3

The empirical evidence: 'Stylised', and 'less stylised' facts on technology, growth and trade

Contrary to a tradition in economic theory that commences its analysis by choosing a set of assumptions on the grounds of formal tractability and/or consistency with the established doctrine, and more in line with the spirit of the preceding chapter, we begin our analysis by presenting a list of what we shall refer to as 'stylised facts' – that is, broad empirical regularities – which are in need of theoretical explanation. These 'stylised', and some 'less stylised', facts are based on a long stream of empirical investigations and theoretical explorations undertaken by a number of authors in the area of technical change who have retained an empirical interest in the patterns of structural change in modern economies.

Many of the pioneering investigations on the complex dynamics linking technical change, growth and transformation, undertaken by such major contributors to economics as Schumpeter, Kuznets, Gerschenkron and Svenilsson have often been neglected in the broad reductionist vein that was characteristic of the economic approach prevailing after the Second World War, particularly in Anglo-Saxon countries. Our central interest in innovative phenomena brings us quite naturally closer to these often neglected 'classics'. It leads us to present the empirical evidence on technological activities within a framework which focusses on change, through time and differences between countries, instead of on timeless equilibria and uniformity between countries. The 'stylised facts' that follow thus aim to provide the reader with an account of some of the regularities, differences and similarities through time and across countries in innovation, efficiency in inputs use, particularly in labour productivities, and composition of trade flows.

3.1 The international and intersectoral patterns of innovation

The international location of innovation: some preliminary evidence

We begin with two measures of long-term trends in the location of innovative activities among countries. One method is simply to identify significant innovations and their locations and to trace any change over time. This is (not surprisingly) a difficult undertaking involving difficult methodological problems about definition of concepts (significant innovations), consistency over time, comparability between countries, etc. Some authors have attempted to carry out such inventory listings. Feinman and Fuentevilla (1976), Davidson (1976) and Townsend *et al.* (1981) have tried to do this, but none of them have yet completed a sample of innovations that is comprehensive, representative and international. In Table 3.1, we present some country-share data based on a list of 1,012 major inventions, discoveries and innovations since 1750, based on Streit, as reported in Pavitt and Soete (1982). This is one of the rare lists which identifies the country of origin. We limited the sample to primarily technical inventions and innovations, excluding major 'social innovations' for which the definitional problems appeared too severe.

Compiled shortly after the Second World War, Table 3.1 is probably biased towards the United States. Nevertheless, the picture which

Table 3.1 Major inventions, discoveries and innovations by country, 1750–1950 (as a percentage of total)

Period	Total	Inventions, discoveries and innovations (Percentage of total)				
		Britain	France	Germany	United States	Others
1750–75	30	46.7	16.7	3.3	10.0	23.3
1776–1800	68	42.6	32.4	5.9	13.2	5.9
1801–25	95	44.2	22.1	10.5	12.6	10.5
1826–50	129	28.7	22.5	17.8	22.5	8.5
1851–75	163	17.8	20.9	23.9	25.2	12.3
1876–1900	204	14.2	17.2	19.1	37.7	11.8
1901–25	139	13.7	9.4	15.1	52.5	9.4
1926–50	113	11.5	0.9	12.4	61.9	13.3

Source: Calculated from Streit, 1949.

emerges is consistent with what we know from economic historians: the very strong position of the United Kingdom as the major innovating country in the period 1750–1825, which very rapidly saw its position challenged by both the United States and Germany by the middle of the late nineteenth century; the overall decline of France from the middle of the nineteenth century until 1950; and the emergence in the twentieth century, of the United States as the major technological power, leading to a huge technological gap between the United States and Europe. As for the other countries, their innovative activity in terms of major innovations, inventions or discoveries has remained relatively limited, with the partial exception of Sweden and Switzerland.

Using an alternative technology indicator, we present in Table 3.2 the share of each of a number of OECD countries in the total number of foreign patents granted in the United States over the period 1883–1986. With the exception of Canada, whose proximity to the United States overstates its importance, Table 3.2 shows a similar pattern to Table 3.1: the long-term decline of the United Kingdom only temporarily halted by the First and Second World Wars; and the steadily growing importance of Germany as a technological power which, after the Second World War, returned to its pre-War patenting level in less than nine years. It also shows the emergence of Italy, the Netherlands, Sweden and Switzerland with larger shares in the twentieth century, and a somewhat increased share for France since the Second World War.

But the most striking change in patent share relates to Japan. Its level of innovative activity, as measured by the number of US patents granted, remained until the 1920s among the lowest of all OECD countries; and it was only in the late 1950s and 1960s that, after having returned by 1957 to its pre-War patenting level, its share of foreign US patents started to grow very rapidly. In 1986, the latest year for which data were available, Japan was the major foreign country patenting in the United States, accounting for more than 40 per cent of total US patents of foreign origin.

Apart from Japan, there have been no newcomers to the very select group of world innovators. The share of Eastern Europe and the USSR has remained small throughout the twentieth century. What are now called the newly industrialising countries (NICs) have increased their share slightly, but it remains very small.

In terms of R&D expenditures, a similar picture emerges. Figure 3.1 shows industrial R&D shares for a number of OECD countries for 1967 and 1987, the latest year for which international comparable R&D data were available. As in Table 3.2, the increase in the Japanese share is worth noting. But it is the decline in the US share which is probably the most striking feature of Figure 3.1. In 1967, the United States was

Table 3.2 Patents granted in the United States by country of origin, 1883–1986 (as a percentage of all foreign patenting)

Country	1883	1890	1900	1913	1929	1938	1950	1958	1965	1973	1979	1986
Australia	1.11	1.20	2.33	1.97	1.96	1.18	1.54	0.60	0.94	0.92	1.12	1.14
Austria	2.62	3.37	3.36	3.99	2.47	2.91	0.48	1.12	1.16	1.02	1.19	1.09
Belgium	1.59	0.86	1.35	1.28	1.30	1.23	1.07	1.14	1.50	1.23	0.98	0.74
Canada	19.94	17.63	10.54	13.22	10.25	6.35	11.16	7.99	7.00	6.20	4.56	4.01
Denmark	0.56	0.38	0.46	0.67	0.71	0.71	1.36	0.74	0.74	0.70	0.56	0.56
France	14.22	8.46	9.79	8.07	9.76	9.23	15.54	10.36	10.90	9.38	8.46	7.22
Germany	18.67	21.47	30.72	34.02	32.36	38.18	0.57	25.60	26.40	24.25	23.87	20.80
Italy	0.24	0.29	0.92	1.31	1.91	1.43	0.86	3.02	3.38	3.39	3.14	3.05
Japan	0.16	0.10	0.03	0.45	1.40	1.51	0.03	1.93	7.43	22.10	27.69	40.35
Netherlands	0.24	0.29	0.75	0.47	1.57	3.38	8.10	5.71	4.15	3.03	2.80	2.20
Norway	0.32	0.14	0.49	0.74	0.71	0.54	0.95	0.61	0.42	0.42	0.43	0.25
Sweden	0.95	1.52	1.32	2.07	3.19	3.13	6.67	4.64	4.50	3.40	3.02	2.70
Switzerland	1.75	2.66	2.27	3.11	4.46	3.72	9.73	8.80	6.97	5.79	5.40	3.70
United Kingdom	34.55	36.15	30.52	23.29	22.23	22.70	36.00	23.45	20.62	12.56	10.07	7.37
Eastern Europe including USSR	0.40	0.67	1.49	1.19	1.62	1.61	1.23	0.55	0.89	2.53	2.76	1.13
NICs	0.40	1.19	1.12	1.21	1.03	0.90	1.41	1.31	1.71	1.36	1.45	1.50
Others	3.28	3.62	2.54	2.94	3.07	1.29	3.28	2.43	1.29	1.72	2.50	2.19

Source: Calculated from US Department of Commerce (OTAF, 1977, 1980).

still responsible for more than two-thirds of total OECD R&D expenditures, which is consistent with the 1950 figure obtained for our sample of major inventions and innovations in Table 3.1. By 1987, this figure had dropped to just under 53 per cent. Nevertheless, as in the case of major innovations and international patenting, R&D expenditure is and has remained highly concentrated, with the five major OECD countries responsible for more than 94 per cent of the total in 1987.

In contrast to the patent data, the R&D expenditures data also illustrate the very rapid growth of such activities in the NICs. In terms of R&D/GDP ratios, some of these countries, such as South Korea or Taiwan, now have ratios above those of many OECD countries.

In the next section we go somewhat deeper into differences and complementarities between both indicators.

R&D and patenting: what do these indicators tell us?

A meaningful use of technological indicators depends of course on an understanding of the relationship between them, and of their economic significance. Our basic hypothesis is that both R&D and patent statistics show different aspects of the same process of industrial *innovation*. This is somewhat different from the assumption that, since patents by definition involve novelty, and since invention is defined as novelty, patents capture and measure the earlier stages of a process that leads from novelty/invention, through development, testing and engineering, to full-scale innovation.

Such a view neglects the fact that, as Schumpeter pointed out, the essential process for the industrial firm is innovation, not invention. Patents can thus be viewed as one of the means by which entrepreneurs protect their innovations. Or, to put it another way, patents are means by which entrepreneurs try to augment the monopoly profits from innovation by making it more difficult for potential competitors to copy or imitate. Other methods of discouraging imitation involve secrecy, further technological advance based on firm-specific R&D and skill, influence over suppliers or marketing outlets and manipulation of standards. Patenting activity may extend over the whole of the product lifecycle: from the patents protecting the basic invention, through those related to product and process engineering, to a myriad of improvement and blocking patents. What concern us here are the relationships between industrial R&D activity, patenting and innovation. In interpreting the data, we shall have two working hypotheses in mind.

