INTERNATIONAL COMPARISONS OF OUTPUT AND PRODUCTIVITY

Manufacturing Productivity Performance of Ten Countries from 1950 to 1990

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Chapter 1 - Introduction

This study measures and explains comparative levels of performance in manufacturing. Its main aim is to establish the relative output and productivity position in manufacturing for ten countries during the postwar period on the basis of the industry of origin approach.

In recent decades, important changes in comparative economic performance among nations have occurred. For the economy as a whole, the unprecedented rise in output and productivity from 1950 to 1973 has been well documented, but the slowdown of the world economy since the 1970s and the slow recovery of the 1980s has raised new questions. A comparative study of productivity levels from a sectoral perspective may be appropriate in the search for explanations.

Much of the evidence on comparative performance by sector of the economy is based on case studies for industries producing products which either are intensively traded among countries or have a high technology content (e.g. cars, computers or pharmaceuticals). On the basis of such studies it is often concluded that in the past decades the United States has gradually lost most of its productivity leadership in manufacturing to Japan. It also widely believed that Germany is, or at least until recently was, the most successful industrial power of Western Europe. Furthermore, countries in Asia are supposed to have been more successful in creating a manufacturing sector than Latin American nations.

Studies of a more aggregate nature face a major problem in comparing sectoral output levels between nations, which is that output is expressed in different currencies. Exchange rates are of little help, because they do not indicate the comparative value of currencies in the production of all goods and services. In principle exchange rates refer only to price relatives for tradeable goods and services. Furthermore, in particular during recent decades exchange rates have been subject to substantial short term fluctuations and capital movements. So even for tradeables, they may be substantially misleading when used to convert output to a common currency.

An alternative conversion factor is the purchasing power parity of a currency. It represents the number of currency units required to buy the goods equivalent to what can be bought with one unit of the currency of another country. Estimates of purchasing power parities (PPPs) are now provided on a regular basis by the International Comparisons Project (ICP) mainly to compare income per head of the population. However, these are expenditure PPPs which are derived from prices of final goods and services and for investment, and which are not designed for output comparisons at a sectoral level. The sectoral approach to cross country comparisons was pioneered by Rostas (1948) and Paige and Bombach (1959). Unlike ICP there was no systematic follow-up, although the historical overview in chapter 2 shows that many individual scholars have followed in the footsteps of these pioneers.

Since 1983 a substantial research effort has been made at the University of Groningen to further develop the industry-of-origin approach. The research has been placed under the International Comparisons of Output and Productivity (ICOP) project. ICOP has a threefold aim:

1) to provide a systematic and transparent methodology for industry-of-origin comparisons of prices, real output and productivity. It is designed in such a way as to improve the comparability of the results from such studies and to allow others to replicate the methodology for their own sample of countries or industries.
2) to work towards cross-country comparisons which cover all sectors of the economy including services and the government sector.
3) to expand industry of origin comparisons to a sufficiently large number of countries to match a substantive part of the world's population and production.

Over the past ten years some 32 ICOP titles have appeared which represent the contribution of 10 past or present members of the research team. Most studies dealt with the manufacturing sector, which now covers 16 countries (Argentina, Australia, Brazil, Czechoslovakia, France, Germany (FR), Germany (GDR), India, Indonesia, Japan, Korea, Mexico, the Netherlands, Spain, the United Kingdom and the United States). Substantial progress has also been made in measuring comparative productivity performance in agriculture covering 14 countries (van Ooststroom and Maddison, 1984; Maddison and van Ooststroom, 1993) and in services for Japan, Korea and the USA (see, for example, Pilat, 19-91a). New work on the sectoral performance in services is in progress for Brazil and Mexico (see Mulder and Maddison, 1993).[1]

The emphasis in this thesis is on ICOP comparisons for the manufacturing sector. This is the sector most extensively covered by ICOP so far. Of the ten countries included in this thesis, six are OECD members

[1] For a description and presentation of the ICOP project, see also Maddison and van Ark (1993) and van Ark (1993).

(France, Germany[2], Japan, the Netherlands, the United Kingdom and the United States). In addition estimates for four lower income countries, of which two are located in Asia (India and Korea) and two are Latin American countries (Brazil and Mexico).[3] These ten countries represent over 70 per cent of manufacturing output in the capitalist world (i.e. excluding centrally planned economies) and between 55 to 60 per cent of world trade in manufacturing goods.[4] The methods and procedures to measure the comparative levels of output and productivity in manufacturing are described in chapters 3 and 4.

The contribution of manufacturing to economic growth has changed over time. In the advanced countries, manufacturing now accounts for a much smaller share of output and employment in the total economy than at the beginning of the postwar period. In lower income countries, industrialisation was often a much slower process than in the advanced countries, and in many cases this sector did not achieve the relative size it had in advanced countries. However, irrespective of its size, manufacturing has usually been seen as playing a key role in the process of economic growth. It generates most of the new technology, and it has important spillover effects to other parts of the economy, i.e. to agriculture and services.

This study shows that the process of a relatively fast growth of GDP per worker in most OECD countries compared to that of the leading country, i.e. the United States, was largely reflected in manufacturing up to the late 1970s. Since then manufacturing growth has slowed down in most countries. In fact the slowdown in the advanced countries could have been predicted on the basis of the catch-up hypothesis. Countries with relatively low initial levels of productivity exhibit relatively high growth rates compared to the country which is leading in terms of comparative productivity. Technology diffusion from the leading country

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2 In this study ‘Germany’ refers to the former Federal Republic of Germany.

3 The other ICOP comparisons for manufacturing are for Argentina (Pilat and Hofman, 1990), Australia (Pilat, Prasada Rao and Shepherd, 1993), Czecho-slovakia (van Ark and Beintema, 1992) and Indonesia (Szirmai, 1993). The studies for East Germany and Spain have not yet been published. The comparisons for some of the European countries vis-a-vis the United Kingdom (Netherlands/UK; France/UK; Germany/UK) are not formally part of the ICOP program, as they were carried out by the National Institute of Economic and Social Research in London (van Ark, 1990a; 1990b; O’Mahony, 1992). However, as the methodology in these studies has been developed in consultation with the ICOP team, I treat them here as ‘ICOP-related’.

4 See United Nations (1990), *Handbook of Industrial Statistics*, United National Industrial Development Organisation, Edward Elgar.

to the follower countries is seen as one of the main mechanisms behind the catch-up process. Once countries get nearer to the productivity frontier, the potential for catch-up weakens.

However, it seems the catch-up hypothesis cannot fully explain the slow-down in manufacturing productivity growth of the past two decades. Between 1973 and 1979 not only the growth rates of the follower countries declined but also that of the leader, i.e. the United States. Since the early 1980s manufacturing productivity growth (in contrast to the growth rate for the economy as a whole) restored most strongly in the United States compared to the decade before. Japan returned on the 'catch-up' track in the mid 1980s, but the European countries in the sample (i.e. France, Germany, the Netherlands and the United Kingdom) were left behind.

In recent years the catch-up hypothesis has also become under criticism from other directions. For example, catch-up appeared not to be a global phenomenon, even not for comparisons of the total economy. This has given rise to new empirical and theoretical contributions to the literature on economic growth. Instead of looking at the catch-up in each country with the leading country, the analytical focus shifted more to the analysis of convergence which measures the reduction in the variation of income or productivity levels among countries. Some authors have aimed to measure 'conditional convergence'. This means that convergence only takes places after one controls for certain conditions, such as a critical level of education or investment. Others have aimed to reformulate the neo-classical model of growth underlying the catch-up and convergence hypotheses, by replacing constant returns to scale by increasing returns to scale. The latter allows countries with a relatively large stock of human and physical capital to grow faster instead of slower than countries which are further behind.

My aim in chapters 5 and 6 of this thesis is to test the catch-up and convergence hypotheses on the basis of measuring and explaining the change in the manufacturing productivity gap between each of the advanced countries and the United States. For this purpose I reworked the traditional growth accounting technique, which was pioneered among others by Denison, Jorgenson, Kendrick and Maddison, into a 'level accounting' approach. Differences in levels of capital intensity and quality of labour are often seen as the most important proximate causes for productivity differences. This thesis shows that at present such forces have only a limited part to contribute to the productivity gaps in manufacturing among these countries. Although not explicitly dealt with in this thesis, ultimate causes ranging from institutional to socio-political differences as well as branch specific factors appear to play an important role as well.

Comparative productivity levels form the core of this thesis. Productivity is a term widely used, but often ill-defined and easily misinterpreted in different contexts. For example, it is often confused with efficiency or competitiveness. Before we measure and analyse our productivity estimates, we need to define it and explain how it is related to other indicators.

In this study, labour productivity is the productivity concept mostly used. It is defined as value added per working hour, and it is often referred to as 'single factor productivity' or 'partial productivity'. Labour productivity can be higher in one country compared to another country for different reasons. For example, two countries can use different amounts of factor inputs other than labour, in particular capital. Alternatively, two countries can use the same amount of factor inputs, but utilise them at different degrees of efficiency. Efficiency is therefore a narrower concept than productivity.

A proxy for efficiency can be obtained by measuring joint factor productivity, which is defined here as the real value added per composite unit of labour and capital. However, even comparative levels of joint factor productivity are not an exact indicator of differences in efficiency between two countries. Firstly, not only the quantity but also the quality of the production factors between countries needs to be taken into account. For labour one can distinguish between quality characteristics such as the level of education, the age of the work force, and its sex distribution. The quality of the capital stock can be determined by the distribution of different vintages of assets.

A second reason why joint factor productivity is not synonymous with efficiency is that that the former still includes a variety of other factors. In growth accounting, the difference in joint factor productivity between countries is interpreted as a residual, which can be further decomposed into factors which influence efficiency as well. Examples of such factors are differences in scale advantages, the openness of the economy to international trade, and institutional changes related to legal and political factors.

In micro-economic terms one distinguishes between allocative efficiency and technical efficiency. From a productivity perspective, technical efficiency is the more interesting concept, because it measures the output which can be obtained with a chosen bundle of factor inputs. However, our productivity measure relates to the average productivity performance, and therefore the measure itself does not distinguish between these different types of efficiency.

Competitiveness differs from productivity as the former does not only relate to comparative performance in real terms, but also to the nominal costs at which a product is produced and sold. Costs are not only determined by the prices of factor inputs, but also by those of intermediate inputs and by the exchange value of a country's currency. For example, a devaluation of the currency makes a country more competitive, but (at least in the short run) not more productive.

Some studies of competitiveness used productivity figures for the estimation of unit labour costs. The latter is defined as the ratio of hourly compensation for labour divided by the productivity ratio between two countries. These estimates are highly sensitive to the definition of labour compensation and to the conversion factors which are applied to convert it to a common currency.[5]

Apart from the conceptual differences between productivity, efficiency and competitiveness, it is also important to emphasise that productivity, and in particular labour productivity, is essentially a concept for analysis in the long run. In the short run, productivity measures can be volatile in particular at a disaggregated level, as they are strongly affected by changes in capacity utilisation and shifts in product composition due to competitive pressures. In the long run labour productivity is directly related to income per head of the population, after adjusting the former measure for differences in labour participation rates and the number of hours each person works.

It may be concluded that labour productivity is not just a poor substitute which is inferior to joint factor productivity measures, technical efficiency or competitiveness. Historically speaking labour came before capital and technology. The latter two were the driving forces behind the emergence of the capitalist world, but after all one should see them in perspective as factors which primarily augmented the productive power of labour.

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5 See for example Roy (1982) and Hooper and Larin (1989). They both converted hourly labour compensation at the market exchange rates and output per hour at expenditure based 'proxy PPPs' (see chapter 3 for details on proxy PPPs). It was shown that relative levels of labour compensation are highly sensitive to the nominal exchange rates.

Chapter 2 - A Methodology for Cross Country Comparisons

International comparisons of per capita income and labour productivity go back to at least to the late seventeenth century. In 1690 Sir William Petty published comparisons of wealth between England, France and Holland for around 1675[1], followed by comparisons of per capita income in the same countries for 1688 by Gregory King (1696) and for 1695 by Charles Davenant (1698). At the end of the nineteenth century Mulhall (1899) published estimates of per capita income for 21 countries, including most West European countries, Argentina, Australia, Canada and the United States.[2]

Since the beginning of this century the quantitative approach to the study of economic growth and development got an important stimulus from the increased availability of official statistics on income, output and expenditure. The creation of national accounts on a consistent basis for many countries greatly facilitated systematic comparison of economic performance of nations. However, cross country comparisons of *levels* of per capita income and productivity have remained relatively scarce. The main reason for this is probably the lack of an appropriate way of converting national income and output for all nations into a common currency.

International comparisons of levels are mostly made from either the expenditure side or from the production side of the economy. The difference between the two approaches can be illustrated with an input-output table, such as the one for the USA in 1987 in table 2.1.

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1 Perhaps the first direct comparison of productivity was made by Samuel Pepys between the Netherlands and England: ‘And coming home, did go onboard Sir W. Petty’s *Experiment* - which is a brave roomy vessel - and I Hope may do well. So went on shore to a Dutch house to drink some Rum, and there light upon some Dutchmen, with whom we had a good discourse touching Stoveing and making of cables. But to see how despicably they speak of us for our using so many hands more to do anything then they do, they closing a cable with 20 that we use 60 men upon’ (Samuel Pepys’ diary for 13 February 1665).

2 See Studenski (1958) for a historical review of national income and output estimates.

Table 2.1
Input-Output Table of the US E conomy in 1987

	Intermediate Use		Final Expenditure					Statistical Adjustment	Total
	Manufac-turing Inputs	Non-Manu-facturing Inputs	Consumption	Government	Investment	Net Export	Total		
Sales of Commodities									
Agriculture, Forestry and Fishing	**92,436**	65,959	23,158	-2,323	-1,591	6,429	25,673		184,068
Mining	**95,623**	51,613	441	-385	1,001	-26,395	-25,399		121,898
Manufacturing	**835,218**	**499,246**	**709,506**	**175,496**	**332,096**	**-175,192**	**1,041,906**		**2,394,370**
Public Utilities	**118,582**	213,905	232,137	43,922	12,777	26,183	315,020		647,507
Construction	**12,519**	104,193	1,278	141,230	365,750	155	508,413		625,125
Trade, Hotels and Restaurants	**261,520**	536,354	773,213	57,590	60,432	45,069	936,303		1,734,178
Financial Services	**35,668**	403,105	649,566	17,088	22,175	22,845	711,674		1,150,446
Other Services	**42,278**	116,592	631,150	30,045	-24,969	-74,202	562,024		720,894
Statistical Adjustment								455,629	
Total	**1,511,844**	1,990,968	3,020,450	462,662	767,671	-175,109	4,074,673	455,629	8,034,114
Factur Inputs (= value added)	**882,526**	3,193,147							

[a] includes adjustment for value added in government industry (465,441), value added in household industry (6,766) and an inventory valuation adjustment (-16,578).

Source: US Dept. of Commerce, ‘Annual Input-Output Accounts of the US Economy, 1987’, *Survey of Current Business*, April 1992.

Expenditure comparisons focus on the rows of the input-output table. For example, the third row in table 2.1 shows the purchases of manufactured goods by other producers, by consumers, government, investors and by the foreign sector. The total expenditure on manufactured goods comes, after a statistical adjustment, to billion US$ 2,394, of which only less than half (billion US$ 1,042) represents demand for final use. For the economy as whole, final expenditure (billion US$ 4,075) equals value added (billion US$ 883 in manufacturing plus billion US$ 3,193 for non-manufacturing). However, at sectoral level value added and final expenditure are not by definition the same.

The comparisons in this study focus on value added created by the manufacturing sector, which equals the value of the factor inputs. One therefore needs to focus on the columns of the input-output table. The column for manufacturing in table 2.1 distinguishes between the intermediate inputs used (billion US$ 1,512) and the factor inputs used in the production process (billion US$ 883). Intermediate inputs and factor inputs add up to gross output. In contrast to comparisons of final expenditure, industry of origin comparisons include the production of goods which are used as intermediate inputs elsewhere, and it excludes the part in the value added chain created by non-manufacturing industries, such as transport and distribution sector. Industry of origin comparison also exclude imports of manufactered finished goods for consumption.

The Expenditure Approach

Although in this thesis the approach is from the production side, expenditure comparisons have been more prominent in the postwar literature. The first studies which explicitly rejected the use of exchange rates for international comparisons go back to the beginning of this century with the investigation of the UK Board of Trade into the real wages of workers in Belgium, France, Germany, the United Kingdom and the United States, and with the ILO-Ford studies into comparisons of living costs between Europe and the United States. These studies adopted purchasing power parities for the conversion of wages and living costs to a common currency.[3]

A purchasing power parity can be defined as 'the number of currency units required to buy goods equivalent to what can be bought with one unit of the currency of a base country' (Kravis, Heston and Summers,

3 See Kravis (1984) for a complete review of pre-world war II studies of purchasing power parities.

1982). One range of studies has focussed specifically on the relation between purchasing power parities and exchange rates. Cassel (1916) claimed that in the long run purchasing power parities would converge to, or at least change parallel with, the exchange rate. However, in most of the postwar literature this 'purcha largely consists of tradeable goods, the relation between price relatives and the exchange rate is quite weak. Exchange rate controls, quantitative trade restrictions and other barriers to trade prevent the purchasing power parity from converging to the exchange rate. Recent developments, such as the increased impact of international capital movements and speculation on the foreign exchange market made clear the obsolete nature of the old doctrine and underlined the need to distinguish between PPPs and official exchange rates (Edwards, 1990).

The first major work on international price comparisons for the purpose of studies of real income and output was that of Colin Clark (1940, 1957). The first edition of *Conditions of Economic Progress* included comparisons of real expenditure for 29 countries. Expenditure was expressed in terms of 'international units', defined as the quantity of goods that can be purchased in each country for one US dollar from 1925-34. His PPPs are only for consumer goods and services. In the third expanded edition, Clark also applied 'oriental units' (i.e. Indian units) for his comparisons, and included some crude comparisons at sectoral level, but the latter were not integrated in his overall results.

International comparisons based on PPPs received an enormous impulse from the pioneering studies at the OEEC by Milton Gilbert and Irving Kravis (1954) and Milton Gilbert and Associates (1958). Their reliance on average values and the binary nature of the comparisons make these works show more resemblance to the methodology in the present study than the later ICP studies. A more detailed discussion of these OEEC studies is therefore appropriate.

Both OEEC studies were concerned with the measurement of real expenditure by category between the United States and Europe. Gilbert and Kravis compared France, Germany, Italy and the United Kingdom to the United States for 1950. Gilbert and Associates added four other European countries and the comparisons were extrapolated to 1955. Both studies start from comparisons of physical quantities and corresponding average values. In the 1954 study some 250 goods and services are listed and slightly more in the 1958 study. The expenditure on each of the listed items was 'blown up' with that of related goods and services to arrive at total expenditure by product class. 'Quantities' were obtained by dividing total expenditure by the average value of the listed items. These quantities were then expressed at either US prices, prices of one of the European countries or an average European price. Purchasing power parity equivalents were implicitly derived from the valuation in different currencies. For some expenditure categories (e.g. footwear and clothing, household goods and produced durables) PPPs were directly derived through comparisons of prices for specified items. Such PPPs based on specification prices covered almost 50 per cent of total expenditure in the USA in 1950.

The shift to multilateral PPPs and to an almost exclusive reliance on specification prices are the most distinctive characteristics of the International Comparison Project (ICP) which followed the OEEC studies of the 1950s. Irving Kravis, Alan Heston and Robert Summers carried out the first three phases of ICP for 1967, 1970 and 1975.[4] Expenditure was divided up into 151 categories (called 'basic headings'), of which over 100 categories private consumption, some 35 categories in investment and four categories in government. An adjustment category for net exports was also included. In ICP III for 1975, on average 500 price specifications were obtained for each of the 34 countries. Most of the price information was derived from surveys which were specifically designed for this purpose, though some use was made of catalogues and information from experts. For government services, ICP followed the national accounting practice of pricing output on the basis of input. For certain 'comparison-resistant' services, such as health and education, quantity comparisons were made.

In ICP III (Kravis, Heston and Summers, 1982), which can be regarded as the *magnum opus* of ICP, world prices were applied as weights. These world prices were obtained on the basis of a multilateral index method, which originated from Geary (1958) and Khamis (1970, 1972). According to this method, an average 'international price' is derived for each basic heading level

[4] Zoltan Kenessey participated in phase I for 1967.

simultaneously with a PPP for the aggregate on the basis of two interdependent equations.[5]

Below the basic heading-level an ingenious system was developed to ‘fill’ gaps in the price matrix for countries and products, which is called the Country Product Dummy (CPD) method. The price of a missing item in a particular country is regarded as depending on the prices of other products within that basic heading in the same country and on the prices of the same product in other countries. It is obtained through regression analysis using two sets of dummies for the prices of other products and other countries.[6]

Since 1980 the gigantic task of compiling PPPs for many more countries in all continents of the world was taken over by international organisations, namely the Statistical Office of the European Community, the OECD and the United Nations. ICP PPPs are now available on a quinquennial basis, though the country coverage differs between the various rounds. In total 86 countries have been included in at least one of the ICP rounds (see United Nations, 1992, pp. 67-69). In some cases the international organisations used slightly different methods compared to the earlier ICP studies. For example, in some cases the multilateralisa-tion of price weights is now confined to certain regions, for example to the EC and the OECD areas. The results for the different regions are linked via a binary comparison for benchmark countries.[7]

Heston and Summers have continued to contribute to ICP-type of studies, with the publication of long term series on expenditure and per capita income and various other variables. Their estimates also include countries for which no direct PPP comparisons were made, and which were obtained through short-cut methods for example by using price information from cost of living surveys for diplomats, UN officials, and people working abroad for private business (Summers and Heston, 1991).

Expenditure PPPs have also been widely and legitimately used for international comparisons of productivity for the total economy, most predominantly in the work of Angus Maddison (1964, 1982, 1989, 1991).

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5 See chapter 3 for more details on these pricing methods.

6 For a detailed account of the CPD method, see the report on phase III of ICP (Kravis, Heston and Summers, 1982, pp. 86-89) and Kravis (1984). Alternative methods to estimate ‘missing’ prices, such as the EKS-method are also discussed in these sources and in Hill (1981) and Ward (1985). See also United Nations, 1992.

7 This element of conservation of weighting systems within a region is called ‘bloc fixity’. See for example EUROSTAT (1983), Ward (1985) and UN (1988).

However, these PPPs cannot be used for sectoral comparisons of productivity. Some authors have used PPPs of selected expenditure categories as proxy estimates for producer price ratios by economic sector, but as I will show later this can easily lead to substantial errors.[8]

The Industry of Origin Approach

The first major attempt to compare real output and productivity by industry of origin was made by Laszlo Rostas for the United Kingdom and the United States in the second half of the 1930s (Rostas, 1948). Rostas in fact covered all sectors of the economy, but the most detailed comparisons were for industry. On the basis of each country's Census of Production, physical quantity comparisons were made for 108 products distributed over 31 industries. The product comparisons were weighted by the number of operatives in one of the two countries.[9] The publication of Rostas' first results in 1943 raised fierce discussion among British economists, as can for example be distilled from the inaugural address of Lord Snow for the Royal Statistical Society in 1944 (Snow, 1944). In fact, Snow raised various methodological points which were valid for all subsequent 'physical quantity' comparisons (for example, Maddison, 1952; Frankel, 1957). These points included the calculation of 'equivalent units' for the products not covered in the comparison, the allocation of the work force to individual products, and the emphasis on gross output.

A major problem of postwar comparisons based on 'physical quantities' was the increasing complexity of manufacturing production. Firstly, it became impossible to get information on factor inputs for individual products from most postwar production censuses. Secondly, the number of different product varieties in each country increased substantially. For example, in 1987 the production statistics in the USA distinguish as many as 10,000 product items for manufacturing only, and in Germany information on approximately 6,000 items is collected. Some of these items are unique in one of the two countries, whereas in other cases the specifications of the items differ between the countries. It therefore became increasingly difficult to get a satisfactory

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8 See for example the NIESR studies by Jones (1976) and Roy (1982); see also Guinchard (1984), Gault (1985), Roy (1987) and Hooper and Larin (1989).

9 Rostas also included a comparison with Germany and, though based on much smaller samples, with some other countries including the Netherlands. For an 'up-date' of the Germany/UK comparison of Rostas, see Broadberry and Fremdling (1990).

coverage of output by physical quantity comparisons.

This made it necessary to consider the representativity of comparisons of 'matched output' for 'non-matched' output. A general concensus has emerged in the literature on national accounts and real output series that the representativity of measured prices for unmeasured prices is better than that of measured quantities for unmeasured quantities. Products which are closely related in terms of input contents or which are manufactured on the basis of one and the same production technique, are likely to exhibit similar price movements, but there is less reason to assume that their quantities move parallel as well.[10]

This difference in the degree of representativity of quantity versus price relationships of 'matched' output for 'non-matched' output can also be applied to cross-country comparisons. It is more likely that the relative prices of different products in two countries are similar than their relative quantities. This led to a gradual shift in methodology from physical quantity comparisons to unit value ratios (or industry-of-origin 'purchasing power parities'). According to the latter method average ratios of unit values for a sample of products are used to convert the total value of output to a common currency. These unit values are obtained by dividing the total ex-factory sales value of products by their corresponding quantities.[11]

Naturally, the 'physical quantity' method and the 'unit value' method lead to exactly the same results if output is fully covered in both countries. As quantities times the unit value equals the gross value of output, the two methods are in fact simply each other's mirror-image. This direct relation between unit values and quantities makes the 'unit value' method fundamentally different from the pricing method used in expenditure comparisons. In the latter case, prices are specification prices which do not have a quantity counterpart, so that quantities times prices do not necessarily equal the value equivalent.

The use of unit value ratios in sectoral output studies was first adopted by Maizels (1958) for a comparison of manufacturing in Canada and Australia, and

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10 See for example Burns (1934), Fabricant (1940) and Stone (1956).

11 Comparisons of physical output are still appropriate where manufacturing production concerns a relatively small number of items of a fairly homogeneous nature and where labour input can be relatively easily associated with those individual products, such as for example in agriculture. The physical quantity method is also still in use where price information is hard to get or is very unreliable, for example for comparisons including lower income countries or (former) socialist economies.

by Paige and Bombach (1959) for a comparison of the UK versus the USA. In the latter study, which was carried out in conjunction with the expenditure comparisons of Gilbert and Associates (1958), 29 per cent of all manufacturing output was compared on the basis of unit values. Another 59 per cent was compared on the basis of physical quantities, whereas 12 per cent was based on employment indicators. Later studies, such as the ICOP comparisons presented here are almost entirely based on unit values.

Table 2.2 gives an overview of studies on comparative output productivity performance in manufacturing which are all based on the 'industry of origin' approach as discussed above.[12] For each study a brief description is given of the method, sample size, country coverage and benchmark years.

The census of production is the basic source for most comparisons in manufacturing, though in some cases the results were adjusted at the aggregate level to a national accounts basis. Adjustment to a national accounts basis has certain advantages, because in some countries (for example in the United States) the census provides a somewhat anachronistic concept of value added, which includes non-industrial services inputs and is therefore 'grosser' than the national accounts concept.[13] However, the main advantage of using censuses for productivity level comparisons is that output and input information can be obtained from the same primary source.

The earliest comparisons of manufacturing productivity during the 1940s and 1950s, including those of Rostas (1948), Maddison (1952) and Paige and Bombach (1959), were on the United Kingdom compared to the United States. These two countries have the longest tradition of detailed production censuses.[14] Recently, Broadberry and Crafts (1990) and Broadberry (1992) made a

12 See Drechsler and Kux (1972) and Kravis (1976) for other surveys of interna-tional comparisons of productivity, which also include studies at more disaggregated levels (for example for branches or industries) and those which apply proxy approaches to productivity.

13 In some countries, including the United Kingdom, census value added is referred to as 'net output'. I have not used this terminology in the remainder of this thesis, because I consider the usage of the term 'net' as confusing in the present context. For further details on output concepts see chapter 4.

14 In the United States, censuses of production have been available since 1849, first decenially for 50 years and since then quinquennially. Two major quantitative studies on growth of output and employment in US manufacturing based on the production censuses for the early 20th century were carried out by Solomon Fabricant (1940, 1942) for the National Bureau of Economic Research (NBER). In Britain, the first census was published in 1907, followed by censuses in 1924, 1935, 1948, 1954, 1958, 1963 and 1968, and annually since 1970. Deane and Cole (1962) made extensive use of the British pre-war production censuses for their analysis of changes in economic structure.

detailed analysis of the various Anglo-American cross-country comparisons and linked them to time series which were also obtained from subsequent censuses of production.

Other manufacturing comparisons between advanced countries and the United States included Australia, Canada, Germany, Japan and the Netherlands. In the 1980s the manufacturing productivity gap which had emerged between the United Kingdom and other West European countries during the postwar period, received attention in studies by the National Institute of Economic and Social Research.[15]

During the 1960s and early 1970s a range of studies supported by the UN Conference of European Statisticians were carried out for two socialist countries (Czechoslovakia and Hungary) in comparison with Austria and France.[16] These comparisons were partly based on physical quantity comparisons and partly on unit value ratios. Compared to the earlier work, the UN studies include some important refinements in terms of methodology, in particular concerning the aggregation procedures. These refinements, which were largely adopted in the ICOP studies, will be discussed in more detail below.

