to modern economic growth, but whose 20th century performance was much more disappointing, especially during the Golden Age.

6.7.1 The European Golden Age and the Subsequent Slowdown[30]

We have seen that Western Europe achieved its highest ever growth rates, roughly 4% per annum, during the Golden Age which lasted from 1950 to 1973. The period between the Second World War and the first oil crisis has subsequently passed into folk memory as the *Trente Glorieuses* (glorious thirty) or the *Wirtschaftswunder* (economic miracle). Eastern Europe and the former USSR also grew rapidly, although somewhat less so than Western Europe, when in a convergence perspective they should have grown more quickly. Relative to other miracles, for example in East Asia, a relatively large share of Western Europe's growth was due to TFP improvements, suggesting a large role for technological catch-up and structural change (Crafts and Toniolo, 2008). What explains the European growth miracle and the subsequent slowdown?

Western Europe's per capita GDP stood at just 31% of the American level in 1945. Austria's GDP had regressed to its 1886 level, France's to its 1891 level, and Germany's to its 1908 level (Crafts and Toniolo, 1996, p. 4). Rapid growth as a result of post-war reconstruction is hardly surprising. However, pre-war levels of GDP were restored by 1951 at the latest. Strikingly, in that year, Western Europe's relative GDP stood at only 47%.

The potential for catch-up growth seems obvious, and it seems even more obvious when a number of supplementary factors are taken into account. First, American technology and European conditions were more technologically congruent than they had been in earlier decades, as natural resources and larger markets became more easily available to European firms (Abramovitz and David, 1996). European economic integration would make both even more easily available as the 1950s progressed. Second, Western Europe possessed a high level of social capability: a generally well-educated population, and a history of well-functioning political and market institutions. According to Abramovitz

30 This section draws in part on Crafts (2013a).

and David the war further strengthened Western Europe's social capability, by sweeping aside lingering *Ancien Régime* attitudes toward such things as mass education, mass production, industry, and economic growth. Finally, the disastrous experience of Depression and war gave a powerful impetus to European integration, and thus to the reversal of the protectionist policies of the interwar period.

High levels of social capability in an economically backward society—impoverished sophistication, in Sandberg's (1979) memorable phrase—should be optimal for achieving economic growth, especially if that society is engaged in a process of economically integrating disparate national economies into a continental common market. A further factor emphasized by many economic historians (Kindleberger, 1967; Broadberry, 1997; Temin, 2002) is the large agricultural workforces in most European countries that could be redeployed to higher productivity non-agricultural occupations. Such structural change accounted for a large share of Golden Age labor productivity growth (Crafts and Toniolo, 2008). And so the European growth miracle can be comparatively easily explained in terms of the convergence framework outlined earlier—which is hardly surprising, since it was this European experience that largely gave rise to the convergence paradigm in the first place. Not only did Western Europe as a whole grow more rapidly than the United States, but there was strong unconditional income convergence within Western Europe as well. And yet there is more to be said about this episode, for at least two reasons. First, economic growth in some countries was a lot faster than would be expected on the basis of post-war reconstruction and convergence alone (Crafts, 1992a, Table 6, p. 401). Second, some countries did a lot better during the Golden Age than others, even once their initial incomes have been taken into account.

Eichengreen (1996) shows that growth was positively correlated across Western European countries with both investment and export growth, consistent with Hausmann et al. (2005). According to Eichengreen, who further develops his argument in Eichengreen (2007), high levels of investment and trade were sustained by a variety of domestic and international institutions. Domestic institutions, which can be collectively described as corporatist, ensured that workers moderated their wage demands so that profits were high, and as a quid pro quo ensured that profits were reinvested rather than being paid out as dividends, thus ensuring higher wage growth in the future. Worker representation on firm's boards helped ensure that employers did not defect from this mutually beneficial equilibrium; centralized wage bargaining overseen by government, which had both sticks and carrots at its disposal, ensured that workers did not defect. The welfare state was one way in which workers were compensated for wage moderation in the short run. The result was high investment, capital deepening, high rates of TFP growth, and an economic miracle.

The international institutions that mattered were those associated with European integration: the European Payments Union; the European Coal and Steel Community, the European Economic Community; and EFTA. These facilitated the resumption of multilateral trade in Europe, which was necessary both for standard efficiency reasons, and so that firms could be ensured of foreign markets when making their investment decisions. European international integration was one of the demands of the US government, which used Marshall Aid as a lever to obtain this and other market-friendly structural reforms (DeLong and Eichengreen, 1993). Crafts and Toniolo (2008) portray the Golden Age as a period in which there was scope for growth simply by undoing the policy mistakes of the interwar period.

If Eichengreen is right, then investment, trade, and growth should have been higher in countries which adopted appropriate domestic institutions, and liberalized their trade earlier. Ireland is one example of a country which only liberalized its trade in the late 1950s and early 1960s, and which, like the UK, had a more fragmented and less corporatist trade union structure. Both countries performed relatively disappointingly during the Golden Age. On the other hand, Belgium, West Germany, the Netherlands, and Scandinavia all had relatively corporatist systems of industrial relations, and liberalized their trade policy relatively early. The Eichengreen argument is thus a priori plausible, although econometric testing of the hypothesis is difficult (Crafts, 1992b).

What explains the post-1973 growth slowdown? The arguments outlined above suggest that to a large extent this was inevitable, as Europe caught up to the technological frontier, and the pool of agricultural workers who could be redeployed gradually vanished. While this is surely a large part of the story, it is not the whole story, for several reasons (Crafts and Toniolo, 2008). First, while GDP per capita convergence on the US ceased in the 1970s, labor productivity convergence continued until some point in the 1990s. The difference is due to diverging trends in hours worked in the two continents: how to interpret this remains unclear (Blanchard, 2004; Prescott, 2004; Alesina et al. 2006). Second, the distributional conflicts associated with the oil crises of the 1970s may have undermined the viability of the cooperative political institutions which Eichengreen believed had promoted growth during the Golden Age. Third, even if these institutions had remained as viable as they had been before, it is unclear that they were well adapted to a new era in which growth based on importing best-practice technology from abroad was no longer as easy as it had been when Europe had been more backward (Eichengreen, 2007; Aghion and Howitt, 2006). Rather than mobilizing large amounts of capital to mass produce well-understood technologies that had been developed elsewhere, the problem was now how to innovate: the argument is that this required more competitive product markets, different methods of finance, and alternative training systems.

The growth rate of real GDP per hour worked increased in the United States between 1973–1995 and 1995–2007 from 1.28% per year to 2.05% per year. In contrast, in the EU15 it fell from 2.69% per year to 1.17% per year. The rate of labor productivity growth fell in most European countries: in Italy and Spain it was below 1% per year after 1995. By contrast, Sweden saw a productivity revival while for part of the period Ireland continued to be a Celtic Tiger, and both countries exceeded the American productivity growth rate.