First, in spite of the many perversities (real and imagined) of imperfect and oligopolistic competition, it is implausible that a firm would

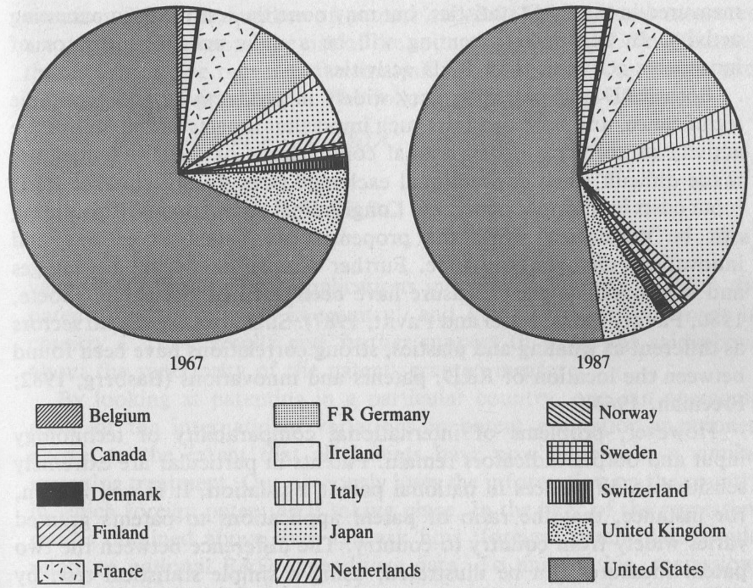


Figure 3.1 Research and development expenditures in the business enterprise sector as a percentage of the OECD-total (1967 and 1987)

commit resources to R&D and to patenting activities in order not to innovate. It might not wish to be the first to innovate; it might even wish to control or to delay the innovation process. But eventually it knows that it will have to innovate. In other words, we argue that R&D activities and patenting activities are positively related to innovative activities.

Second, we suggest that R&D and patenting activities are also positively related to each other; in other words, that they are complementary activities in the sense that higher or lower R&D activities are reflected in higher or lower patenting activities. However, we recognise that R&D and patent activities are not always perfect reflections of each other. The results of R&D activity may not be patented because secrecy is felt to be a better protection than patenting or because its results are in the form of unpatentable know-how (especially in relation to production and to systems design); in this case R&D will be a more reliable indicator of innovative activity than patenting. On the other hand, innovative activities undertaken outside formal R&D institutions may not be measured in the R&D statistics, but may none the less result in patenting activity. In this case, patenting will be a more reliable indicator of innovative activities than R&D activities.

Both R&D and patenting vary widely in productivity and economic significance, and both can miss such important aspects of the innovative activity as software. International comparisons of R&D activities are made difficult when conventional exchange rates do not equalise R&D input costs in different countries. Longitudinal comparisons of patenting can be misleading when the propensity to patent inventions and innovations changes over time. Further discussions of the advantages and drawbacks of each measure have been pursued elsewhere[1] (Soete, 1980; Pavitt, 1985a; Patel and Pavitt, 1987). Suffice to say that in sectors as different as whaling and plastics, strong correlations have been found between the location of R&D, patents and innovations (Basberg, 1982; Freeman, 1963).

However, problems of international comparability of technology input and output indicators remain. Patents in particular are extremely sensitive to differences in national patent legislation. It is well known, for instance, that the ratio of patent applications to patents granted varies widely from country to country. The difference between the two patent measures can be illustrated, using a simple statistical test, by relating both measures to R&D expenditures. Alternatively, using as dependent variables the number of domestic patent applications and the number of domestic patents granted, we regressed these variables, with intramural R&D expenditure in the business sector as the independent variable, for a number of years.[2]

The following results were obtained:[3]

$$PA_i = 7129.05 + \underset{(1.10)}{3.11}\ R\&D_i \qquad R_2 = 0.29 \quad F(1,16) = 8.07 \qquad (3.1)$$

$$PG_i = 1525.29 + \underset{(0.20)^*}{1.75}\ R\&D_i \qquad \bar{R}_2 = 0.81 \quad F(1,16) = 75.20^* \qquad (3.2)$$

where PA_i is the number of patent applications in country i, PG_i is the number of patents granted in country i and $R\&D_i$ the amount spent on R&D in the business enterprise sector in country i. The results suggest that, not surprisingly, the patents-granted measure is a better technology output indicator. For example, in terms of patent applications, Japan would be by far the most technologically advanced country, twice as advanced as the United States and four times as advanced as Germany, as compared to an estimated R&D expenditure figure of only a fourth of the US figure. In terms of patents granted, though, Japan's patent figure falls back to just below the US figure.

One should, however, remain cautious about such simple regression

exercises. Both the number of patents and R&D expenditure measures are partly a function of the size of the countries considered. To eliminate this influence, we repeated the analysis, dividing both the patent and R&D figures by population. The following results were obtained:

$$PAC_i = 0.099 + \underset{(1.23)}{3.66}\ R\&DC_i \qquad \bar{R}_2 = 0.32 \quad F(1,16) = 8.87 \qquad (3.3)$$

$$PGC_i = 0.001 + \underset{(0.34)^*}{2.25}\ R\&DC_i \qquad \bar{R}_2 = 0.72 \quad F(1,16) = 43.83^* \qquad (3.4)$$

where PAC_i is the patent-applications intensity in country i, PGC_i the patents-granted intensity in country i and $R\&DC_i$ the R&D intensity in country i. These results give further support to what was said above about the superiority of the patents-granted measure.

By looking at patenting in a particular country, one can overcome some of the international variations in patent evaluation mentioned above, to the extent that all patents have now undergone a similar screening treatment. One obviously loses the information on the country in which foreign patenting is taking place. In the light of the regression results obtained above, one can ask how 'foreign' patent data would relate to national R&D expenditure data. To answer this, regressions identical to the ones above were carried out using foreign patents granted and foreign patents granted per capita as dependent variables and the same R&D expenditure data as independent variables.

Data limitations forced us to sacrifice two countries (Iceland and Portugal); however we now also had patent data for Italy. The sample thus consisted of the seventeen major OECD countries, each time, however, excluding the country in which foreign patenting was taking place. Patenting of foreign origin in the United States, Japan, France, Germany and the United Kingdom was analysed.

The following results were obtained:

In the United States:

$$FP_i = -18.51 + \underset{(0.46)^*}{0.965}\ R\&D_i \qquad \bar{R}_2 = 0.97 \quad F(1,14) = 444.59^* \qquad (3.5)$$

$$FPC_i = -0.01 + \underset{(0.076)^*}{1.143}\ R\&DC_i \qquad \bar{R}_2 = 0.94 \quad F(1,14) = 228.79^* \qquad (3.6)$$

In Japan:

$$FP_i = 28.15 + \underset{(0.004)^*}{0.151}\ R\&D_i \qquad \bar{R}_2 = 0.99 \quad F(1,14) = 1291.22^* \qquad (3.7)$$

$$FPC_i = -0.004 + \underset{(0.025)^*}{0.245}\ R\&DC_i \qquad \bar{R}_2 = 0.86 \quad F(1,14) = 92.63^* \qquad (3.8)$$

In France:

$$FP_i = 499.61 + 0.240\ R\&D_i \qquad \bar{R}_2 = 0.73$$
$$(0.038)^* \qquad F(1,14) = 41.07^* \qquad \textbf{(3.9)}$$

$$FPC_i = -0.019 + 0.977\ R\&DC_i \qquad \bar{R}_2 = 0.71$$
$$(0.159)^* \qquad F(1,14) = 37.71^* \qquad \textbf{(3.10)}$$

In Germany:

$$FP_i = 227.97 + 0.127\ R\&D_i \qquad \bar{R} = 0.84$$
$$(0.014)^* \qquad F(1,14) = 80.63^* \qquad \textbf{(3.11)}$$

$$FPC_i = -0.012 + 0.585\ R\&DC_i \qquad \bar{R}_2 = 0.74$$
$$(0.094)^* \qquad F(1,14) = 38.79^* \qquad \textbf{(3.12)}$$

In the United Kingdom:

$$FP_i = 978.97 + 0.073\ R\&D_i \qquad \bar{R} = 0.01$$
$$(0.068) \qquad F(1,14) = 1.4 \qquad \textbf{(3.13)}$$

$$FPC_i = -0.013 + 0.991\ R\&DC_i \qquad \bar{R}_2 = 0.68$$
$$(0.174)^* \qquad F(1,14) = 32.43^* \qquad \textbf{(3.14)}$$

where FP_i is the number of foreign patents granted to each country i, and FPC_i the foreign-patent intensity of each country in the United States, Japan, France, Germany and the United Kingdom respectively. With the exception of the United Kingdom, these results suggest that foreign patenting is a more 'reliable' technology output proxy than domestic patenting.

Particularly in the case of the United States, good results between foreign patenting and domestic R&D expenditures were obtained, both in absolute as well as in per capita terms.

The good results obtained here using US foreign patenting as a technology output indicator supports the use of this innovation proxy in a number of earlier studies,[4] where foreign patenting in the United States was used as a direct measure of international innovative performance. The United States as a major technology 'market' indeed appears to be a good mirror of the OECD or world technology market.

The analysis presented has been based on patent data collected and published by the World Intellectual Property Organisation (WIPO) and OECD R&D data. It might be useful to verify whether the results obtained above in relation to foreign patenting in the United States also hold for US patent data.