Finally, ICOP itself embarked on the first international productivity comparisons to include lower income countries. So far this group inclu-des three Latin American countries (Argentina, Brazil and Mexico) and three Asian countries (India, Indonesia and Korea). Except for Argentina and Indonesia, the ICOP results for manufacturing are included in this thesis.

Besides comparisons of real output and productivity in manufacturing, there are also some comparative studies of this kind for the agricultural sector.[17] These comparisons mostly rely either on FAO or on EC sources, with the exception of a detailed comparison for Japanese and Dutch agriculture by Van der Meer and Yamada (1990), who use a great variety of national sources.

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15 For comparisons between the UK and Germany, see Smith, Hitchens and Davies (1982) and O'Mahony (1992a); between the UK and the Netherlands, see van Ark (1990a); and between the UK and France, see van Ark (1990b). The results from the latter three studies will be discussed in more detail below.

16 See Laszlo Drechsler and Jaroslav Kux (1972) for a more detailed overview of studies including the former USSR and Eastern European countries.

17 See, for example, Maddison (1970), Hayami and Ruttan (1971), van Ooststroom and Maddison (1984), FAO (1986), Terluin (1990) and Maddison and van Ooststroom (1993).

As there are only approximately 200 product items in agriculture to be distinguished, physical quantity comparisons are easier to make than for other sectors of the economy. In addition some agricultural comparisons applied double deflation procedures and multilateral weighting systems. Both issues will be discussed in more detail in chapter three.

There are few industry of origin studies for the economy as a whole. This is mainly due to problems in estimating real output and productivity in the service sector, in particular for non-market services, such as health care, education and government. Common practice has been to assume that output and labour input move parallel which suggest no difference in productivity. At least for cross country comparisons, this clearly is an unrealistic assumption given the different structure of the services sectors in lower income countries compared to advanced countries.

Rostas (1948) provided some rather crude estimates for sectors other than industry for the UK and the USA. Maddison (1970) made estimates for agriculture and industry, together with rough estimates for real output in services to arrive at a comparative output figure for the total economy in 1965. He assumed that real output in transport, communication and construction was related to output in agriculture and industry combined in the same way as in the United States. For the other services, he assumed a productivity ratio to the United States ranging from one quarter for the country with the lowest productivity in agriculture and industry combined (i.e. India), to three quarters for the country with the highest productivity level relative to the USA (i.e. France).[18]

The pioneering study on sectoral comparisons for the economy as a whole was made by Paige and Bombach (1959). For some non-commodity sectors Paige and Bombach applied physical indicators. For example, for the transport sector passenger- and ton kilometres were weighted by prices. For distribution, the volume of traded goods was weighted at gross margins in distribution. For most other service industries expenditure information from Gilbert and Kravis (1954) was used with net output as weights. So far the contribution by Paige and Bombach to the measurement of comparative productivity in services has not been superceeded in terms of coverage, transparency and clarity.

Recently Pilat (1991a) applied the industry-of-origin approach to a comparison of sectoral output and productivity for Japan and the United States.

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18 There are also a number of comparisons including centrally planned economies, but these largely concentrate on commodity production. These include studies by the CMEA, Gosplan and the CIA. See Drechsler and Kux (1972) for details.

In contrast to Paige and Bombach, Pilat aimed to cover all sectors by unit value- or price comparisons. In 40 to 50 per cent of the cases, PPPs were obtained from ICOP or implicitly derived from physical quantity comparisons.

During the past three decades, a range of studies has emerged with short-cuts or proxies for the methods described above. One example of a short-cut method for physical quantity comparisons was the study by Shinohara (1966). It compared quantities for 53 commodities in 89 countries obtained from the UN *Statistical Yearbook* (and now available from UNIDO) weighted by census value added from Japan, the UK and the USA.[19] Unfortunately the UN sources leave many blanks for major industries, in particular those producing relatively complex products. Moreover, the concepts of output and labour input are not always consistent between countries (Beintema, 1992). Another favourite source for cross country industry comparisons is the OECD International Sectoral Data Base, which is for example used by Dollar and Wolff (1988, 1993). In some cases, there are big differences between the figures in this data base and the original country material from the production censuses and national accounts which is not explained in the data description. Moreover, frequently gaps in the data are filled with information from various sources which are not comparable to the main source (Meyer-zu-Schlochtern, 1988).

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[19] See Maddison (1970) who uses a trade adjusted version of Shinohara's estimates at US prices for 29 countries in 1965.

Table 2.2
Overview of Studies on International Comparisons of Real Output and Labour Productivity in Manufacturing [i]

Author(s)	Benchmark Year(s)	Country Coverage	Size of Sample	Methodology and Sources
Rostas (1948)	1935-1939	USA/USA	108 products; about 50% of UK net output 40% of US net output	Comparisons of physical quantities in 31 industries weighted by operatives. Quantities of by-products converted into main product on the basis of relative unit values; 1935 UK Census of Production and 1937 US Census of Manufactures.
Maddison (1952)	1935	UK/USA Canada/USA	34 products, 14% of UK 8% of US 1935 employment	Comparisons of physical quantities in 12 industries weighted by operatives. For USA/UK largely derived from Rostas (1948), with some adjustments for industry classification and weights. Canada/USA extrapolated to 1947.
Galenson (1955)	1936to 1939	USSR/USA	23 products; 17% of US industrial gross output in 1939	Comparisons of physical quantities in 8 industries, including three mining industries (coal, iron ore, oil and natural gas). For some machinery groups Soviet output was converted to US dollars on the basis of dollar values from Gerschenkron (1951).
Frankel (1957)	1948/7	USA/UK	50 products[ii]; 18% of1947 US, 16% of 1948 UK employment	Comparisons of physical quantities in 34 industries, 21 of which are also covered by Rostas (1948), weighted by employees. 1948 UK Census of Production and 1947 US Census of Manufactures.
Heath (1957)	1948	UK/Canada	50 products[2]; 21% of 1948 UK employment[iii]	Physical quantities for 14 industries were valued at British or Canadian prices. Raw materials and fuel were also compared but these were not used in the presentation of labour productivity. The production censuses for 1948 were used as the basic source.
Maizels (1958)	1950-51	Canada/Australia	30 products[2]; 19% of Canadian, 17% of Australian census value added	Physical quantities from censuses of manufactures valued at Canadian and Australian prices for 21 industries. Implicit unit value ratios for gross output were used to convert census value added to a common currency. For 4 industries double deflation was feasible.

Author(s)	Benchmark Year(s)	Country Coverage	Size of Sample	Methodology and Sources
Paige and Bombach (1959)	1950	USA/Uk	380 products; 51% of UK and 48% of US census value added	Detailed matchings from 1948 UK Census of Production and 1947 US Census of Manufactures. 59% of matches on the basis of physical quantity comparisons; 29% by unit value comparisons; 12% by employment indicators. Updated to 1950 with price and quantity indexes. 1950 census value added adjusted to national accounts GDP. Employment includes head offices.
Mensink (1966)	1958	Netherlands/UK	78 products; 14% of UK 1958 employment	Physical quantities from production censuses for 1958 weighted at Dutch census value added by product obtained from unpublished census information. Shipbuilding on the basis of double deflation.
Kudrov (1969)	1963	USSR/USA	224 products[4]	
Conference of European Statisticians (1969a, b and c)	1962 (with extrapolation to 1967)	Czechoslovakia/ France; Czechoslovakia/ Hungary; Hungary/Austria	Czechoslovakia/ France: 303 products (other studies unknown)	Details for the Czechoslovakia/France comparison: 113 products on the basis of the physical quantity method and 190 products on the basis of the unit value method. Covers 50 branches, including mining and public utilities. The results for the four countries are also presented in Conference of European Statisticians (1972). Methodology in Conference of European Statisticians (1971).
West (1971)	1963	Canada/USA	150 products[2]; industry coverage of 28% of US shipments and 38% of Canadian shipments	Unit value ratios calculated for sales, materials and supplies and fuel and electricity for 33 industries. Based on censuses of manufactures for 1963. Includes adjustment of census value added to national accounts GDP.
Frank (1977)	1972 with extrapolation to 1967-74	Canada/USA	150 products[2]; about 38% of US shipments[3]	Unit value ratios calculated for sales, materials and supplies and fuel and electricity for 33 industries. Based on censuses of manufactures for 1972.
CSO Budapest (1977)	1975	Hungary/Austria	620 product groups 75% of Austrian and 80% of Hungarian output	Comparisons of physical quantities per unit of labour input valued at Hungarian or Austrian prices.

Author(s)	Benchmark Year(s)	Country Coverage	Size of Sample	Methodology and Sources
Yukizawa (1973)	1935	Japan/USA	18 industries coverage unknown	Physical quantities from censuses of manufactures and factory statistics weighted at labour input of operatives. For machinery output was compared on the basis of exchange rates.
Yukizawa (1978)	1958/9, 1963, 1967 and 1972	Japan/USA	60 products; 26% of year labour input. value added in 1972	Physical quantities from censuses of manufactures weighted at manyear labour input.
Smith, Hitchens and Davies (1982)	1967/8	USA/UK	487 matches in 87 industries[iv]; industry coverage of 66% of UK, 64% of US value added[v]	UK Census of Production 1968; 1967 US Census of Manufactures; Primarily based on unit value comparisons, but some matches are Based on ICP PPPs and direct quantity comparisons.
		Germany/UK	350 products in 69 industries[4]; industry coverage of 39% of German and 37% UK value added[5]	Comparisons for Germany/UK on the basis of market prices instead of factor costs.
Davies and Caves (1982)	1977	USA/UK	386 matches[4]; industry coverage of 60% of UK, 61% of US value added[5]	UK Census of Production 1977 and Quarterly Sales Inquiry; 1977 US Census of Manufactures; includes matches based on ICP PPPs and direct quantity comparisons. Details reported in Smith (1985).
Maddison and Van Ark (1988, incl. Expansion of industry coverage)	1975	Brazil/USA	276-417 products; 28% and 23% of gross output	Method as in present study. Censo Industrial Brasil; X Censo Industrial 1976; 1977 US Census of Manufactures.
		Mexico/USA	252-451 products; 23% and 32% of gross output	The 1988 edition of this study includes a direct comparison between Brazil and Mexico. USA adjusted to 1975 with price and quantity indexes by industry.
Van Ark (1988)	1975	Brazil/UK	167 products in Brazil; 197 products in UK	Method as in present study. Censo Industrial Brasil; Quarterly Sales Inquiry and Census of Production 1975 for UK.

Author(s)	Benchmark Year(s)	Country Coverage	Size of Sample	Methodology and Sources
Van Ark (1990a, b)	1984	Netherlands/UK	106 matches; 18-16% of gross output	Method as in present study. Produktiestatistieken; Quarterly Sales Inquiry and Census of Production;
		France/UK	102 matches; 13-9% of gross output	Enquête de Branches and Enquête Annuelle d'Entreprise.
Szrmai and Pilat (1990)	1975 with update to 1985	Japan/USA	126 matches; 22% of Japanese and US shipments	Method as in present study. Censuses of manufactures for 1975 in Japan and 1977 in US. US price and quantity adjustment to 1975 at industry level. Includes an adjustment to national accounts GDP.
		Korea/USA	230 Korean and 536 US products; 46% and 22% of Korean and US gross output respectively	As above. Report on Mining and Manufacturing Survey 1975 in Korea.
Pilat and Hofman (1990)	1973	Argentina/USA	575-450 products; 32% and 22% of value added in Argentina and USA respectively	Method as in present study. Censo Nacional Economico 1974, Industria; US 1977 Census of Manufactures. USA adjusted to 1973 with price and quantity indexes at industry level. Includes national accounts adjustment and update to 1975.
Van Ark (1991)	1975	India/USA	108 matches; 19% of Indian gross output and 10% of US gross output	Method as in present study. For India from Annual Survey of Industries 1973-74; US 1977. Census of Manufactures; adjusted to 1975 on the basis of price and quantity indexes.
Pilat (1991b)	1967, 1975 and 1987	Korea/USA	for 1987: 192 matches; 37% of Korean gross output and 21% of US gross output	Method as in present study. Report on Mining and Manufacturing Survey and US Censuses of Manufactures. Intermediate years are interpolated on the basis
Pilat and Van Ark (1991)	1987	Germany/USA	277 matches; 25% of gross output;	Method as in present study. From Produktion im Produzieren den Gewerbe 1987, and Kosten-struktur der Unternehmen;
		Japan/USA	193 matches; 20% of gross output	1987 US Census of Manufactures and Japanese Census of Manufactures.

Author(s)	Benchmark Year(s)	Country Coverage	Size of Sample	Methodology and Sources
O'Mahony (1992a)	1987	Germany/UK	236 matches; 22% of gross output	Method as in present study, but with adjustments using ICP PPPs in machinery and electrical engineering. From Produktion im Gewerbe 1987, and Kostenstruktur der Unternehmen; UK Census of Production 1987.
Van Ark (1992)	1987	UK/USA	171 matches; 17.6% of UK and 18.1% of US sales value	Method as in present study. UK Census of Production 1987 and Quarterly Sales Inquiry; 1987 US Census of Manufactures.
Szirmai (1993)	1987	Indonesia/USA	204 matches; 54.1% of Indonesian output and 16.9% of US output	Method as in present study. Survey of Large and Medium Scale Manufacturing; US 1987 Census of Manufactures.
Pilat, Prasada Rao and Shepherd (1993)	1987	Australia/USA	178 matches; 23.1% of Australian output and15.1% of US gross output	Method as in present study. 1986-87 Manufacturing Industry: Details of Operations, Australia and 1986-87 Manufacturing Commodities: Principal Articles Produced, Australia; US 1987 Census of Manufac-tures.

i. Excluded from the table are studies only covering particular industries in manufacturing, such as a comparison for the iron and steel industry by the US Dept. of Labor (1968). Also excluded are studies based on proxy-type information such as Shinohara (1966).

ii. In the absence of information from the authors these are rough estimates.

iii. The author does not say how big the sample is, but I derived the sample size by taking the employment of `matched' industries to total manufacturing employment.

iv. Information kindly provided by authors.

v. Coverage percentages refer to industry matches based on price ratios.

Chapter 3 - Unit Value Ratios for Industry of Origin Comparisons

Unit Value Comparisons by Industry of Origin

The Matching of Sample Products

International comparisons of unit values are the key element of the comparisons of real output and productivity in this thesis. As mentioned in the previous chapters, exchange rates cannot be used to convert output to a common currency. Neither are purchasing power parities (PPPs) derived from the expenditure side suitable for comparing value added by industry.

Average ratios of the ex-factory unit value were therefore compiled for sample products. Except for adjustments for quality discussed below, no use was made of specification prices such as those used in the ICP. As discussed at length in chapter 2, the main advantage of using unit values instead of specification prices is that the quantities and unit values are consistent with the total value of output.

My unit value ratios are of a binary nature. In most cases the United States is the `numéraire' country, though in three cases comparisons were made between European countries with the United Kingdom as the base country. These detailed cross-country comparisons were only made for selected benchmark years. In some countries, for example in the United States, full-scale censuses which include product information are only available once in five years. The benchmark years for the comparisons included here are 1975 for Brazil, India and Mexico, 1984 for France and the Netherlands and 1987 for Germany, Korea, Japan and the UK.

The term `unit value ratio' (UVR) is preferable to the more familiar expression `purchasing power parity' (PPP) used elsewhere. The two are interchangeable, but for output comparisons the former identifies more clearly the nature of the prices I use. My `prices' are unit values obtained by dividing the ex-factory sales value by the corresponding quantities obtained from each country's production census or survey.

The first step in estimating the unit value ratios was to match products between countries. The description of the products in the production censuses do not always make such comparisons straigthforward. For example, the production of bricks in one country may be specified in terms of cubic metres and for the other country in tons. In some cases, expert information from industry sources provided a way out of this problem, but in other instances the product match could not be made.

Table 3.1
Coverage of Unit Value Ratios in terms of Total Manufacturing Sales for Benchmark Years (1975, 1984, 1987), in %

Binary Comparison with United States	Own Country(%) (1)	United States (%) (2)	Number of UVRs (3)
1975			
Brazil/USA	27.9	22.9[a]	129
India/USA	19.4[b]	9.6[a]	108
Mexico/USA	31.8	22.8[a]	130
1987			
Korea/USA	36.7	21.0	192
Germany/USA	24.4	24.8	277
Japan/USA	20.0	19.9	193
UK/USA	15.7	14.3	170
Binary Comparison with United Kingdom	**Own Country (%)**	**United Kingdom(%)**	**Number of UVRs**
1984			
France/UK	13.1	9.4	102
Netherlands/UK	17.5	14.5	106
1987			
Germany/UK	21.4	21.9	236

[a] Original product data for the USA are for 1977.
[b] Original product data for India are for 1973/74.
Source: See appendix II. Korea/USA from Pilat (1991b); Japan/USA by Pilat from Pilat and van Ark (1992); Germany/UK from O'Mahony (1992a)

Secondly, for some products no information on sales values or quantities is reported by the census, generally because to do so would breach confidentiality. Thirdly, certain products have a unique character and are produced only in one country and not in the other (for example, super-tankers or guided missiles). Finally, a problem which will be dealt with in more detail later in this chapter, is that many products cannot be matched because they represent different qualities in terms of product content or performance.

Table 3.1 shows the coverage ratios in terms of a percentage of the total sales value and the total number of matches for each binary comparison in this study. Coverage ratios varied from 9.6 to 36.7 per cent of total sales, and was just over 20 per cent on average. There is quite some variation among branches. In some manufacturing branches, close to 50 per cent of sales or even more could be matched, but in other branches coverage was much lower, in particular in the machinery and transport equipment industries.[1]

The Aggregation Procedure

As it is not possible to match all product items in manufacturing, a method is required to fill the holes for the on average 80 per cent of output which could not covered by unit value ratios (UVRs). The aggregation procedure up to the level of total manufacturing was carried out in a number of stages.

The manufacturing sector was divided up in 16 branches, which roughly correspond to the 2-digit level of the International Standard Industry Classification (ISIC) of the United Nations.[2] For each binary comparison, a maximum number of industries within each branch were distinguished which produced the same products in both countries.

Product matches were made for as many products as possible within each industry. The average unit value ratio for the industry was obtained by weighting the unit values by the corresponding quantity weights of one of the two countries:

1 See the tables in appendix II for coverage ratios by branch.
2 See appendix I for the branch and industry classification used for this study.

$$UVR_{j(m)}^{XU(X)} = \frac{\sum_{i=1}^{s} P_{ij}^{X} * Q_{ij}^{X}}{\sum_{i=1}^{s} P_{ij}^{U} * Q_{ij}^{X}} \tag{3.1a}$$

at quantity weights of country X, and:

$$UVR_{j(m)}^{XU(U)} = \frac{\sum_{i=1}^{s} P_{ij}^{X} * Q_{ij}^{U}}{\sum_{i=1}^{s} P_{ij}^{U} * Q_{ij}^{U}} \tag{3.1b}$$

at quantity weights of country U (the USA or the UK).

i =1...s is the sample of matched items in matched industry j(m).

In some cases, the coverage percentage in terms of total sales within the industry was so low, that one could not reasonably assume that the UVRs were representative for the whole industry. On average, there were some 30 industries in each binary comparison for which at least 25 per cent of total sales were matched. These industries represented approximately 40 to 50 per cent of total value added in manufacturing.

For industries for which less than 25 per cent of output was matched, or for which no matches were made at all, the quantity weighted unit value ratio of all matched items in a branch were assumed to be representative for the unknown unit value ratio of a non-matched industry `j(n)' in that branch ‘k’:

$$UVR_{j(n)}^{XU(X)} = \frac{\sum_{i=1}^{s} P_{ik}^{X} * Q_{ik}^{X}}{\sum_{i=1}^{s} P_{ik}^{U} * Q_{ik}^{X}} \tag{3.2a}$$

at quantity weights of country X, and:

$$UVR_{j(n)}^{XU(U)} = \frac{\sum_{i=1}^{s} P_{ik}^{X} * Q_{ik}^{U}}{\sum_{i=1}^{s} P_{ik}^{U} * Q_{ik}^{U}} \tag{3.2b}$$

at quantity weights of country U (the USA or the UK).

The second stage of aggregation from industry to branch level is made by weighting the unit value ratios for gross output (UVR_{go}) as derived above by the value added of each industry in country X or country U, i.e.:

$$UVR_k^{XU(U)} = \frac{\sum_{j=1}^{r}[UVR_{j(go)}^{XU(U)} * VA_j^U]}{VA_k^U} \qquad (3.3a)$$

for the UVR of branch k at quantity weights of country U, and:

$$UVR_k^{XU(X)} = \frac{VA_k^X}{\sum_{j=1}^{r}[VA_j^X / UVR_{j(go)}^{XU(X)}]} \qquad (3.3b)$$

for the UVR of branch k at country X's quantity weights. In the final stage, branch UVRs were weighted at branch value added to obtain a unit value ratio for total manufacturing.[3]

The stage-wise aggregation using either quantities (in the first stage from product to industry level) or value added (in the following stages) has the advantage that the original product UVRs are successively reweighted according to their relative importance in the aggregate. At the end of this chapter the results of sensitivity tests with regard to different aggregation procedures will be presented. It appears that the difference between a stage-wise aggregated UVR and one which is directly build up from the product level using quantity weights of matched products, is largest for comparisons between countries with substantial structural differences. But even for these comparisons (for example, India versus the USA, and the Netherlands versus the UK), the difference in the UVRs is only just over 10 per cent.

Table 3.2 shows the UVRs for total manufacturing for each binary comparison in this study. The own country weighted UVRs are indexes of the Paasche type, whereas the base country weighted UVRs are Laspeyres indexes. Unit value ratios for countries with a similar structure

3 The treatment of 'non-matched' industries was slightly different in the earlier ICOP studies, including the 1975 comparisons for Brazil/USA, Mexico/USA and India/USA (see Maddison and van Ark, 1988; van Ark, 1991; see also Szirmai and Pilat, 1990). In these studies the value added-weighted UVR for matched industries was applied to non-matched industries. By using a larger sample of products for the non-matched industies, the average unit value ratio becomes less sensitive to individual matches.

of manufacturing output and employment are not very sensitive to these different weighting systems. However, in comparisons between, for example, India and the United States, the UVRs at US quantity weights are substantially higher than those at Indian weights. Because of the negative relationship between prices and quantities, an item with a relatively high price will be associated with relatively small quantities in the own country. The quantity weights of the other country (in this case the US) are therefore relatively large. As a result, if one weights a country's prices at US quantities, the unit value ratio will be higher than with quantities of the own country. This index number phenomenon is sometimes called the 'Gerschenkron effect', as Alexander Gerschenkron (1962) described it in detail in his analysis of relative backwardness in historical perspective.

The Fisher index, which is a geometric average of the Paasche and Laspeyres indexes, is mostly used in the remainder of this study. Compared to other biliateral index numbers, the Fisher index stands out relatively well in terms of certain index number properties. For example, in contrast to the Paasche and Laspeyres, the Fisher index satisfies the country reversal test (i.e. changing the denominator and numerator does not alter the results) and the factor reversal test (i.e. a Fisher price index times a Fisher quantity index gives a Fisher value index).[4] In addition, Diewert (1981) stressed some economic theoretic properties of the Fisher index, one of them being that it is a 'superlative' index number.[5] Another attractive property of the Fisher index compared to the Paasche or Laspeyres indexes is that when used for extrapolation of price indexes it tends to show a smaller margin of error from the 'true' measure in the year of extrapolation (Krijnse Locker and Faerber, 1984).[6]

Table 3.2 also shows the market exchange rate of the currencies. The ratio of the unit value ratio to the exchange rate gives an indication of relative price levels in each country. For the lower income countries, relative price levels in 1975 are clearly above those of the United States when the

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4 The Paasche and Laspeyres indexes satisfy the 'weak' factor reversal test, which is that a Paasche price index times a Laspeyres quantity index give a value index which is identical to a Laspeyres price index times a Paasche quantity index.

5 Superlativity means that the index is exact for a flexible functional form, i.e. a function which closely approximates a class of other functions without having to know, or estimate, the parameters of the latter. For a relatively non-technical discussion, see Hill (1988). Recently Diewert (1992) also emphasised the usefullness of Fisher indices in relation to productivity studies.

6 See chapter 4, p. 81-82, for a more detailed discussion of this point. Multilateral weighting systems are discussed in more detail below.

UVR is weighted by US weights, whereas it is close to or below the US price level when based on own country weights. For 1987 relative price levels of the advanced countries are above those of the USA irrespective of the weighting system, apart from Korea. This reflects the relatively low exchange value of the US dollar in that year. For the European comparisons relative price levels are lowest in France and the Netherlands and highest in Germany.

Table 3.2
Unit Value Ratios for Benchmark Years, Total Manufacturing national currency to numéraire currency (1975, 1984, 1987)

Binary Comparison with United States	US Quantity Weights (1)	Own Quantity Weights (2)	Geometric Average (3)	Exchange rate (4)	Relative Price Level (US=100.0) (3)/(4)
1975					
Brazil/USA[a] (Cr/US$)	8.77	6.91	7.79	8.13	95.8
India/USA[b] (Rs/US$)	12.77	6.70	9.25	8.65	106.9
Mexico/USA[a] (Ps/US$)	15.60	11.97	13.67	12.50	109.4
1987					
Korea/USA (Won/US$)	848.73	576.80	699.60	822.60	85.0
Germany/USA (DM/US$)	2.25	2.16	2.21	1.80	122.8
Japan/USA (Yen/US$)	218.80	150.59	181.52	144.64	125.5
UK/USA (£/US$)	0.748	0.670	0.708	0.612	115.7

Binary Comparison with United Kingdom	UK Quantity Weights (1)	Own Quantity Weights (2)	Geometric Average (3)	Exchange rate (4)	Relative Price Level (UK=100.0) (3)/(4)
1984					
France/UK (FF/£)	11.29	10.70	10.99	11.68	94.1
Netherlands/UK (Dfl/£)	4.23	3.79	4.01	4.29	93.5
1987					
Germany/UK (DM/£)	3.56	3.44	3.50	2.94	119.0

[a] Original product data for the USA are for 1977, and were adjusted to 1975 at the industry level. See Maddison and van Ark (1988).

[b] Original product data for India are for 1973/74, and were adjusted to 1975 at the industry level. See van Ark (1991). For USA see footnote a).

Sources: See appendix II. Matchings for Korea/USA from Pilat (1991b); Japan/USA by Pilat from Pilat and van Ark (1992); Germany/UK from O'Mahony (1992a); exchange rates from IMF, *International Financial Statistics*.

An Assessment of the Unit Value Method

A Comparison with Alternative Converters

Table 3.3 compares my unit value ratios with PPPs for total expenditure from ICP and with 'proxy ICP PPPs' for expenditure on manufacturing products. The ICP PPPs in table 3.3 which are expressed in terms of national currencies to the US dollar are based on direct binary comparisons with USA.[7] For the European countries the ICP PPPs are weighted by multilateral European weights. The proxy PPPs are compiled on the basis of a set of PPPs for expenditure categories which mainly consist of manufacturing products, including food products, beverages, and tobacco, clothing and footwear, transport equipment and producer durables. These PPPs were weighted by value added derived from the production censuses to obtain proxy PPPs for total manufacturing.

For the lower income countries the expenditure PPPs are substantially below my manufacturing UVRs. This is caused by the fact that expenditure PPPs include comparisons of prices for services, which are relatively low in lower income countries. The manufacturing proxy PPPs for these countries are much closer to the UVRs.

Unit value ratios are a more appropriate indicator for price comparisons in manufacturing than the purchasing power parities from ICP which cover total expenditure. The latter are designed for expenditure comparisons, and most scholars actively involved in compiling these estimates refrained from using them for sectoral productivity comparisons.

Proxy PPPs serve no purpose and can easily lead to misleading results. Firstly, expenditure by category adds up to national income and not to domestic output. Although ICP makes an adjustment at the economy-wide level to arrive at GDP, expenditure prices for individual items include prices of imported products and exclude prices of exported items. Secondly, the PPPs include relative transport and distribution margins which are more difficult to take out. For example, one reason for the high ICP proxy PPP in Japan might be the relatively high distribution margins in Japan. Thirdly, PPPs are usually expressed at market prices, which may explain the relatively high proxy PPP for Germany, as it includes value added tax and excise duties. For comparisons of the

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7 Binary PPPs for 1975 are from Kravis, Heston and Summers (1982). Since ICP III binary PPPs have not been published anymore, but they were kindly provided by Eurostat.