So while there was falling behind in productivity performance on average, there was also considerable diversity in European performance.

The acceleration in American productivity growth was underpinned by ICT. As we have seen, historical comparisons reveal that the impact of ICT has been relatively large and that it has come through very quickly. The main impact of ICT on economic growth comes through its diffusion as a new form of capital equipment rather than through TFP growth in the production of ICT equipment. This is because users get the benefit of technological progress through lower prices, and as prices fall more of this type of capital is installed.[31] The implication is that ICT has offered Europe a great opportunity to increase its productivity growth. However, as we saw in Table 6.22, European countries have been less successful than the United States in seizing this opportunity.

The empirical evidence is that the diffusion of ICT has been aided by complementary investments in intangible capital and high-quality human capital, but weakened by relatively strong regulation in terms of employment protection and restrictions to competition, especially in the distribution sector (Conway et al. 2006). Since these forms of regulation have weakened over time, the story is not that European regulation has become more stringent, but rather that existing regulation became more costly in the context of a new technological era. Of course, European countries have varied considerably in these respects; for example, the UK and Sweden have been better placed than Italy and Spain.

The example of ICT prompts some more general comments on European supply-side policies in the decades before the crisis. In some respects, these provided conditions more favorable to growth. European countries became more open to trade, with positive effects on productivity, partly as a result of the European single market. Years of schooling were steadily increased and product market regulation inhibiting competition was reduced. Corporate tax rates have fallen since the early 1980s. Nevertheless, supply-side policies are in need of further reform if the issue of disappointing growth performance is to be adequately addressed and catch-up resumed. Aghion and Howitt (2006) stress that as countries get closer to the frontier it becomes more important to have high-quality education and strong competition in product markets. These are areas where European countries generally have room for significant improvement.

There have been serious question marks about the quality of schooling in many European countries, which recent research suggests exacts a growth penalty. A measure of cognitive skills, based on test scores, correlates strongly with growth performance (Hanushek and Wössmann, 2012) and it is striking that even the top European countries such as Finland have fallen behind Japan and South Korea, with some countries such as Germany and, especially, Italy deteriorating. These authors estimate that, if cognitive

[31] In a country with no ICT production, a neoclassical growth model whose Cobb-Douglas production function has two types of capital (ICT and other) shows that the steady-state rate of growth will be TFP growth plus a term denoting the rate of real price decline for ICT capital multiplied by the share of ICT capital in national income, all divided by labor's share of national income (Oulton, 2012).

skills in Italy were at the standard of South Korea, its long-run growth would be raised by about 0.75 percentage points per year. Wössmann et al. (2007) show that the variance in outcomes in terms of cognitive skills is explained by the way the schooling system is organized rather than by educational spending.

Competition and competition policy has tended to be weaker than in the United States. This has raised mark-ups and lowered competitive pressure on managers to invest and to innovate with adverse effects on TFP growth (Buccirossi et al. forthcoming; Griffith et al. 2010). Productivity growth in market services has been very disappointing in many European countries (Timmer et al. 2010). One reason is continued weakness of competition reflected in high price-cost mark-ups which have survived the introduction of the Single Market (Høj et al. 2007). Addressing these issues by reducing the barriers to entry maintained by member states would have raised productivity performance significantly but governments still have considerable discretion to maintain these barriers notwithstanding the Services Directive (Badinger and Maydell, 2009).

Western Europe remains a tremendously rich and successful economy, despite the slowdown in its relative growth rate. The major problems facing it at the time of writing have to do with its broken banking system and dysfunctional monetary union, a reminder that growth experiences even over quite lengthy periods of time can be influenced by what are often thought of as short-run monetary factors. Once these issues have been sorted out, one way or another, a longer run issue will remain: how to reshape European economies so as to make them more dynamic without abandoning those elements of the postwar settlement that are most valued by Europe's citizens.

6.7.2 The UK in the Golden Age and After[32]

After being the undisputed economic leader for much of the 19th century, Britain entered a prolonged phase of relative economic decline. This became so pronounced during the Golden Age that by the end of the period Britain had been overtaken by seven other European countries in terms of real GDP per person, and by nine others in terms of labor productivity. Growth was at least 0.7 percentage points per year slower in the UK than in any other country, including those which started the period with similar or higher income levels. The proximate reasons for relatively slow labor productivity growth were weak growth in capital per worker and TFP compared with more successful economies like West Germany. Although slower growth was partly due to convergence forces, being overtaken is a clear indicator of failure.

What is particularly interesting about this episode is the way in which long-standing institutions interacted with changes in the political and economic environment in a way that not only rendered them toxic, but also precluded reform for several decades. The key changes in the economic and political environment were a serious erosion of competition

[32] This section draws in part on Crafts (2012, 2013b).

in product markets, and the need to maintain very low levels of unemployment in order for governments to be re-elected. There were two distinctive institutional legacies that turned out to be costly when the Golden Age opportunity for rapid growth came along. First, corporate governance exhibited an unusual degree of separation of ownership and control in large companies without dominant shareholders (Foreman-Peck and Hannah, 2012). Given that the market for corporate control through takeovers did not work effectively as a constraint (Cosh et al. 2008), weak competition allowed considerable scope for managerial underperformance. Second, the system of industrial relations was characterized by craft control, multi-unionism, and legal immunities for industrial action (Crouch, 1993).

Britain did not achieve the transformation of industrial relations—Eichengreen's cooperative equilibrium—that happened elsewhere in Europe and this implied a considerable growth penalty (Gilmore, 2009).[33] When it is not possible to write binding contracts, either the absence of unions or strong corporatist trade unionism would have been preferable to the idiosyncratic British system. In Britain it was generally not possible to make corporatist deals to underpin investment and innovation, because bargaining took place with multiple unions or with shop stewards representing subsets of a firm's workforce. These unions had considerable bargaining power as a result of full employment and weak competition, but no incentive to internalize the benefits of wage restraint. This exposed sunk cost investments to a hold-up problem, with knock-on implications for investment and growth.[34]

Failure to successfully reform industrial relations was a major shortcoming of British governments from the 1950s through the 1970s. However, throughout this period there were continual efforts to persuade organized labor to accept wage moderation, not only to encourage investment, but even more to allow low levels of unemployment without inflation at a time when politicians believed that this was crucial to electoral success after the interwar trauma. At worst this was tantamount to allowing a de facto trade union veto on economic reforms. In any event, British supply-side policy, which was shaped by the postwar settlement, was unhelpful toward growth in several respects. Problems included a tax system characterized by very high marginal rates, described by Tanzi (1969) as the least conducive to growth of any of the OECD countries in his study; missing out on benefits from trade liberalization by retaining 1930s protectionism into the 1960s (Oulton, 1976); a misdirected technology policy that focused on invention rather than diffusion (Ergas, 1987); and an industrial policy that ineffectively subsidized physical investment (Sumner, 1999) and slowed down structural change by protecting ailing industries through subsidies (Wren, 1996).