Results are given in equations (3.15)–(3.18):

$$FP_i = 4.97 + 0.735\ R\&D_i \qquad \bar{R}_2 = 0.97$$
$$(0.034)^* \qquad F(1,13) = 476.40^* \qquad \textbf{(3.15)}$$

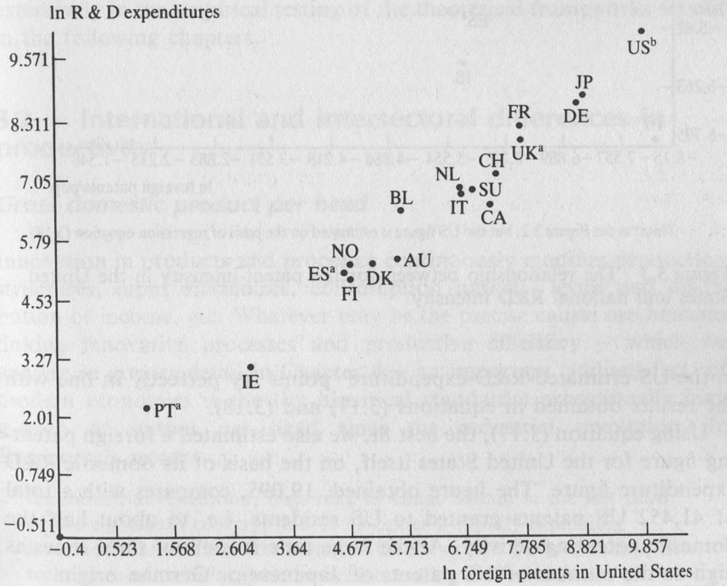
$$FPC_i = -0.005 + 0.825\ R\&DC_i \qquad \bar{R}_2 = 0.93$$
$$(0.061)^* \qquad F(1,13) = 187.44^* \qquad \textbf{(3.16)}$$

$$\ln FP_i = -1.06 + 0.966 \ln R\&D_i \qquad \bar{R}_2 = 0.98$$
$$(0.040)^* \qquad F(1,13) = 591.89^* \qquad \textbf{(3.17)}$$

$$\ln FPC_i = -0.62 + 0.902 \ln R\&DC_i \qquad \bar{R}_2 = 0.90$$
$$(0.079)^* \qquad F(1,13) = 120.14^* \qquad \textbf{(3.18)}$$

The graphical representation of the results obtained in equations (3.17) and (3.18), shown in Figures 3.2 and 3.3, illustrates the 'neatness' of the fit well.

The United Kingdom's, Spain's and Portugal's 'number-of-patents-



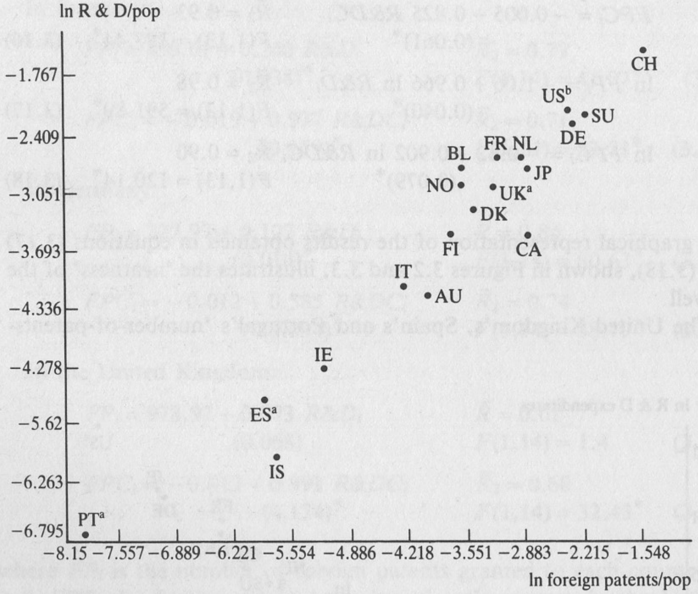
Notes:

Countries: CA = Canada, US = United States of America, JP = Japan, AU = Australia, BL = Belgium - Lux., DK = Denmark, FI = Finland, FR = France, DE = Germany, IS = Iceland, IE = Ireland, IT = Italy, NL = The Netherlands, NO = Norway, PT = Portugal, ES = Spain, SU = Sweden, CH = Switzerland, UK = United Kingdom.

[a] Portugal, Spain and the United Kingdom are represented here on the basis of estimated 1977 R & D expenditure.

[b] The US figure is estimated on the basis of regression equation (3.17).

Figure 3.2 The relationship between foreign patenting in the United States and national R&D expenditure



Note: as for Figure 3.2, but the US figure is estimated on the basis of regression equation (3.18).

Figure 3.3 The relationship between foreign patent-intensity in the United States and national R&D intensity

in-the-US-estimated-R&D-expenditure' points lay perfectly in line with the results obtained in equations (3.17) and (3.18).

Using equation (3.17), the best fit, we also estimated a foreign patenting figure for the United States itself, on the basis of its domestic R&D expenditure figure. The figure obtained, 19,095, compares with a total of 41,452 US patents granted to US residents, i.e. to about half the domestic patenting activity. At the same time it is about three times as high as the number of US patents of Japanese or German origin.

This short empirical exploration of R&D and patenting across countries and through time allows us to draw a number of empirical and methodological conclusions.

First, it shows a highly diversified distribution of innovative capabilities, however measured, between countries. The number of participants to the 'club of innovators' is rather small and relatively stable through time. Following a predominant British position from the time of the industrial revolution, the United Kingdom was joined in the second part

of the nineteenth century by a small group of Western countries (Germany, the United States, France, etc.), while the only major newcomer in the post-War period has been Japan. In most recent times, one or two NICs – in particular South Korea – might also have joined this still very select club. For our purpose, this differentiated pattern of innovative capabilities corresponds to an equally differentiated distribution of country-specific advantages/disadvantages which demand a theoretical explanation: What determines them? How are they being reproduced? What explains different trends in different countries?

Second, on more methodological grounds, despite many of the shortcomings of the patent concept, the above analysis supports the robustness of the variable 'patenting in the United States' as proxy for the relative innovative capability of a country in empirical analyses of technological change and innovation. Consequently, we shall use it extensively in the empirical testing of the theoretical frameworks set out in the following chapters.

3.2 International and intersectoral differences in productivity

Gross domestic product per head

Innovation in products and processes continuously modifies production structures, input efficiencies, consumption baskets, levels and distribution of income, etc. Whatever may be the precise causal mechanisms linking innovative processes and productive efficiency – which we analyse in greater detail in Chapter 4 – an important 'stylised fact' of modern economies is the (by historical standards) exceptionally high growth of output per head since the industrial revolution. In Rosenberg's words:

> the industrial revolution, beginning in Great Britain in the last third of the eighteenth century, had at its center a rapidly expanding armamentarium of new technologies involving new power sources, new techniques of metallurgy and machine-making and new modes of transportation. These new technologies, when successfully organised and administered, brought in their wake immense improvements in productivity which eventually transformed the lives of all participants. (Rosenberg, 1984, p. 9)

This process of industrialisation, analysed by classical economists such as Smith and Marx and by modern economic historians including, among others, Rosenberg himself and Landes,[5] spread unevenly across a relatively small group of countries in Europe, the United States and, later, Japan. The national specificities in the timing, intensity and success in industrialisation and development correspond to distinguishable levels and patterns of evolution of productivities and incomes. The persistent difference in the levels and rates of growth of output per head and per man hour is a fundamental feature of industrialised economies and, *a fortiori*, of the whole set of developed and developing countries.

The measurement problems involved in any comparison over time and across countries of 'the amount of product per unit of labour input' are of course formidable. Any estimating procedure is bound to involve high degrees of 'informed guesswork'. None the less, one may still obtain useful information on the orders of magnitude and approximate pace of change. Tables 3.3 and 3.4, taken from Maddison (1987), show the patterns over a century in GDP per man hour for sixteen countries. It is difficult to rely on the precise values of the estimates. However, it is striking that these productivity gaps, even within the group of OECD countries, have remained persistently high. Moreover, the only period of evident convergence appears to have been after the Second World War. The century from 1870 to 1970 also witnessed a changing world leadership among the major countries, from the United Kingdom to the United States, which took the lead around the turn of the century.

Table 3.3 Comparative levels of productivity, 1870–1985 (US GDP per man hour = 100)

	1870	1890	1913	1938	1950	1973	1979
Australia	186	153	102	89	72	73	78
Austria	61	58	54	(47)	29	62	71
Belgium	106	96	75	70	50	75	88
Canada	87	81	87	67	78	87	85
Denmark	63	58	60	60	43	63	64
Finland	41	35	43	44	35	63	64
France	60	55	54	64	44	76	86
Germany	61	58	57	56	33	71	84
Italy	63	44	43	49	32	66	70
Japan	24	(23)	22	33	14	46	53
Netherlands	106	(92)	74	68	53	81	90
Norway	57	53	49	62	48	69	80
Sweden	44	42	50	59	55	79	81
Switzerland	79	70	60	70	52	62	62
United Kingdom	114	100	81	70	56	64	66
United States	100	100	100	100	100	100	100
Arithmetic average of 15 countries (excluding the United States)	77	68	61	61	46	69	75

Source: Maddison (1982), p. 98.

Table 3.4 Productivity growth (GDP per man hour), 1870–1979

	Annual average compound growth rate				
	1870–1913	1913–50	1950–73	1973–9	1870–1979
Australia	0.6	1.6	2.6	2.6	1.5
Austria	1.7	0.9	5.9	3.8	2.4
Belgium	1.2	1.4	4.4	4.2	2.1
Canada	2.0	2.3	3.0	1.0	2.3
Denmark	1.9	1.6	4.3	1.6	2.3
Finland	2.1	2.0	5.2	1.7	2.7
France	1.8	2.0	5.1	3.5	2.6
Germany	1.9	1.1	6.0	4.2	2.6
Italy	1.2	1.8	5.8	2.5	2.4
Japan	1.8	1.3	8.0	3.9	3.0
Netherlands	1.2	1.7	4.4	3.3	2.1
Norway	1.7	2.5	4.2	3.9	2.6
Sweden	2.3	2.8	4.2	1.9	2.9
Switzerland	1.4	2.1	3.4	1.3	2.1
United Kingdom	1.2	1.6	3.1	2.1	1.8
United States	2.0	2.6	2.6	1.4	2.3
Arithmetic average	1.6	1.8	4.5	2.7	2.4

Source: Maddison (1982), p. 96.

The pace of change in the aggregate productivity gap between countries seems to have accelerated in the post-War period, with every country reducing the gap between itself and the United States, as compared to the 1950 values. Among the countries catching up, Japan shows the most striking performance.

In earlier work (Pavitt and Soete, 1982), we showed that increases in the 1960s and 1970s in countries' productivity levels relative to the world frontier, were associated with increases in innovative activities, measured in terms of R&D expenditure and foreign patenting. More recently, Fagerberg (1987, 1988b) has shown strong correlations between countries' levels of GDP per capita, and their levels of innovative activities. He has also explained international differences in growth rates between 1960 and 1983 in terms of each country's scope for catching up with world best-practice productivity, its investment share, and its rate of increase of technological activities.