Table 3.3
Comparisons of Unit Value Ratios, ICP Purchasing Power Parities and Proxy Purchasing Power Parities for Manufacturing

Binary Comparison with United States	Unit Value Ratios for Manufactu-ring (1)	ICP PPPs for Total Economy (2)	Proxy ICP PPPs for Manufac-turing (3)	Exchange rate (4)
1975				
Brazil/USA(Cr/US$)	7.79	5.40	7.77	8.13
India/USA (Rs/US$)	9.25	2.82	7.28	8.65
Mexico/USA (Ps/US$)	13.67	7.17	12.46	12.50
1987[a]				
Germany/USA (DM/US$)	2.21	2.57	2.64	1.80
Japan/USA (Yen/US$)	811.52	235.65	250.53	144.64
UK/USA (£/US$)	0.708	0.604	0.663	0.612

Binary Comparison with United Kingdom	Unit Value Ratios for Manufac-turing (1)	ICP PPPs for Total Economy (2)	Proxy PPPs for Manufac-turing (3)	Exchange Rate (4)
1984				
France/UK (FF/£)	10.91	12.77	11.83	11.68
Netherlands/UK (Dfl/£)	3.99	4.66	4.30	4.29
1987				
Germany/UK (DM/£)	3.50	4.23	3.63	2.94

[a] ICP PPPs for Korea versus the USA are not available.

Note: Proxy PPPs for manufactured products were obtained from the Fisher or multilateral average PPPs for the following categories: food, beverages and tobacco; clothing and footwear; furniture; household textiles and appliances; personal transport equipment and machinery and equipment. The PPPs were weighted at value added weights derived from each country's production statistics.

Sources: UVRs are geometric averages taken from table 3.2. PPPs for 1975 are 'augmented' binary PPPs derived from Kravis, Heston and Summers (1982). PPPs for 1987 (apart from Germany/UK) are Fisher binary PPPs for 1985 kindly provided by Eurostat, updated to 1987 on the basis of national deflators. 1987 Germany/UK PPPs from O'Mahony (1992a). PPPs for 1984 were obtained from multilateral PPPs at European weights from Eurostat (1988) for 1985, and backdated to 1984 on the basis of national deflators.

performance of production factors, value added should ideally be expressed at factor cost, i.e. excluding indirect taxes and including subsidies. This implies that output prices should be exclusive of indirect taxes as well. The fourth argument against the use of proxy PPPs is that these price ratios only refer to final expenditure items, and exclude price comparisons of intermediate goods. Finally, below the basic heading level (of which there are 151), ICP PPPs are unweighted and at basic heading level they are weighted by expenditure per capita. This may lead to quite different results from the output weights required for the purpose of this study.

The Quality Problem

The accuracy of the unit values used for the converters in this thesis depends to an important extent on the detail of product descriptions given in the censuses of each country. In practice unit values mostly represent an average price for a mix of product varieties which may be available in different proportions in two countries.

The expenditure approach uses specification prices for narrowly defined product items, which to some extent meets the product mix-problem. Despite this advantage of expenditure comparisons on the whole, the quality problem is not necessarily more serious in industry of origin studies. Firstly, quality differences are most important in consumer durables and investment goods, but less so for basic goods which represent intermediate stages of production. This latter group, which includes relatively homogeneous products such as paper, steel, cement, planed wood, etc., makes up a large share of manufacturing output but is by definition excluded from final expenditure comparisons.[8] Secondly, compared to specification prices unit values relate to a relatively large share of output and they cover the production of a whole year. In particular for comparisons between countries with a different structure in manufacturing, it is questionable how representative specification prices are of the total output in the countries.

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8 This also explains why in the UVR comparisons, relatively high matching percentages of output were achieved in countries such as Brazil, Mexico and Korea (see table 3.1). In these countries homogeneous items are relatively more important than in the more advanced capitalist countries. On the other hand, vague descriptions of many product items in the censuses of lower income countries and the lack of a suitable product classification system seriously hampers comparisons for some industries, notably for investment industries. See also Beckerman (1966).

Even if the product mix-problem can be tackled, both approaches still face the second aspect of the quality problem, namely 'product content'. This is related to the capacity of the product to perform certain functions, which are not easily observed from even the most detailed product description. For example, for a passenger car one can specify its physical characteristics, such as cylinder capacity, the type of fuel it uses, the number of gears and doors, whether it is equipped with a sunroof or not, etc.. It is more difficult to indicate the durability of its parts, the degree of safety of the car and its actual performance in terms of speed, braking distance, etc.. It should be emphasised that, from a conceptual point of view, 'product-mix' and 'product content' are not different. The distinction lies in the fact that even the most detailed product description will not pick up quality aspects related to product content.

There is an extensive post-war literature on the problem of quality differences in comparisons of real output and income, most of it in relation to time series, such as the retail price index and the producer price index. In recent decades the quality problem has shown a new dimension. Previously quality improvements were mostly reflected in a price rise, and the debate revolved around the question which part of the price rise should be interpreted as a quality increase and which part as a price increase. Presently, one of the major items in manufacturing, namely computers, has shown a continuous and very substantial price fall over the past two decades, which was largely caused by a continued supply of cheaper components with a higher performance.[9]

The problem of adjusting for quality differences is even more difficult for cross-country comparisons than for time series. Over time the quality of most products can be expected to increase along with real output, but

9 The early postwar literature on the quality problem was concerned with the debate what to view as quality change. Stone (1956), Denison (1957) and Gilbert (1961) suggested measuring only quality differences, which are proportional to the change in resource costs (or the price) of a product. However, Griliches (1964, 1971) argued that there are also quality differences which are non-proportional to the price of the product. According to Jaszi (1964) and Denison (1964a) many of these quality differences are related to the 'user value' rather than to the resource costs of the product, and should not be taken into account in real product comparisons. Nowadays there appears to be consensus that non-proportional quality changes should also be taken into account (Baily and Gordon, 1988). Gordon (1990) shows that the measurement of the fall in resource cost per 'computer box' results in a deflator which shows a much slower price decline than the change of the computer price per unit of 'calculating power'.

quality differences between countries are not gradual. In particular when countries have traded off comparative advantages, relative quality advantages in one area of production may go together with quality backwardness in other areas.

There are basically two approaches to handle the quality problem. The first is the conventional method of comparing prices of 'matched' models, i.e. products which possess similar quality characteristics. The second is the hedonic pricing technique. Here a product is not matched directly, but considered as a bundle of quality characteristics. Each quality characteristic is considered as a premium on the price. This premium is derived by way of regression analysis. The hedonic technique has been applied in the US producer price index for computers since 1986 (Sinclair and Catron, 1990). It was also used by ICP for the estimation of PPPs of dwellings and cars (Kravis, Heston and Summers, 1982). A strong point of the hedonic technique is that it can pick up 'product mix' and certain 'product content' characteristics as described above. Its main disadvantage is that the results depend strongly on which quality characteristics are specified. Gordon (1990) pointed also at the problem of multicollinearity and the unclear relation between the characteristics within and outside the hedonic pricing model.

For the comparisons in this thesis, the conventional approach was adopted. In this respect one can distinguish between 'identical products', which have the same specifications and characteristics in both countries, 'common products', which serve the same purpose and have the same product name but with different specifications, and 'unique products' which are products available in one country and not to be found in the other country (Gilbert and Kravis, 1954, p. 79). For example, a steel product of a particular size or thickness and a specified carbon content is typically an identical product. Similarly, for cement one can assume quality differentials to be insignificant. A textile yarn made of a particular fibre may not be identical in terms of thickness compared to the yarn in the other country but it can still be taken as a common product. In our approach we included identical and common products, but in the latter case only when the product mix was judged to have a negligible effect on the unit value ratio.

The crucial assumption in the conventional approach is that the unit value ratio for the matched products is representative for that of the non-matched products, and it needs to be considered whether or not a bias may have occurred. For example, one could assume that the identical and common products included in the matches have a relatively 'low-quality content'. As a result relative prices of the matched products in the country with relatively low productivity levels may be too low, because the non-matched high quality items in the latter country are relatively scarce and are therefore produced at a relatively higher price. This downward bias in the UVR of the low-productivity country compared to the high-productivity country is reinforced by the fact that in case the matched items are not entirely free from quality differences in terms of product content, the relative price in the high productivity country is too high as it embodies an uncaptured quality premium on the price. The assump-tions of the conventional approach therefore imply that the productivity gaps between low-productivity and high-productivity countries which are presented in this thesis, are more likely to slightly understate rather than overstate the 'actual' productivity gap.[10]

Table 3.4
Quality Adjustment of Unit Value Ratios for Passenger Cars

Binary Comparison	Before Quality Adjustment (1)	After Quality Adjustment (2)	Ratio (2):(1) (3)
1975			
Brazil/USA[a] (Cr/US$)	3.97	4.97	125
India/USA[ab] (Rs/US$)	3.20	4.13	129
Mexico/USA[a] (Ps/US$)	9.13	10.94	120
1987[c]			
UK/USA (£/US$)	0.510	0.604	118
1984			
France/UK (FF/£)	8.16	9.02	111
Germany/UK (DM/£)	4.28	4.05	95

[a] Original product data for the USA are for 1977, and were adjusted to 1975 at the industry level. See Maddison and van Ark (1988).
[b] Original product data for India are for 1973/74, and were adjusted to 1975 at the industry level. See van Ark (1991).
[c] No quality adjustments were made for the comparisons between Germany and the USA and between Japan and the USA.
Source: As for table 3.2.

[10] Alternatively one can put forward the argument that due to the availability of high quality products in the high productivity-country, low quality products will be lower priced than in the low productivity-country, because they are regarded as old fashioned. However, this argument primarily relates to the consumer price of the products and not to their ex-factory cost price.

Passenger cars were the one product item included in these comparisons for which a quality adjustment was made using information from secondary sources. The production censuses of most countries only provide figures for the total quantity and sales value of passenger cars. Only the censuses in Germany, Japan and Mexico make a crude distinction between passenger cars on the basis of cylinder capacity. Information from industry and trade sources was therefore used to allocate the passenger cars in each country to four or five size categories on the basis of their cylinder capacity. It was not possible to obtain ex-factory prices for different cylinder categories, but trade sources were consulted to obtain retail prices for domestically manufactured models representing 'typical' models for each size group. On average 3 to 4 typical prices were collected for each size group. The average unit value for each group was then inferred from the average retail prices by category and the actual unit value for all passenger cars which was taken from the production census.

Table 3.4 compares the original unit value ratio for passenger cars with the unit value ratio after adjustment for quality differences. In the binary comparisons with the USA, the unit value ratio after adjustment for quality differences goes up, because of the relatively larger cylinder capacity of cars in the United States. For the France/UK comparisons the UVR also increases as France produces relatively more small cars than the United Kingdom.[11]

The Problem of Double Deflation

Industry of origin comparisons of real output and productivity face a major problem not encountered in comparisons from the expenditure side. This concerns the need to get UVRs for both the value of gross output (GO) and intermediate inputs (I). The UVR for value added of branch 'k' is then obtained as:

[11] No quality adjustments were made at this stage for the other binary comparisons. The procedure for the adjustments in the Brazil/USA and the Mexico/ USA comparisons was slightly different from that described above. See Maddison and van Ark (1988), Statistical Appendix (Notes).

$$UVR_{k(va)}^{XU(U)} = \frac{\sum_{j=1}^{r} [UVR_{j(go)}^{XU(U)} * GO_j^U] - [UVR_{j(i)}^{XU(U)} * I_j^U]}{VA_k^U} \tag{3.4a}$$

at quantity weights of country U, and:

$$UVR_{k(va)}^{XU(X)} = \frac{VA_k^X}{\sum_{j=1}^{r} [GO_j^X / UVR_{j(go)}^{XU(X)}] - [I_j^X / UVR_{j(i)}^{XU(X)}]} \tag{3.4b}$$

at country X's quantity weights.

The double deflation-method has been used in a number of output and productivity comparisons for agriculture, which is a sector characterised by a relatively simple input structure.[12] So far no cross-country comparisons of manufacturing output systematically applied a full-scale double deflation procedure. To convert intermediate inputs to a common currency, one needs separate UVRs for raw materials, fuels, electricity, and for industrial and non-industrial inputs. The coverage of inputs by UVRs needs to be high in particular for raw materials. In contrast to output prices one cannot assume that the UVRs for a few main inputs are representative for the other 'non-matched' inputs in an industry.

Some countries publish information on the value of the main inputs by industry, but quantity information is often lacking. For the United Kingdom and the United States figures on physical quantities of raw materials, packaging materials and energy inputs are provided at the (four-digit) industry level but only for a few main items. Paige and Bombach (1959) and van Ark (1990a) adjusted output UVRs for price differences of elec-tricity and fuel input, but these adjustments made only little difference to the results at the level of branches and for manufacturing as a whole.

Table 3.5 shows the results of an experiment with double deflation on the basis of input-output tables in the Netherlands and the United Kingdom for 1984. For domestic raw materials, output UVRs were used for the branches from which the inputs were used. Service inputs were converted with ICP PPPs and imported inputs at the official exchange rate. The double deflated UVRs for value added show very large fluctua-

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[12] See, for example, FAO (1986), van der Meer and Yamada (1990) and Maddison and van Ooststroom (1993).

Table 3.5
Conversion Factors in Double Deflation Procedure of Manufacturing Output, Netherlands/UK, 1984, DFL/£

	Gross Output (DFL/£)		Intermediate (DFL/£)		Imports (DFL/£)	Value Added (DFL/£)	
	Neth quantity weights (1)	UK quantity weights (2)	Neth quantity weights (3)	UK quantity weights (4)	(5)	Neth quantity weights (6)	UK quantity weights (7)
Food Products and Beverages	3.72	3.94	3.69	3.79	4.27	3.14	4.16
Tobacco Products	2.50	2.93	3.84	3.82	4.27	0.82	1.59
Textiles	3.81	4.19	3.95	4.19	4.27	3.13	4.14
Wearing Apparel	4.78	5.14	4.28	4.32	4.27	6.46	6.37
Leather and Footwear	5.42	5.67	4.27	4.46	4.27	11.28	7.67
Wood Products	3.79	4.23	4.40	4.13	4.27	3.08	4.36
Paper Products	2.36	2.34	3.51	3.49	4.27	1.18	-1.08
Printing and Publishing	3.79	4.23	3.75	3.98	4.27	3.69	4.42
Chemicals	3.74	3.90	4.17	4.07	4.27	2.67	3.43
Rubber and Plastic Products	3.79	4.23	4.24	4.07	4.27	3.18	4.38
Stone, Clay and Glass Products	2.45	2.39	3.86	3.81	4.27	1.57	0.27
Basic Metals and Metal Products	4.40	4.46	5.85	4.32	4.27	3.75	4.88
Electric Engineering	3.79	4.23	4.22	4.29	4.27	3.32	4.17
Machinery and Transport Equipment	4.85	4.96	5.15	4.46	4.27	5.25	5.80
Instruments and Other Manufacturing	3.79	4.23	4.68	4.22	4.27	3.09	4.23
Total Manufacturing	3.79	4.23	4.06	4.11	4.27	3.07	4.31

Note: Gross output UVRs from appendix table II.10. Domestic raw materials were converted by gross output UVRs for branches from which inputs were obtained; imported raw materials were converted at exchange rate. Services were converted at ICP PPPs for specific services categories. The results shown here are only on Fisher-basis.
Source: UK from BSO (1988), *Input-Output Tables for the United Kingdom 1984*, London; Netherlands from CBS (1987), *Nationale Rekeningen 1986*, The Hague.

tions at branch level, though errors appear to cancel out at the level of total manufacturing.[13]

For better results with double deflation at a more disaggregated level one requires much larger input-output tables, and more specific information on the prices of intermediate inputs by industry. Such information cannot be obtained without separate surveys at firm level for individual product items.

Apart from practical data limitations, there are also certain methodological objections against double deflation. Firstly, value added UVRs at Paasche or Laspeyres weights can be far apart in particular if the share of intermediate inputs in gross output differs strongly between countries. Secondly, relatively small measurement errors in the price ratios of output or inputs tend to become magnified in the UVR for value added, in particular when intermediate inputs make up a large part of gross output.

Instead of applying an incomplete and unsatisfactory double deflation procedure, I followed the practice of earlier industry of origin studies, which derive the UVR for value added from the UVR for gross output weighted by the value added of the corresponding industry, as shown by equations (3.3a) and (3.3b) above. This method is called the 'adjusted single indicator' method, because although the product UVRs refer to the gross output level, it is adjusted for value added weights.[14] The method is based on the following assumptions:

1) at the product level, the value share of intermediate inputs in each unit of output is the same for all products within that industry and across countries.
2) the UVRs for inputs of industries and branches equal the corresponding UVRs for gross output.

Paige and Bombach (1959) defended the superiority of the adjusted single indicator method which 'although not so tidy and conceptually less satisfying' (p. 82) tends to provide more robust results than the double deflation method.

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13 Szirmai and Pilat (1990) experimented with a similar kind of double deflation procedure for their Japan/USA and Korea/USA comparison for 1975, which also showed rather volatile results at branch level. See Frank (1977) for a partial double deflation procedure, which included fuels, electricity and raw material inputs.

14 This method is similar to what has been common practice in compiling wholesale- or producer price indexes in many countries, namely to weight the indexes of producer prices at the value added of specific industries (see, for example, Carter, Reddaway and Stone, 1948).

Binary versus Multilateral Weighting Systems

The unit value ratios presented in this thesis are all based on binary comparisons, with either the United States or the United Kingdom as the ‘numéraire' or base country. In fact these binary comparisons take the form of a star comparison with the base country as the centre of the star. Comparisons between two or more countries representing points of the star can be made when using unique weights, for example the weights of the star country. However, as discussed above, the use of single country weights creates biases in one or the other direction. In the present study the binary results are expressed in terms of the Fisher index.[15]

Binary comparisons are characterised by some major index number problems of which the three most important are discussed here. Firstly, binary indexes are not transitive. In the present context this means that the unit value ratio between two countries does not equal the ratio of the UVRs between each of those two countries and a third country.

Secondly, binary indexes lack base country invariance, which implies that the results depend on the base country with which each country is compared. Base country invariance can only be achieved if the weights represent an average of all countries in the sample.

Finally, a binary index does not generate additivity (or matrix consistency). The requirements for additivity are twofold. If one conceives of an international comparison of output as a matrix with the columns representing the countries in the sample and the rows representing the products or industries, then each row should add up to the total value of output of all countries for one particular product or industry, and each column should add up to the total value of output in a country.[16]

The problems of transitivity, base country variance and additivity can be tackled by multilateral weighting systems. Multilateralisation is now

15 The comparisons in the OEEC studies (Gilbert and Kravis, 1954; Gilbert and Associates, 1958; Paige and Bombach, 1959) are also of a binary nature comparing each country on an individual basis with the United States. Gilbert and Kravis (1954) and Gilbert and Associates (1958) employed a rather primitive multilateral weighting system to obtain average European price weights. In each European country, products were priced in terms of US dollars. The average European dollar price for each product was then obtained weighting the dollar prices for each country at the national product in US prices.

16 Other index properties such as the factor reversal test and transaction equality are discussed in Kravis, Heston and Summers (1982). See also Pilat and Prasada Rao (1991).

common practice for all ICP studies.[17] Recently Pilat and Prasada Rao (1991) calculated multilateral indexes on the basis of industry of origin estimates from ICOP for the benchmark year 1975. Their study covers six originally binary comparisons with the United States, which include Brazil, Mexico, India, the United Kingdom, Korea and Japan.[18]

The first index variant used by Pilat and Prasada Rao is the Geary-Khamis method, which is also mostly applied by ICP. It derives average prices at a disaggregated level simultaneously with a PPP for the aggregate on the basis of two interdependent equations. In ICOP-terminology this implies that the average 'international' unit value, P_k, for each branch 'k' and the Geary-Khamis unit value ratio, $UVR_m^{Z(GK)}$, for total manufacturing 'm' of any country Z are derived on the basis of two interdependent equations:[19]

$$P_k = \sum_{Z=1}^{N} \frac{P_k^Z}{UVR_m^{Z(GK)}} [Q_k^Z / \sum_{Z=1}^{N} Q_k^Z] \tag{3.5a}$$

and

$$UVR_m^{Z(GK)} = \frac{\sum_{k=1}^{t} P_k^Z Q_k^Z}{\sum_{k=1}^{t} P_k Q_k^Z} \tag{3.5b}$$

where P_k^Z and Q_k^Z are the unit value and quantity of branch k in country Z.

For their sample of seven countries Pilat and Prasada Rao found that the Geary-Khamis index moves into the direction of or even beyond the Paasche VR. This is caused by the fact that the Geary-Khamis index is

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17 A range of methodological studies on multilateralisation methods for ICP has appeared over the past decade, including Hill (1981), Kravis, Heston and Summers (1982), Ward (1985), Salazar-Carillo and Prasada Rao (1988) and Kurabayashi and Sakuma (1990).

18 Multilateral indexes were calculated at three different aggregation levels, i.e. at branch level, at industry level and at product level (for food products and chemicals). In the remainder of this section I will only deal with multilateralisation at branch level, which implies that the results below that level are still of a binary nature.

19 The terminology and sub-scripts of our equations are adjusted to that used for this study and different from the original ICP terminology.

dominated by the largest country in the sample, which affects the results in particular if the distance between the Paasche and the Laspeyres index is wide.

Other multilateralisation methods have been developed, some of them aiming to obtain results which are independent of country size. For example, the Gerardi-method derives the international unit value P_k on the basis of a simple unweighted geometric average of each country's unit value, adjusted for purchasing power. The Gerardi international price for each country is then derived as follows:[20]

$$P_k = \prod_{Z=1}^{N} [\frac{P_k^Z}{PPP}]^{1/N} \tag{3.6}$$

Pilat and Prasada Rao also show results for a multilateral version of the binary Theil-Tornqvist indexes. The binary Theil-Tornqvist UVR for manufacturing between two countries X and U, $UVR_m^{XU(TT),}$ is a geometric average of binary branch (Fisher) UVRs weighted at the average value share of the two countries in each branch:

$$UVR_m^{XU(TT)} = \prod_{k=1}^{t} [UVR_k^{XU(F)}]^{\frac{v_k^X + v_k^U}{2}} \tag{3.7a}$$

where $UVR^{XU(F)}$ is the Fisher UVR between countries X and U, and v_k^X and v_k^U are the value of branch 'k' in countries X and U

These binary index are multilateralised (and therefore made transitive) on the basis of a procedure developed by Eltetö, Köves and Szulc (EKS). This index aims to minimise the distortion between the original binary index between country X and U and the multilateral version, which can be seen from the following equation:

$$UVR_m^{XU(EKS)} = [UVR_m^{XU(TT)^2} * \prod_{Z \neq X,U}^{N} UVR_m^{XZ(TT)} * UVR_m^{ZU(TT)}]^{\frac{1}{N}} \tag{3.7b}$$

The main problem with the EKS procedure is that it does not provide full additivity, so that no UVRs for the sub-aggregates can be obtained.[21]

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20 See Hill (1981, pp. 54-61) for a critical analysis of the Gerardi procedure. Compared to the Geary-Khamis method, one disadvantage is that the PPP is not simultaneously derived with the international price.

21 See Prasada Rao and Pilat (1991) for attempts to achieve additivity in the EKS system, but so far this has not produced satisfactory results.

I calculated the Geary-Khamis and the TT-EKS indexes to obtain a transitive unit value ratio between the Germany/USA, the Germany/UK and the UK/USA comparison for 1987. Table 3.6 compares these multilateral UVRs with the original binary UVRs taken from table 3.2. In contrast to the binary indexes, one can see that the Geary-Khamis index and the TT-EKS indexes produce a transitive result, as the actual and implicit UK/USA UVRs coincide (see the last two entries in the third and fourth row).

Table 3.6
Comparison of Binary UVRs and Multilateral UVRs for Manufacturing in Germany, the United Kingdom and the United States, 1987

	Binary UVRs			Geary-Khamis UVR	EKS Theil-Tornqvist
	Paasche	Laspeyres	Fisher		
(1) Germany/USA (DM/US$)	2.16	2.25	2.21	2.24	2.21
(2) Germany/UK (DM/£)	3.42	3.59	3.50	3.29	3.23
(3) UK/USA (£/US$)	0.670	0.748	0.708	0.680	0.684
(4) UK/USA - implicitly derived from (1)/(2) (£/US$)	0.619	0.627	0.631	0.680	0.684

Source: Binary UVRs from table 3.2; multilateral UVRs were calculated from binary branch results.

Despite the attractive properties of multilateral methods for comparisons between more than two countries, I have reservations about multilateralising the complete price system for the purpose of this study. As shown above there is no index number which can possess all desirable properties. The most important shortcoming of all multilateral methods is the loss of a very important property which binary index numbers possess, i.e. country characteristicity.[22] For a comparison between any pair of countries, the weights of the two countries themselves most adequately reflect the relative price structures. In particular if one is primarily interested in how each country's productivity compares to and catches up with the leading country, a comparison based on weights of third countries is less valid. Among the binary indexes, the Fisher index stands out relatively well in terms of its index number characteristics and economic theoretic properties, and it does not produce the biases which are inherent of the Paasche and the Laspeyres indices.

[22] The term was first coined by Laszlo Drechsler (1973).

Testing the Unit Value Ratios

One can of course question the realism of some of the assumptions and adjustments made above to derive unit value ratios. It is therefore necessary to analyse carefully the sensitivity of the unit value ratios to the various assumptions and adjustments. These tests were carried out for five of the ten binary comparisons included in this thesis.

My first sensitivity tests were aimed at checking the robustness of the average UVRs for the inclusion of UVRs for small products or for outlier UVRs. As can be seen from the UVRs in the country tables in appendix II the unit value ratios varied substantially between the branches. This appears also also from the coefficients of variation for the product UVRs in column (1) of table 3.7, which range from 0.26 in the France/UK comparison to 0.77 in the India/USA comparison.

One might infer that this large variation in product UVRs is caused by 'outlier' UVRs for relatively small products. However, it appears from columns (2) and (3) in table 3.7 that the coefficient of variation does not change much if one drops from the sample the relatively small items with a value of less than 0.1 per cent of total sales. This implies that 'outlier' UVRs, i.e. UVRs which are very high or very low compared to the average, are not just those of the smaller items.

In column (4) of table 3.7, 'outlier' UVRs which are more than 0.5 times the standard deviation below the mean of the full sample or more than one time the standard deviation above the mean are excluded from the sample.[23] Naturally, the coefficient of variation fell, but there was no statistically significant difference between the averages. So even if one is suspicious of 'outlier' UVRs it does not make much difference to the overall results. Of course these tests can be repeated for each of the 16 manufacturing branches. The UVRs will then be slightly more sensitive to the exclusion of outliers.

The second test is related to the aggregation procedure explained above. In column (1) of table 3.8 the product UVRs are directly aggregated to the level of total manufacturing weighted by their quantities. In column (2) an intermediate stage of value added-weights at industry level is included, whereas column (3) shows my preferred unit value ratios which are reweighted by industry- and branch value added.

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23 The exclusion criteria are skewed, as the UVRs can never fall below zero, whereas at least in theory they can become many times higher than the mean.

Table 3.7
Testing the Sensitivity of the Unit Value Ratios to the Exclusion of Outliers

	All Unit Value Ratios (1)	UVRs more than 0.1% of total matched value own country (2)	UVRs more than 0.1% of total matched value base country (3)	UVRs less than 0.5*STD below mean or 1*STD above mean (4)
Germany/USA (1987)				
number of UVRs	273	131	141	153
arithmetic mean UVR	2.48	2.52	2.47	2.54
standard deviation (STD)	1.03	0.99	0.91	0.41
coefficient of variation	0.42	0.39	0.37	0.16
UK/USA (1987)				
number of UVRs	170	107	77	92
arithmetic mean UVR	0.755	0.737	0.737	0.767
standard deviation (STD)	0.28	0.24	0.24	0.11
coefficient of variation	0.38	0.33	0.33	0.14
Netherlands/UK (1984)				
number of UVRs	106	89	92	61
arithmetic mean UVR	3.984	3.866	3.914	4.097
standard deviation (STD)	1.22	1.21	1.26	0.47
coefficient of variation	0.31	0.31	0.32	0.12
France/UK (1984)				
number of UVRs	102	80	102	60
arithmetic mean UVR	11.457	11.337	11.457	11.613
standard deviation (STD)	3.01	3.05	3.01	1.02
coefficient of variation	0.26	0.27	0.26	0.09
India (1973/74)/USA (1977)				
number of UVRs	108	87	83	81
arithmetic mean UVR	6.379	6.485	6.138	5.958
standard deviation (STD)	4.90	5.15	3.88	1.88
coefficient of variation	0.77	0.79	0.63	0.32

Sources: see tables in appendix II.