[33] Gilmore (2009) finds that coordinated wage bargaining was positive for investment and growth prior to 1975 but not subsequently. This fits with the suggestion in Cameron and Wallace (2002) that the key to the Eichengreen equilibrium is that both sides be patient, and that this was no longer the case when the macroeconomic turbulence of the 1970s erupted.

[34] This can readily be understood in terms of the Eichengreen (1996) model or an extension of it to incorporate endogenous innovation.

A key feature of the Golden Age British economy was the weakness of competition in product markets that had developed in the 1930s and intensified subsequently. Competition policy was largely ineffective while market power was substantial and entrenched politically (Crafts, 2012). The lack of competition had an adverse effect on British productivity performance during the Golden Age working at least partly through industrial relations and managerial failure. Broadberry and Crafts (1996) found that cartelization was strongly negatively related to productivity growth in a cross-section of manufacturing industries for 1954–1963, a result which is confirmed by the difference-in-differences analysis in Symeonidis (2008). In the 1970s and 1980s, greater competition increased innovation (Blundell et al. 1999) and raised productivity growth significantly in companies where there was no dominant external shareholder (Nickell et al. 1997). Both these results underline the role of weak competition in permitting agency cost problems to undermine productivity performance.

Case studies strongly implicate bad management, and restrictive labor practices resulting from bargaining with unions, in poor productivity outcomes. Pratten and Atkinson (1976) reviewed 25 such studies and found evidence of either or both of these problems in 23 of them. Prais (1982) reported similar findings in 8 out of 10 industry case studies and in each case noted that competition was significantly impaired. Multiple unionism, unenforceable contracts, and plant bargaining with shop stewards created an environment in which, unlike West Germany, workers and firms could not commit to "good behavior." This weakened incentives to invest and innovate (Bean and Crafts, 1996; Denny and Nickell, 1992).

The competitive environment that had largely precluded failure in the pre-1914 period had disappeared. This allowed the problems of poor management and dysfunctional industrial relations, often seen as the Achilles' heel of the British economy in the Golden Age, to persist. The politics of economic policy operated to prevent supply-side reforms that could have prevented relative economic decline by enhancing social capability. This period only ended with the election of a maverick prime minister in 1979.

The post-Golden Age period is helpful as a test of this interpretation, since government policy moved in the direction of increasing competition in product markets. In particular, protectionism was discarded. Trade liberalization in its various guises reduced price-cost margins (Hitiris, 1978; Griffith, 2001). The average effective rate of protection fell from 9.3% in 1968 to 4.7% in 1979, and 1.2% in 1986 (Ennew et al. 1990). Industrial policy was downsized as subsidies were cut, and privatization of state-owned businesses was embraced while de-regulation was promoted. In addition, legal reforms of industrial relations reduced trade union bargaining power, which had initially been undermined by rising unemployment. Reforms of fiscal policy were made including the re-structuring of taxation by increasing VAT while reducing income tax rates. The Thatcher government saw itself as ending the trade unions' veto on economic policy reform. Many of the changes of the 1980s would have been regarded as inconceivable by informed opinion in the 1960s and 1970s.

European productivity growth slowed down markedly after the Golden Age, but less so in the UK than in most other countries. Increased competition and openness in the later 20th century was associated with better productivity performance. Proudman and Redding (1998), exploring differing experiences across British industry between 1970 and 1990, found that openness raised the rate of productivity convergence with the technological leader. In a study looking at catch-up across European industries, Nicoletti and Scarpetta (2003) found that TFP growth was inversely related to product market regulation (PMR). The implication of a lower PMR score as compared with France and Germany was a TFP growth advantage for the UK of about 0.5 percentage points per year in the 1990s. At the sectoral level, when concentration ratios fell in the UK in the 1980s, there was a strong positive impact on labor productivity growth (Haskel, 1991). Entry and exit accounted for an increasing proportion of manufacturing productivity growth, rising from 25% in 1980–1985 to 40% in 1995–2000 (Criscuolo et al. 2004).

The impact was felt at least partly through greater pressure on management to perform and through firm-worker bargains that raised effort and improved working practices. Increases in competition resulting from the European Single Market raised both the level and growth rate of TFP in plants which were part of multi-plant firms, and thus most prone to agency problems (Griffith, 2001). Liberalization of capital market rules allowed more effective challenges to incumbent management. A notable feature of the period after 1980 was divestment and restructuring in large firms and, in particular, management buyouts (often financed by private equity) which typically generated large increases in TFP levels in the 1988-1998 period (Harris et al. 2005).

The 1980s and 1990s saw major changes in the conduct and structure of British industrial relations. Trade union membership and bargaining power were seriously eroded. This was prompted partly by high unemployment and anti-union legislation in the 1980s but also owed a good deal to increased competition (Brown et al. 2008). Increased competition may have been the more important factor in boosting British performance, since the 1980s saw a surge in organizational change in those unionized firms exposed to increased competition (Machin and Wadhwani, 1991). De-recognition of unions in the context of increases in foreign competition had a strong effect on productivity growth in the late 1980s (Gregg et al. 1993). The negative impact of multi-unionism on TFP growth, apparent from the 1950s through the 1970s, evaporated after 1979 (Bean and Crafts, 1996). The productivity payoff was boosted by the interaction between reforms to industrial relations and product market competition.

6.8. CASE STUDIES II: SUCCESS, AT LEAST FOR NOW

In this section we briefly examine three more postwar growth miracles, in East Asia, China, and Ireland. While the East Asian Miracle was called into question after the crisis of 1997, growth there soon resumed. It remains to be seen whether Irish growth will go the way of Japan in the 1990s, but income levels there are massively higher than in the 1980s; the same is true of China, despite concerns about the future of economic growth in that country.

6.8.1 The East Asian Miracle

We have seen that the four East Asian Tiger economies enjoyed one of the most impressive growth experiences of the 20th century, although they had to wait until the end of World War II for it to begin. The four countries concerned differed in terms of size, history, and political system. In 1950, South Korea had the largest population, some 20 million, while the Taiwanese population was almost 7.5 million. Hong Kong and Singapore were both city states, with populations of just 2 million and 1 million, respectively. Korea and Taiwan had both been Japanese colonies, and were on the front line of the struggle between communism and the West. Singapore and Hong Kong were both British colonies, but whereas Singapore sought and eventually obtained independence, first as part of Malaysia in 1963, and then as an independent state in 1965, Hong Kong remained British until the handover to China in 1997. GDP per capita in South Korea and Taiwan was around $900 in 1990 international prices, at or below the level of several countries in sub-Saharan Africa; it was slightly over $2000 in Hong Kong and Singapore. Korea, Singapore, and Taiwan all developed more or less authoritarian systems of government, while Hong Kong was ruled as a Crown Colony until 1997. And yet all four countries achieved spectacular growth, with the result that per capita GDP in 2007 was as high in Korea and Taiwan as in Western Europe, and substantially higher in Hong Kong and Singapore. This is a sufficiently impressive performance deserving of the label miraculous, irrespective of the relative contributions of factor accumulation and TFP growth in producing it.