Manufacturing

Figures on aggregate output are necessarily impressionistic. A somewhat more accurate picture can be gathered by looking at manufacturing. First, its degree of international openness guarantees smaller international price differences than for the economy as a whole. Second, a separate treatment of manufacturing and, even more so, of a set of manufacturing subsectors, reduces the problems of biases stemming from a simple 'composition effect'. Third, and more importantly, manufacturing is both the major source and the primary field for economic application of technical change.

The construction of internationally comparable labour productivity estimates, even those that are limited to manufacturing, remains heroic by any standard. In particular, the problem of comparability remains severe. It is related to possible international differences in price levels (expressed in current exchange rates), different prices of intermediate inputs, different product mixes, different degrees of vertical integration (and thus different ratios of value added to output), etc. Ideally, one would have liked some kind of 'physical' measure of output with precise weights for the commodity mix. These problems can be partially dealt with in the case of time series by means of the 'double deflation' procedure which yields the value-added deflator.[6] In terms of international comparisons, however, equivalents of double deflators are not generally available.[7]

Straightforward utilisation of the detailed analysis undertaken by Kravis *et al.*[8] on purchasing power parities is not possible either, since the latter produces estimates which may not bear any simple relationship with producer prices and costs. On the other hand, the instability of exchange rates over the most recent period is likely to lead to significant biases in international comparisons of value added per employee.[9]

One must also be aware of the fact that labour productivity indices in multiproduct sectors are a synthetic indicator both of labour productivities in each product and of the mix between high-value-added and low-value-added products.[10] Such indicators, even for our purposes, are nevertheless still useful in two senses. First, from a behavioural point of view, changing product mixes towards higher value-added products and improving labour productivity on existing lines of products are sometimes alternative strategies, both of which represent 'technological upgrading' by microeconomic units. Second, and as a consequence, the resulting proxy for labour productivity at each level of disaggregation is a 'mixed' indicator of output in terms of value added, irrespective of whether it is obtained through high 'physical' productivity, or through the manufacturing of products that yield a higher value added (e.g. through a higher 'use value' compared to competing products).[11]

With these caveats in mind, let us consider the patterns of manufacturing value added per employee in a sample of developed and developing countries. These are shown in Figure 3.4, calculated at current exchange rates and based on 1977–80 averages. Figure 3.4 also indicates comparable proxies for capital/labour and capital/output

ratios.[12] Below, we present a number of regression equations, correlating the intercountry variation in level of development, manufacturing labour productivity, capital intensity, capital/output ratios, wages and profit margins.

$$\pi = 40.15 - 113.62\,(K/Y) \quad \bar{R}_2 = 0.37 \quad F = 7.17 \quad n = 14 \qquad (3.20)$$
$$(-2.678)$$

$$\ln K/Y = -1.955 - 0.237\,\ln(K/N) \quad \bar{R}_2 = 0.04 \quad F = 0.72 \quad n = 19 \qquad (3.21)$$
$$(-0.859)$$

$$K/Y = 0.159 - 0.004\,(GDP/N) \quad \bar{R}_2 = 0.07 \quad F = 1.20 \quad n = 19 \qquad (3.22)$$
$$(-1.10)$$

$$\ln \pi = -0.876 + 0.870\,\ln(GDP/N) \quad \bar{R}_2 = 0.86 \quad F = 84.3 \quad n = 14 \qquad (3.23)$$
$$(9.186)^{*}$$

$$\ln K/N = -0.04 + 0.297\,\ln(GDP/N) \quad \bar{R}_2 = 0.45 \quad F = 13.7 \quad n = 19 \qquad (3.24)$$
$$(3.704)$$

$$\ln \pi = 2.384 + 1.36\,\ln(K/N) \quad \bar{R}_2 = 0.66 \quad F = 22.7 \quad n = 14 \qquad (3.25)$$
$$(4.774)^{*}$$

where

π = value added per employee (1977–80 averages at current prices and exchange rates);

GDP/N = per capita income (1970–80 average at current prices and exchange rates);

K/N = gross fixed capital investment per employee (1968–80 averages divided by one plus the average rate of growth of manufacturing output at constant prices over the period);

K/Y = gross fixed capital investment per output (1968–80 averages divided by one plus the average rate of growth of manufacturing output at constant prices over the period);

$$K/Y = 0.152 - 0.0029w \quad \bar{R}_2 = 0.04 \quad F = 0.72 \quad n = 16 \qquad (3.26)$$
$$(-0.86)$$

$$m = 0.482 + 0.214\ (K/Y) \quad \bar{R}_2 = 0.005 \quad F = 0.08 \quad n = 18 \tag{3.27}$$
$$(0.29)$$

$$w = 0.358 + 1.094\ (GDP/N) \quad \bar{R}_2 = 0.79 \quad F = 55.2 \quad n = 16 \tag{3.28}$$
$$(7.43)^*$$

$$m = 0.652 - 0.24\ (GDP/N) \quad \bar{R}_2 = 0.25 \quad F = 5.42 \quad n = 18 \tag{3.29}$$
$$(2.33)$$

where

w = wages and supplementary benefits per employee (1968–80 averages); and
m = one minus the ratio of wages and benefits to value added (1968–80 averages)

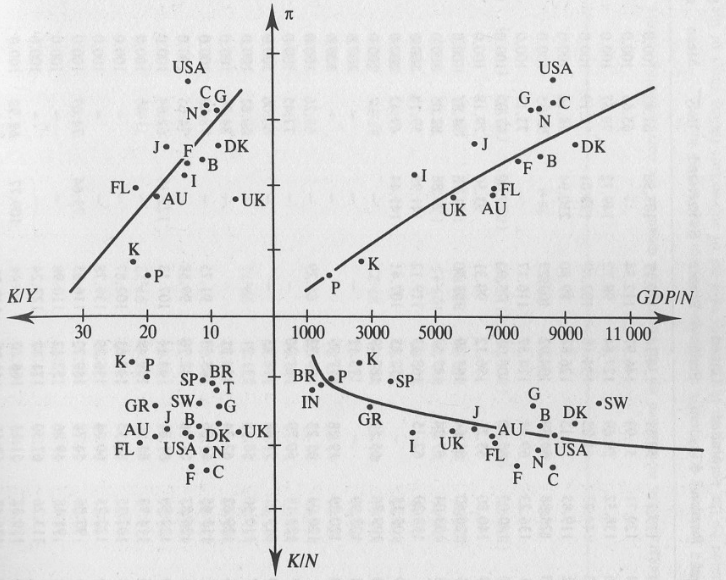
Analysis of the trends in these various proxies and their correlation with levels of per capita income point to the following broad relations.

First, and not surprisingly, there is a strong correlation between inter-country differences in levels of manufacturing labour productivity and levels of per capita income (equation (3.23)).

Second, the differences between countries in productivity in manufacturing are bigger than for the economy as a whole (compare the right-hand top quadrant of Figure 3.4 with the last two rows of Table 3.5 for those countries included in both samples). In other words, the activity of the economy – manufacturing – where a large part of innovations are generated and used, is also the one where the international diffusion of technology does not easily keep pace with the generation of innovations, thus leading to relatively wide productivity gaps between countries.

Third, both per capita incomes and manufacturing productivities are strongly correlated with the levels of capital accumulation, and 'mechanisation' as approximated by investment/labour ratios (equations (3.24) and (3.25)). These positive relations show 'increasing returns' of accumulation in terms of productivity. In our interpretation, this would tend to suggest that increasing levels of development are associated with a set of dynamic and static economies of scale, positive externalities, and increasing innovative capabilities, as argued more recently in the so-called 'new' growth tradition by Romer (1987, 1990) and Lucas (1988). This feature makes the differential efficiency of the advanced countries more than proportional to the differential degrees of capital accumulation.

The same property holds in relation to the capital/output ratios



Notes:
π = value added per employee (1977–80 averages at current prices and exchange rates).
GDP/N = per capita income (1970–80 average at current prices and exchange rates).
K/N = gross fixed capital investment per employee (1968–80 averages divided by one plus the average rate of growth of manufacturing output at constant prices over the period).
K/Y = gross fixed capital investment per output (1968–80 averages divided by one plus the average rate of growth of manufacturing output at constant prices over the period).
Countries: USA = United States of America, N = The Netherlands, G = West Germany, DK = Denmark, B = Belgium, F = France, J = Japan, SW = Sweden, FL = Finland AU = Austria, UK = United Kingdom, I = Italy, SP = Spain, GR = Greece, K = South Korea, BR = Brazil, T = Turkey, P = Portugal, IN = India.
Source: elaboration on UN, *Yearbook of Industrial Statistics*, various years, and national sources.