Table 3.8
Comparison of Quantity-Weighted UVRs for Total Manufacturing with Value Added-Weighted UVRs for Benchmark Years

	Quantity-Weighted UVR (1)	Reweighted at Industry Level (2)	Reweighted at Industry and Branch Level (3)
Germany/United States (DM/US$) - 1987			
own quantity weights	2.06	2.10	2.16
US quantity weights	2.16	2.19	2.25
geometric average	2.11	2.15	2.21
United Kingdom/United States (£/US$) - 1987			
own quantity weights	0.643	0.664	0.670
US quantity weights	0.703	0.718	0.748
geometric average	0.675	0.690	0.708
France/United Kingdom (FF/£) - 1984			
own quantity weights	10.26	10.83	10.70
US quantity weights	11.21	11.27	11.29
geometric average	10.73	11.05	10.99
Netherlands/United Kingdom (Dfl/£) - 1984			
own quantity weights	3.42	3.61	3.79
US quantity weights	3.82	3.95	4.23
geometric average	3.62	3.78	4.01
India/United States (Rs/US$) - 1975			
own quantity weights	5.57	5.98	6.70
US quantity weights	11.99	12.46	12.77
geometric average	8.17	8.63	9.25

Source: see tables in appendix II

Table 3.9
Sensitivity Tests of Unit Value Ratio by Product Category

	All Unit Value Ratios (1)	UVRs Consumer Goods (2)	UVRs Basic Goods (3)	UVRs Investment Goods (4)
Germany/USA (1987)				
number of UVRs	273	187	69	21
arithmetic mean UVR	2.48	2.61	2.32	1.91
standard deviation (STD)	1.03	1.06	0.95	0.72
coefficient of variation	0.42	0.41	0.41	0.38
UK/USA (1987)				
number of UVRs	170	119	42	9
arithmetic mean UVR	0.755	0.743	0.814	0.640
standard deviation (STD)	0.28	0.26	0.34	0.29
coefficient of variation	0.38	0.35	0.41	0.45
Netherlands/UK (1984)				
number of UVRs	106	82	23	1
arithmetic mean UVR	3.984	4.058	3.719	4.038
standard deviation (STD)	1.22	1.29	0.95	0.00
coefficient of variation	0.31	0.32	0.25	0.00
France/UK (1984)				
number of UVRs	102	56	39	7
arithmetic mean UVR	11.457	11.682	10.879	12.876
standard deviation (STD)	3.01	3.28	2.42	3.08
coefficient of variation	0.26	0.28	0.22	0.24
India (1973/74)/USA (1977)				
number of UVRs	108	52	55	1
arithmetic mean UVR	6.397	6.365	6.490	2.962
standard deviation (STD)	4.90	3.56	5.91	0.00
coefficient of variation	0.77	0.56	0.91	0.00

Sources: see appendix II.

The table shows that the difference in UVRs according to the alternative weighting procedures is largest in the case of the India/USA comparison. The structure of the Indian and US industry is very different, which makes reweighting necessary in order to correct for products which are important in one country but unimportant in the other country. The geometric average UVR on the basis of the stage-wise aggregation procedure is more than 13 per cent above the product-weighted UVR. This confirms the observations made above concerning the quality problem, namely that the product sample in the low-productivity country is characterised by relatively low unit values. By reweighting this bias is reduced and the UVR increases. For the other countries, the unit value ratios also turn out to be slightly higher when based on the stage-wise aggregation procedure, but the differences are less than for the India/US case.

The conventional approach to the quality problem in this thesis has led to a relative overrepresentation of UVRs for durable and non-durable consumer goods in the product sample. Table 3.9 shows that, on average, some three-quarters of the sample consists of this kind of products, with the remainder covering basic goods and a limited number of investment goods. Although the average UVRs show substantial differences between the three sub-samples, there was only a statistically significant difference between the average UVR for investment goods and the overall manufacturing UVR for Germany versus the USA and for India versus the USA. This implies that one cannot speak of a systematic bias in our sample due to a relatively large number of consumer goods in the sample. In any event because of the stage-wise aggregation procedure described above, the impact of consumer good UVRs on industries which mainly consist of basic and investment goods is substantially reduced.

Conclusion

The conclusion of this assessment is that, at least for aggregates such as for branches and for manufacturing as a whole, the unit value method as applied here is sufficiently robust for obtaining appropriate indicators to convert output to a common currency. For comparisons at more disaggregated levels, such as for industries and products, a careful assessment is required in every case to assess quality differences and to evaluate the impact of different unit value relationships for inputs compared to output. This requires consultation of experts and trade sources. Some adjustments of this nature, in particular for passenger cars, have been included in this thesis, but further research is necessary to cover other goods as well, in particular for investment goods.

Unit value ratios, which are derived from the quantities and ex-factory sales value of products, are more suitable for industry of origin comparisons than ICP purchasing power parities. The latter are designed for expenditure comparisons, and as far as productivity comparisons are concerned only applicable for the economy as a whole. Our UVRs for manufacturing are clearly superior to proxy PPPs for expenditure on manufactured products. The latter include transport and distribution margins, reflect prices of imported goods, and are largely exclusive of information on intermediate products.

A particular strong point of the unit value method compared to the expenditure PPP method is the direct relationship between values and quantities. The unit values and quantities are also directly related to the concepts of gross output and value added which are used in real output and productivity comparisons which follow in the next chapter.

Chapter 4 – Comparative Real Output and Productivity Levels

Benchmark Comparisons of Output and Labour Productivity

The unit value ratios (UVRs), which were presented and discussed in chapter 3, can be used to convert manufacturing value added in each country to a common currency. Value added comparisons have been made for 13 to 16 branches, which together constitute the manufacturing sector.[1] Branch UVRs were obtained from industry UVRs using value added as weights. Real output comparisons for total manufacturing are derived in similar way, i.e. by summing branch value added converted at their unit value ratios, as shown by the following equation:

$$\frac{VA_m^{X(U)}}{VA_m^{U(U)}} = \frac{\sum_{k=1}^{t}[VA_k^{X(X)} / UVR_k^{XU(X)}]}{\sum_{k=1}^{t} VA_k^{U(U)}} \qquad (4.1a)$$

or

$$\frac{VA_m^{X(X)}}{VA_m^{U(X)}} = \frac{\sum_{k=1}^{t} VA_k^{X(X)}}{\sum_{k=1}^{t}[VA_k^{U(U)} * UVR_k^{XU(U)}]} \qquad (4.1b)$$

with VA_k and UVR_k representing value added and the unit value ratio for branch k; superscripts refer to country X and country U with the superscript between brackets referring to weights of country X or country U.

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[1] See appendix I for the classification of branches and industries. See chapter 3 (pp. 27-31) for a discussion of the aggregation procedure of unit value ratios from product level to industry and branch level.

Table 4.1

Value Added, Persons Engaged, Annual Hours Worked and Comparative Productivity Levels in Total Manufacturing in Benchmark Years

Binary Comparison with United States	Census Value Added (mln. US$)	Number of Persons Engaged (000s)	Annual Hours Worked	Census Value Added per Person Engaged (USA=100)	Census Value Added per Hour Worked (USA=100)
1987					
Germany	284,674	6,768	1,630	67.2	78.7
Korea	53,115	3,264	2,758	26.4	18.2
Japan	571,333	10,867	2,161	85.4	75.5
United Kingdom	158,833	4,819	1,763	53.6	58.0
United States[a]	1,165,747	18,951	1,909	100.0	100.0
1975[b]					
Brazil	39,354	3,672	2,017	41.6	38.1
India	8,402	5,661	2,256	5.8	4.7
Mexico	16,134	1,674	2,026	37.4	34.1
United States	442,486	17,174	1,848	100.0	100.0

Binary Comparisons with United Kingdom	Gross Value Added (mln. £)	Number of Persons Engaged (000s)	Annual Hours Worked	Gross Value Added per Person Engaged (UK=100)	Gross Value Added per Hour Worked (UK=100)
1984					
France	62,855	3,797	1,610	116.1	126.2
Netherlands	14,597	711	1,611	143.1	155.4
United Kingdom[a]	64,101	4,467	1,749	100.0	100.0
1987					
Germany	137,325	6,602	1,630	112.7	121.8
United Kingdom	84,367	4,571	1,763	100.0	100.0

[a] The figures on value added and employment for the numéraire country can slightly differ for each binary comparison, due to differences in classification or employment concepts. See individual country tables in appendix III.

[b] 1975 comparisons are made on the basis of employment, excluding employees in auxiliary units (head office employment, etc.). The employment figures for 1975 are therefore not strictly comparable to those for 1987.

Note: census value added is gross value added plus purchases of non-industrial inputs.

Sources: see appendix III. Japan/USA compiled by Pilat (Pilat and van Ark, 1992); Korea/USA from Pilat (1991b, updated). Germany/UK from O'Mahony (1992a).

It is important to take account of the fact that branch output is first converted to the currency of the other country, and only after that the sum of branch output is compared to manufacturing output in the other country. This implies that the output ratios are at this stage unadjusted for compositional differences in branch structure. The effect of compositional differences on the productivity ratios is discussed in more detail in chapter 6.

Table 4.1 shows the comparative levels of value added, value added per person employed and value added per hour worked for the benchmark years of the various binary comparisons. The corresponding results for manufacturing branches are shown in appendix tables III.12 to III.21. The results will be discussed and analysed in chapters 5 and 6. In the remainder of this chapter, the basic sources from which output and labour input are derived, and the methodology to extrapolate the benchmark results to non-benchmark years are discussed in more detail.

Production Censuses and Surveys

The main source for the benchmark comparisons of output and productivity is the production census or industrial survey. This is typically a primary statistical source, which provides the raw data on the transac-tions of manufacturing units (e.g. sales, stocks, purchases of raw materials, salaries, etc.) classified by industry. In some countries (for example Germany and France) this information is now gathered entirely on a sample survey basis, whereas in other countries (for example India and the USA) full censuses are carried out every five years with surveys for intermediate years. For simplicity I refer hereafter to all these sources as production censuses.[2]

Production censuses are the most suitable sources for cross country comparisons of labour productivity levels. Firstly the level of detail on individual industries and on the various components of output, intermediate inputs and factor inputs is substantial. It allows one to make the necessary adjustments to obtain consistent figures across countries. Secondly the information for output and inputs is based on one and the same questionnaire for which the information is supplied by the same firms, so that there is no risk that the output and input figures cover different activities.

[2] Appendix tables III.1 to III.11 contain for each country a detailed description of the main characteristics of the production census or survey and a table including output, employment, hours worked and the comparative productivity ratios.

The basic statistical unit

In the production censuses three types of manufacturing units are distinguished:

- The legal unit. This is the manufacturing unit as a legal entity representing the ownership as it is recognised in the national laws. Usually the legal unit is also the reporting unit to the census.[3]
- The local unit. This unit is characterised by its geographical location and usually it represents a manufacturing unit located at a single postal address. In France the local unit is named `l'établissement', and in the US and Japanese censuses the `establishment', which should not be confused with the third statistical unit.
- The activity unit. The activity unit is the smallest unit representing a particular manufacturing activity for which separate production accounts can be compiled. A local unit may consist of more than one activity unit, but it is also possible that an activity unit comprises more than one local unit.

The activity unit (which is named the establishment in the UK census) is the ideal concept for productivity analysis, because it represents a homogeneous production activity, so that comparisons of productivity are not too much affected by the secondary activities or services production of the manufacturing unit.

To reduce the administrative burden for companies, it has increasingly become practice, in particular in Europe to take the reporting unit (usually the legal unit) also as the statistical unit. This implies that for France, Germany and the United Kingdom (for 1987) value added per employee could only be obtained for legal units, whereas in the Netherlands and the United Kingdom (for 1984) we used information for activity units. For the other countries we could only work on the basis of information for local units.[4]

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3 Legal bodies which are owned by a parent company (e.g. a holding) or fellow subsidiary companies are counted separately. In most statistics the legal unit is named the enterprise or firm (in Germany ‘das Unternehmen’). However in the United Kingdom the enterprise represents a consolidated group of legal units owned by the same parent company.

4 The definition of the statistical unit raised in some cases major problems, for example for the comparisons of productivity in petroleum refining. Depending on statistical practice in each country, some oil companies provide data to the census for oil refining separately, whereas in other statistics the highly capital intensive refining process was not separated from secondary activities. For this reason petroleum refining was left out of the comparisons among the European countries.

Sampling procedures and coverage of production statistics.

In most countries, production censuses provide an almost complete picture of industrial activity. However, below a certain cut-off level (in terms of numbers of employees per unit) the estimates are often based on a sample survey (Brazil, Japan, USA) or are obtained on the basis of information for the total number of employees (for example by applying productivity estimates from the larger units as in the United Kingdom). For other countries the information is only provided for units with more than 5, 10 or 20 employees. In most lower income countries, only information for 'registered' units is included, which in practice means that a substantial part of manufacturing activity at the lower end of the firm size-scale is not taken into account. The comparisons between the European countries (with the UK as the numéraire country) are made on the basis of legal units with more than 20 persons only.

Activity classifications

All censuses in our sample are based on industrial classifications which are very close to the 1968 version of the International Standard Industrial Classification (ISIC) of the United Nations or the 1980 version of the General Industrial Classification of Economic Activities (NACE) of the European Community. However, many countries have made some adjust-ments to these classification systems by conforming to national practices taking account of specific domestic circumstances.

Most censuses include information on mining (and sometimes also public utilities and construction), which was taken out for the comparisons in this study. The German manufacturing survey includes a substantial amount of repair work which I excluded because in other countries it is included with services. By contrast, I added back in some activities which are excluded from manufacturing by a few countries, such as petroleum refining in the United Kingdom and processed food products in France. For comparisons with Germany, publishing is excluded because no census information could be obtained for this industry.

In some cases activities needed to be shifted from one branch to another to make classifications comparable between the countries. Most important in this respect was the reclassification of Japanese `electronic computing and processing machines' from electrical equipment to machinery (see Pilat and van Ark, 1992). As appendix I shows, I consolidated figures for some manufacturing branches (e.g. basic metals and metal products; machinery and transport equipment). This was largely determined by the lack of sufficient unit value ratios for metal products and for machinery to allow a separate comparison for these branches.

The output concept

In this study value added is taken as the output concept. Table 4.2 shows the relation of value added to alternative output concepts which can be used for productivity comparisons. Some of the earliest productivity studies (e.g. Rostas 1948; Frankel 1957) were based on comparisons of gross value of output. With the latter concept a good deal of double counting occurs, because part of output is used as intermediate inputs elsewhere. Columns (1) and (2) in table 4.3 show the percentage of inter-mediate inputs, i.e. all current inputs, to gross output for the countries in our sample according to the production census and input/output table respectively.

Table 4.2

Output Concepts Used in Production Censuses and Industrial Surveys

	Total sales of products excluding value added tax
plus	Industrial services rendered
minus	Margin of goods merchanted or factored
plus	Increase in stocks and work in progress
=	*Gross value of output at market prices*
minus	Purchases: • raw materials, components, semi-manufactured goods • packaging materials • workshop materials • energy inputs
plus	Increase in stocks of raw materials, packaging materials, etc.
minus	Purchases of industrial services • work done on materials supplied • repair and maintenance
=	*Census value added at market prices ('net output')*
minus	Net indirect taxes (indirect taxes minus subsidies)
=	*Census value added at factor cost*
minus	Purchases of non-industrial services • insurance premiums • bank charges[a] • hires and rents • legal and accountants charges • transport and communication costs • advertising • other business services
=	*Gross value added at factor cost*[a]

[a] in the present national accounts concept of gross domestic product, bank charges are excluded from gross value added at sectoral level as opposed to the former national accounts concept which was in use before 1968.

Table 4.3
Total Intermediate Inputs and Non-Industrial Service Inputs in Manufacturing according to Production Censuses and Input/Output Tables

	Intermediate Inputs as a % of Total Gross Value of Output[a]		Non-Industrial Services Inputs as a % of Total Intermediate Inputs	
	Production Census	Input/Output Table	Production Census	Input/Output Table
France (1984)	65.9	64.4	-	17.2
Germany (1987)	63.3	61.2	15.6	25.6
Japan (1987)	-	62.9	-	23.8
Netherlands (1984)	74.2	72.0	12.2	11.5
United Kingdom (1984)	66.1	62.3	12.1	19.2
United States (1987)	-	63.1	-	22.5
India (1975-76)	76.8	63.6[b]	6.0	20.3[b]
Brazil (1975)	66.4	61.8	8.4	11.3
Mexico (1975)	62.8	65.0	16.6	25.2
United States (1977)	-	64.0	-	19.9

[a] Gross value of output is inclusive of net indirect taxes; intermediate inputs excludes net indirect taxes.
[b] 1973-74

Source: For full references to production censuses and surveys see appendix tables III.1 to III.10. For detailed adjustments for Brazil and Mexico, see also Maddison and van Ark (1988). Sources for input/output tables as follows: France from INSEE (1988), *Rapport sur les Comptes de la Nation 1987*. Germany from Statistisches Bundesamt (1990), *Input-Output-Tabellen, 1985 bis 1988*, *Volkswirtschaftliche Gesamtrechnungen,* Wiesbaden. Japan from MITI, *Input-Output Tables 1987*, Tokyo; Netherlands from CBS (1987), *Nationale Rekeningen 1986*, The Hague. UK from BSO (1988), *Input-Output Tables for the United Kingdom 1984*, London; Netherlands from CBS (1987); US from 1977 from US Dept. of Commerce (1984), *The Detailed Input-Output Structure of the US Economy, 1977*; for 1987 from US Dept. of Commerce (1992), diskette on Input-Output Accounts of the US Economy, 1987, see also *Survey of Current Business* (April 1992); India from print-out on input-output transaction 1973-74 obtained from Indian Statistical Institute, Delhi. Brazil from IBGE (1987), *Matriz de Relacoes Intersetoriais Brasil 1975*, Rio de Janeiro, prepared by Peter Palesch (ECLAC, Santiago). Mexico from SPP (1981), *Matriz de Insumo-Producto*, Vol. VII.

These percentage shares show a remarkably stable pattern of between 60 and 70 per cent. The high share in the Netherlands may be caused by its open economy with a relatively specialised manufacturing sector. These two factors make it that firms purchase relatively many inputs from outside.

In some production censuses (e.g. in those of the United States and Japan) only purchases of raw materials, energy inputs, packaging mate-rials and industrial services are treated as intermediate inputs. The value added concept which results from deducting these intermediate inputs from gross output is called 'census value added'.[5] This output concept is broader than 'gross value added', which is mostly used in the national accounts. In addition to deducting the intermediate inputs listed above, the latter also excludes purchases of non-industrial services, such as for example transport services, advertising, cleaning and financial accounting (see table 4.2).

It is generally believed that the degree of 'outsourcing' of service inputs by manufacturing firms increases during the process of industrialisation. However, table 4.3 provides no clear evidence of such a pattern. The variation in the share of non-industrial service inputs in total intermediate inputs shown in columns (3) and (4) is quite substantial. For example, the table suggests on both accounts a relative high share of non-industrial service inputs in Germany. Some other authors have in fact argued the contrary for Germany, i.e. a relatively low degree of outsourcing. For example, Elfring (1988) reports for Germany a lower share of employment in 'producer services' than for France, the Netherlands and the United Kingdom, which implies that many German companies produce these services themselves.[6]

Table 4.3 also shows that on the basis of input-output tables, the share of non-industrial services in total intermediate inputs is larger than according to the production censuses. Firstly, input-output tables are usually more strictly related to manufacturing activities only than production censuses. This implies that sources which are supplied within the legal unit are reallocated as purchases in the input-output table.[7] An additional problem is that production censuses in general underreport the purchases of non-industrial

5 In the UK it is called 'net output'.

6 Producer services include business services, financial services, insurance services and real estate services. See also Ochel and Schreyer (1988a, 1988b), which also shows a substantially lower degree of externalisation in Germany compared to the United States.

7 In fact this makes the I/O tables unsuitable for an assessment of outsourcing, which needs to be studies at firm (i.e. legal unit) level.

services.[8] A more careful analysis than was possible within the scope of this study will be required to settle the evidence on the degree of outsourcing.

Due to the lack of conclusive evidence on purchases of non-industrial service inputs, and because the US *Census of Manufactures* does not even include an estimate for these inputs, I based all my comparisons with the United States on census value added. The comparisons among the European countries are on a 'gross value added' basis.

Two further remarks on the value added concept need to be made. Firstly, for productivity comparisons I took the gross concept of value added which implies that depreciation on capital goods is not deducted as an input. The relationship between depreciation rules and the actual decrease in the productivity capacity of capital goods is weak.[9] On the other hand, a gross measure of value added tends to slightly overstate the labour productivity level for the countries which are most capital intensive, because depreciation as a percentage of value added is relatively high in these countries.

Secondly, value added is expressed at factor cost. This implies that factor inputs are valued at their actual renumeration, i.e. including the subsidies provided. Output on the other hand is measured at producers' value, i.e. excluding transfer payments from the consumers to the government, such as value added tax and excise duties.

The employment concept

The denominator of the productivity equation, which is labour input, needs to be carefully defined as well. In most cases the production censuses and surveys only provide labour input in terms of numbers of persons employed.[10] In general the censuses include all employees on the payroll of the reporting unit, but some categories of employees are treated differently in the various censuses, such as part-timers and casual workers, working proprietors, unpaid family workers, outworkers (i.e. people who work in their own homes on materials supplied by establishments), and personnel which were on the payroll of third parties.

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8 This is, for example, explicitly stated in the introductory notes of the 1984 input/output table for the United Kingdom (BSO, 1988, p. 11, point 7.4). For recent developments in standardising concepts and definitions in national production censuses and surveys, see United Nations (1981), *Recommenda-tions for the 1983 World Programme of Industrial Statistics, Part One, General Statistical Objectives*, Statistical Papers, Series M, No. 71, New York.

9 See appendix VI on details concerning the estimation of capital stock.

10 See below for estimates of hours worked.

Unfortunately the data did not always allow us to make all necessary adjustments, but in general these categories made very little difference to the overall results. The only substantial adjustment was made for employees in head offices and auxiliary units, which makes up for approximately 5 to 6 per cent of the manufacturing labour force in advanced countries. In the comparisons with the lower income countries head office employment was excluded.

Reconciling Census Material with National Accounts

In most countries production censuses are an important source for the construction of gross domestic product (GDP)-estimates in the national accounts. The source description in appendix III shows how production censuses for each country are related to the national accounts. In lower income countries, production censuses are mostly the only source on which the national accounts estimates of output by industry are based, but for advanced countries a detailed reconciliation of information from production censuses and income tax records is often pursued.

With the exception of the United States, Korea and Japan, the production censuses and surveys provide sufficient detail to permit rearrangement of the information to produce an estimate on the basis of the 'national accounts concept' of gross value added. Table 4.4 shows that in all these countries, except the United Kingdom, the 'census estimates' of value added are lower than the national accounts estimates, but that there is a substantial difference among countries.

For the Netherlands and the United Kingdom the production census estimates of value added are within a range of 3 per cent of the national accounts estimate. Some differences between the two sources still could not be captured, such as the valuation adjustment for inventories and the treatment of indirect taxes on inputs in the national accounts. The wide range of sources used for the construction of the national accounts in France seems to imply an incomplete coverage of the production survey.

The value added estimate from the industrial survey in India is, after an adjustment for depreciation, almost identical to the national accounts estimate. Here it should be emphasized that this estimate only relates to registered manufacturing units, and exclude the very large unregistered sector in India (see also van Ark, 1991)

For Brazil and Mexico the census estimates of value added are well below the national accounts estimates. It appears that the Mexican census makes a more substantial adjustment for unregistered units than the production in Brazil. These adjustments are necessarily based on scattered information for small scale manufacturing. In this thesis, I

Table 4.4
Gross Value Added and Employment in Manufacturing in Production Censuses as a Percentage of National Accounts

	Gross Value Added	Number of Employees
	(national accounts = 100.0)	
France (1984)	87.3[a]	89.5[a]
Japan (1987)	n.a.	77.4
Netherlands (1984)	97.3[a]	97.8[ab]
United Kingdom (1984)	102.8[c]	92.3[c]
United States (1987)	n.a.	97.2
India (1975-76)	99.2[d]	n.a.
Brazil (1975)	84.1	n.a.
Mexico (1975)	72.4	83.6
United States (1977)	n.a.	98.0

[a] production census figures include estimates for units with less than 10 persons employed. Adjustment for France based on INSEE, *Les Petites Entreprises Industrielles 1983*; adjustment for the Netherlands based on employment for CBS, *Statistiek Werkzame Personen* and gross value added per person employed for units with 10 or more employees.

[b] excluding estimates for 'other manufacturing'.

[c] production census figures adjusted for stock appreciation.

[d] net value added from national accounts gross up with deprecia-tion from production survey. Estimates only for registered manufacturing, i.e. factories with 10 or more employees using power and factories with 20 or more employees not using power.

Note: Germany is excluded from this table as the production censuses exclude legal units with less than 20 employees, which makes comparisons with the national accounts inappropriate.

Source: For full references to production censuses and surveys see appendix tables III.1 to III.10. National accounts figures: France from INSEE, *Rapport sur les Comptes de la Nation 1987*. Japan from EPA, *Annual Report on National Accounts 1991*. Netherlands from CBS, *Nationale Rekeningen*; employment from CBS *Statistiek Werkzame Personen*. United Kingdom from CSO, *United Kingdom National Accounts 1986 Edition*; employment from Census of Employment provided by Department of Employment. USA from US Dept. of Commerce, *National Income and Product Accounts 1929-1982* and *Survey of Current of Business*, various issues. India see van Ark (1991). Brazil see Maddison and van Ark (1988) and M.A. Gusmao de Veloso, 'Brazilian National Accounts', update July 1989. Mexico see Maddison and van Ark (1988).

refrain from adjustments for the real output and productivity of small firms.[11]

In contrast to the output estimates, which form part of the hard core of the national accounts, employment figures obtained from national accounts are mostly compiled in a much cruder way (if published at all), and are usually based on a mix of figures from employment censuses, labour force surveys and production censuses. As a result, one cannot be as confident about the consistency of the numerator and the denominator in a productivity comparison based on national accounts as with production censuses and industrial surveys.

In Japan the production census shows a number for total employment which is less than 80 per cent of the national accounts estimate. There are indications that the employment in the Japanese national accounts includes a substantial amount of double counting (see Pilat and van Ark, 1992). It is not feasible to make a direct comparison for value added between the census and the national accounts (as the census-concept includes purchases of non-industrial services), but gross value of output in manufacturing according to the census is only 10 per cent below the national accounts. As a consequence productivity estimates based on the national accounts are likely to substantially understate the labour productivity level for manufacturing in Japan.

Although the UK national accounts does not contain an estimate for employment, the national accounts GDP figures are often used in combination with employment figures from the *Census of Employment*. The latter source is based on a different business register than the production census. Employment according to the production census is almost 8 per cent below the estimate from the *Census of Employment*.[12] As census output was 2.8 per cent above the national accounts level, output per employee in Britain is 11.4 per cent higher in the production census compared to an estimate based on the national accounts and the employment census.

In summary, for cross country comparisons of productivity at sectoral level the use of output and employment figures from the production census is preferred over the national accounts, because of the internal consistency of output and employment data and the greater degree of detail in the census.

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11 See van Ark (1991) for a discussion and estimates of output and productivity in unregistered manufacturing units in India.

12 For a discussion of the different estimates of the Dept. of Employment, which produces the *Census of Employment*, and the Business Statistics Office, which is responsible for the *Census of Production*, see Pickford et. al. (1989).

Measurement of Working Hours

Estimating the number of hours worked per person is an area in which there has hardly been any effort at standardisation. Maddison (1980) proposed a comprehensive system of labour market accounts to compile consistent estimates of hours worked. It combines figures on weekly (or daily) hours including overtime, with estimates of the average number of weeks (or days) actually at work. From a total of 52 weeks, time is deducted for holidays and vacation, sickness, industrial disputes and work stoppages, for which the information is derived from various sources. The number of weeks actually worked is then multiplied by the weekly paid hours to obtain the number of annual hours actually worked per employee. These estimates cover only paid employees, which in advanced countries account for almost all persons employed in the manufacturing sector.

The labour market accounting framework underlies the estimates of hours worked in manufacturing for the European countries in this study and for the USA in 1975. Table 4.5 shows my calculations for the manufacturing sectors of the Netherlands, the United Kingdom and the United States, and compares them with figures for Germany from the Institut für Arbeitsforschung, which are based on the same method.

Compared to the European countries, actual hours in the USA are relatively high because of shorter holidays. Furthermore, in the case of the Netherlands, paid sickness accounted for a substantial part of poten-tial working time.

Table 4.6 shows estimates of annual working hours for all the countries in the sample. For the 1987 US estimate I obtained the information on hours actually worked directly from the US Bureau of Labor Statistics. BLS now provides estimates of the ratio of hours worked to hours paid for the USA on an annual basis. It shows the ratio for 1987 at 0.909 which (after applying it to 52 weeks in a year) equals 47.3 weeks.[13]

Hours estimates for Japan and Korea are directly based on monthly hours actually worked which exclude paid hours not worked. However, it is not clear from these sources how much was accounted for by holidays, vacation, sickness, etc..

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13 Jablonski, Kunze and Otto (1990) als provided a corresponding estimate for earlier years, which showed a ratio of 0.917 for 1975. This is slightly above the implicit ratio derived from my estimate in table 4.6 which shows a ratio of 0.908 (47.24 weeks to 52 weeks).

Table 4.5
Hours Worked by Employees in Manufacturing, Germany (1986), Netherlands (1984), United Kingdom (1984), United States (1975)

	Germany (1986)	Nether-lands (1984)	United Kingdom (1984)	United States (1975)
Average weekly paid hours	40.1	40.1	40.2	39.1[a]
Regular	38.2	39.3	37.0	36.9
Overtime	1.9	0.8	3.2	2.2[a]
Number of weeks worked	40.7	40.2	43.6	47.2
Total weeks per year	52.0	52.0	52.0	52.0
minus:				
Holidays and vacation	8.6	7.4	6.2	4.1
Sickness, incl. absence for personal reasons	2.5	4.2	1.9	0.5
Other (work stoppages, industrial disputes, etc.)	0.2	0.2	0.3	0.2
Annual hours worked per employee (weekly hours * weeks)	1,633	1,611	1,749	1,848
Number of employees (000s)	7,859	842	5,015	18,658
Number of hours worked (mln.) (employees * annual hours)	12,831	1,356	8,768	34,482

[a] As the weekly hours were only for production workers, it was assumed that non-production workers work the same amount of normal hours but only half the amount of overtime.