Several features of this growth experience fit neatly into the general convergence framework outlined above. The four countries were relatively poor in 1950, and had high levels of social capability. The famous index of Adelman and Morris (1967) showed that both Korea and Taiwan having extremely high levels of social and economic development in the late 1950s and early 1960s, and Temple and Johnson (1998) have found that this indicator was strongly correlated with subsequent growth. As elsewhere, growth in the Tiger economies was characterized by high rates of investment—in human as well as physical capital—and rapidly growing trade. Investment stood at around 30% of GDP in both Korea and Taiwan in 1980 (Rodrik, 1995, p. 59). Technology transfer was actively encouraged via licensing, technical assistance, inward investment by multinationals, and joint ventures (with the mix differing between countries: for example, Korea discouraged inward direct investment, while Singapore actively encouraged it). Another feature of East Asian growth was that it was based on industrialization, with countries specializing first in textiles, then in heavy industry, and then in electronics and high-tech industries. This pattern of switching over time from labor-intensive, to capital-intensive, and finally to technology-intensive industries, promoted spillover effects on neighboring countries in Southeast Asia, as later industrializers started manufacturing goods which earlier industrializers were no longer producing: the so-called flying geese phenomenon (Ito, 2001).

A substantial literature emerged in the late 1980s and early 1990s which argued that these economies had developed on the basis of institutions and policies which differed greatly from the hands-off prescriptions of the Washington Consensus, involving among other things public enterprise, active industrial policy, export promotion, and protectionism. For Amsden (1989, p. 6), the institutions that mattered in Korea were "an interventionist state, large diversified business groups, an abundant supply of competent salaried managers, and an abundant supply of low-cost, well-educated labor." The key policies were to provide subsidies to firms that, crucially, were conditional on better performance and export market share; and to establish what were effectively multiple prices for capital and foreign exchange, via subsidies or other policies. According to Amsden, these multiple prices were needed in order to accommodate conflicting objectives, for example to encourage savings while keeping the cost of capital to firms low; or to encourage exports while keeping the cost of imports low. For Wade (1990) activist East Asian governments not only influenced the growth rate, but the sectoral composition of output, with beneficial consequences. Some of these conclusions, but not all, were taken on board in a 1993 World Bank study (World Bank, 1993), before the TFP literature reviewed above stimulated a debate about whether the East Asian Miracle was really as impressive as all that: if TFP growth was low, after all, then interventionist arguments based on learning by doing or other growth-promoting externalities seemed less convincing (Krugman, 1994, p.78).

While Amsden and Wade emphasized export performance, subsequent work has downplayed the role of exports. Rodrik (1995) argues that exports cannot have been a prime mover of industrialization, since if they had been, this would have been manifested in a rising relative price of exports as world demand rose. Since there was no such price rise, the ultimate sources of growth must have been internal, with exports arising as a consequence. For Rodrik the key to growth was investment, consistent with the growth-accounting evidence. State intervention was required, not just to boost savings and investment rates via subsidies, public investment, and other measures, but to coordinate investment across a range of complementary sectors for "big push" reasons. Rodrik shows a striking positive correlation over time in both Korea and Taiwan between investment and imports, which can be explained by the fact that investment required large imports of machinery and other capital equipment. Exports were needed to pay for these imports, and were thus necessary for the investment drive, but they were not the ultimate cause of rapid growth. This does not mean that exports were not essential: they were, both to finance required imports of capital goods, and to sell the output that the high investment rates were designed to produce. An implication is that while countries like Korea and Taiwan were not liberal free traders themselves, they did benefit from the generally open international trade policies of the major Western economies during this period.

Some of the same features which had been seen as aiding rapid East Asian convergence on the frontier—in particular, close relationships between the state and big business, and heavy reliance on bank finance—were blamed for the East Asian financial crisis which erupted in 1997. Given the debate that had recently taken place about East Asian TFP, it is not surprising that the crisis emboldened some to argue that these institutional features of East Asian growth had been a hindrance rather than a help, all along. It is difficult to see how one could establish such counterfactual claims convincingly. For example, studies failing to find correlations across sectors between subsidies or other policy interventions, on the one hand, and productivity or other outcomes on the other, would presumably not convince an advocate of big push policies, which are based on intersectoral complementarities. The argument that the financial crisis proves anything about the sources of rapid East Asian growth from the 1960s to the 1990s seems somewhat dated today, in the light of the global financial crisis of 2007–2008. This hit some of the richest countries in the world, with very different institutional structures than those found in, say, Korea. The experience of the Eurozone periphery shows the dangers of being exposed to capital inflows in the presence of a currency peg; unlike Korea or Thailand these countries do not have the option of devaluation, and by 2013, have not yet recovered. In sharp contrast, East Asian growth resumed rapidly in 1999. We thus agree with Ito (2001), who argues that the debate about which institutions and policies mattered for East Asian growth during the growth miracle needs to be sharply distinguished from the debate about how to regulate banks and international capital flows. This does not mean, however, that at some stage East Asia may not have to rethink its institutional mix as it moves even closer to the international technological frontier.

6.8.2 China

While Chinese economic statistics are unreliable, it is clear that China's growth since the start of economic reforms in the late 1970s has been extraordinary.[35] Even if Maddison and Wu's (2008) data are accepted, GDP growth averaged 7.85% per annum between 1978 and 2003, as compared with an official growth rate almost 2 percentage points higher. As in the Western European and East Asian cases, very high levels of investment, the importation of technology, and increasing links with the outside world played key roles in China's growth acceleration. As in East Asia, Chinese industry went through successive phases, from exporting labor-intensive toys, clothes, and footwear to producing more capital-intensive, and ultimately high-tech goods. The Chinese savings rate averaged an extraordinary 37% between 1978 and 1995 according to Kraay (2000), although Heston and Sicular (2008) favor a lower (but still large) figure somewhere in the 20–30% range.

[35] Our account draws heavily on the collection of essays in Brandt and Rawski (2008a), the standard reference on the subject.

This has allowed an equally high investment rate to be internally financed (Lee et al. 2012).

What makes the Chinese experience unique is the way in which a gradualist reform program has seen the role of the state in economic life being steadily diminished over time, at the same time as that state has maintained a highly authoritarian political system. China is no poster child for the Washington Consensus. It still maintains exchange controls, state-owned enterprises remain an important drag on the economy (Brandt et al. 2008), and the government intervenes in the economy in myriad other ways. But the facts that the direction of change since 1979 has so clearly been in a market-friendly direction, and that China's economic situation has improved so much since then, mean that the literature on China's economic miracle has tended to focus on how gradual liberalization improved performance, rather than (as in the East Asian Tiger case) on whether some government interventions helped speed China's convergence on the technological frontier.