Figure 3.4 Labour productivity, capital/labour and capital/output ratios (manufacturing, 1968–80)

(equation (3.20)). Higher levels of manufacturing productivity are associated with lower capital/output ratios, or higher capital productivity rather than lower capital productivity – as one would expect from a traditional production-function model. Higher degrees of development are, in other words, associated with both higher labour productivity and higher capital productivity. This is consistent with the finding that higher-growth countries in the post-War period are generally

Table 3.5 Labour productivity by country and by sector, 1977–8 (unweighted mean = 100)

ISIC	Austria	Belgium	West Germany	Japan	Norway	Netherlands	Portugal	Sweden	United Kingdom	United States	France	Switzerland	Italy	Mean	Standard deviation
330	95.93	120.29	166.08	80.95	–	134.67	19.74	115.21	53.51	134.14	110.17	107.88	61.42	100.0	38.74
3312	72.79	185.67	131.64	51.80	–	130.05	21.24	129.71	51.93	146.97	112.54	–	65.65	100.0	47.91
32	78.52	95.80	136.60	51.40	106.56	149.58	27.96	138.52	59.69	127.84	98.72	149.12	79.67	100.0	37.81
321	79.19	102.26	141.19	58.46	103.18	151.45	27.10	144.23	61.85	134.18	102.69	122.01	72.19	100.0	36.87
322	76.93	91.35	129.69	43.17	113.02	132.28	25.82	119.85	52.15	126.84	89.80	210.94	88.16	100.0	45.90
323	78.76	–	140.81	–	99.72	115.83	37.96	128.88	64.89	134.92	103.29	–	94.35	100.0	30.90
324	80.95	134.71	126.92	76.78	104.94	141.36	24.31	136.23	69.88	114.57	116.17	–	73.17	100.0	33.80
33	80.63	126.63	157.40	121.80	120.83	100.88	20.31	140.05	65.40	106.08	75.92	117.02	67.03	100.0	35.55
34	82.92	94.80	132.12	78.03	93.10	(161.41)	32.48	140.80	65.21	156.12	90.31	93.50	79.18	100.0	35.95
341	85.53	102.84	139.52	91.93	83.46	131.45	42.45	126.40	61.64	165.49	102.70	91.78	74.81	100.0	32.33
342	79.50	93.91	122.56	70.04	100.47	161.15	24.48	158.04	67.34	145.57	–	94.88	82.05	100.0	38.91
35	63.68	85.42	160.03	121.94	82.60	22.19	–	118.20	62.15	163.53	119.12	141.95	59.18	100.0	42.39
351	56.09	–	143.19	72.19	62.99	167.60	22.39	105.15	–	172.13	107.41	141.44	49.42	100.0	48.70
3511	–	–	143.04	59.07	74.27	141.28	23.50	109.76	65.59	183.49	–	–	–	100.0	49.99
3512	–	–	–	71.86	78.44	127.59	18.03	128.99	–	175.11	–	–	–	100.0	50.36
3513	71.58	–	102.13	139.33	–	–	29.99	120.29	59.28	177.39	–	–	–	100.0	46.78
352	70.71	–	150.70	119.97	89.60	131.25	26.21	120.04	65.23	189.72	68.29	–	68.26	100.0	44.75
3521	–	–	–	–	86.40	146.95	41.27	125.18	60.79	161.96	–	–	77.45	100.0	42.02
3522	64.21	–	146.08	136.26	86.14	123.14	20.39	119.21	71.64	172.85	–	–	60.06	100.0	44.57
3523	–	–	146.54	63.68	79.48	123.02	25.47	110.50	58.58	231.91	–	–	60.81	100.0	58.45
3529	–	–	–	93.10	117.52	131.91	26.45	129.62	62.24	154.31	–	–	84.86	100.0	39.15
355	84.91	106.67	136.41	111.98	87.70	129.05	33.37	113.45	61.06	165.57	91.75	–	78.08	100.0	33.82
356	74.55	–	119.24	105.86	98.11	162.58	34.13	126.83	61.76	142.70	99.58	–	74.65	100.0	35.62
36	83.95	89.88	132.47	78.29	121.64	146.08	26.59	122.99	61.81	144.14	107.13	122.18	62.84	100.0	34.78
361	94.35	–	123.73	69.81	113.48	150.86	31.96	114.73	61.60	139.48	–	–	–	100.0	36.75
362	68.88	–	115.46	121.39	96.38	161.14	22.64	107.25	66.35	137.63	102.87	–	–	100.0	37.43
369	81.67	–	136.42	72.84	122.83	–	26.68	122.75	60.74	136.29	139.78	–	–	100.0	38.38
37	66.49	83.59	125.82	148.21	–	163.01	36.16	97.06	54.78	159.73	116.85	73.64	74.67	100.0	40.49
371	62.23	–	121.44	174.17	–	–	38.02	91.18	49.86	152.12	110.98	–	–	100.0	45.63
372	84.17	–	134.18	74.25	107.65	–	25.27	113.26	67.50	171.47	127.24	–	–	100.0	40.49
38	81.79	111.55	144.76	96.28	100.77	–	27.50	130.32	61.13	166.20	–	109.77	69.92	100.0	37.60
381	82.02	–	131.90	58.64	108.31	133.91	29.19	126.42	62.60	148.27	147.00	–	71.73	100.0	38.99
3813	–	–	151.49	–	98.83	112.54	20.31	114.53	71.97	130.33	–	–	–	100.0	39.78
382	79.80	–	139.89	126.58	97.47	125.99	15.95	118.07	61.80	158.44	98.84	–	77.16	100.0	38.35
3822	–	–	112.07	52.15	–	125.64	27.57	–	87.18	195.39	–	–	–	100.0	54.16
3823	–	–	127.76	74.73	99.42	137.08	23.41	118.07	61.60	157.92	–	–	–	100.0	41.54
3824	–	–	130.55	63.25	–	118.06	25.48	130.99	65.37	166.30	–	–	–	100.0	45.85
3825	–	–	190.83	–	–	–	15.55	70.81	51.60	123.97	–	–	–	100.0	59.70
3829	–	–	141.42	–	97.43	122.32	22.58	114.87	57.36	144.02	–	–	–	100.0	41.73
383	81.33	–	138.90	83.73	120.60	153.33	32.43	122.18	56.96	147.42	91.22	–	71.90	100.0	37.44
3831	–	–	130.98	–	117.26	118.85	29.42	98.86	61.98	142.64	–	–	–	100.0	37.53
3832	72.14	–	159.89	–	114.27	–	28.34	126.03	55.11	144.23	–	–	–	100.0	45.28
3833	–	–	129.74	93.65	93.56	–	34.40	136.52	46.74	165.40	–	–	–	100.0	44.27
3839	–	–	120.33	–	115.95	–	37.20	105.40	–	121.12	–	–	–	100.0	31.89
384	75.67	–	144.43	116.15	–	108.60	28.90	131.21	54.27	173.53	99.74	–	67.49	100.0	41.81
3841	63.60	–	130.69	78.60	–	133.91	35.69	165.75	57.46	134.29	–	–	–	100.0	43.76
3843	69.73	–	135.45	108.08	–	107.10	27.04	133.07	51.58	167.94	–	–	–	100.0	44.25
3844	–	–	141.27	–	–	114.68	30.85	114.92	56.19	136.08	–	–	–	100.0	39.48
3845	–	–	100.36	106.18	103.93	–	–	97.81	43.87	147.84	–	–	–	100.0	30.27
3849	–	–	97.04	–	–	111.41	–	98.13	–	93.42	–	–	–	100.0	6.81
385	64.00	–	125.42	79.50	138.45	–	27.49	135.64	62.57	193.96	87.25	–	85.70	100.0	45.79
3851	–	–	132.25	64.26	–	–	22.84	129.55	–	151.10	–	–	–	100.0	48.49
3852	–	–	85.37	66.61	–	–	27.44	96.08	–	224.50	–	–	–	100.0	66.50
390	88.35	–	156.21	25.36	115.91	–	30.23	138.46	72.11	150.25	105.15	139.21	78.76	100.0	43.47
3	78.25	106.60	145.45	86.26	88.88	146.44	24.08	126.01	59.56	149.31	106.84	112.91	68.39	100.0	32.02
(at constant prices and exchange rates)[a]															
	(86.91)	(99.65)	(142.42)	(77.64)	(90.80)	(135.82)	(28.97)	(127.62)	(63.37)	(157.76)	(112.92)	(103.19)	(72.92)	(100.0)	(34.23)
Normalised standard deviation by country[(b)]															
	13.4	28.3	14.3	39.0	16.4	13.4	22.3	14.8	13.5	18.5	17.6	28.3	14.8		
Mean of the standard deviations by sector															42.8

Notes:

(a) Manufacturing at 1975 prices and exchange rates.

(b) Standard deviation of the values across each column at the maximum available disaggregation, normalised by the unweighted mean of the corresponding sectors.

N.B. – The standard deviations have been calculated on a marginally greater set of data including a few more disaggregated sectors not shown here.

– The value of the manufacturing aggregate for the Netherlands has been estimated by the authors on the grounds of a set of sub-sectors falling short of the total.

Source: UN Yearbook of Industrial Statistics (various issues), see also the Appendix to Chapter 6.

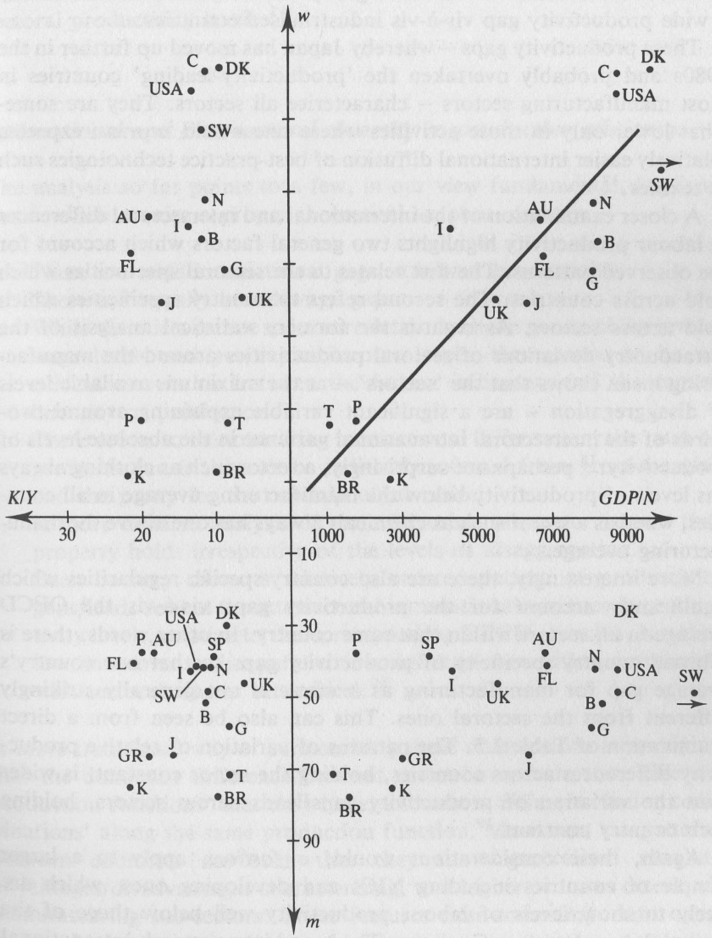
characterised by lower marginal capital/output ratios, as compared to slow-growing ones (see Maddison, 1964).