Source: Germany calculated from H. Kohler and C. Reyher (1988), *Arbeitszeit und Arbeitsvolumen in der Bundesrepublik Deutschland*, 1960-1986, Institut für Arbeitsmarkt und Berufsforschung, Nürnberg; UK and the Netherlands calculated from various sources as shown in van Ark (1990a), annex C. US paid hours from Bureau of Labor Statistics, *Monthly Labor Review*, October 1977; holidays and sickness from Bureau of Labor Statistics, *Employee Compensation in the Private Non-Farm Economy, 1977*, April 1980. Work stoppages from US Dept. of Commerce, *Statistical Abstract of the United States, 1979*, table 681 and 710.

Table 4.6
Annual Hours Paid and Annual Hours Actually Worked in Manufacturing for Benchmark Years

	Employees			All Persons
	Annual Hours Paid	Annual Hours Actually Worked	Ratio Actual/ Paid Hours	Annual Hours Actually Worked
France (1984)	1,993[a]	1,610	0.808	n.a.
Germany (1986)	2,086	1,633	0.782	2,048
Japan (1987)	2,386[b]	2,161	0.906	2,136
Korea (1987)	2,945[c]	2,758	0.937	2,760
Netherlands (1984)	2,084	1,611	0.773	n.a.
UK (1984)	2,086	1,749	0.838	n.a.
USA (1987)	2,100	1,909	0.909	1,911
Brazil (1975)	2,280[d]	2,017	0.885	n.a.
India (1975)	n.a.	2,256	n.a.	n.a.
Mexico (1975)	2,289[d]	2,026	0.885	n.a.
USA (1975)	2,034	1,848	0.908	n.a.

[a] Estimate based on adjustments for sickness, strikes, short-time working and holidays and vacation for 1981 from B. Ernst (1988), *Le Facteur de Production Travail Dans la Base 80 Des Comptes Nationaux*, No. 1.

[b] Estimate derived from actual hours by taking 3.4 weeks of holidays calculated from Ministry of Labour (1987), *Yearbook of Labour Statistics*, Tokyo, and assuming 1.5 weeks for sickness.

[c] Estimate derived from actual hours by assuming two weeks of leave (including public holidays) and 1.3 weeks for absence due to sickness on the basis of Ministry of Labour (1988), *Yearbook of Labour Statistics*, Seoul.

[d] Estimate based on multiplying actual hours worked by the ratio of 52 to 46 weeks.

Sources: Germany, Netherlands, UK and USA (1975) see table 4.5. France from INSEE, *Rapport sur les Comptes de la Nation 1987*. Korean annual hours actually worked from Pilat (1991a). Japan calculated from Ministry of Labour (1988), *Yearbook of Labour Statistics 1987*, Tokyo; adjustment for owners and family workers from Statistics Bureau (1990), *Monthly Statistics of Japan*, June. See Pilat and van Ark (1992). USA weekly hours for 1987 from BLS, *Monthly Labor Review* with adjustment for overtime hours of non-production workers (see table 4.5) and ratio of hours worked to hours of paid from Jablonski, Kunze and Otto (1990). Monthly hours for Brazil from information provided by Federacao das Industrias do Estado de Sao Paulo. Weekly hours for Mexico from INEGI (1985), *Estadísticas Históricas de México*. India from *Annual Survey of Industries 1975-76*.

The estimates for the two Latin American countries were substantially cruder. Firstly, it was assumed that the average working year has 46 weeks. For Brazil, monthly hours 'usually worked' (unadjusted for sickness, short-time working etc.) were obtained for the state Sao Paulo.[14] This estimate of monthly hours came at 190 hours for 1975 which, if divided by 4.33 weeks per month (52/12), comes at 43.8 hours per week or at 2,017 hours on an annual basis. For Mexico, average weekly hours were 44.1 for 1975 which came to an annual figure of 2,026 hours assuming 46 weeks actually worked.

The hours estimate for India is very crude and is the only one which is directly based on the industrial survey. The *Annual Survey of Industries* provides total labour input in terms of man-days defined as 'the number of persons attending in each shift over all the shifts worked on all days'. This figure was multiplied by 8 hours (per shift) and then divided by the total number of employees.

It appears from table 4.6 that despite the wide variation among the advanced countries in terms of hours actually worked, the estimate of hours paid are surprisingly close, with the exception of Japan and Korea. In Japan and Korea the actual hours are substantially above those of the European countries and the USA, but also above the estimates for Brazil and Mexico.

The Extrapolation of Benchmark Results Over Time

A Methodology for Linking Benchmarks and Time Series

The benchmark results of comparative output and productivity levels as derived in the preceeding part of this chapter, can be extrapolated forwards and backwards by national time series on output and labour input. For the manufacturing sector as a whole I include (as far as possible) extrapolations from the benchmark year back to 1950 and up to 1990.[15] In addition, I extrapolated the results for six major groups of manufacturing branches back to 1973 and up to 1990.

There are basically two methods to extrapolate benchmark results, which are illustrated in tables 4.7 and 4.8 showing the extrapolations

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[14] I am most grateful to Regis Bonelli (Instituto de Planejamento Economico e Social, Rio de Janeiro) for his help and advice in using these figures.

[15] In the case of Mexico I encountered too many problems in compiling a reliable time series on manufacturing value added and employment from the Mexican national accounts, so I have excluded this country in the remainder of this thesis.

between two years, i.e. 1975 (the benchmark year for Brazil/USA and India/USA comparisons) and 1987 (the benchmark year for the Germany/USA, Japan/USA, Korea/USA and UK/USA comparisons).[16]

The first method is to extrapolate the comparative value added figure for the benchmark year by time series on real output:

$$\frac{VA_{t+1}^{X(U)}}{VA_{t+1}^{U(U)}} = \frac{VA_t^{X(U)} * [VA_{t+1}^{X(X)} / VA_t^{X(X)}]}{VA_t^{U(U)} * [VA_{t+1}^{U(U)} / VA_t^{U(U)}]} \qquad (4.2a)$$

and

$$\frac{VA_{t+1}^{X(X)}}{VA_{t+1}^{U(X)}} = \frac{VA_t^{X(X)} * [VA_{t+1}^{X(X)} / VA_t^{X(X)}]}{VA_t^{U(X)} * [VA_{t+1}^{U(U)} / VA_t^{U(U)}]} \qquad (4.2b)$$

where superscripts refer to country X or U with between brackets the prices of country X or U at which value added is expressed, and where subscripts refer to the benchmark year t and the year for extrapolation t+1.

Table 4.7
Extrapolation of Gross Value Added in Manufacturing (USA=100) from Benchmark Year to Other Years with Real Output Indexes, 1975 and 1987

	Census Value Added 1975 (US=100)	Real Manufacturing Output in 1987 (1975=100)		Census Value Added 1987 (US=100)
		Own Country	USA	
Brazil	**8.9**	154.4	151.0	*9.1*
France	*17.3*	113.2	151.0	**13.0**[a]
Germany	*34.6*	117.9	151.0	**27.0**
India	**1.9**	218.8	151.0	*2.7*
Japan	*39.2*	188.6	151.0	**49.0**
Korea	*1.5*	450.6	151.0	**4.5**
Netherlands	*3.9*	121.6	151.0	**3.1**[a]
United Kingdom	*19.6*	104.7	151.0	**13.6**
United States	100.0	-	151.0	100.0

[a] For link of France/UK and Netherlands/UK to the United States, see below.
Note: All benchmark figures are on Fisher basis. Figures in bold are original benchmarks; italics are extrapolations.
Source: Benchmark figures on value added from table 4.1. Time series on real output from appendix table IV.1.

[16] The comparisons for the Netherlands and France were originally based on the UK. See below for the method of rebasing them on the USA.

Table 4.7 shows the results of this method of extrapolation for two years, i.e. 1975 and 1987. The benchmark figures are put in bold, whereas the extrapolated estimates are shown in italics.

The second method of extrapolation is to update or backdate the unit value ratio for the benchmark year with national price indices:

$$UVR_{t+1}^{XU(X)} = UVR_{t}^{XU(X)} * \frac{[P_{t+1}^{X(X)} / P_{t}^{X(X)}]}{[P_{t+1}^{U(U)} / P_{t}^{U(U)}]} \qquad (4.3a)$$

and

$$UVR_{t+1}^{XU(U)} = UVR_{t}^{XU(U)} * \frac{[P_{t+1}^{X(X)} / P_{t}^{X(X)}]}{[P_{t+1}^{U(U)} / P_{t}^{U(U)}]} \qquad (4.3b)$$

where superscripts refer to country X or U with between brackets the quantity weights of country X or U at which the index is expressed, and where subscripts refer to the benchmark year t and the year for extrapolation t+1.

The extrapolated unit value ratios for year 't+1' are then used to convert the value added for year 't+1' expressed in its own currency to a common currency, as was also done for the benchmark year figures in equations (4.1a) and (4.1b):

$$\frac{VA_{t+1}^{X(U)}}{VA_{t+1}^{U(U)}} = \frac{VA_{t+1}^{X(X)} / UVR_{t+1}^{XU(X)}}{VA_{t+1}^{U(U)}} \qquad (4.4a)$$

or

$$\frac{VA_{t+1}^{X(X)}}{VA_{t+1}^{U(X)}} = \frac{VA_{t+1}^{X(X)}}{VA_{t+1}^{U(U)} * UVR_{t+1}^{XU(U)}} \qquad (4.4b)$$

Table 4.8 shows the results of the unit value extrapolation.

If quantity and price indexes are consistent, i.e. their product represents the change in value between 1975 and 1987, both methods described above lead to the same result. In this study the time series of real output in manufacturing (used for the first extrapolation method) were mostly derived from national accounts, and as price indices I took the corresponding deflators (used for the second extrapolation method). As these two series are consistent, the results from table 4.7 match those of table 4.8. In the remainder of this thesis, I based the extrapolations exclusively on the first method, i.e. on real output indicators taken from the national accounts in combination with time series on employment and working hours.

Table 4.8
Extrapolation of Gross Value Added in Manufacturing (USA=100) from Benchmark Year to Other Years with Unit Value Ratios, 1975 and 1987

	Census Value Added 1975 (US=100)	Extrapolition of Unit Value Ratios				Census Value Added 1987 (US=100)
		Unit Value Ratio 1975	Price Index in 1987 (1975=100)		Unit Value Ratio 1987	
			Own Country	USA		
Brazil	8.9	**7.79**	6718.7	162.3	*322.48*[a]	9.1
France	17.3	*4.85*	254.8	162.3	**7.61**[b]	13.0
Germany	34.5	*2.39*	150.3	162.3	**2.21**	27.0
India	1.9	**9.21**	222.1	162.3	*12.60*	2.7
Japan	39.3	*250.73*	117.5	162.3	**181.52**	49.0
Korea	1.5	*393.84*	288.3	162.3	**699.60**	4.5
Netherlands	3.9	*2.85*	142.6	162.3	**2.50**[b]	3.1
United Kingdom	19.6	*0.395*	290.7	162.3	**0.708**	13.6
United States	100.0	1.00	-	162.3	1.00	100.0

[a] New cruzeiros to the US dollar, which were replaced by cruzados (=1,000 new cruzeiros) in 1986.
[b] For link of France/UK and Netherlands/UK to the United States, see below.
Note: All benchmark figures are on Fisher basis. Figures in bold are original benchmarks; italics are extrapolations.
Source: Benchmark figures on value added from table 4.1; unit value ratios from table 3.2. Deflators taken from the same sources as the real output series in appendix IV.

The Linking of France and the Netherlands to the United States

For two of the countries in the sample, i.e. France and the Netherlands, binary comparisons were only made with the United Kingdom as the `numéraire' country. A problem therefore occurs in comparing these countries to the United States, as a link could only be made via one or more third countries. The most straightforward way of linking France and the Netherlands to the United States would be via the UK/USA comparison, as shown in column (1) of table 4.9. Alternatively, the link could also be made via, subsequently, the Germany/UK and Germany/USA comparisons (see column 2). Although these two methods do not change the relative positions among the European countries, the latter leads to substantially higher productivity levels for the European countries compared to the United States. This inconsistency is due to the lack of transitivity in the unit value ratios between Germany, the UK and the USA, as discussed in chapter 3.

I therefore used the multilateral Geary-Khamis UVRs between Ger-many, the UK and the USA from table 3.6 to obtain a link for France and the Netherlands to the USA. Column (3) of table 4.9 shows the productivity figures, based on multilateralisation of all four comparisons with the USA. The most important effect of this multilateralisation method is the relative improvement in the productivity performance of Germany compared to the other European countries. My compromise measures are shown in column (4), which imply that the binary comparisons for Germany and the UK to the USA are maintained because of their greater country characteristicity, and that the multilateral results from column (3) are only used for the countries (France and the Netherlands) for which no direct comparison with the USA was available.

Table 4.9
Alternative Estimates of Value Added per Hour Worked in France, Germany the Netherlands and the United Kingdom in Manufacturing (USA=100), 1987

	Value Added per Hour (USA=100)			
	Bilateral Comparison via UK/USA	Bilateral Comparison via Germany/Uk & Germany/USA	Multilateral Comparison	Preferred Compromise Measure
	(1)	(2)	(3)	(4)
France	70.5	78.5	73.3	73.3
Germany	70.7	**78.8**	77.4	**78.8**
Netherlands	80.6	89.8	83.9	83.9
United Kingdom	**58.0**	64.6	60.4	**58.0**
United States	100.0	100.0	100.0	100.0

Note: original binary results are in bold.
Source: original benchmark results see table 4.1; time series see appendix IV; multilateralisation procedure based on Geary-Khamis method, see text.

It should be emphasised that this linking procedure is a purely pragmatic solution to obtain a link based on a transitive UVR between Germany, the UK and the United States. It would be more appropriate to make direct comparisons for each country with the United States. In fact, before one begins to multilateralise, one should investigate the reasons behind the lack of transitivity between the comparisons between Germany, the UK and the USA, which might have been caused by other reasons than different price structures.[17]

[17] The UVR for the direct comparison between Germany and the UK was DM 3.50 to the £ for 1987 (O'Mahony, 1992) compared to DM 3.12 which is derived indirectly (i.e. DM 2.21 to the US$ and £0.708 to the US$). See also table 3.6. There is a slight difference between O'Mahony's method and mine. O'Mahony used UVRs for machinery and electrical engineering which were derived from a ratio of the `proxy PPP' for machinery and engineering products and the UVR for total manufacturing.

The Consistency of Time Series and Benchmark Comparisons

For extrapolation of the benchmark figures for comparative real output and productivity, use was primarily made of national accounts series. In contrast to the benchmark comparisons presented above, estimates from production censuses are less useful for the construction of time series.[18] Firstly, the frequent updating of business registers which are used to allocate manufacturing units in the census to a particular activity creates breaks in census series. For example, when units grow to a particular size they may at once come within the scope of the census. Similarly, when a new unit has come into existence it is included in the census only at the time the business register is updated. The national accounts often includes techniques to smooth out such changes in statistical coverage.

Secondly, when censuses are based on information for legal units, a change in the product mix causes a reallocation of the unit to another activity. National accounts are mostly more strictly on an activity basis than production censuses, so that such reallocations are not necessary.

A third problem with censuses concerns changes in sampling techniques and the recent reductions in sample size to ease the administrative burden on firms. In the national accounts, such breaks are less important because more than one primary source is used to compile consistent estimates of output and employment over time. Finally, another important disadvantage of time series taken from production censuses concerns the need to use deflators from secondary sources to recalculate output values in constant prices.

As the proxy PPP between Germany and the UK was higher than the manufacturing UVR, this explains (after weighting for the share of machinery and electrical engineering in total manufacturing value added) about one third of the difference between the direct and the implicit Germany/UK unit value ratio. Other factors which may explain this gap are the use of different product samples. The product sample of each two-country comparison should be seen as the one which is most characteristic of the industries compared so that a greater trust should be put into the results obtained from direct rather than from indirect comparisons.

18 For this brief survey I made use of a study by Pieter Al and Guus Broesterhuizen (1985), 'Comparability of Input-Output Tables in Time', *National Accounts Accounts Occasional Paper*, No. NA-004, Centraal Bureau voor de Statistiek, The Hague.

The merger of national accounts sources for extrapolation with production censuses for benchmark years creates problems of overall consistency. There are three reasons why, for a given year, 'extrapolated' figures may differ from the result of a benchmark comparison:

(1) Differences in methodology and basic data underlying the construc-tion of time series on real output and labour input between countries.
(2) Differences in methodology and basic data underlying the construc-tion of benchmark comparisons.
(3) The inherent index number problems in linking time series and benchmark comparisons.

Methodology and basic data for the National Accounts

During the postwar period major efforts were made to standardise national accounts between countries and to improve their comparability.[19] However, the building blocks and methods with which the national accounts are constructed still differ substantially between countries. In lower income countries, time series from the national accounts are mostly similar to the production census, as the latter is often the only source on which the national accounts estimates for industry can be based.[20]

For advanced countries a variety of primary sources is used to compile national accounts estimates. For example, in the Netherlands and France, national accounts GDP estimates for the postwar period are based on annual input-output tables for which the production surveys are one of the basic sources. In Germany, the production survey is in fact the major source for the national accounts estimates of manufacturing output, but only for enterprises with more than 20 employees. National accounts estimates of GDP for the United States and the United Kingdom are only very partially based on census information and to a larger extent on income and expenditure sources. The latter two are discussed in some more detail below.

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[19] See, for example, the core document by the United Nations (1968), *A System of National Accounts*, Studies in Methods, Series F, No. 2, Rev. 3, New York. For an extensive review of the 1968 SNA and the recent developments of a new SNA, see Pyatt (1991).

[20] This argument should not be confused with the fact that in absolute terms the national accounts in developing countries usually show substantially higher levels of output. This is primarily caused by the usual adding-up of 'guesstimates' on small scale industries, which are not taken into account in the production censuses.

During the first two decades after world war II, the British estimates of manufacturing GDP at constant prices were largely based on indexes of physical output weighted by net output (i.e. value added). These indexes were linked to benchmark year estimates of manufacturing output at current prices. The latter were essentially income-based estimates derived from national income which was distributed over the industries on the basis of production census information on net output. Table 4.10 compares the national accounts growth rates of real output in manufactu-ring with an index based on net output at current prices from the production census deflated by the producer price index. The latter shows significantly faster growth up to 1973. The production index used for the national accounts may therefore have understa-ted manufacturing output growth in the UK during this period. It may have taken insufficiently account of new products which, particularly in a period of relatively fast growth, add substantially to the increase in real output. Secondly, it is believed that physical indicator series make insuf ficient

Table 4.10
Growth of Manufacturing Value Added in the United Kingdom, 1950-89

	National Accounts Production Index	Census Net Output Deflated by Producer Price Index
1950-1958	2.0	3.5
1958-1968	3.9	4.5
1968-1973	2.9	3.6
1973-1979	-0.7	-1.1
1979-1989	1.1	1.1
1950-1968	3.1	4.1
1968-1989	1.0	1.1

National accounts series see appendix III. UK census value added (net output) and employment from CSO (1978), *Historical Record of the Census of Production*, and *Report on the Census of Production, Summary Volume*, various issues. UK census value added for total manufacturing from 1950 to 1968 deflated at wholesale index for total manufacturing from CSO, *Annual Abstract of Statistics*; from 1968 onwards deflated by branch with producer price index from CSO, *Annual Abstract of Statistics*.

adjustment for quality changes.[21] Since the late 1960s a greater part of the GDP index came to be based on sales figures deflated by a producer price index rather than on an index of physical production.[22] Despite the objections against using production census series for extrapolation, I substituted the series from the production census for the official national accounts growth figures for the period 1950 to 1968 (see appendix table III.1).

In the United States, the national accounts estimates of real GNP in manufacturing are largely derived by annual double deflation of gross value of output and intermediate inputs. As there are no independent estimates of intermediate inputs at current prices, the latter are implicitly derived by deducting value added from the value of shipments (adjusted for inventories) in manufacturing. As in the UK, value added at current prices is derived from an income-based measure, and is distributed over industries on the basis of information from the input-output table.[23]

In recent years the US national accounts series on GNP in manufacturing have been increasingly criticised for, among other things, their use of a fixed base year, an inadequate double deflation procedure, and the inclusion of a statistical adjustment factor to make the double deflated results consistent with the rest of the GNP accounts. The overall implication of these criticisms is that the growth of US manufacturing output during the 1980s may have been overstated.[24]

However, the evidence of an upward bias in the growth rates of US manufacturing output is by no means conclusive. Recent revisions by the US Department of Commerce include an estimate of real output growth based on shifting base years (i.e. 1977 for the period 1977-1982, 1982 for the period 1982-87 and 1987 for the period from 1987 onwards). Table 4.11 shows that for the period 1977 to 1987 taken as a whole, the shifting benchmark year index shows almost the same growth rate as the original series for manufacturing GDP using 1982 weights. However, the alternative

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21 Obviously the same can be said of the deflators used to obtain real value added estimates from the census. However, here the same argument as what I argued in chapter 2 concerning the characteristics of the physical quantity method versus the UVR method is valid, namely that price indicators usually are more representative for the non-measured part of output than quantity indicators. See also Carter, Reddaway and Stone (1948, pp. 31-34).

22 See CSO (1968, 1985).

23 Despite some adjustments this method essentially remained unchanged throughout the postwar period. See, for example, Gottsegen and Ziemer (1968) and US Dept. of Commerce (1976, 1985)

24 For the most explicit criticism of the US national accounts output series in recent times, see Mishel (1988) and Denison (1989). For a defence see Lawrence (1991).

estimates suggests that the slowdown in manufacturing output growth from 1977 to 1982 was less substantial than the original estimates suggested, whereas the rise since 1982 was more moderate.

A unique feature of the US national accounts compared to other countries concerns the introduction in 1986 of a hedonic price index for data processing equipment (computers, etc.) back to 1969. This price index allowed for a substantially larger quality improvement in computers than the conventional approach where price changes were based on comparing matched models (see also chapter 3). For example, the hedonic price index for computers in the US shows a price fall of as much as 40 per cent between October 1988 and January 1992.[25]

Table 4.11
Annual Compound Growth Rates of GNP in Manufacturing in the United States, 1977-87

	Gross National Product		
	1982 fixed weights	shifting benchmarks weights	exclusive of computer price index[a]
1977-1982	-0.9	0.1	-0.7
1982-1987	6.1	5.2	4.6
1977-1987	2.5	2.6	1.9

[a] obtained by deflating GNP at current prices in machinery (which includes computers) by the implicit deflator for electrical machinery (which excludes computers)

National accounts series at 1982 fixed weights see appendix III. At shifting benchmark weights from *Survey of Current Business*, April 1992. Deflator for electrical engineering implicitly derived from national accounts.

25 See Sinclair and Catron (1990) and subsequent issues of BLS, *Producer Price Indexes*. In Germany the price decline for electronic data processing machines between 1987 and May 1992 was estimated at about 10 per cent (Statistisches Bundesamt, *Preise und Preisindizes für gewerbliche Produkte*, various issues), whereas a pilot study by the Statistisches Bundesamt showed that in the five quarters from March 1985 to June 1986 only, prices fell by some 20 per cent (Gnoss, von Minding *et. al.*, 1990). In Japan the price fall for personal computers between 1987 and 1991 was only 7 per cent, though it was taken to be more than 25 per cent between 1985 and 1987 (Bank of Japan, *Price Indexes Annual*, 1991). It is not clear whether this price index is actually used as a deflator in the national accounts of Japan. There is not a separate computer price index available for the United Kingdom.

There is little doubt that the hedonic price deflator for data processing equipment added to the relatively high growth rates of US real output in manufacturing. As a sensitivity test I dropped the hedonic price index from the US series to make them more comparable to those of other countries. The price deflator for electrical machinery (which excludes computers) was substituted for the price deflator for US non-electrical machinery (which includes computers). This led to a downward adjustment of the overall growth rate for US real output in manufacturing from 2.5 to 1.9 per cent per year over the period 1977 to 1987.

I did not include these adjustments in my comparisons, because dropping the hedonic price index cannot be seen as an improvement to the US series which quite correctly takes account of the substantial price fall for computers. On the contrary, the other countries should make more substantial adjustments for the price decline of computers as well. However, it is uncertain whether producer prices of computers in the other countries have fallen as much as in the United States.[26] In any event, as shown below, even if these adjustments were made, the main facts on comparative productivity performance in manufacturing would not change.

Methodology and basic data for benchmark comparisons

ICOP comparisons of real output and productivity are based on almost identical methods and sources, and the results of different benchmark comparisons should therefore be comparable. However, other benchmark studies may have used different methods, which creates another source of error in comparative productivity estimates over time.

The longest tradition in cross country comparisons of productivity in manufacturing is between the United Kingdom and the United States. It was shown in chapter 2 that there are eight individual comparisons of output per person engaged between these two countries in total, of which five are for a year since 1950.

Column (1) of table 4.12 shows benchmark estimates for 1950 (Paige and Bombach, 1959), for 1968 (Smith, Hitchens and Davies, 1982), for 1975 (van Ark, 1990c), for 1977 (Smith, 1985) and the 1987 benchmark of the present study (see also van Ark, 1992).

26 See also Baily and Gordon (1988) and Gordon (1990). For a comparison of the methods on compiling deflators for computers and for other industries between the United States and other OECD countries, see Gordon and Baily (1991). For a German pilot study, see Gnoss, von Minding *et. al.* (1990).

In column (2) some adjustments are included to make the other benchmark estimates more comparable to mine for 1987. For 1968, 1975 and 1977, working proprietors were taken out of the employment figures for the UK. A more substantial adjustment was made for the 1950 benchmark from Paige and Bombach (1959). They adjusted their estimate of comparative productivity from a census to a national accounts base, which increased the productivity gap between the two countries (see their Appendix A). I adjusted the Paige and Bombach estimate back to a census basis to make it consistent with the other estimates.

Table 4.12
UK Value Added per Person Engaged (USA=100.0),
Benchmarks and 1987 Extrapolations, 1950-1990

	Benchmark Estimates (USA = 100.0)		Extrapolations from 1987 Benchmark (USA = 100.0)		
	Original Estimate (1)	Adjusted Estimate (2)	Unadjusted US 1982 fixed weights (3)	With shifting weights in US (4)	Excluding computer price index in US (5)
1950	36.6	38.5	39.7	-	-
1968	36.7	37.0	49.2	-	-
1975	44.5	44.3	50.8	-	-
1977	39.8	40.2	49.1	49.6	46.4
1982	-	-	53.4	51.2	49.8
1987	53.6	53.6	53.6	53.6	53.6
1990	-	-	54.0	-	-

Notes: adjustment for 1950 refers to adjustment from national accounts figures to census figures. For other years adjustments refer to excluding working proprietors from UK employment figures.
Source: Benchmarks: 1950 from Paige and Bombach (1959); 1968 from Smith, Hitchens and Davies (1982); 1975 from van Ark (1990c); 1977 from Smith (1985); 1987 see appendix table III.18. Extrapolated trends based on time series from appendix table IV.1 and I VI.2. For adjustments to US series see table 4.11.

The benchmark estimates in columns (1) and (2) suggest that between 1950 and 1968 the UK/US productivity gap remained almost unchanged, and that since then a substantial narrowing has taken place, in particular since 1977. However, column (3) of table 4.12, which shows an extrapolation of the 1987 benchmark with national accounts time series GDP (and UK employment from the Census of Employment), suggests that the productivity gap narrowed over the whole post-war period.

A comparison between the benchmarks and the extrapolated results shows that these two series rarely match exactly, but that the difference is particularly large between my result for 1968 and the benchmark study of Smith, Hitchens and Davies (1982). Looking in detail at their method, it appears that a substantial part of their benchmark estimate is based on ICP PPPs instead of industry UVRs. The £/US$ PPPs from ICP for 1967 were on average above my industry UVRs. In fact a backward extrapolation of the 1987 UVR to 1968 (using the UVR - i.e. the second - extrapolation method described above) shows that the UVR is only 0.29 £ to the US dollar compared to the Smith, Hitchens and Davies estimate of 0.38. Thus Smith, Hitchens and Davies somewhat overestimated the productivity gap between the UK and the USA for 1968.[27]

Columns (4) and (5) of table 4.12 and graph 4.1 show the effects on comparative UK/US productivity of the adjustments to the US series for shifting benchmarks and dropping the computer price index respectively. Incorporating these adjustments in my estimates of comparative productivity ratios would make the closing of the productivity gap between the UK and the USA somewhat less pronounced for the late 1970s. On the other hand these revisions also remove the widening of the productivity gap during the early 1980s shown by the unadjusted series. In any case, these adjustments do not alter the basic fact that during the 1980s the United States has been doing relatively better compared to the United Kingdom than in the period before. This point will be analysed in more detail in a broader perspective including the other countries in the following chapter.