China's reforms came in two stages (Brandt and Rawski, 2008b), which according to Naughton (2008) corresponded to different configurations of political power. In the first stage, which lasted from 1979 to 1992, political power was fragmented, and reforms were incremental, and concerned with not creating losers. Agricultural households were permitted to engage in cultivation. A growing number of firms, notably township and village enterprises (TVEs), were allowed to enter an increasing range of sectors. Once firms had satisfied their plan targets, they were able to sell additional output at what evolved into market prices. Four special economic zones were set up in the southern coastal provinces, in which Hong Kong and Taiwanese firms produced labor-intensive goods for export. Fourteen additional zones were created in 1984, and regulations regarding foreign direct investment were further relaxed in 1986 (Branstetter and Lardy, 2008, pp. 640-1).

In the second stage, from 1993 onwards, power was consolidated as the first generation of Communist leaders left the political stage. Reforms became more decisive, and capable of producing losers as well as winners. The plan component of the dual pricing system was abandoned; restrictions on mobility between town and countryside were relaxed, setting the stage for a mass migration of rural workers to industrial cities; TVEs were privatized; state-owned enterprises (SOEs) were subjected to more market discipline, and were downsized and occasionally closed. The number of workers in SOEs fell from 76 million in 1992–1993 to 28 million in 2004 (Naughton, 2008, p. 121): Brandt et al. (2008) estimate that the resulting reallocation of workers toward more productive firms elsewhere in the economy made an even more important contribution to GDP growth than rural to urban migration. For Hsieh and Klenow (2009), the reallocation added 2 percentage points to China's TFP growth rate between 1998 and 2005, while for Song et al. (2011), it not only helps explain China's growth since the early 1990s, but its growing external surpluses as well (since the growing private sector relies more on internal financing for its investment needs than the SOEs). The growing liberalization of Chinese trade policy culminated with China's accession to the WTO in 2001. Even prior to that, foreign companies had been enabled to operate in China subject to many fewer restrictions and less interference, leaving China well positioned to benefit from the boom of the last few years of the Great Moderation (Branstetter and Lardy, 2008, p. 645). Despite the clear acceleration in the pace of reforms, Chinese reforms remained gradual compared with the experience of Eastern Europe and the former Soviet Union (Svejnar, 2008).

Given that corruption is a severe problem in China, and that other aspects of its institutional structure remain deeply problematic, it is perhaps not surprising that much analysis has focused on the dismantling of Communist economic controls as being at the heart of China's economic success: merely getting rid of obstacles can lead to significant growth if these were costly enough (Brandt and Rawski, 2008b, p. 9). And yet government intervention may have helped growth as well as hindered it. The size of the Chinese market has allowed national and regional officials to extract concessions from foreign multinationals, notably with respect to the transfer of technology and research and development activities, that could in principle have accelerated China's catching up relative to that of other poor economies (Brandt et al. 2008, p. 623). The fact that China's real exchange rate depreciated by 70% vis à vis the dollar between 1980 and 1995 presumably increased the attraction of China as a manufacturing location. This in turn helped make China's exchange rate policy more politically sustainable, by creating overseas political constituencies favorable to it (Branstetter and Lardy, 2008, pp. 639, 675–676). And underlying everything else has been competition between regional officials, whose promotion prospects depend on their region's economic performance. This "regionally decentralized authoritarianism" (Xu, 2011) has been a major factor in China's economic success.

There were clear signs in 2013, that the Chinese financial sector might be heading for a major crisis with unpredictable consequences for the Chinese economy and political system. Even aside from this risk, it may be that the policies and institutional structures which have underpinned China's economic growth since 1978 are beginning to outlive their usefulness and will have to be changed. Relative prices skewed in favor of exports may be distorting the Chinese economy (Branstetter and Lardy, 2008, p. 676), and are in any rate leaving the economy vulnerable to overseas shocks. Many commentators argue that an investment rate approaching 50% of GDP may no longer be sustainable, and that an increasing focus on consumption is now required. For some China is now approaching its "Lewis (1954) moment," as rural to urban migration slows and wages start to rise. Elastic supplies of labor from agriculture (and, if Song et al. 2011 are right, from SOEs as well) made high Chinese investment rates consistent with high returns on capital; as both pools of labor shrink, diminishing returns to capital will set in (Das and N'Diaye, 2013; Krugman, 2013).

If extensive growth at current rates becomes more difficult, and the need for intensive growth thus increases, deeper institutional changes may be needed. Perhaps, as Naughton (2008, p. 127) speculates, as China moves closer to the technological frontier its economy will need "transparency and recourse to impartial independent regulatory authority that the current system is not yet able to provide." It is not yet clear that China will be able to escape the middle income trap. Eichengreen et al. (2012) find that the probability of a growth slowdown (defined as a decline in growth rates of 2 percentage points or more) increases not only at income levels which China can be expected to attain in the next few years, but in countries which have maintained undervalued exchange rates, have low consumption shares of GDP, and aging populations. On all fronts China appears vulnerable, implying that the probability of a growth slowdown is high there, and that is even before taking the country's financial problems into account. Whether such a slowdown will occur, and how the country's economy, society, and political system would respond, are among the major uncertainties facing the world economy in the early 21st century.

6.8.3 Ireland: The Celtic Tiger

The spectacular growth of the Celtic Tiger period when a small economy rode the globalization wave with massive success attracted enormous attention. Its proximate sources in export platform FDI and ICT production are apparent. Less well understood is the fact that up through the mid-1980s Ireland had been a failure (Ó Gráda and O'Rourke, 1996). We saw earlier that affluent Western economies experienced unconditional convergence after 1950, with poorer countries growing more rapidly than richer ones. Seen in this perspective, Ireland was the great underperformer prior to 1987, as Figure 6.3 shows, with growth rates well below those that would have been expected given its relative poverty in 1950. Ireland's average growth rate between 1950 and 1987, 2.8% per annum, was approximately the same as that in the Benelux countries, despite the fact that its 1950 per capita income lay between those of Austria and Italy. In the context of the Golden Age, this was a spectacular economic failure.

The reasons for this failure are related to the reasons for success in the rest of Western Europe at the same time. The 1950s were particularly unimpressive in Ireland, with per capita growth rates of only 1.7%. Education remained underfunded and underprovided. Instead of corporatist labor market institutions as in continental Europe, Ireland had a fragmented British-style trade union system incapable of delivering wage moderation in return for high investment. Even if such wage moderation had been delivered, Irish firms were small, unproductive, and focused on the home market, while foreign firms were discouraged from investing in the country. This was the legacy of 1930s protectionism, which might have been the correct response to the Great Depression, but should have been abandoned much earlier than it actually was. Such investment as there was too often went to relatively unproductive purposes, with Irish savings being invested in low-yielding projects for political reasons. Not surprisingly, Irish TFP was very low by European standards in 1960 (Crafts, 2009).