Fourth, and as shown in Figure 3.5, wide international gaps in per capita income are associated with equally wide differences in wage rates (equation (3.28)). Conversely, if one considers the percentage part of non-wage value added as a proxy for gross profits, there is no evident trend in the relationship profitability/development/accumulation. One can see from the left-hand side of Figure 3.5 that no significant correlation exists between profit margins, capital intensity and wage rates.[13] Certainly, measurement of profit rates involves considerable statistical difficulties, related to the measurement of both capital stock and net profits.[14] However, what we can argue on the basis of the available data is that: (i) international differences in profit rates are not big enough to determine a clear pattern in gross margins as a percentage of value added;[15] (ii) these differences, even when they exist, do not show any evident correlation with the technological level of the manufacturing process and in particular with the proxies for capital/output ratios; (iii) international differences in profitability are orders of magnitude smaller than differences in wage rates.[16]

Sectoral patterns in labour productivity

Additional insights can be obtained from a more disaggregated analysis of some of the sub-sectors within manufacturing. Table 3.5 shows the indices of labour productivity for each sector, compared to the unweighted mean for the sample of countries within that same sector. Data availability restricted the investigation to the group of OECD countries and to 1977–8 averages.

A typical feature of modern industrial economies is the persistence of wide productivity gaps, even among the group of industrialised countries within the OECD area. These differences do not depend only (or primarily) on a composition effect between different industrial sectors; a wide variance across countries remains at all levels of available disaggregation. By the mid-1970s, a few countries appeared to have almost caught up with (and in some sectors even overtaken) the productivity levels of the United States. This group of 'productivity leaders' included (in addition to the United States) Germany, the Netherlands, Sweden, Switzerland, France and, somewhat behind, Belgium and Japan. A second group of industrialised countries still presented productivity levels significantly 'below the frontier': this group included Austria, Norway, Italy and the United Kingdom. Within this group the United



Notes: as for Figure 3.4, and
w = wages and supplementary benefits per employee (1968–80 averages).
m = one minus the ratio of wages and benefits to value added (1968–80 averages).

Figure 3.5 Wages, profit margins and capital/output ratios (manufacturing, 1968–80)

Kingdom was at the lower productivity end. Finally, Portugal can be taken as representative of an entire group of NICs, still characterised by a wide productivity gap vis-à-vis industrialised countries.

These productivity gaps – whereby Japan has moved up further in the 1980s and probably overtaken the 'productivity-leading' countries in most manufacturing sectors – characterise all sectors. They are somewhat lower only in those activities where one would *a priori* expect a relatively easier international diffusion of best-practice technologies such as textiles.[17]

A closer examination of the international and intersectoral differences in labour productivity highlights two general factors which account for the observed patterns. The first relates to the sectoral specificities which hold across countries. The second refers to country specificities which hold across sectors. As regards the former, statistical analysis of the intracountry deviations of sectoral productivities around the manufacturing mean shows that the 'sectors' – at the maximum available levels of disaggregation – are a significant variable explaining around two-thirds of the intersectoral intranational variance in the absolute levels of productivity:[18] perhaps not surprisingly, a sector such as clothing always has levels of productivity below the manufacturing average in all countries, whereas a sector such as chemicals always has one above the manufacturing average.

More interestingly, there are also country-specific regularities which significantly account for the productivity gaps vis-à-vis the OECD average in all sectors within that same country. In other words, there is a broad country-specificity of productivity gaps so that one country's average gap for manufacturing as a whole is not generally strikingly different from the sectoral ones. This can also be seen from a direct examination of Table 3.5. The patterns of variation of relative productivity differences across countries, holding the sector constant, is wider than the variation of productivity gaps/leads across sectors, holding each country constant.[19]

Again, these considerations would, *a fortiori*, apply to a larger sample of countries including NICs and developing ones, which are likely to show levels of labour productivity well below those of the United States, Japan or Germany. The broad intersectoral, intranational homogeneity in productivity gaps is common to all the countries considered here (again, see the last row of Table 3.5), although less strong in the case of two small countries (Belgium and Switzerland)[20] and, interestingly, in Japan. This latter case probably shows the outcome of a fast process of technological catching-up characterised by more sectoral selectivity. This general country-specificity of productivity

gaps/leads is also confirmed by formal statistical analysis: the country-variable accounts for around three-quarters of the variance in relative sectoral productivity levels.[21]

International and intersectoral diversity in productive efficiency

The analysis so far points to a few, in our view fundamental, 'stylised facts' which require a proper theoretical account, namely:

1. There are wide international gaps in labour productivity.
2. There are equally broad wage gaps.
3. While there is a rather strict correlation between productivity levels, wage levels and per capita income levels, there seems to be no evident correlation between the former indicators and the capital intensity of production.
4. There seems to be no striking international difference in the rates of profit, as far as this can be indirectly inferred from gross margins and the proxy for the capital/output ratios.
5. A more detailed analysis of manufacturing sub-sectors shows that property holds irrespective of the levels of disaggregation.
6. Each country shows a relatively ordered pattern of productivity gaps/leads so that the intersectoral intranational variance in productivity levels, relative to the corresponding OECD averages, is rather low; moreover such a pattern does not show any evident correlation with sectoral 'factor intensities'.[22]

A more traditional way of summarising these observations is by saying that the dominant difference between countries rests in the 'different production functions' that they have, and *not* in different 'factor combinations' along the same production function. Moreover, the patterns between countries are such that they show generalised absolute advantages/disadvantages characterising, to a higher or lower extent, all manufacturing sub-sectors. These features raise some important questions, which need to be discussed in the following chapters. A number come immediately to the forefront. For example: what explains international differences in labour productivity if these do not appear to be the result of interfactoral substitution along an identical production function? How do these productivity gaps relate to the innovative differences analysed in Section 3.1? What accounts for the country-specificity of these productivity advantages/disadvantages?

3.3 International competitiveness, specialisations and trade

Trade flows and market shares

A third set of 'stylised facts', which will serve as a basis for our analysis of the relationship between technical change, trade and growth, relates to the volume, commodity composition and intercountry distribution of trade flows. From a secular point of view, one observes a great acceleration in the rate of growth of international exchanges of commodities around the time of the industrial revolution and a persistently high growth of trade flows throughout the nineteenth century, with a deceleration between the two world wars and, again, an accelerated growth after the Second World War. According to Kuznets, per capita trade in 1913 was twenty-five times higher than in 1800 and the proportion of foreign trade to world productivity increased over eleven times in the same period.[23] This high elasticity of world trade to world growth fell below one in the inter-War period and rose again to a value of around one-and-a-half in the post-War period. However, in 1963, the proportion of world trade to world production was still below its 1913 value.[24]

This secular growth of trade is associated with a long-term shift in the commodity composition from agricultural and primary products to manufactures. Moreover, within the trade of manufactures, one observes a secular relative growth of producer goods, transport equipment and chemicals and a marked relative decline of textile and clothing products. These divergent commodity trends are even more impressive if measured at constant prices, since the most dynamic commodities are generally characterised by falling relative prices. For example, the share of chemicals in the exports of the industrial countries rose only from 8.3 per cent in 1899 to 11.5 per cent in 1971, when measured at current values. However, that corresponded to a threefold increase in volume terms.

As regards the market shares of the various countries within trade of manufactures, Table 3.6 shows their evolution for a group of OECD countries from 1899 to 1980, while Figures 3.6 ((a), (b) and (c)) present the trends in some manufacturing sub-sectors for the United States, United Kingdom, Germany, France, Japan and Italy. Three features are worth noticing.

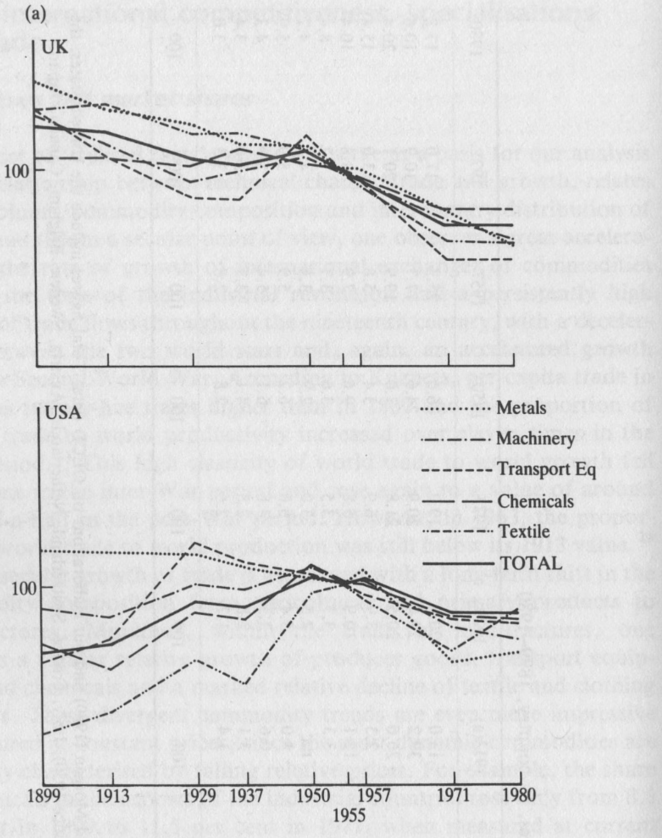
First, one may observe pronounced country-specific trends which characterise the international distribution of manufacturing exports. In particular, there is a marked decline in UK shares throughout this century. The US share rises until the 1950s and then starts declining rather rapidly. France, after a disappointing first half of the century, improves

Table 3.6 Export shares of manufactures, by country, 1899–1980

	1899(a)	1913(a)	1929	1937	1950	1957	1971	1980
United States	11.7	13.0	20.4	19.2	26.6	25.3	17.0	17.8
United Kingdom	33.2	30.2	22.4	20.9	24.6	17.7	10.9	10.6
Germany	22.4	26.6	20.5	21.8	7.0	19.9	20.1	20.4
Japan	1.5	2.3	3.9	6.9	3.4	5.8	13.0	15.4
France	14.4	12.1	10.9	5.8	9.6	7.9	8.8	10.4
Italy	3.6	3.3	3.7	3.5	3.6	3.7	7.2	8.4
Netherlands	na	na	2.5	3.0	2.9	3.5	4.7	4.7
Belgium–Luxembourg	5.5	5.0	5.4	6.6	6.2	5.9	5.9	5.9
Canada	0.4	0.6	3.5	4.8	6.1	5.4	5.9	4.3
Switzerland	4.0	3.1	2.8	2.8	4.1	3.3	3.0	3.4
Sweden	0.9	1.4	1.7	2.6	2.8	2.8	3.3	3.0
Total industrialised countries	100	100	100	100	100	100	100	100

Notes:
(a) 'World' totals exclude the Netherlands.