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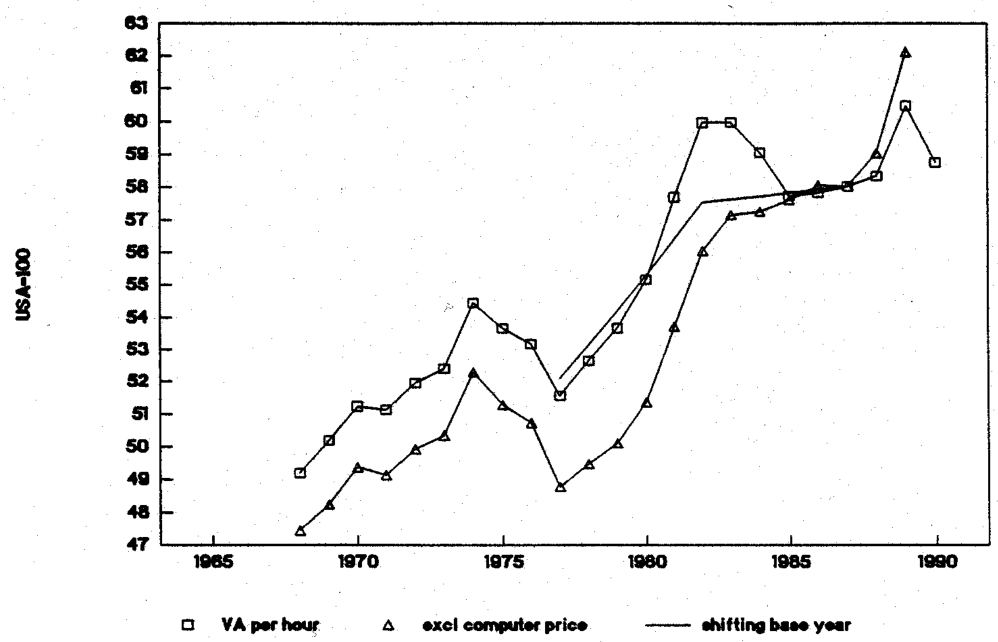
[27] I am grateful to Tony Smith for showing me his worksheets to search for the differences between their estimates and those obtained here. Smith (1985) himself already noticed that an extrapolation of the 1968 benchmark on the basis of time series did not show the reduction in the productivity gap obtained from the 1977 benchmark. Feinstein (1988) also pointed out that the Smith, Hitchens and Davies-estimate of the manufacturing productivity gap between the UK and the USA for 1968 looked implausibly big.

Graph 4.1
Comparative Levels of Value Added per Person Employed in the UK as a percentage of the USA, with and without adjustment to US national accounts series, 1968-1990, USA=100



Source: table 4.12

Index number problems in linking benchmarks and time series

Even after a careful analysis of time series and benchmarks on their coverage and consistency, extrapolated figures on comparative output and productivity are unlikely to match exactly with a new benchmark estimate, because of inherent index number problems.

Szilagyi (1984) argued that in the extrapolation procedure one should distinguish between two elements of the index number problem. The first element is that the prices of the base year are preserved as the weighting system for the complete time series. This element is called 'price conservation'. The second element, which is called 'weights inconsistency', relates to the fact that the time series are based on national weights of each individual country whereas benchmark estimates are based on a common weighting system for both countries.

Krijnse Locker and Faerber (1984) looked at the sensitivity of the results to different index number methods in combining time series and benchmarks. As far as binary comparisons are concerned, the authors show that on the condition that the basic data for the benchmarks and time series are consistent, extrapolations from a Fisher benchmark show a relatively small deviation from a new Fisher benchmark. This is related to the fact that the Fisher index is the geometric average of the Laspeyres and the Paasche indexes. If the production structures of two countries converge over time, the results from a Paasche and a Laspeyres index will get closer to each other, but this change in production structure is not necessarily reflected in the national price indices because of price conservation. In the case of a Fisher index the effect of a change in production structure is averaged out, and makes it therefore more compatible with the time series.

Summers and Heston (1988, 1991) attempt to straighten out differences between benchmarks and extrapolated time series by way of a statistical technique which distributes errors in measurement of the 'true' values over the benchmarks and time series. These smoothing methods seem attractive, but they do not solve the fundamental problem, and tend to move our attention away from the need to establish the sources of differences between the various estimates, as I aimed to do, for example, above for the UK/US comparisons.[28]

The problems of the inconsistency between time series and benchmark comparisons have also been encountered in the ICP literature. Blades and Roberts (1987) found that time series of real per capita income show higher growth rates for the European countries compared to the USA than can be implicitly derived from a comparison of 1980 and 1985 ICP benchmarks. This difference was primarily ascribed to an error in calculating the US PPPs for 1980. Maddison (1991) found that the time series between 1970 and 1985 again showed rather higher growth rates for European countries relative to the USA compared to the implicit growth rates derived from ICP II (for 1970) and ICP V (for 1985). However, a comparison of the most recent ICP benchmark results for 1990 with estimates extrapolated from 1985 shows that the former overstates rather than understates the 1985-90 growth rates for European countries relative to the USA.[29]

It could be argued that the best approach to provide a dynamic perspective of cross-country comparisons is to make benchmark estimate every year. It would tackle the 'price conservation'-problem, as price weights change every year. In addition, it would also deal with weights inconsistency,

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[28] Recently Heston and Summers (1993) went more deeply into the reasons for differences between benchmarks and extrapolations for ICP benchmark studies between 1970 and 1990.

[29] See OECD (1992). Interestingly, the extrapolated and benchmark results concerning per capita growth in Japan relative to the United States do not show significantly different results.

if the price weights for each year are derived from the same country or group of countries.

Apart from the cost of frequent benchmark studies, there is a methodological objection to such an approach. Over time such cross-country comparisons would become a 'chain index'. Chain indices, such as for example the Divisia index, affect the comparibility of the estimates over longer periods, as they may make the series 'path dependent'. In the present context this means that a comparison for two different benchmark years is affected by the comparative performance for the intervening years. Usher (1980) claimed that if the actual data do not fulfill the strict requirements of the continuous function from which the Divisia specification of the index is derived, the index can in fact perform quite badly.[30] A compromise needs to be sought between a regular updating of benchmark comparisons and the use of time series for extrapolation, but one cannot determine an unambiguous time span for updating benchmarks. It partly depends on the different speeds at which structural changes in the two countries occur. If output growth by industry is growing or declining much faster in one country than in another there is more need to reconcile extrapolated series with benchmarks than when growth rates have been fairly similar. For example, the major breaks in the manufacturing productivity growth rates in the UK and the USA in the early 1980s clearly justified the 'rebasing' of benchmark comparisons between these two countries to 1987, instead of continuing to rely on pre-1980 benchmarks.

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[30] These requirements concern in particular the need for the function on which the Divisia index is based to be homothetic. This means that the function has to be homogeneous in the first degree, i.e. a rise in the dependent variable of the function should lead to a proportional rise of the independent variables. See Hill (1988) for a more positive view on the use of chain indices in national accounts.

Chapter 5 - Catch-Up and Convergence in Manufacturing

The Catch-Up and Convergence Debate

In the past four decades major changes have occurred in the relative performance of countries in terms of per capita income and productivity levels. Although the United States has remained the leader in terms of labour productivity and total factor productivity throughout the postwar period, other OECD countries have substantially reduced the gap between themselves and the United States (Maddison, 1991). The dispersion in comparative productivity levels also decreased over time, i.e. the advanced countries did not only make progress in catching up with the US level but also converged towards each other (Abramovitz, 1979 and 1986).[1]

The diffusion of technology from the lead country to the followers is usually regarded as the main mechanism behind the catch-up and convergence process. However, many scholars have suggested that technology transfer can only take place under specific conditions. For example, in the historical literature Gerschenkron (1962) emphasised that the 'late industrialising' countries of continental Europe (such as Germany, Italy and Russia) could only benefit from the 'advantages of backwardness' compared to 19th century Britain, if they could carry out the institutional changes necessary to facilitate the absorption of technology from abroad.

In the literature on postwar catch-up and convergence, Abramovitz has stressed the importance of the social capability of a society to catch-up. He describes social capability as 'the state of a country's political, commercial and financial institutions, its levels of general and technical education, and the experience of its entrepreneurs and managers with large-scale organisation and practice' (Abramovitz, 1991, p. 20; see also Abramovitz, 1979 and 1986).

[1] Here I follow Abramovitz's distinction between catch-up and convergence. Catch-up is defined as the narrowing of the productivity gap compared to the leading country, whereas convergence is related to the fact that the productivity gaps among the follower countries narrowed as well. Convergence is measured by the decline in the coefficients of variation of the productivity levels.

There are at least two distinct reasons why the convergence debate has been restaged in the past decade. Firstly the slowdown of growth in the world economy since 1973 raised interest in how this affected the catch-up process within the OECD (Helliwell, Sturm and Salou, 1985; Dow-rick and Nguyen, 1989; Abramovitz, 1991). In particular the slowdown of growth in the United States led to concern about the possible drying up of the potential for further catch-up by follower countries.

Secondly, it became apparent that the catch-up and convergence process during the postwar period had been limited to a relatively small group of countries at the top end of the productivity scale. Maddison (1992a) shows that only a few countries in Asia (China, Taiwan, Thailand, South Korea) and Latin America (Brazil) have been able to catch up with the OECD countries, though in absolute terms the gap in per capita income and productivity is still large. On the whole, for most countries in Africa, Asia and Latin America one should speak of a process of divergence rather than convergence and falling behind rather than catching-up during the postwar period.[2]

One way to understand the mechanisms behind the catch-up and convergence process for the economy as a whole is to look in more detail at the comparative productivity performance at sectoral level. In this respect the manufacturing sector plays an important role. In the early stages of economic growth its importance is clear from its increasing share of the sector in total production and employment, and its relatively fast rise in productivity. But even at later stages, when manufacturing becomes less important in relative terms, as is presently true for most OECD countries, it continues to play a crucial role in generating new technologies, with important spillover effects to other sectors.

Growth and Levels of Manufacturing Productivity

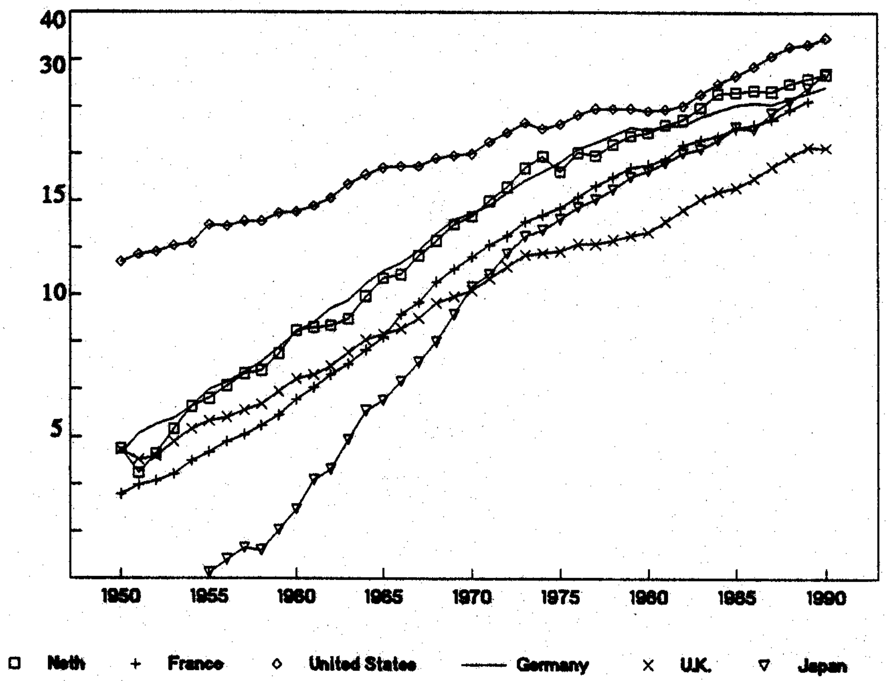
The Experience of Advanced Capitalist Countries

Graph 5.1 shows the change in value added per hour worked in manufacturing in France, Germany, Japan, the Netherlands, the United Kingdom and the United States (in 1987 US dollars) from 1950 to 1990. As explained in the previous chapters, productivity levels by industry of origin were compared for the benchmark year on the basis of unit value ratios for product samples. These benchmark results were extrapolated forwards

[2] For further details see Maddison (1989, 1991, 1992a). For a critical view on the traditional convergence model, see De Long (1988).

to 1990 and backwards to 1950 by using the national time series on output and labour input. Productivity in France and the Netherlands was indirectly compared to the United States through the binary comparisons with the UK, using a multilateral unit value ratio which was derived in chapter 3.[3]

Graph 5.1
Value Added per Hour Worked in Manufacturing in Advanced Countries, 1950 to 1990, US 1987 dollars



Source: benchmark years from table 4.1; time series from table 5.1 and appendix IV.

The graph shows that all countries experienced a continuous increase in manufacturing productivity throughout the postwar period. Table 5.1 shows the national growth rates of real output and labour productivity from 1950 to 1973, 1973 to 1979 and 1979 to 1989. In all countries, real output and productivity in manufacturing increased much faster in the period before 1973 than thereafter. From 1950 to 1973 manufacturing productivity growth was highest in Japan, followed by the continental countries of Europe. Growth in the UK was significantly slower, and in US manufacturing it was the slowest of all countries in the sample.

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3 The multilateral unit value ratio was taken from a three-way comparison between Germany, the United Kingdom and the United States (see table 3.6 in chapter 3). See table 4.9 in chapter 4 for the benchmark productivity ratios for France and the Netherlands compared to the United States.

Table 5.1
Annual Average Compound Growth Rates of Gross Value Added and Gross Value Added per Hour Worked, Total Manufacturing, 1950-90

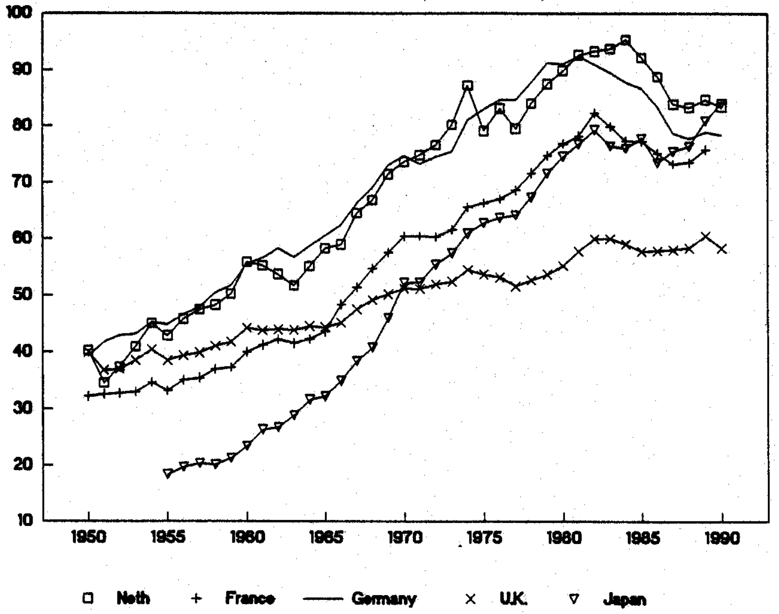
	Gross Value Added			Gross Value Added per Hour		
	1950-73	1973-79	1979-90	1950-73	1973-79	1979-90
France	6.6	2.3	0.6	5.9	4.5	3.3[b]
Germany	6.7	1.7	1.0	6.0	4.4	1.8
Netherlands	6.9	0.3	2.3	6.1	2.6	2.8
United Kingdom	4.1	-0.7	1.0	4.2	1.6	4.0
Japan	13.0[a]	3.2	5.8	9.5[a]	5.0	4.7
United States	3.9	1.8	2.6	3.0	1.2	3.2

[a] 1955-73; [b] 1979-89
Sources: see appendix tables IV.1 to IV.3. Based on real GDP in manufacturing from national accounts and employment statistics, except for the United Kingdom, for which the information on net output and numbers of employees from 1950 to 1968 was obtained from the Census of Production, with net output deflated at the producer price index per branch (see chapter 4, pp. 75-76).

During the 1970s growth slowed down in all countries. Japan was hit very hard by the oil crisis of the mid 1970s, but its growth of output and productivity was still the highest of all countries. Productivity growth in the United States and the United Kingdom remained very low. After 1979 the dynamics of manufacturing productivity growth showed greater variation. Growth recovered strongly in the United States, whereas France and Germany showed a further slowdown in both output and productivity growth. Germany's productivity growth was in fact lowest of all countries in the sample. In the United Kingdom, output growth was slow, but as the number of employees in manufacturing fell by about 25 per cent during the 1980s, British productivity performance has been relatively good since the late 1970s.

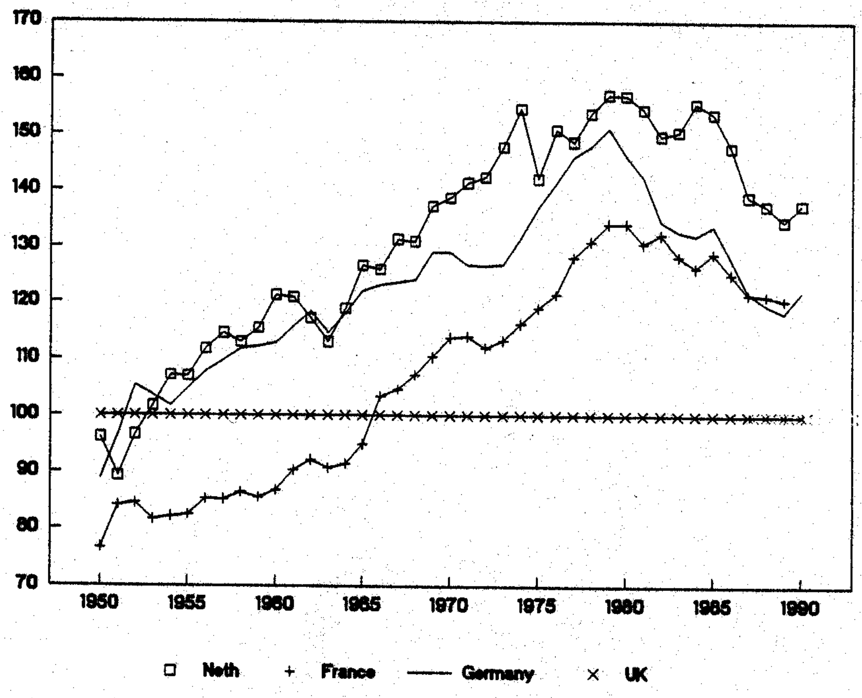
Graph 5.2 and table 5.2 reproduce the same results as those in graph 5.1, but now in terms of the relative productivity levels of the five follower countries compared to the United States. Up to the mid 1970s all countries caught up with the USA in terms of productivity. The strongest catch-up took place in Japan, and the process was weakest in the United Kingdom. However, during the first half of the 1980s all countries lost the momentum of 'catch up'. This slowdown was brief in Japan but quite strong and long-lasting in Germany and the Netherlands.

Graph 5.2
Value Added per Hour Worked in Manufacturing in Advanced Countries (USA=100), 1950 to 1990,



Source: see table 5.2

Graph 5.3
Gross Value Added per Hour Worked in Manufacturing in European countries (UK=100), 1950 to 1990



Source: see table 5.3

Table 5.2
Value Added per Hour Worked in Manufacturing (USA=100), 1950-1989

	1950	1965	1973	1979	1989
France	32.1	43.7	61.5	74.7	75.8
Germany	39.3	60.5	75.5	91.3	78.9
Netherlands	40.3	58.3	80.3	87.5	84.7
United Kingdom	40.0	44.4	52.4	53.7	60.5
European Average	38.0	51.6	65.5	75.4	72.7
Japan	18.4[a]	32.1	57.4	71.6	80.9
United States	100.0	100.0	100.0	100.0	100.0

[a] 1955
Note: census value added equals gross value added plus non-industrial service inputs. France and Netherlands were linked to the USA via a Geary-Khamis weighted index for Germany/UK, Germa-ny/USA and UK/USA. The average figure for the European countries was obtained by weighting the country series at their labour input for the following sub-periods: 1950-1965 at 1960 weights; 1965-1980 at 1975 weights; 1980-1989 at 1985 weights.
Source: Appendix table IV.4.

Table 5.3
Value Added per Hour Worked in Manufacturing[a] in European Countries (UK=100), 1950-1989

	1950	1965	1973	1979	1989
France	76.7	94.8	113.3	134.1	120.4
Germany	88.8	122.0	126.8	151.0	117.4
Netherlands	96.1	126.5	147.8	157.0	134.6
United Kingdom	100.0	100.0	100.0	100.0	100.0

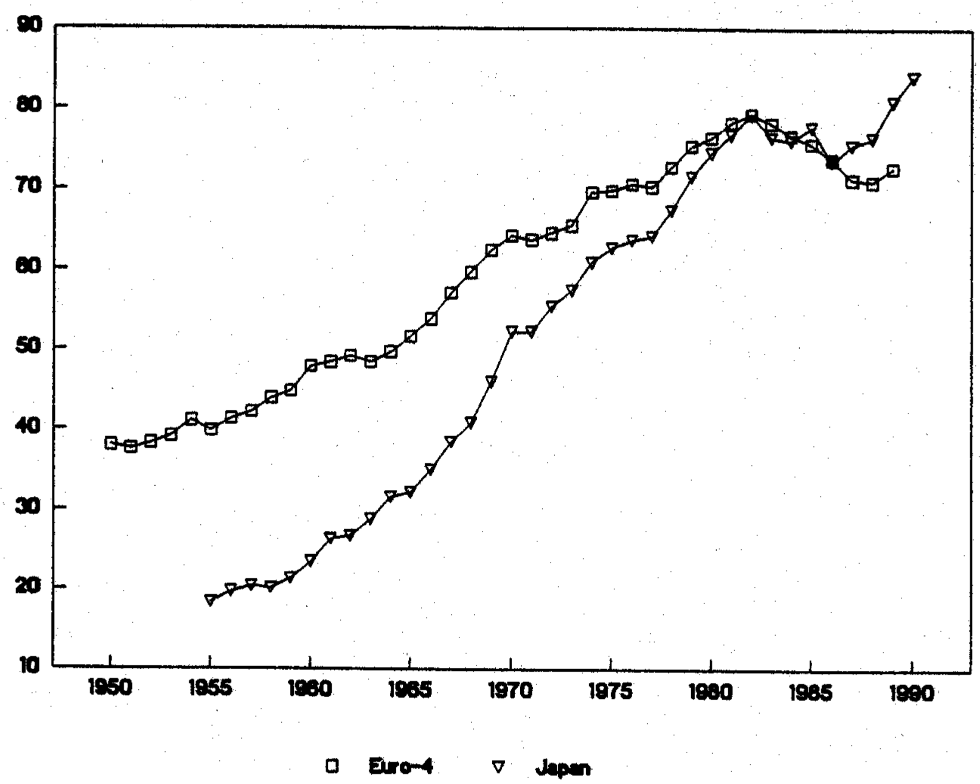
[a] excluding oil refining
Source: Appendix table IV.5.

Graph 5.2 also shows that the catch-up process with the USA was very similar for France, Germany and the Netherlands but different in the United Kingdom. It is therefore useful to look in more detail at the comparative productivity performance within Europe, focussing on binary comparisons with the United Kingdom.

Graph 5.3 and table 5.3 show that in 1950 the productivity level in British manufacturing was close to that of Germany and the Netherlands, but it lost ground to these two countries up to 1980. France overtook the

United Kingdom in the mid 1960s. In the past decade, Britain's comparative performance has improved, but Germany's productivity performance deteriorated compared to the other European countries. The relatively good position of the Dutch manufacturing sector is mainly explained by its high capital intensity, which will be discussed in more detail in chapter 6.[4]

Graph 5.4
Gross Value Added per Hour Worked in Manufacturing in the Euro-4 Group[a] and Japan (USA=100), 1950 to 1990



[a] France, Germany, the Netherlands and the United Kingdom.
Source: see table 5.2

4 In another article (van Ark, 1990c), I showed that manufacturing productivity in the Netherlands and Germany stayed below the level of the United Kingdom until the mid 1950s. However, as I showed in chapter 4, I now use higher growth rates for manufacturing output in the UK between 1950 and 1968. The productivity gap between Germany and the UK is not the same in a direct comparison between the two countries (graph 5.3) as in an indirect comparison via the USA (graph 5.2). There is a lack of transitivity in the binary comparisons between these three countries (see chapter 3, table 3.6 and chapter 4, footnote 16, p.73).

Graph 5.4 reproduces the relative performance of the four European countries (hereafter referred to as the 'Euro-4') in comparison with Japan and United States. The comparative performance of the four European countries was averaged on the basis of each country's relative importance in terms of their manufacturing labour input for three sub-periods.[5] The graph shows that by 1982 the Euro-4 and Japan were more or less at par in terms of their comparative performance to the United States. During the early 1980s the productivity gap with the USA increased, but for Japan it has begun to narrow again since 1987.

The Experience of the Lower Income Countries

Compared to the advanced countries, levels of labour productivity for the lower income countries in our sample (Brazil, Korea and India) are substantially lower. Table 5.4 and graph 5.5 show the situation for these countries relative to the United States. The manufacturing productivity level in Brazil is substantially above that of the two Asian nations. This striking difference between Latin America and Asia was also found in other ICOP comparisons. Maddison and van Ark (1988, updated) estimated value added per hour in Mexico at 34.1 per cent of the United States for 1975. Pilat and Hofman (1990) arrived at an estimate of 22.3 per cent for Argentina compared to the United States for 1975. On the other hand, Szirmai (1993) showed value added per person employed in the manufacturing sector of Indonesia at 9.7 per cent of the United States.

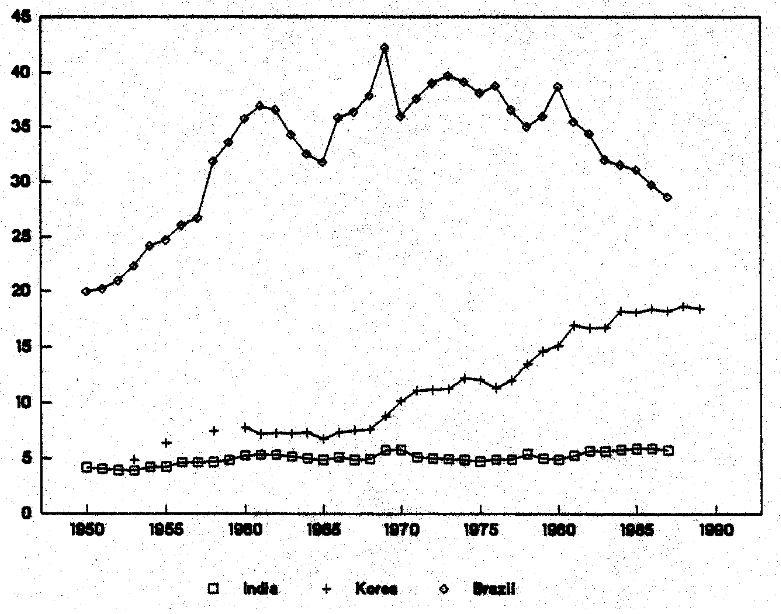
Table 5.4
Value Added per Hour Worked in Manufacturing in Brazil, India and Korea (USA=100), 1950-1989

	1950	1965	1973	1979	1989
Brazil	20.0	31.8	39.7	36.0	28.6[b]
India	4.2	4.9	4.9	5.0	5.7[b]
Korea	4.9[a]	6.8	11.2	14.6	18.4

[a] 1953; [b] 1987
Note: census value added equals gross value added plus non-industrial service inputs.
Source: Appendix table IV.4. Korea/USA from Pilat (1991b).

[5] For the period 1950-1965 I used labour input weights for 1960; for the period 1965-1980, 1975 weights; for the period 1980-1990, 1985 weights.

Graph 5.5
Gross Value Added per Hour Worked in Manufacturing in Brazil, India and Korea (USA=100), 1950 to 1989



Source: see table 5.4

For Brazil most of the catch-up with the United States took place during the 1950s. Since the mid-1970s the relative productivity level in Brazilian manufacturing has deteriorated strongly in comparison with the USA and with the Asian countries. Comparative productivity in Korean manufacturing has steadily improved since 1968. Productivity in India was at a very low level compared to the USA throughout the period, although the rise from 5 per cent of the US level in 1980 to almost 6 per cent in 1987 should be interpreted as substantial in absolute terms.