Gradually these impediments to growth were done away with. The late 1950s and early 1960s saw the introduction of export tax relief, and measures to attract foreign direct investment, which was to become the key to Ireland's convergence on the technological frontier. Trade was gradually liberalized: Ireland entered an Anglo-Irish free trade area in 1965, and the EEC in 1973. The late 1960s saw belated educational reforms that made secondary schooling available to everyone. Growth was twice as high in the 1960s as in the 1950s, but was slightly less than the Western European average: Ireland was still not converging, and in 1973 was poorer than Greece, Portugal, and Spain. EEC membership helped to modernize the economy in many ways, but the oil crisis that coincided with entry ushered in a period of low growth, large government budget deficits, and a subsequent fiscal crisis, which led to a second post-war lost decade during the 1980s.

After 1987, Ireland's economic performance was transformed out of all recognition. Between 1987 and 2000 its per capita growth rate averaged 5.7% per annum, with the result that by 2000 Ireland lay on the advanced economy "convergence line" (Figure 6.4). So how was Ireland turned around? Figures 6.3 and 6.4 suggest a straightforward explanation: that the Irish miracle was simply a delayed version of the Western European growth miracle of the 1950s and 1960s (Ó Gráda and O'Rourke, 2000; Honohan and Walsh, 2002). What changed was that many of the structural impediments to convergence had been eliminated over the course of the 1960s and 1970s, leaving Ireland well positioned to take advantage of deeper European integration and a buoyant international economy in the 1990s. The catastrophe of the 1980s meant that trade unions were willing to

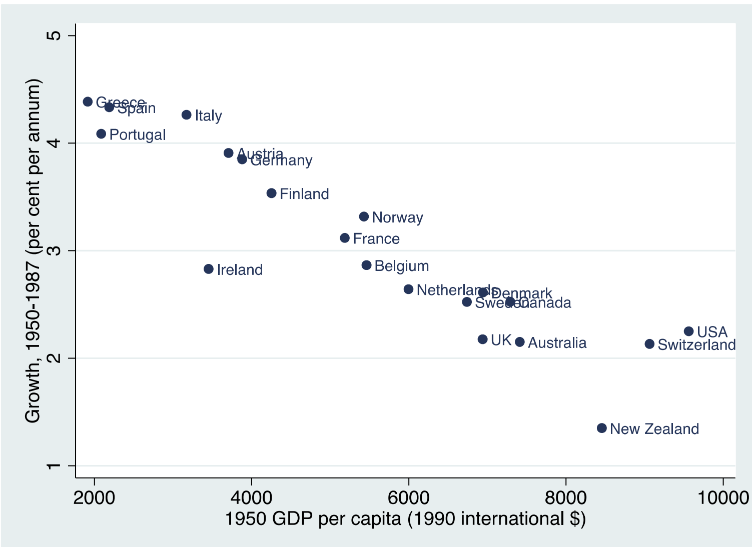

Figure 6.3 GDP per capita growth, 1950–1987. *Source:* *Bolt and Van Zanden (2013)*.

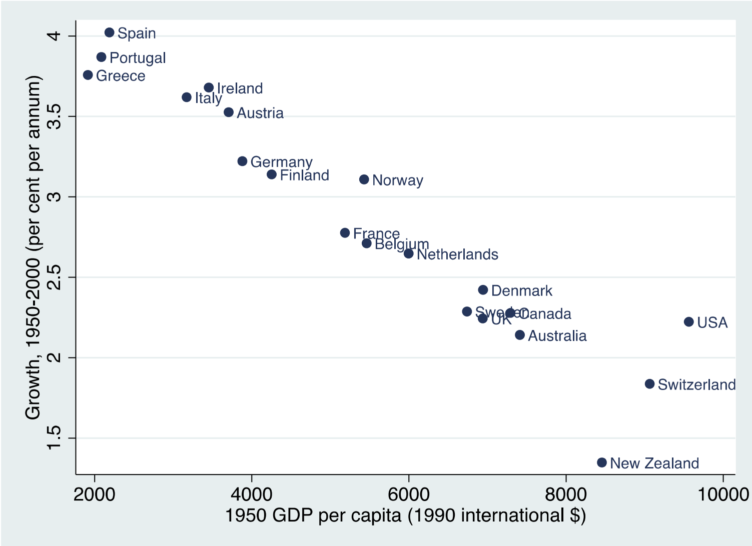

Figure 6.4 GDP per capita growth, 1950–2000. *Source:* *Bolt and Van Zanden (2013)*.

enter into corporatist social partnership agreements, trading wage restraint against the promise of growth and employment. Irish workers were now far better educated than they had been during the 1960s. Devaluations in 1987 and 1993 helped to boost Irish competitiveness. A healthier labor market now interacted with Ireland's long-standing low corporate taxes and produced a surge of inward investment, rising TFP levels, and increases in employment.

Imports of technology, corporatist labor bargains leading to investment, and a reliance on exports are all reminiscent of the Western European miracle of three or four decades previously. The differences were also noteworthy, and reflected the period. Much of the investment occurred via FDI, rather than being financed via retained profits by domestic firms. Workers' wage restraint was compensated more with tax cuts than with an expansion of the welfare state. And Ireland did not go through all the stages of industrialization to the same extent as other countries, specializing far more in ICT and other high-tech sectors than the typical fast grower of the 1950s or 1960s. This specialization did not just reflect the invisible hand of the market, but active Irish government attempts to develop clusters of activity in ICT, pharmaceuticals, and similar sectors (Barry, 2002).

The Celtic Tiger period ended in 2000 or 2001, and was replaced by the Celtic Bubble of 2001–2007, financed by cross-border capital flows which boomed in the aftermath of Ireland's entry into the Euro. Not only the bubble, but also the crash which followed, was reminiscent of the East Asian crisis of 1997, but with the important difference that Ireland was not able to respond to the crisis by adjusting its exchange rate. Foreign observers have not subjected the Irish model to the same sort of scrutiny that the East Asian model faced after 1997, which is perhaps ironic since the Irish economy had still not started to recover by 2013, in stark contrast with the rapid and durable post-crisis recovery in East Asia. The net result is, that at the time of writing, it seemed that Ireland risked facing a third post-war "lost decade," after those of the 1950s and 1980s. It is too soon to say whether and when growth will resume, in Ireland or in the rest of the Eurozone periphery. Nonetheless, the Celtic Tiger was no mirage: Ireland is now one of the richest countries in Western Europe, not one of the poorest.

6.9. CASE STUDIES III: FAILURES

In this section we look briefly at two cases which can fairly be considered failures, the USSR and Africa.