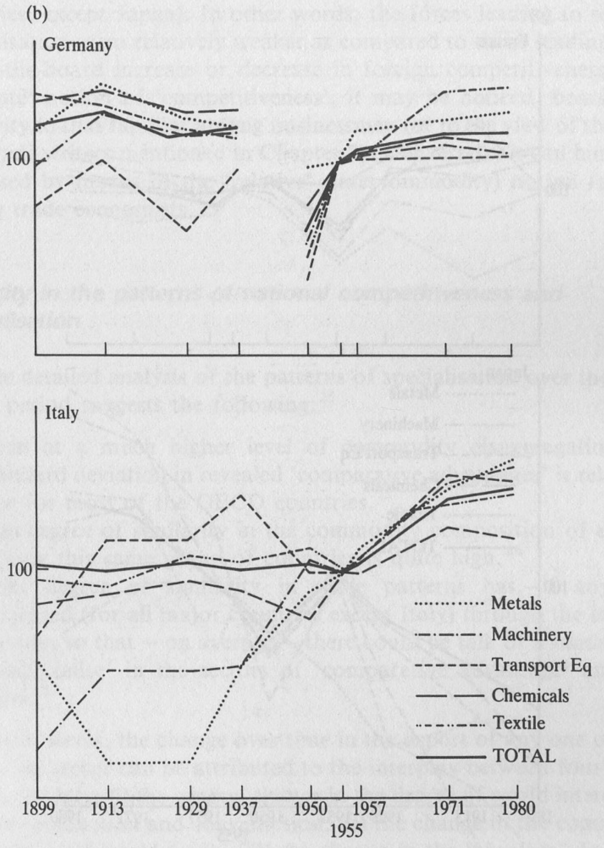
Sources: Maizels (1963), Batchelor, Mayor and Morgan (1980) and our elaborations on OECD data. Total figures include the United States, the United Kingdom, Germany (West Germany since 1950), Italy, France, Switzerland, Netherlands, Austria, Sweden, Belgium, Canada, Japan.



Source: as Table 3.6

Figure 3.6 Export shares, manufacturing and some manufacturing sub-sectors; United Kingdom, United States, France, Japan, Germany and Italy; 1899–1980; indices, 1955 = 100

its export performance, especially since the late 1950s. Japan presents a spectacular performance with a steady and rapid growth of its share, interrupted only by the period around the Second World War. The German share, which achieved its maximum just before the First World War, tends to reach the pre-War levels at the end of the 1930s. Again, after the Second World War rapid West German export growth leads to

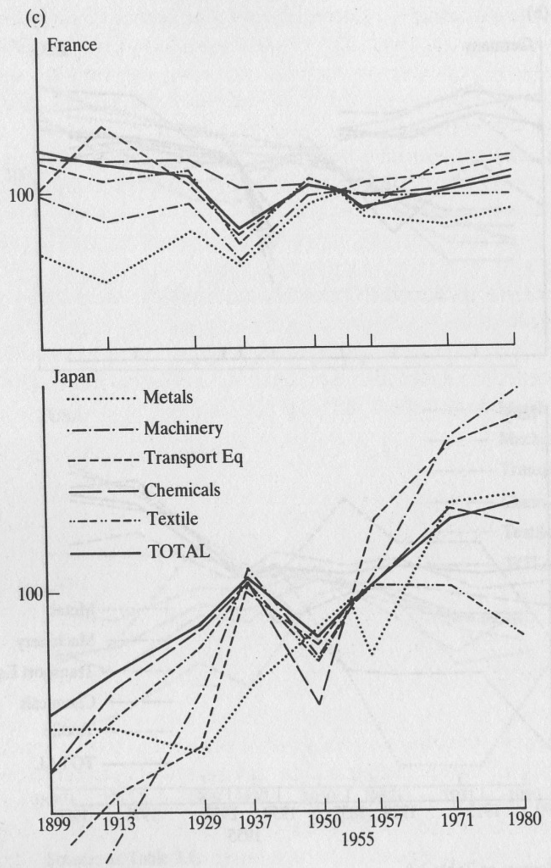


Source: as Table 3.6

Figure 3.6 *continued*

levels not far from those of pre-War Germany. The relative stagnation of Italian export shares ends in the 1950s with a steeply rising trend matched only by Japan.

Second, one can see that these differing national trends in manufacturing export shares correspond to similar trends for each of the major groups of commodities shown in Figure 3.6. In other words, there seem to be sector-independent patterns of evolution of national competitiveness which go beyond the changes in sectoral comparative advantages.



Source: as Table 3.6

Figure 3.6 *continued*

Certainly, there are changes in the latter, as represented in Figure 3.6 by the different slopes of the sectoral shares compared to the total manufacturing shares. However, in most cases these varying 'comparative advantages' appear to be the result of somewhat different sectoral rates of change along an underlying trend common to all sectors in any particular country.

Third, this national homogeneity between sectoral and average trends appears to be more pronounced after the Second World War (for all countries, except Japan). In other words, the forces leading to sectoral specialisation seem relatively weaker as compared to those leading to an across-the-board increase or decrease in foreign competitiveness. This 'absolute' notion of 'competitiveness', it may be noticed, bears some similarity to that familiar among businessmen (or to the view of the 'heretic' trade writers mentioned in Chapter 2). Conversely, it can hardly be expressed by means of the 'relative' (intercommodity) notion familiar among trade economists.

Diversity in the patterns of national competitiveness and specialisation

A more detailed analysis of the patterns of specialisation over the more recent period suggests the following:[25]

1. Even at a much higher level of commodity disaggregation, the standard deviation in revealed 'comparative advantages' is relatively low for most of the OECD countries.
2. The degree of similarity in the commodity composition of exports among this same group of countries is quite high.[26]
3. That degree of similarity in trade patterns has, if anything, increased (for all major countries except Italy) through the last two decades so that – on average – there could be talk of a tendency to 'despecialise' in the sectors of 'comparative advantage' and vice versa.[27]

In general terms, the change over time in the export of any one country in any one sector can be attributed to the interplay between four major factors, namely: (i) the general change in the degree of world interdependence in production and consumption; (ii) the change in the commodity composition of world trade; (iii) the change in the 'absolute' degree of competitiveness of the country; (iv) the change in the comparative advantage of that country in that sector relative to other sectors of that same country.

This can be written as the following simple identity:

$$\dot{x} \equiv \dot{Y} + (\dot{X/Y}) + (\dot{y/Y}) + \dot{CA}$$

where x represents the exports of country j in sector i, X are total world exports in sector i, Y are total world exports, y are total exports of country j, CA is the comparative advantage[28] of j in i, and the dots stand for rates of change.

The broad tendencies mentioned above highlight some fundamental questions. For example: what determines the general trend in national

Table 3.7 The evolution of comparative advantages in some industrial sectors, 1899–1980(a)

	1899	1913	1929	1937	1950	1955	1971	1980
Metals								
United Kingdom	1.07	0.85	0.96	0.83	0.67	0.65	0.75	0.51
United States	2.26	2.00	1.22	1.10	0.71	0.72	0.44	0.46
Japan	1.13	0.71	0.15	0.36	1.41	1.25	1.55	1.43
France	0.51	0.45	0.90	1.09	1.30	1.59	1.14	1.14
Germany (b)	0.72	1.05	0.91	0.78	1.54	0.74	0.90	0.96
Italy	0.17	0.06	0.05	0.18	0.35	0.48	0.58	0.68
Machinery/other electrical equipment								
United Kingdom	1.19	0.93	0.80	0.93	0.96	1.03	1.06	0.87
United States	2.32	1.85	1.72	1.65	1.57	1.41	1.25	1.05
Japan	0	0.04	0.15	0.34	0.26	0.31	0.81	1.14
France	0.39	0.34	0.46	0.43	0.56	0.62	0.89	0.80
Germany (b)	0.86	1.28	1.31	1.29	1.14	1.29	1.18	1.05
Italy	0.11	0.27	0.24	0.29	0.86	0.82	1.03	1.05
Transport equipment								
United Kingdom	1.68	1.19	0.92	0.96	1.59	1.39	0.92	0.94
United States	1.17	1.37	2.07	2.20	1.33	1.31	1.31	1.21
Japan	0	0.13	0.13	0.39	0.44	0.47	1.11	1.25
France	0.47	1.25	0.68	0.72	0.75	0.76	0.94	0.93
Germany (b)	0.49	0.70	0.40	0.75	0.64	1.18	0.93	0.93
Italy	0.22	0.70	0.62	1.12	0.43	0.48	0.65	0.53
Chemical								
United Kingdom	0.60	0.66	0.78	0.76	0.72	0.86	0.99	1.03
United States	1.24	0.87	0.83	0.88	1.30	1.17	1.13	1.11
Japan	0.27	0.42	0.46	0.43	0.24	0.47	0.56	0.38
France	0.97	1.10	1.24	1.71	1.05	1.02	1.11	1.12
Germany (b)	1.58	1.50	1.50	1.45	1.49	1.14	1.12	1.04
Italy	0.64	0.76	0.78	0.76	0.51	0.97	0.72	0.57
Textile/clothing								
United Kingdom	1.27	1.42	1.48	1.56	1.09	1.07	0.88	0.91
United States	0.21	0.23	0.27	0.21	0.44	0.51	0.35	0.52
Japan	1.67	1.79	2.45	2.70	2.44	2.96	1.40	0.69
France	1.05	1.25	1.38	1.14	1.35	1.29	1.28	1.10
Germany (b)	0.74	0.55	0.58	0.49	0.34	0.50	0.83	0.87
Italy	1.75	1.76	2.30	2.24	2.43	2.09	1.97	1.99

Notes:
(a) Comparative advantages are, as usual, the ratio of the sectoral share in 'world' export for any one particular country to that country's share in total 'world' manufacturing exports. That is:

$$\frac{x_{ij}/\sum_j x_{ij}}{\sum_i x_{ij}/\sum_{ij} x_{ij}}$$

with $i = 1 \dots n$, the sectors, $j = 1 \dots m$, the countries.
(b) West Germany only since 1950.

competitiveness – as expressed by the changing trends in export shares in, for example, Table 3.7? What is the relationship between sectoral trends and overall national trends? How do the determinants of sectoral comparative advantages relate to the determinants of these general changes in the competitive position of each country?