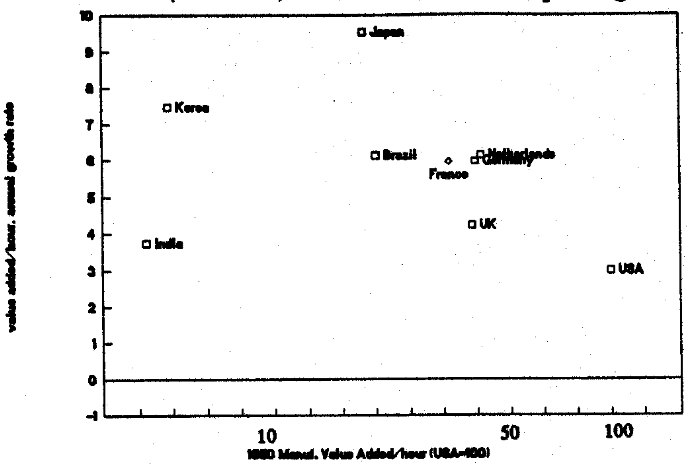
Measuring the Degree of Catch-Up and Convergence

The degree to which follower countries participate in the catch-up process can be analysed more accurately by plotting the productivity growth rates for three sub-periods (i.e. 1950-1973, 1973-1979 and 1979-1989) on the levels of the initial year of each period (1950, 1973 and 1979). Panel A of graph 5.6 shows that up to the early 1970s all countries had a lower productivity level than the United States and therefore showed a faster growth rate, although the Indian growth rate was clearly below what one would expect on basis of the straightforward interpretation of the catch-up model, i.e. that there is a negative relationship

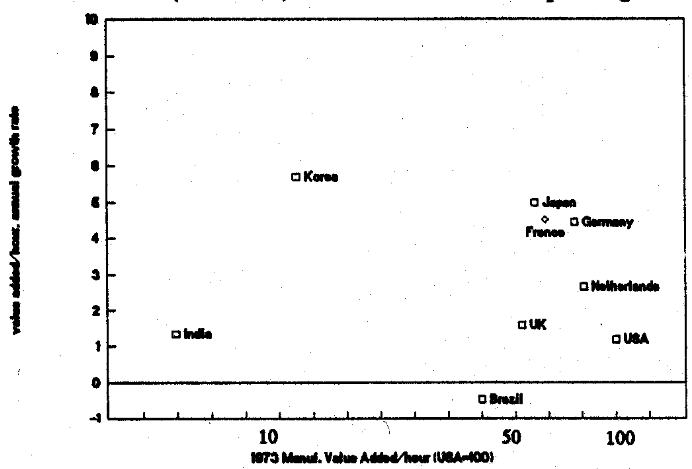
Graph 5.6

Initial Level of Value Added per Hour Worked in Manufacturing (USA=100) Compared to the Annual Compound Growth Rate for Sub-Periods

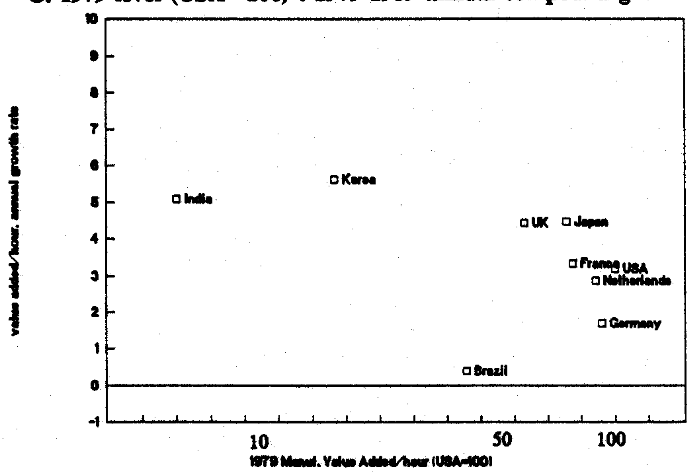
A: 1950 level (USA=100) : 1950-1973 annual compound growth rate



B: 1973 level (USA=100) : 1973-1979 annual compound growth rate



C: 1979 level (USA=100) : 1979-1989 annual compound growth rate



Note: x-axis is on logarithmic scale. Korean series start in 1953; Japanese series in 1955. Series for India and Brazil end in 1987.

Source: see tables 5.1 and 5.2.

Table 5.5
Annual Compound Growth Rates of Value Added per Hour Worked in Manufacturing, Actual and Estimated Growth Rates, 1950-1989

	Actual Annual Compound Growth Rate (%) (1)	Difference Between Actual and Estimated Growth Rates (percentage points)		
		Advanced Countries only (2)	All Countries (3)	Dummy for Lower income Countries (4)
1950-1973				
France	5.94	-0.37	1.88	1.13
Germany	5.96	0.30	2.03	1.38
Japan (1955-73)	9.54	1.09	5.04	3.93
Netherlands	6.13	0.62	2.23	1.61
United Kingdom	4.22	-1.51	0.27	-0.39
United States	3.00	0.76	-0.23	-0.31
Brazil	6.12		1.68	3.37
India	3.74		-1.89	-2.58
Korea (1953-73)	7.46		1.95	1.49
1973-1979				
France	4.51	0.49	0.92	0.54
Germany	4.44	1.17	1.00	0.75
Japan	4.98	0.71	1.33	0.92
Netherlands	2.64	-0.40	-0.75	-0.96
United Kingdom	1.58	-3.02	-2.13	-2.60
United States	1.18	-1.05	-2.05	-2.12
Brazil	-0.47		-5.97	-1.66
India	1.34		-3.54	-4.60
Korea	5.70		2.27	1.64
1979-1989				
France	3.34	0.04	-0.13	-0.36
Germany	1.70	-0.86	-1.59	-1.72
Japan	4.46	1.01	0.99	0.71
Netherlands	2.86	0.14	-0.46	-0.62
United Kingdom	4.43	-0.09	0.73	0.28
United States	3.19	0.96	-0.04	-0.11
Brazil (1979-87)	0.39		-3.61	-1.02
India (1979-87)	5.09		-0.40	-0.83
Korea	5.62		0.94	2.15

Note: all regression results shown are statistically significant. For details see appendix V. See also footnote graph 5.6.
Source: see tables 5.1 and 5.2; appendix V, regressions (1) to (3).

between the comparative productivity level in the beginning year and the productivity growth rate. During the 1970s, both India and Brazil showed low growth rates relative to their comparative productivity ratios (panel B). During the 1980s a more diverse pattern emerged (panel C). Productivity growth was relatively strong in the United States. Nevertheless some countries, including Japan, Korea and the UK, more or less stayed on the 'catch-up track' whereas other countries (in particular Brazil and Germany) in fact diverged from the US level.[6]

Because of the small sample of countries for each sub-period, I made To measure the degree by which each country's productivity performance differs from its 'predicted' growth rate on the basis of the catch-up hypothesis, a statistical regression was carried out relating the actual growth rates for the countries to their initial productivity levels. The results of these regressions are presented in table 5.5. The first column shows the actual growth rate of value added per person-hour worked. Column (2) shows the difference between the actual rate and the estimated rate based on a regression for the advanced countries only. Column (3) shows the percentage point difference based on a regression for all countries in the sample. In column (4) the regression includes an interaction dummy variable for the lower income countries (Brazil, India and Korea).[7]

these regressions by pooling the observations for the three sub-periods. It could be argued that this affects the results, because the growth rate for a country may partly depend on the growth rate in the previous period irrespective of the initial productivity level. However, the results from regressions based on the smaller samples for each sub-period, were not very different from the pooled regression results, with the exception of the 1973-79 period for which the pooled sample 'predicted' somewhat higher growth rates for France, Japan and the UK and somewhat lower

[6] Obviously alternative periodizations will produce slightly different results. I tried one alternative by dividing the period up into 1950-1965, 1965-1982 and 1982-1989. This periodization changes some of the positions of individual countries. For example Brazil shows a much more rosy picture during the period from 1965 to 1982 than during the shorter period from 1973 to 1979. Japan's performance is also considerably better for the longer middle period. Finally, the US growth shows even better during the 1982-1989 period than during the 1979-1989 period.

[7] See Crafts (1991) who applied a similar approach to comparative productivity at GDP level for OECD countries. Crafts speaks of a 'catch-up bonus' as the difference between the estimated growth rates of the each country and the United States, and of a 'residual' as that part of the actual growth rate which exceeds the catch-up bonus.

rates for the USA (i.e. in the order of 1 percentage point). However, the coefficients of the sub-period samples were much less significant.[8]

During the period 1950 to 1973 the rise in productivity was close to or above the estimated growth rate for most countries. In particular Brazil, Japan and Korea performed better than what one would expect on the basis of their initial productivity level in the early 1950s, whereas the productivity performance of Britain and India was below expectation during this period. Focussing explicitly on the European countries in the sample it appears that despite their relatively close levels of productivity in 1950, the productivity growth rates for France and the United Kingdom were relatively low compared to Germany and the Netherlands.

During the slowdown period of the 1970s, the Netherlands, the United Kingdom and the United States showed the most disappointing performance among the advanced countries considering their initial level in 1973, whereas Germany, France and Japan grew relatively fast. The performance of Brazil and India was far below expectations during this period. Korea performed even further beyond expectations compared to the 1950s and 1960s.

Finally during the 1980s the productivity growth rates of most advanced countries were relatively close to the estimated rates, except for Germany where productivity growth was far below expectation. Among the advanced countries the United States showed an above average growth. This is reflected in the relative widening of the productivity gap between each of the advanced countries and the USA as observed above. Brazilian growth rates stayed close to zero during the most recent period, but the growth rate for India was much closer to the estimated rate compared to the two earlier sub-periods.

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8 I also experimented with a regression using an interaction dummy for sub-periods, but this produced insignificant results both with and without the developing countries in the sample. See also appendix V.

Comparative Productivity Levels by Major Branch

For the advanced countries in the sample, time series were also compiled for six major branches for the period 1973 to 1989.[9] Three of the six major branches largely represented consumer non-durables, i.e. 'food, beverages and tobacco', 'textiles, wearing apparel and leather products', and 'other industries'. The latter included wood and paper products and stone, clay and glass products. Two other major branches, namely 'chemicals and allied products' and the 'basic metals and metal products' largely represent intermediate goods from basic, heavy industries. Finally, 'machinery, electrical machinery and transport equipment' represents investment industries.[10]

Graph 5.7 shows the comparative productivity levels by major branch in Britain, Germany and Japan relative to the United States, and table 5.6 reproduces these figures for some key years. It appears that the productivity gap between Germany, Japan and the United Kingdom on the one hand and the USA on the other is largest in consumer non-durables. In these products the United States achieved productivity leadership relatively early because of its advantage in mass production, and it has retained a significant lead over the other countries since then. In food manufacturing, the comparative productivity level in the United Kingdom showed a slight improvement over the years. In Germany it remained virtually unchanged over the period, whereas in Japan it worsened from an already exceptionally low level of 28 per cent of the US level in 1973 to 22 to 25 per cent for the period after 1985. In textiles, clothing and leather products and in the group of 'other industries' all three countries only slightly reduced the gap to the United States.

In the chemicals branch the picture is more diverse. On the whole, the productivity gap between Japan and Germany on the one hand and the USA on the other hand, which had narrowed during the 1970s, widened again during the 1980s. In Germany the comparative productivity performance of the chemicals branch in 1989 was even worse than in 1973. In the United Kingdom a substantial improvement occurred during the early 1980s.

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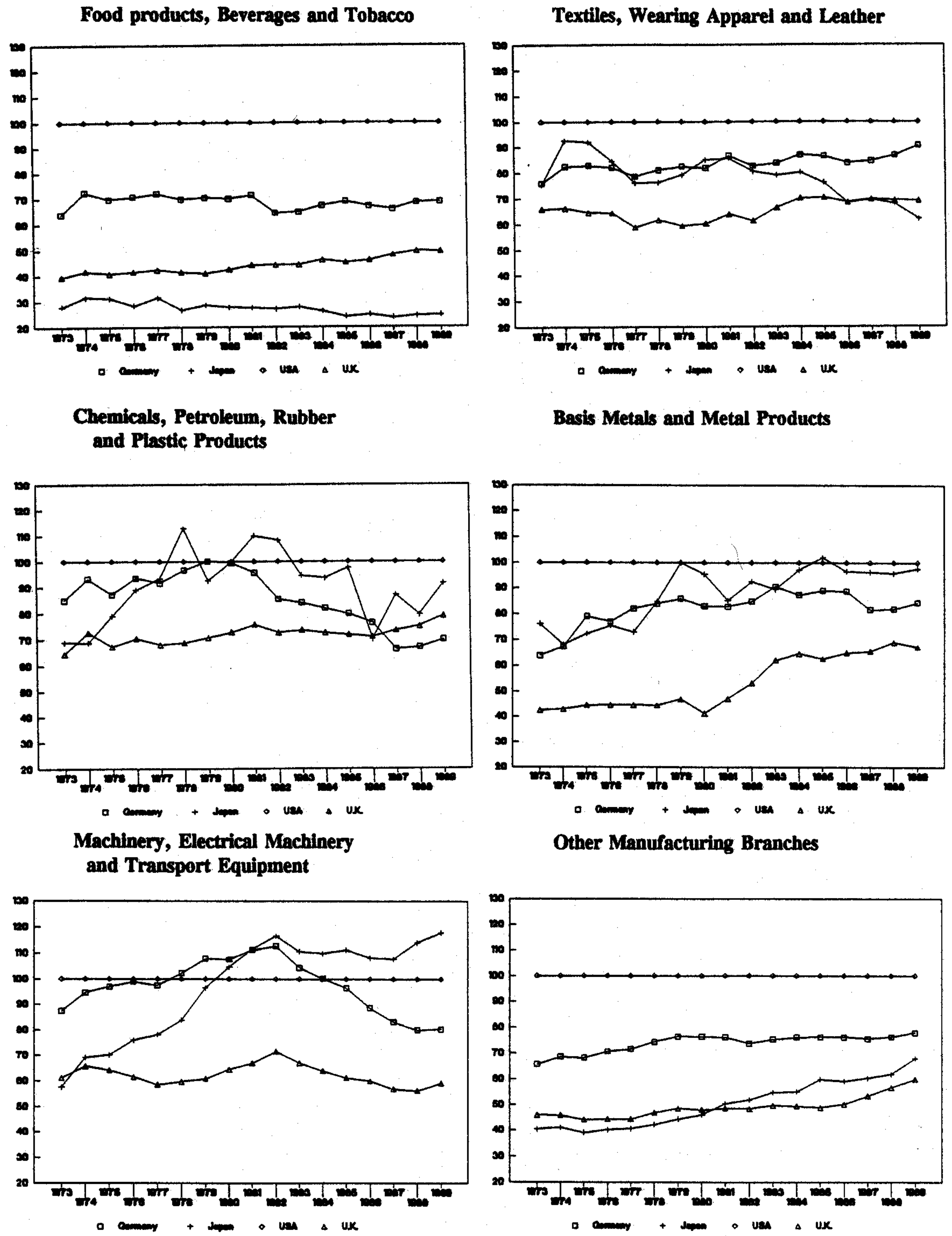
9 See appendix I for a classification of major branches, branches and industries.

10 Within chemicals and metal products many goods are more of a 'consumer goods' nature. 'Other industries' represents a mix of branches including wood and paper products and stone, clay and glass products. See also van Ark (1992) for a finer disaggregation according to light, basic and investment industries in the UK/USA comparison.

Graph 5.7
Value Added per Hour Worked by Major Branch (USA=100), 1973-1989



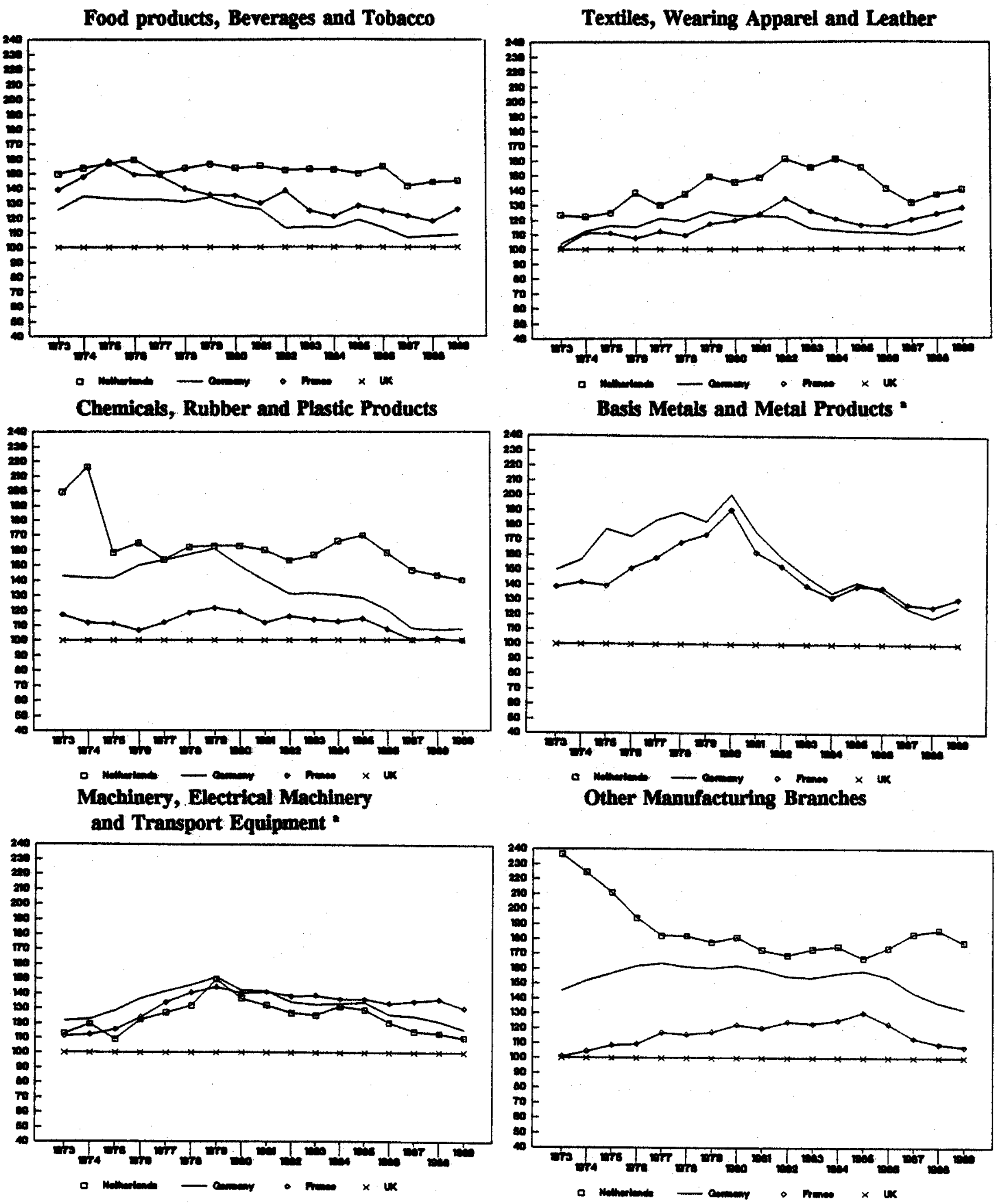
Source: see appendix table IV.9

Table 5.6
Value Added per Hour Worked by Major Branch (USA=100), 1973-1989

	1973	1979	1982	1989
Food Products, Beverages and Tobacco				
Germany	63.8	70.4	64.4	68.6
Japan	28.0	28.6	27.1	24.6
United Kingdom	39.5	40.9	44.2	49.3
Textiles, Wearing Apparel and Leather Products				
Germany	75.9	82.4	82.6	90.6
Japan	75.2	79.1	80.4	62.0
United Kingdom	65.9	59.3	61.3	69.0
Chemicals, Petroleum, Rubber and Plastic Products				
Germany	85.0	100.1	85.5	70.0
Japan	68.9	92.5	108.2	91.5
United Kingdom	64.5	70.8	72.6	79.1
Basic Metals and Metal Products				
Germany	63.9	85.9	84.9	84.4
Japan	76.2	99.9	92.7	97.7
United Kingdom	42.5	47.0	53.4	67.3
Machinery, Electrical Machinery and Transport Equipment				
Germany	87.4	108.0	112.7	80.4
Japan	57.5	96.4	116.6	117.9
United Kingdom	61.2	60.8	71.5	59.1
Other Industries				
Germany	65.6	76.4	73.7	77.9
Japan	40.4	44.3	51.8	67.9
United Kingdom	45.9	48.4	48.4	59.8
United States	100.0	100.0	100.0	100.0

Source: see appendix table IV.9.

Graph 5.8
Value Added per Hour Worked by Major Branch (UK=100), 1973-1989



a Netherlands/UK comparison of basic metals and metal products included in machinery, electrical machinery and transport equipment.

Source: see appendix table IV.10

Table 5.7
Value Added per Hour Worked by Major Branch (UK=100), 1973-1989

	1973	1979	1982	1989
Food Products, Beverages and Tobacco				
France	138.9	135.3	138.1	125.8
Germany	125.6	133.7	113.2	108.3
Netherlands	149.6	156.5	152.2	144.8
Textiles, Wearing Apparel and Leather Products				
France	101.0	117.1	134.1	127.8
Germany	104.1	125.5	121.7	118.5
Netherlands	123.3	149.3	161.1	140.3
Chemicals, Rubber and Plastic Products				
France	117.1	121.5	116.0	99.6
Germany	143.0	161.0	130.7	107.2
Netherlands	199.0	162.9	153.2	139.9
Basic Metals and Metal Products				
France	138.8	173.8	152.6	125.3
Germany	150.1	182.7	158.9	131.0
Netherlands	a	a	a	a
Machinery, Electrical Engineering and Transport Equipment				
France	111.4	144.6	138.3	130.2
Germany	121.6	151.3	134.3	115.8
Netherlands[a]	113.0	149.8	127.0	110.1
Other Manufacturing Branches				
France	101.0	117.3	124.1	107.2
Germany	145.0	160.3	154.5	132.2
Netherlands	236.6	177.6	168.9	177.5
United Kingdom	100.0	100.0	100.0	100.0

[a] Netherlands/UK comparisons for basic metals and metal products included in machinery, electrical machinery and transport equipment.
Source: appendix table IV.10; Germany/UK from O'Mahony (1992a).

In basic metals and metal products, all three countries narrowed the productivity gap to the United States during the 1970s, but the increase in comparative productivity levelled off during the second half of the 1980s.

The catch-up on the US productivity level during the 1970s has clearly been strongest in the investment industries. Around 1980 both Germany and Japan had a labour productivity lead in this major group well over the United States. However, during the 1980s Germany lost most of the relative improvement in productivity compared to the USA which it had achieved during the 1970s, whereas Japanese productivity in this group stabilised at some 10 to 20 per cent above the US level in the second half of the 1980s.

The productivity results by major groups of branches for the European countries compared to the UK level are presented in graph 5.8 and table 5.7. Since 1973 Dutch manufacturing has been leading in consumer non-durables and in chemicals. This was to a large extent the result of a high degree of Dutch specialisation in relative capital intensive products within these sectors (see van Ark, 1990a). For machinery, electrical machinery and transport equipment, productivity levels have been relatively close among France, Germany and the Netherlands throughout the period. During the 1980s France has taken over the leadership position in this group from Germany, which is mainly due to its good performance in electrical machinery. Britain's productivity relative to the other European countries increased in almost all industries during the 1980s, and in particular in basic metals and metal products.[11] Finally, graph 5.8 shows the strong decline in comparative productivity performance in German chemicals.

Catch-Up and Convergence Experience by Major Branch

Graph 5.9 reproduces the catch-up pattern for major branches in Germany, Japan, the United Kingdom and the United States. In contrast to the analysis for total manufacturing, it relates each country's initial productivity level relative to the USA to the *difference* between that country's growth rate and the US growth rate (instead of each country's actual growth rate). This slightly different way of analysis is necessary in order to eliminate the effect of differences in growth rates between the six major branches within the United States.

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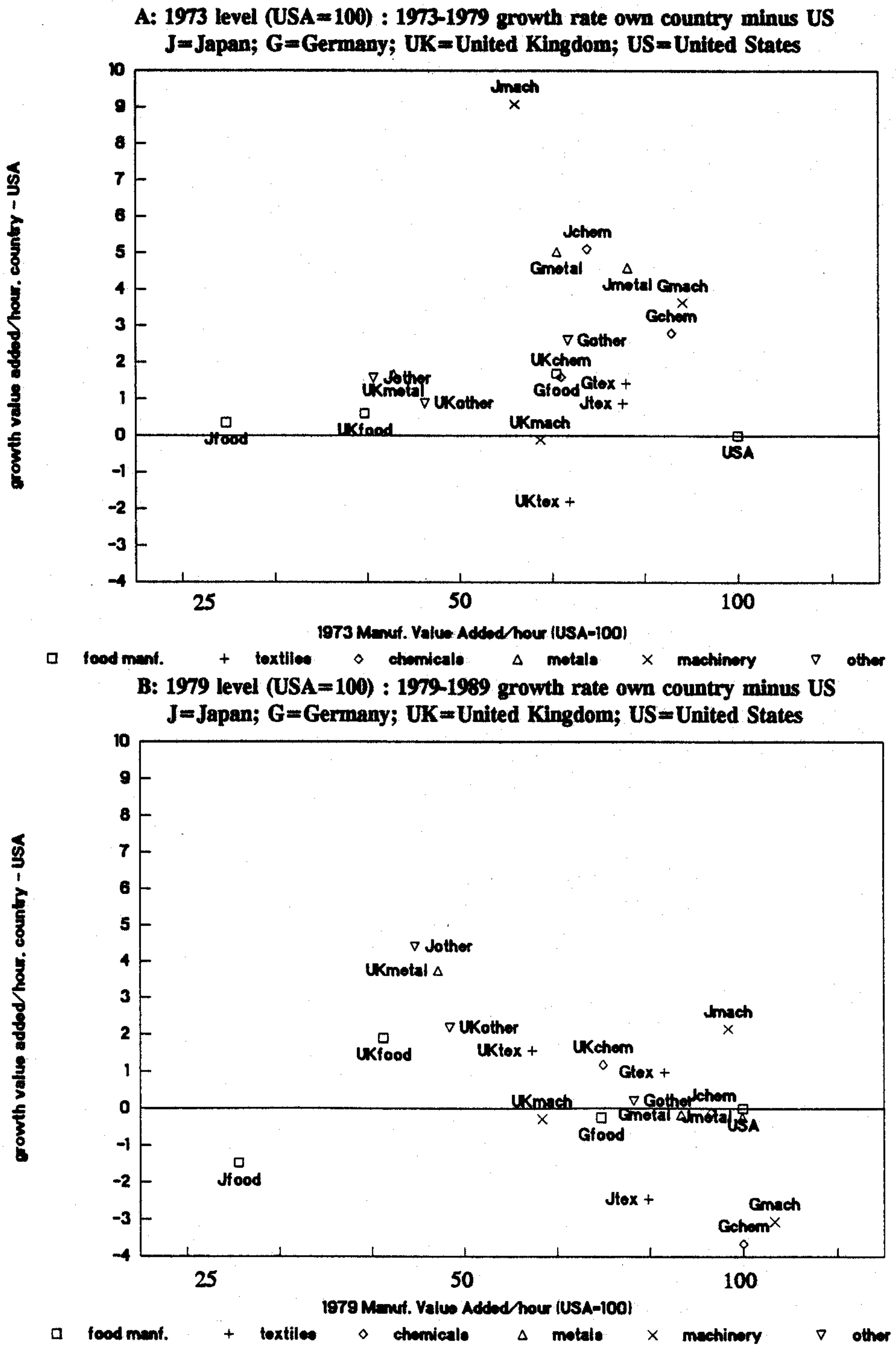
11 For evidence of Britain's relatively strong productivity performance in basic metals and metal products, and in basic goods in general, see also my comparison between the United Kingdom and the United States (van Ark, 1992).

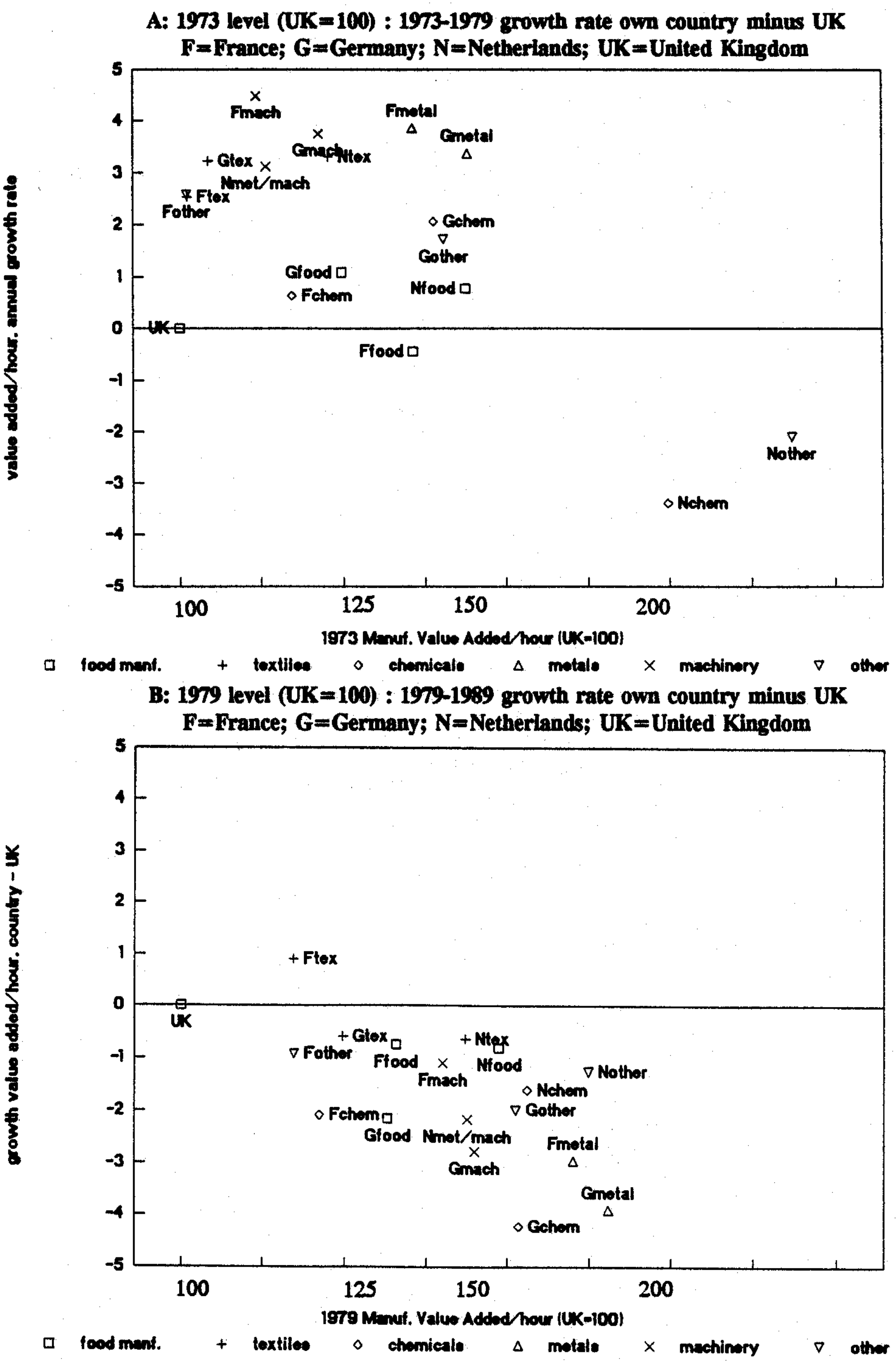
Graph 5.9
Initial Level of Value Added per Hour Worked by Major Branch (USA=100) Compared to the Difference in Annual Compound Growth Rates between each Country and the USA.