6.9.1 Failed Catch-Up in USSR[36]

The USSR was always a long way below the United States in terms of real GDP per person—about 30% in 1950 and 36% in 1973—and, despite a promising start, only reduced the gap very slowly. A growth rate of 3.37% per year in the Golden Age compares quite unfavorably with the achievements of Western European countries like Italy or Spain which also started out with relatively low income levels. Growth regression evidence confirms that communist countries underperformed in the Golden Age: allowing for initial income levels, their growth rate was about 1.3 percentage points lower than that of their Western European counterparts (Crafts and Toniolo, 2008).

Worrying signs of a serious slowdown in productivity growth did not appear until the 1970s. Golden Age Soviet growth was extensive, in that the investment/GDP ratio roughly doubled between 1950 and the early 1970s to about 30%. The capital stock grew at about 8.5% per year in this period (Ofer, 1987). However, diminishing returns to capital accumulation exacerbated by slow TFP growth implied that the rate of capital stock growth delivered by a given investment rate was falling over time: the capital-stock growth rate fell from 7.4% per year in the 1960s to 3.4% per year in the 1980s. Negative TFP growth post-1970 (Table 6.16) was driven by "waste of capital on a grand scale" (Allen, 2003, p. 191) as old factories were re-equipped and expansion of natural resource industries in Siberia were pursued.

Relatively low TFP growth was not the result of inadequate volumes of R & D, which by the 1970s were very high by world standards at around 3% of GDP. Rather, the problem lay in the incentive structures that informed innovation at the firm level. This was a classic case of a social capability failure. The planning system rewarded managers who achieved production targets in the short term rather than those who found ways to reduce costs or improve the quality of output over the long term. The balance of risk and

[36] This section draws in part on Crafts and Toniolo (2008).

reward was inimical to organizational and technological change, and the "kicking foot" of competition was absent (Berliner, 1976).

The incentive structures used by the Soviet leadership to motivate managers and workers were a complex mixture of rewards, punishments, and monitoring. Each of these became increasingly expensive over time, implying that the viability of the system was threatened. Product innovation drove up monitoring costs, and this inhibited moves from mass to flexible production. A more educated population meant that punishment (incarceration) was more costly in terms of loss of human capital, and that rewards needed to be higher. The slowdown in productivity growth led to a search for reforms that might improve economic performance and lower monitoring costs, but these ended up undermining the regime's reputation for brutality, which could help sustain high effort in circumstances when punishment costs became particularly high. The interesting feature of this system is that it could be tipped from a high coercion, high effort equilibrium to a low coercion, shirk and steal equilibrium if rewards and punishments were no longer credible and workers understood this. Harrison (2002) argues that such a shift accounts for the sudden collapse at the end of the 1980s.

6.9.2 Post-Colonial Sub-Saharan Africa

As we have seen, average growth performance in this region was dismal between the mid-1970s and the late 1990s. There was stagnation in real GDP per person (Table 6.8), TFP growth was actually negative (Table 6.11), and it became commonplace to talk about a chronic growth failure (Collier and Gunning, 1999). However, the first decade of the 21st century saw a revival in growth performance. Taking a long view of African growth, it may be more accurate to see a picture of growth accelerations followed by growth reversals, with the former typically triggered by strong commodity prices, as in the recent growth spurt (Jerven, 2010). Unfortunately, econometric analysis shows that while commodity price booms have raised income levels in the short run, their long-run effect is to lower them somewhat (Collier and Goderis, 2012).

Very low institutional quality is the most obvious explanation for disappointing growth and low income levels at the end of the 20th century. On average, sub-Saharan African countries score badly on the World Bank's *Governance Matters* and *Doing Business* indicators and do so persistently. Thus, ever since 1996, when it was first compiled, the average score on the "rule-of-law" indicator has been about −0.7 (on a scale of −2.5 to +2.5) compared with an average for Western Europe of around +1.6. Similarly, the norm across the region is a closed access society (Kishtainy, 2011). If the fundamental reason for poverty is insecure property rights (Acemoglu and Johnson, 2005) then sub-Saharan Africa is a prime exhibit. Indeed, this is now often taken as a stylized fact, with "absolutist weak states" having "little ability or interest in providing public goods" and operating on a "neopatrimonial" basis (Acemoglu and Robinson, 2010, pp. 23, 40). Of course, there are exceptions to this dismal picture, such as Botswana and Mauritius, but they are the exceptions that

Table 6.23 Growth of real GDP/person, 1960–2000 (percent per annum)

	Resource-scarce & coastal (%)	Resource-scarce & landlocked (%)	Resource-rich (%)
Africa	0.50 (33)	−0.36 (33)	0.29 (33)
Other developing	3.79 (88)	1.40 (1)	2.89 (11)

Note: numbers in parentheses refer to percentages of population by region in each category.
Source: Collier (2007).

prove the rule, and score relatively well when it comes to governance indicators. This is an account that is entirely consistent with the New Institutional Economic History tradition.

However, the intriguing question remaining is what part geography may have played in explaining African failure. On a range of indicators, including climate, coastal access, disease environment, and population density, Africa scores much less well than other regions of the developing world (Sachs et al. 2004). It seems reasonable to suppose that this carries a growth penalty in terms of adverse impacts on investment and productivity. "Naive" growth regressions suggest that this is the case and accord geographic factors nearly as much weight as institutions in accounting for the differential between African and East Asian growth performance in the late 20th century (Bleaney and Nishiyama, 2002). If the focus is switched to "second-nature" geography, then sub-Saharan Africa scores very badly compared with almost all other parts of the world in terms of market potential, which is strongly correlated with income even after controlling for institutional quality (Redding and Venables, 2004).

Table 6.23 offers a simple but powerful summary of growth performance classified by geographic type. The table shows (in parentheses) the percentages of the population in both Africa and other developing regions in each of three categories: resource-scarce and coastal; resource-scarce and landlocked; and resource-rich. It also shows the average growth rates between 1960 and 2000 in each of these six regions. As can be seen, being both landlocked and resource-scarce is a particularly bad combination for growth, and this is unfortunate for Africa since it has a relatively high percentage of its population in this category. It also has a relatively low proportion of its population in resource-scarce and coastal regions, which saw higher growth rates both in Africa and elsewhere. Geography does not favor Africa, therefore, but this is not the whole story since the table also shows that in each geographic category Africa has seriously underperformed relative to the rest of the developing world.

A more satisfactory way to explain post-colonial African growth failure may be to consider interactions between institutions and geography. One aspect of such interactions is the possibility, noted earlier, that first-nature geography may have its strongest effects through its impact on institutions (Easterly and Levine, 2003). But it is also important to recognize that, "on top of its physical geography and remoteness, Africa has been held back by the fragmentation of its political and economic geography" (Venables, 2010, p. 481)—the median country has a population of only 8 million people. This fragmentation implies a number of serious disadvantages with regard to small city size, weak competition in product markets, reduced supply of public goods, greater difficulty in escaping from bad policies, etc. (Venables, 2010). Payoffs to better policies are often highly dependent on the reform efforts of neighbors, which further hinders economic progress.