Answers to these questions require an analysis of the relationship between commodity/sector characteristics and national characteristics, and of the way different national characteristics affect competitive interactions on world markets. At this preliminary stage of exploration of the main 'stylised facts', it is useful to observe in greater detail the commodity composition of trade by country as revealed by the changing patterns of comparative advantages shown in Table 3.7.

Here one can identify important national specificities which could add to the phenomena to be explained. For example: the relatively stable German strength in chemicals and machinery; the Japanese comparative advantage – after the Second World War – in metals and electro-mechanical machinery and equipment;[29] the continuing Italian advantage in textile and clothing, and its rising advantage in machinery; the worsening British performance in transport equipment and machinery, and its emerging comparative advantage in chemicals.[30] Another set of important questions relates to what accounts for those country-specific regularities in relative specialisations? What reproduces or changes them through time?

At this level of aggregation it is obviously difficult to match sectors with precise commodity/country characteristics. However, casual empiricism hints at an apparent inadequacy of traditional endowment-based explanations. For example, if one accepts the conventional view that metal production is a relatively capital-intensive activity, it is difficult to believe that Japan and France are the most 'capital endowed' OECD countries or that in 1899 Japan was among the 'capital abundant' countries. Conversely, France has in addition to metals, an advantage in textile/clothing, traditionally considered a labour-intensive activity. The 'paradoxes' are numerous. In general, the patterns shown in Table 3.7 do not show any intuitive correspondence with the 'informed guesses' about the commodity/country correlations that one could make on the grounds of traditional trade theory.

3.4 Conclusions

In this chapter we have tried to explore some 'stylised' and 'less stylised' regularities in the international distribution of innovative capabilities (Section 3.1), international differences in input coefficients (Section 3.2) and the trends and characteristics of trade patterns (Section 3.3). More precisely, we identified a rather asymmetric distribution of innovative activities between countries, matched by an equally asymmetric pattern of efficiency in the use of production inputs (and, first of all, labour inputs). These two broad 'stylised facts' represent two fundamental sources of country-specific absolute advantages, which are important in terms of international competitiveness and trade.

In the following chapter we shall investigate their origins, the causes of their changes through time and the links they show with each other. Moreover, we shall analyse their sectoral specificities and study how different features of the various technologies affect the ways in which innovative advances are appropriated and/or diffused among firms, sectors and countries. In the following chapters we will then focus on the relationship between these sector-specific and country-specific technological leads/lags and the corresponding trade patterns.

Notes

1. See, among others, some of our own contributions to this measurement issue (Patel and Soete, 1987; Soete, Verspagen, Pavitt and Patel, 1989).
2. The patent data were based on IPO's Industrial Property Statistics, obliging us to sacrifice one observation; i.e. Italy, for which no domestic patent data were available. The R&D data were based on the 1975 and 1977 OECD data. No R&D data were available for New Zealand, Austria, Greece and Turkey.
3. Standard errors between brackets;
   $\bar{R} = R^2$ adjusted for the degrees of freedom
   *: significant at 1 per cent.
4. Cf. Pavitt, 1979; Pavitt and Soete, 1980; Patel and Pavitt, 1987, 1988.
5. Cf. Rosenberg (1976) and Landes (1969).
6. Even in a single-economy context serious problems remain and among them the question of the (fixed or moving) weights attributed to changing product mixes.
7. For an attempt, unfortunately limited to the United Kingdom and the United States, cf. Paige and Bombach (1959).
8. Cf. Kravis *et al.* (1975), (1982). Adjusted figures also based on Kravis' data can be found in Jones (1976), Smith *et al.* (1982) and Roy (1982).
9. Note, however, that the relative intercountry ratios of aggregate manufacturing productivities obtained on the ground of current prices and exchange rates are rather similar to those obtained through constant prices and exchange rates (see Table 3.4).
10. By high-value-added products, we mean products with higher value per 'physical unit', which ideally should be the numerator of the productivity ratio.
11. More detail on the statistical data base can be found in the appendix to Chapter 6. The reader must be warned about the difference between the results presented here and similar attempts elsewhere. In particular, a significant difference emerges between the productivity ratio Germany/USA from Smith *et al.* (1982) and our estimates, even at current prices. This is due to different statistical sources, whose merits and faults are difficult to assess. Here we consistently use the Industrial Statistics of each country, which are easily comparable throughout the sample of chosen countries, despite some intercountry differences in the sampling coverage. National Accounts data, on the other hand, yield in some cases (as the one mentioned) relatively different figures. *A priori*, one should prefer the latter data which are meant to be adjusted to the universe of industrial activities. However, the sectoral breakdown in the National Accounts is sometimes smaller. Moreover, the adjustment criteria from the sample to the universe are often quite different between countries. For these reasons we chose the former option for the analysis of all manufacturing subsectors (cf. Table 3.5). The comparison of aggregate manufacturing productivity for the sample of developed and developing countries shown in Figures 3.5 and 3.6 is based on the United Nations, *Yearbook of Industrial Statistics*, various years, and on national sources.
12. These proxies are calculated through the yearly averages of investment/labour and investment/value-added ratios over the period 1968–80, divided by one plus the average rate of growth of output and constant prices. This adjustment through the growth rate is necessary in order to approximately 'discount' that part of investment aimed at the expansion of productive capacity, especially if one considers averages over relatively long periods. Calling v the marginal (= average) capital/output ratios; I, the gross investment; Y, output; g, the rate of growth of output; λ, the rate of scrapping; K, the capital stock, then

$$I = v \cdot \Delta\ Y + \lambda K$$
$$I/Y = v \cdot g + \lambda \cdot v$$
$$v = (I/Y)\ (g + \lambda)$$

The actual rate of scrapping is not generally available. However, if these rates do not differ too much between countries, then the ranking of the various $(I/Y)/(1+g)$ for each country should not be very different from the actual $(I/Y)/(g+\lambda)$. Identical considerations apply to the capital/labour ratios.

13. Here and throughout the text, by 'capital intensity' we properly mean the ratio of capital inputs to output at current prices.
14. For an attempt at estimation, see Hill (1979).
15. On the cross-country stability in distributive share, see also Loftus (1969).
16. Some elaborations of ours on the same set of data as those given in Table 3.5 show that (a) the international standard deviation in wage rates, even within our sample of OECD countries, is around three times higher than the standard deviation in gross margins (which can be taken as a rough proxy for the profit rates); (b) international variations in gross margins do not show any strong correlation, with either sign, with GDP per head, where the latter can be taken as a proxy for 'capital abundance'.
17. See, for example, the standard deviation in textiles and clothing, ISIC 32, and compare this with the cross-sectoral average in the standard deviations (last column of Table 3.5).

18. In order to overcome, in a rather simple manner, the problems stemming from a variable number of observations for each country and sector, due to data availability, we regressed the vector of sectoral productivities, normalised by the manufacturing weighted mean of the corresponding countries (X_{ij}) against a number of dummy variables representing the sectors (D_i with $i = 1, \ldots, 23$, the sectors at the maximum level of available disaggregation), which assume as required the values 0 and 1. The estimate

$$X_{ij} = \alpha + \beta_1 D_1 + \ldots + \beta_{23} D_{23} + \mu$$

yielded

$$\bar{R}^2 = 0.62 \text{ and } F = 15.8$$

19. Compare again the mean of the standard deviations in productivities across countries for each sector (yielding a value of 42.8, last column of Table 3.5) with the normalised standard deviation within each country (see the last row of Table 3.5).
20. However, the reliability of the data related to these countries may be biased by a small number of strictly comparable sectoral observations.
21. I.e. the variance across the rows of Table 3.5. We used the same procedure as outlined in note 18, above. In this case the vector of observations of the dependent variable (Y_{ij}) is the set of sectoral productivities normalised with the unweighted OECD mean for the corresponding sector, which is regressed against a number of dummy variables (C_j with $j = 1, \ldots, 13$, for each country), taking the values 0 or 1 as appropriate. The estimate

$$Y_{ij} = \alpha + \beta_1 C_1 + \ldots + \beta_{13} C_{13} + \mu$$

yielded

$$\bar{R}^2 = 0.77, \quad F = 95.9$$

with all the β's significantly different from 0 at 1 per cent level of significance.
22. We tested the correlation between relative productivity gaps, as shown by each column in Table 3.5, and a proxy for capital/output ratios (averages of investment/output ratios) for the corresponding sector and country. The results have uncertain signs and are statistically insignificant.
23. Kuznets (1967), p. 7.
24. *Ibid.*, p. 9.
25. Kuznets (1967), p. 9.
26. *Ibid.*, pp. 36–8. The index of rank correlation between each of the major six countries and the OECD average is always above 0.70 (Italy being the lowest), and for each pair of countries always above 0.55 (with the exceptions of the pairs Italy-USA and Italy-Japan).
27. *Ibid.*, pp. 38–41.
28. I.e.

$$\frac{x/X}{y/Y}$$

29. Note that 'machinery – other electrical equipment' includes here electronics and electrical consumer durables.
30. For a detailed analysis of the evolution of the patterns of specialisation among OECD countries in the post-War period, see CEPII (1983).