A final perspective on sub-Saharan failure is both more historical and, perhaps, more optimistic. Bates et al. (2007) point out that economic performance was also very disappointing in Latin America in the first 50 years following independence in the 1820s, and that it was only in the late 19th century that sustained economic growth began. Furthermore, this growth was as high as that experienced in the British offshoots, as we saw in Section 6.3. Bates et al. explain the initial poor performance as being due to the political instability of the time: international and civil wars, foreign military incursions, and a general atmosphere of violence. This is suggestive, since wars and violence have been prevalent in post-independence Africa as well, and it is often suggested that this is one reason for the continent's poor growth performance. Perhaps the transition to post-colonial independence for new states, with arbitrarily drawn borders, is inherently difficult. If so, Africa may yet see a brighter 21st century, as it gradually leaves these transition problems behind.

6.9.3 The Natural Resource Curse

One major reason for long-term growth failure which has received a great deal of attention in the literature is the so-called natural resource curse. This refers to the tendency for countries with large natural resource exports or minerals production relative to GDP to grow relatively slowly at best, and experience prolonged periods of negative growth at worst. A number of hypotheses have been put forward to explain this correlation and there is a substantial body of empirical work that examines issues of robustness and causality.[37] The standard suggested mechanisms explaining the natural resource curse include crowding out of tradable goods sectors with greater productivity growth potential (Dutch Disease); promoting low quality institutions which undermine growth; making civil war more likely; and engendering macroeconomic volatility. There is some empirical support for all these arguments (Van der Ploeg, 2011). It is also clear that there is a wide range of historical experience that needs to be explained. Some countries have indeed been cursed by natural resources, for example, Angola, Congo, Sierra Leone, and Sudan. However, others have been blessed including, for example, Australia, Canada, Chile, and the United States.

[37] For an excellent recent survey article, see Van der Ploeg (2011).

It seems highly plausible that the implications of a resource windfall will differ depending on whether there are good or bad institutions. In the former case, it might be expected that the bonanza leads to an increase in productive activities, while in the latter case, even more resources will be devoted to rent-seeking. The evidence of growth regressions is consistent with this prediction. Mehlum et al. (2006) use a variable interacting institutional quality, as measured by the ICRG index popularized by Knack and Keefer (1995), and resource abundance. They find that values above 0.60 for the ICRG index make mineral resources good for growth. This accords with common sense: oil has been very good for Norway, but bad for Nigeria.

An economic history perspective allows some of these ideas to be taken further. First, the most notable success story in recent African economic history is Botswana, a resource-abundant country in which diamonds are a large share of GDP. Botswanan success is based not only on diamonds, but also on high institutional quality and secure property rights plus good policies. The underpinnings of good institutions were a combination of historical accident and the economic interests of the pre-diamond era elite, the cattle ranchers (Acemoglu et al. 2003). There was thus a bulwark against the pursuit of mineral rents which led to rent-seeking and states which were ineffective modernizers elsewhere in Africa, for example Angola and Nigeria (Isham et al. 2005).

Second, going beyond the argument that good institutions make natural resources more of a blessing than a curse, it should be noted that natural resource endowments actually reflect the amount of effort devoted to their discovery and effective exploitation. This depends inter alia on the quality of institutions and policies. A classic example is the 19th century United States whose status as a leading minerals producer was the product of big investments in exploration and human capital underpinned by a favorable property rights regime (David and Wright, 1997).

Third, the implications of mineral resources seem to have varied over time for reasons which still need to be fully researched but link to ideas familiar from new economic geography. In the 19th and early 20th centuries, industrialization was encouraged by the proximity of coal, whereas in the later 20th century it seems to have been discouraged by the proximity of oil. Regression evidence for the natural resource curse relates to samples drawn only from the recent past. The difference between now and then is likely to relate to much higher transport costs for minerals, especially over land, in the past; and changes in energy sources with electrification (Wright and Czelusta, 2007).

6.10. CONCLUSIONS

The convergence of a succession of countries onto the technological frontier is a process whose roots lie in the great divergence of the 19th century. That divergence was due to new industrial technologies being implemented in some regions of the world but not in others, and was magnified in the short run by the globalization of the period which, given technological asymmetries, created a stark division of labor between an industrializing West and a deindustrializing Rest.

The key to reducing the resulting regional inequalities has been the erosion of these technological asymmetries, via the spread of modern industrialization. The succession of growth miracles briefly surveyed above seems reminiscent of the process of sequential convergence on the frontier modeled by Lucas (2000, 2009). Since industrial technologies are transferable across borders, convergence should not surprise us. But neither should we assume that convergence will be as smooth as simple growth models assume: the economic history of 20th century growth is also a story of the various frictions that can impede this process. In addition to successes, there have been a variety of failures.

As we have seen repeatedly throughout this chapter, innovation tends to reflect the economic circumstances of the leading economy of the time. This was Britain until some time in the late 19th century, and the United States thereafter. Even in the best of all institutional worlds, with no political or other frictions and Scandinavian levels of social capability, directed technological change would be a factor preventing or at least slowing down the process of technological convergence. Nor is this just a story of developing countries finding it uneconomical to adopt best-practice technology, since European economies, and even Britain itself, found themselves at a disadvantage when it came to adopting American techniques that had been developed with American factor prices, and the American market, in mind.

What is more, we do not live in the best of all institutional worlds, frictions of all sorts are prevalent and we are not all Scandinavian. Social capability matters for growth and not all countries have it. Institutions are path dependent, and can be an impediment to growth. And even in countries where they have always been an asset, they can become a liability, since the right institutional set-up may change over time as countries converge on the technological frontier, or as the nature of frontier technologies change. Chasing a moving target can be a tricky business in a world where history matters.

Geography is another reason why convergence is not as smooth in practice as it can seem in theory. First-nature geography matters, although it may matter in different ways at different points in time: resource abundance may be a blessing in some time periods, but a curse in others, depending on the tradability of resources, on their nature, and on the extent to which frontier technologies are resource-using. It may also be a blessing or a curse depending on a country's institutional set-up, which may in turn reflect that country's geography as well as its history. Being far from trade routes, on the other hand, has never been good for growth in the past, and it is hard to see why it should become so in the future.

Finally, economic historians emphasize the importance of wars, ideological revolutions, financial crises, and other events that are typically regarded as exogenous shocks in economic models, but which are part and parcel of the world in which we live. The First World War, the Russian Revolution, or the Great Depression were not mere complications in the story of 20th century economic growth, but a part of its very fabric. Even episodes which are conventionally regarded as shortrun in nature, having to do with macroeconomic or financial policy, can, if handled sufficiently badly, have a significant impact on economic growth over the course of a lifetime, which is what most of us tend to care about. History, and economic history, have not yet ended.

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