Note: x-axis is on logarithmic scale.
Source: see table 5.6 and appendix IV.

Graph 5.10

Initial Level of Value Added per Hour Worked by Major Branch (UK=100) Compared to the Difference in Annual Compound Growth Rates between each Country and the UK



Note: x-axis is on logarithmic scale.
Source: see table 5.7 and appendix IV.

For the period 1973 to 1979 (panel A) the regression coefficient of the growth rate differentials in relation to the productivity levels showed a positive sign, which would in fact contradict the catch-up hypothesis.[12] A glance at panel A of graph 5.9 shows this was largely caused by the bad performance of UK manufacturing in all major branches, and by the slow growth in Japanese food manufacturing and other (light) industries.

Panel B of graph 5.9 shows a slightly better convergence pattern for the 1980s, because (except for Japanese food manufacturing) major branches with relatively low initial levels clearly showed higher growth rates.

Graph 5.10 shows corresponding results for the comparisons among the European countries in the sample. The below-average performance of British industry during the 1970s already observed in panel A of graph 5.9 is clearly reflected here. In almost all cases, major branches in other European countries showed higher growth rates than the UK despite the fact that their initial productivity levels were also higher.[13]

The 1980s show a clearer convergence pattern between the European countries. Regression analysis produces significant results (see appendix V). The better fit is largely caused by the faster productivity growth in the United Kingdom, which at least to some extent was a once-for-all catch-up effect due to Britain's productivity losses during the 1970s.

It may be concluded that there is no clear evidence of a strong catch-up and convergence process at the level of major branches, though it needs to be emphasised that this part of the analysis relates only to the period after 1973. For the post 1973-period catch-up was also much weaker for the manufacturing sector as a whole than before 1973. Experiments with regression analysis using dummy variables for the individual groups of manufacturing branches did not improve the results (see appendix V).

Table 5.8 shows that for benchmark years, the coefficients of variation (i.e. the standard deviation divided by the mean) of the comparative productivity ratios for sixteen branches was greater than for the six major branches, and that the latter was greater than for total

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12 See appendix V for the regression results.

13 Nevertheless, the corresponding regression for the European countries during the 1973-79 period showed highly significant results (see appendix V, regression 8). This was largely caused by the extremely high levels of Dutch labour productivity in chemicals and other manufacturing in 1973 with corresponding slow growth rates for the period 1973-79. A sensitivity test shows that dropping by these two observations from the sample, the regression results become insignificant.

manufacturing. It appears therefore that the process of catch-up and convergence works better at the level of total manufacturing than at more disaggregated levels, and it suggests the presence of specific 'branch' factors which affect the convergence process at disaggregated levels. Examples of branch specific factors are the degree of international competitiveness in a particular industry, the extent to which countries make use of the same technology in an industry and the effects of government regulations concerning safety, quality or environmental standards.

Table 5.8
Coefficients of Variation of Comparative Productivity Levels at Different Levels for Branches, Major Branches and Total Manufacturing in Benchmark Years

	Branch Level (sixteen branches)	Major Group of Branches (six major groups)	Total Manufacturing
Germany/Japan/ UK/USA (1987)	0.24	0.22	0.19
France/Germany/ Netherlands/UK (1984)	0.19	0.17	0.16

Note: coefficients of variation are the standard deviation divided by the unweighted average. At branch level and for major branches the figure in the table represents the arithmetic average of the coefficients of variation for branches and major branches respectively.
Sources: see appendix III

The importance of branch specific factors in understanding comparative productivity performance suggests there is a need for complementary case studies at industry level. Many of these studies concentrate on short term issues such as relative costs levels or levels of expenditure on research and development. A series of studies by the National Institute for Economic and Social Research (NIESR) reports the results of matched plant comparisons between countries, which included firms in Germany, the Netherlands and the UK producing biscuits, kitchen furniture, metal working products (valves, pumps, etc.) and wearing apparel. Although the main aim of these studies was to establish the link between comparative productivity and relative levels of skills and training, these comparisons confirmed the presence of branch specific factors such as demand characteristics (including consumer preferences) and the type of technology required in an industry (for example craft production versus process production technology).[14] A recent study by Fuss and Waverman (1992) looked in detail at the relation between costs and productivity in the automobile industry of Canada, Germany, Japan and the United States over the past three decades. They in particular pointed at the role of capacity utilisation as a source of differences in efficiency differentials.

Convergence at GDP Level Compared with Manufacturing

The previous sections showed that, during the first part of the postwar period, comparative productivity levels in manufacturing converged quite rapidly on the level of the United States. This is in accordance with the strong convergence process for the total economy as is observed in various other studies, including Abramovitz (1986) and Maddison (1991). However, a more detailed analysis of the catch-up and convergence pattern for the total economy compared to that of the manufacturing sector reveals some important differences.

Table 5.9 shows the relative levels of value added per hour worked compared to the USA for manufacturing and for the total economy for 1950, 1973 and 1989. These productivity ratios are also reproduced in graph 5.11, with the comparative productivity level for the total economy set out along the y-axis and that for manufacturing along the x-axis. The more the data points are to the right of the x=y line, the smaller is the productivity gap for manufacturing relative to that for the total economy.

A comparison between panels A and B confirms a strong catch-up on the US level for both manufacturing and the total economy between 1950 and 1973. In 1973 the productivity gap relative to the United States was slightly narrower for manufacturing than for the total economy for most countries, except the United Kingdom, France and Korea. This suggests that for most countries the catch-up process has been somewhat faster for manufacturing than for the economy as a whole.

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[14] See, for example, Daly, Hitchens and Wagner, (1984), Steedman and Wagner, (1989) and Mason, Prais and van Ark (1992).

Table 5.9
Levels of Value Added per Hour Worked in Manufacturing Compared to the Total Economy (USA=100), 1950-1989

	1950		1973		1989	
	manu-factu-ring	total economy	manu-factu-ring	total economy	manu-factu-ring	total economy
Brazil	20	17	40	25	27[c]	25[c]
India	4	4	5	4	6[c]	4[c]
Korea	5[a]	10	11	15	18[c]	21[c]
France	32	36	62	63	76	85
Germany	39	28	76	60	79	77
Japan	18[b]	12	57	38	80	52
Netherlands	40	42	80	71	85	84
United Kingdom	40	51	52	60	61	73
United States	100	100	100	100	100	100

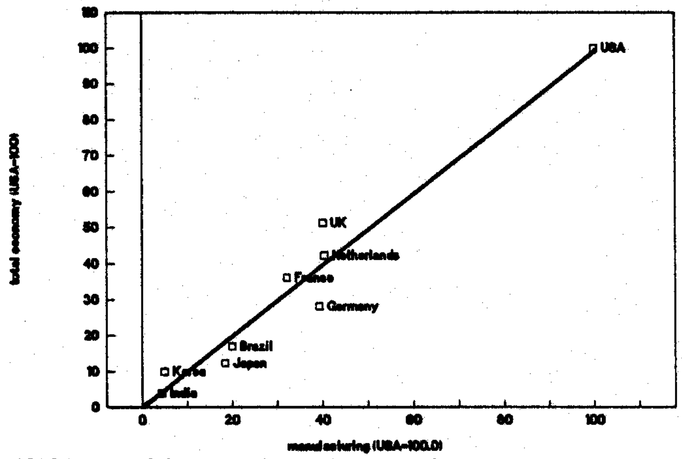
[a] 1953; [b] 1955; [c] 1986;
Notes and sources: manufacturing productivity is measured in terms of 'census' value added (see table 4.2 in chapter 4) and is obtained from table 5.2. Total economy productivity is based on gross domestic product. For the developing countries it is compared to the USA on the basis of multilateral ICP PPPs for 1980 (Brazil, India and Korea), which were obtained from Maddison (1989). For the advanced countries, GDP per hour was taken from Maddison (1992a), though here I replaced Maddison's preferred Paasche PPPs for 1985 by Fisher PPPs which Maddison also obtained from EUROSTAT.

Between 1973 (panel B) and 1989 (panel C), most of the data points in graph 5.11 moved to the left. This means that since 1973 the US improved its relative productivity performance in manufacturing more than in the rest of the economy. Only Japan still showed a significantly better productivity performance relative to the USA in manufacturing than for the economy as a whole. Pilat (1991a) has pointed at the below-average productivity performance of non-manufacturing industries, such as agriculture, mining, retail trade and the real estate sectors, in Japan.

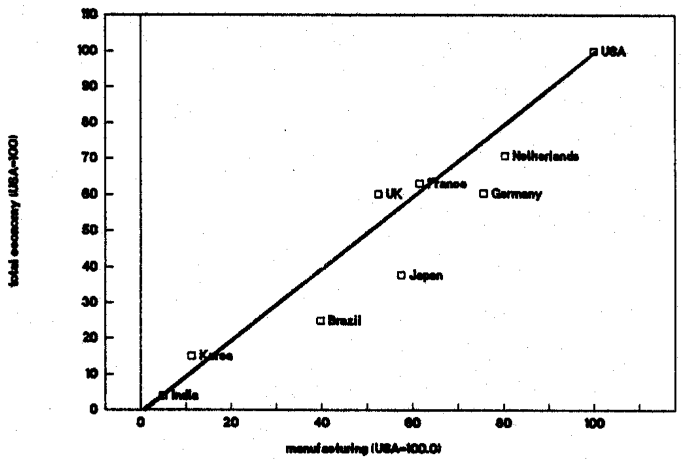
In the United Kingdom the divergence of the relative productivity performance between manufacturing and the total economy is largest. The relatively bad productivity performance of UK manufacturing compared to the comparative productivity performance of the economy as a whole was documented in Smith, Hitchens and Davies (1982).

Graph 5.11
Value Added per Hour Worked in Manufacturing and for the Total Economy as a Percentage of the United States (1950, 1973 and 1989)

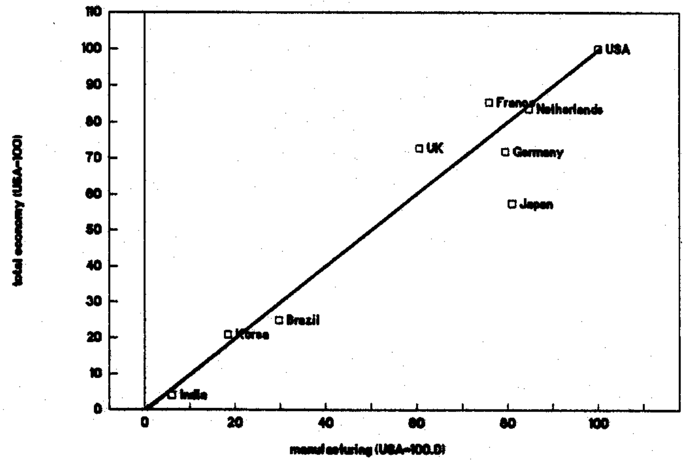
A: 1950 Productivity Level Total Economy Compared to Manufacturing (USA=100)



B: 1973 Productivity Level Total Economy Compared to Manufacturing (USA=100)



C: 1989 Productivity Level Total Economy Compared to Manufacturing (USA=100)



Source: Table 5.9

It needs to be emphasised that comparisons of productivity levels for the total economy with those for manufacturing must be treated with caution as they contain certain elements which affect their comparability. Comparative GDP per hour worked for the economy as a whole is derived with different methods and different sources than the manufacturing estimates. Firstly, GDP is mostly taken from the national accounts, which gives a 'netter' concept than value added on census basis (see chapter 4). Secondly GDP is converted to a common currency with expenditure PPPs rather than with industry of origin UVRs. Thirdly, the benchmark years for the total economy in table 5.9 are updated for 1980 for the developing countries and for 1985 for the advanced countries. Both years are different from our manufacturing benchmark years which are for 1975, 1984 or 1987.

To enhance the comparability of manufacturing productivity estimates with those for the total economy, industry of origin comparisons need to be expanded to other sectors of the economy. Paige and Bombach (1959) who carried out such a study covering the all sectors of the economy for the United Kingdom compared to the United States, showed the productivity ratio for the total economy within a range of 15 per cent of the results from the expenditure study by Gilbert and Kravis (1954). More recently, Pilat (1991a) carried out a comparative study of real output and PPPs for Japan and the USA in 1975. This also showed that results from industry of origin and expenditure comparisons were quite close for the total economy. There is clearly a need for more studies of this kind to evaluate the relative contribution to the productivity gap of individual services industries and the agricultural sector.

Explaining Catch-Up and Convergence Patterns

The first conclusion to be derived from this chapter is that up to the late 1970s the catch-up and convergence pattern for manufacturing productivity largely followed that for total GDP. However, whereas productivity for the total economy has continued to converge on the US level since 1973, almost all countries in the sample lost the momentum of catch-up in manufacturing during the early 1980s. For some countries (in particular Germany) manufacturing productivity even diverged substantially from the US level.

The slowdown in manufacturing catch-up is partly related to the rise in productivity growth in the United States, which was substantially higher after 1979 than it was during the period 1950 to 1973. It was shown in chapter 4 that this acceleration in the US growth rate was largely real, and only to a limited extent affected by measurement problems. In contrast to the faster growth in the United States, productivity increased more slowly than before 1979 in France, Germany, Japan (though only a little more slowly) and the Netherlands. The United Kingdom was the only advanced country showing a significant accelera-tion of manufacturing productivity growth during the 1980s.

Among the lower income countries in the sample, the catch-up process has also been diverse. Korea narrowed its productivity gap vis a vis the US throughout the postwar period. India began to improve its comparative productivity level in manufacturing during the 1980s. Manufacturing productivity in Brazil diverged considerably from the US level since the mid 1970s.

The second conclusion from the analysis so far is that, at least for the period since 1973, the catch-up and convergence process has been weak at the level of major groups of manufacturing branches. For example, the US retained a substantial productivity advantage in non-durable consumer goods over the other advanced countries throughout the past two decades. During the 1980s the productivity gap in chemicals between the US and some of the follower countries even widened. Only in investment goods the US lost its productivity edge to Japan, though it maintained its leadership over the European countries. It was mentioned above that branch specific factors play an important role in explaining the diverse pattern in comparative productivity performance among the major branches.

The lower dispersion of productivity levels for total manufacturing compared to the branches may be an indication that countries have exploited their comparative advantages in branches with relatively high productivity levels. The faster convergence in total manufacturing is then (at least partially) explained by structural change, i.e. by shifts in output and employment shares in each country towards branches with the biggest comparative productivity advantage. However, as will be discussed in detail in the next chapter, the empirical evidence suggests that structural differences in manufacturing were small in cross country comparisons, which is also confirmed by results from other studies. Dollar and Wolff (1988) allocated only a few percentage points of the average productivity gap in manufacturing between OECD countries and the USA to structural shift. O'Mahony (1992) showed that the decline in the level of manufacturing output per worker in Germany compared to the UK from 124.5 in 1968 to 112.5 in 1987, would have been only some three percentage points more if one controls for structural change.

In the virtual absence of structural change as a significant explanatory factor in the convergence process for total manufacturing, one must also analyse the role of 'common' factors (as distinguished from 'branch specific' factors) in explaining the catch-up and convergence process in manufacturing up to 1979, and the lack of it in the period thereafter. These common factors, which have traditionally been within the domain of catch-up and convergence studies, may have different origins, i.e. they are either of a proximate or of an ultimate causility nature.

Among the proximate causes, one distinguishes changes in relative factor proportions, quality increases in capital and labour, effects of foreign trade and energy conservation and the impact of technology diffusion. These factors have a direct influence on productivity performance, and its relative importance can mostly be assessed in quantitative terms. Ultimate causes cover a wide range from socio-political and institutional influences to the impact of rent seeking, bargaining outcomes and economic policy on the degree of convergence. It is unfortunate that so far there have been relatively few successful attempts to underpin the role of ultimate causality empirically.[15] This distinction between proximate and ultimate causes, which is derived from the growth accounting tradition, forms the core of the 'level accounting' approach introduced in the next chapter.

As mentioned above the catch-up and convergence model in its simplest form is empirically supported by the experience of OECD countries, and this chapter shows that the same can concluded for manufacturing, at least up to the 1980s. However, there is now a consensus that countries at the lower end of the per capita income or productivity scale are often not converging on the lead countries. Perez and Soete explain this lack of convergence in terms of a probit model, where countries first need to reach a 'critical' level of per capita income before they will be able to benefit from advantages of backwardness. This critical income level 'itself can be related to any number of personal or economic characteristics' (Perez and Soete, 1988, p. 459).

Given the fact that 'unconditional' convergence is not an overall phenomenon, some scholars aimed to specify the conditions under which convergence can be observed. This 'conditional' catch-up and convergence hypothesis can be tested by including one or more variables which represent so-called ancillary factors in the regression of growth rates of per capita income (see Baumol, 1992). For example, De Long and Summers (1991) observe a strong impact on convergence from the level of investment in machinery. Mankiw, Romer and Weil (1992) and Wolff

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15 See Maddison (1991) for the distinction between proximate and ultimate causality. For some interesting attempts to quantify the contribution of ultimate causes in the convergence process, see De Long (1988) and Crafts (1991, 1992, 1993).

and Gittleman (1993) focussed on the role of education as a conditional factor. This range of factors can be extended to include ultimate causes, for example the degree of market distortion and the degree of political stability.

I have not used the 'conditional' or 'net' convergence concept for the present study. Firstly, as it is based on regression analysis, the sample of countries would have to be larger to obtain statistically significant results. Secondly, if one observes convergence within a group of countries which are characterised by similar conditions, the mechanism behind the convergence within that group still remains unexplained.

It is exactly the latter which interests us mostly when looking in more detail at our relatively small sample of advanced countries in the next chapter. There are indications that the process of catch-up in manufacturing in this group of countries is largely exhausted, and it raises ques-tions about which factors mostly affect the comparative productivity performance in manufacturing nowadays.

6. Explaining Differences in Productivity Levels

The Level Accounting Approach

Labour productivity is often referred to as 'single factor' or 'partial productivity'. A lower level of labour productivity in one country compared to another is either caused by a less efficient use of the production factor labour itself or by a less intensive use of other production factors, which in manufacturing is mainly capital. After adjusting labour productivity ratios for differences in capital intensity, one obtains a measure of joint factor productivity (JFP).

In the traditional growth accounting framework the quality of production factors also needs to be taken into account. Labour input is augmented by estimates of education levels, and vintage effects are included in capital input. After adjusting the productivity estimates for augmented factor inputs, a residual remains which is by some interpreted as a measure of technology. However, in the tradition of Denison, the residual can be further decomposed into other proximate causes, such as the effects of structure, economies of scale, technology diffusion and foreign trade.[1]

In the 'level accounting' approach which I develop in this chapter, I consider the contribution of capital intensity and labour quality to the comparative productivity estimates in detail. The residual is further adjusted for differences in the composition of the manufacturing sector and for differences in firm size.

Level accounting of the kind presented here has not been applied much elsewhere. In his masterpiece Why Growth Rates Differ, Denison provided some estimates on comparative levels output per unit of factor input.[2] He emphasised the problems involved with such comparisons which are related to the lack of comparable estimates on levels of output and factor input, and to the existence of interaction effects between the

1 See Denison (1967) and Maddison (1987, 1991) for a detailed discussion of these factors.

2 See Denison (1967), pp. 195-200.

factors accounting for the productivity gap. A number of studies of comparative levels of total factor productivity levels have been carried out by Christensen, Jorgenson and associates.[3] Furthermore, some recent studies of catch-up and convergence also provide estimates of total factor productivity levels.[4]

The Capital Intensity Effect

It is often suggested that high labour productivity levels in the United States are primarily explained by the greater amount of capital per worker there than in other countries. Some historical studies, including Rostas (1948), Frankel (1957) and Habakkuk (1962), have attached considerable importance to this effect. In most of these studies capital stock was not estimated directly, but instead proxies such as horsepower, investment or at best investment-output ratios were used. In the estimates presented below, capital is defined as the non-residential fixed capital stock in manufacturing, which is the gross stock of buildings, machinery and vehicles.

Techniques for Measuring Capital Stock[5]

The measurement of capital stock has been one of the latest areas into which national accounting practioners have moved during the postwar period. With the exception of the United States, official capital stock estimates have only become part of the national accounts since the 1970s or even later for the countries included in this study. The main reason for this delay is that a direct observation of the capital stock with wealth surveys, fire insurance valuations or companies' current cost accounts is a complicated and resource demanding process.[6]

3 These include Jorgenson and Nishimizu (1978) on Japan and the USA, Christensen, Cummings and Jorgenson (1981) on European countries and the USA, and Conrad and Jorgenson (1985) on Germany and the United States.

4 See, for example, Dowrick and Nguyen (1989) and Wolff (1991) for studies of the economy as a whole, and Dollar and Wolff (1988) and Dollar (1991) for studies on manufacturing only. See also chapter 5.

5 In preparing the capital stock estimates for this study I benefitted greatly from exchanges with Angus Maddison and Mary O'Mahony. See also van Ark (1990c), Maddison (1992b) and O'Mahony (1992b).

6 For an example of capital stock estimate based on fire insurance valuations in Britain, see Barna (1957). For an example of the use of current cost accounts see Smith (1987). Wealth surveys have been carried out on a regular basis only in Japan (see the review by Dean, Darrough and Neef, 1990). Since the early 1980s the Dutch statistical office also conducts a wealth survey, which is used in combination with the perpetual inventory method (see Frenken, 1992).

In most advanced countries official capital stock estimates are compiled on an indirect basis, namely by cumulating annual investment and deducting the annual scrapping of assets and (in case one prefers estimates of net capital stock) depreciation over long periods. This method is called the perpetual inventory method (PIM).[7]

For this study I did not use the official PIM estimates because the comparability of these estimates across countries is weak. Each country applies its own assumptions on asset lives and scrapping patterns which are not always based on very solid empirical grounds. In some cases the assumptions are derived from an ad-hoc sample survey, but more often they are based on tax records, company accounts or expert advice. As a result the assumptions made by various countries are quite different. For example, the average service life of assets used for the official estimates in Britain is more than 1.5 times the average service life in the USA and almost twice the Japanese asset life assumptions. Furthermore, some countries (for example Germany and the UK) assume that service lives have declined over time.

Because there is little hard evidence for large differences in asset lives and scrapping patterns, I compiled my own capital stock estimates on the basis of the PIM using the official investment figures but with 'standardised' assumptions on asset lives and the retirement of the assets. The standardised service lives are based on an average of the assumed lives for 14 OECD countries, which I derived from a detailed OECD survey (OECD, 1993). On this basis I applied a service life of 45 years to investment in non-residential structures in manufacturing and 17 years to investment in equipment and vehicles used in manufacturing. Instead of assuming (like Maddison, 1992b) that all assets are retired at once at the end of the average life time, I used a 'delayed linear' retirement pattern, which assumes that structures are scrapped proportionally after between 36 and 54 years, whereas equipment and vehicles (taken together) are scrapped after between 14 and 20 years.[8]

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7 See Goldsmith (1962) and Ward (1976) for details on the perpetual inventory method.

8 See also O'Mahony (1992b) for the use of spreaded scrapping patterns. Delayed linear retirement appears to make hardly any difference to the overall stock estimates compared to rectangular scrapping. See appendix VI for details on the capital stock estimates. See Blades (1993) for a different view on the degree of comparability of official capital stock estimates between countries and standardised estimates.

Table 6.1
Gross Capital Stock in Manufacturing, Standardised Estimate as a Percentage of the Official Estimates, 1950-1989

	1950	1960	1970	1980	1989
France			99.7[a]	103.5	103.7
Germany		104.8	108.4	112.4	115.5[b]
Netherlands					110.6
United Kingdom	69.1	69.5	74.9	73.5	67.8
Japan		111.8	121.2	128.5	122.6
United States	118.0	118.3	109.9	108.9	108.2

[a] 1981; [b] 1988;

Note: Capital stock estimates are put on a mid-year basis. All official estimates are based on a perpetual inventory method, apart from the estimate for the Netherlands, which is based on a wealth survey.

Sources: Sources and method of standardised capital stock estimates are described in appendix VI. Official estimates for Germany from Statistisches Bundesamt, Volkswirtschaftliche Gesamtrechnungen, Revidierte Ergebnisse 1950-1990; 1989 from Volkswirtschaftliche Gesamtrechnungen, Revised data, September 1991. Japan from Economic Planning Agency (1991), Gross Capital Stock of Private Enterprises; 1960 from Ohkawa and Rosovsky (1973), p. 314, linked to 1965 EPA estimates. France from INSEE, Rapport sur les Comptes de la Nation, various issues and OECD (1989), Flows and Stocks of Fixed Capital 1962-1987. Netherlands from CBS, Kapitaalgoederenvoorraad, various issues. United Kingdom from CSO, United Kingdom National Accounts, various issues, with figures for 1987 extrapolated backwards on the basis of unpublished CSO sources. United States from US Dept. of Commerce (1986), Fixed Reproducible Tangible Wealth in the United States, 1929-1985, Washington D.C.. Recent years from BEA Wealth Data Tape.

Table 6.1 shows the effect of the standardisation procedure on the level of the total capital stock in manufacturing compared to the official estimates for some key years during the postwar period. For France the two estimates are relatively close, whereas for Germany, Japan, the Netherlands and the USA the standardised estimates clearly show higher levels of capital stocks. For Germany and Japan the difference has increased over the years, which at least in the case of Germany may reflect that in the official estimates service lives were reduced over time. The difference between the standardised and the official estimate is biggest for the UK. The extent of the differences is directly related to the assumed asset lives in the various estimates, which is the dominant force behind the level of the capital stock according to the PIM method (see appendix VI).

The comparability of the present capital stock estimates can be further improved by applying the perpetual inventory method at a more detailed level of industries and assets in order to take account of compositional effects. Another issue which affects the comparability of the capital stock estimates concerns the use of deflators in compiling trends in real investment (Gordon and Baily, 1991).

Comparisons of Relative Capital Intensity Across Countries

Table 6.2 shows the gross capital stock, capital intensity, capital productivity, and the PPPs which were used to convert the capital stock from national currencies to US dollars for the benchmark year 1985. These PPPs relate to the expenditure on industrial buildings and equipment and vehicles in manufacturing.[9] The capital-labour ratios for 1985 were extrapolated backwards to 1950 and forwards to 1989 using national time series (see graph 6.1).

Two conclusions emerge from the estimates of capital intensity presented here. Firstly, until the 1980s US capital intensity was above that of the other countries, except for the Netherlands. It appears that the Netherlands is a special case among the six countries in the sample because of its small size and its very open economy. Its manufacturing sector is characterised by a relatively strong specialization in capital intensive industries, in particular in chemicals.[10] However, this structural effect does not account for all of the difference in capital intensity compared to the USA. Table 6.2 also shows that capital productivity in the Netherlands is the lowest of all countries in the sample, which implies that part of the Dutch capital stock is relatively unproductive compared to the other countries.

The second conclusion concerns the change in relative capital intensity over time. All countries show a fairly continuous increase in capital intensity relative to the US level until the mid 1970s, after which it levelled off. Whereas German capital intensity in manufacturing stayed at par with the USA over most of the 1980s, French capital intensity

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9 In contrast to the estimates of labour productivity in the previous chapter, the French and Dutch capital stock estimates are directly compared with the United States instead of via the United Kingdom.

10 See also my adjustments below for structural differences between the countries, which shows that the relatively high labour productivity in Dutch manufacturing is partly caused by its concentration in capital intensive industries. See van Zanden and Griffiths (1989, chapter 9), for an account of the rise of a capital-intensive manufacturing sector in the Netherlands during the postwar period.

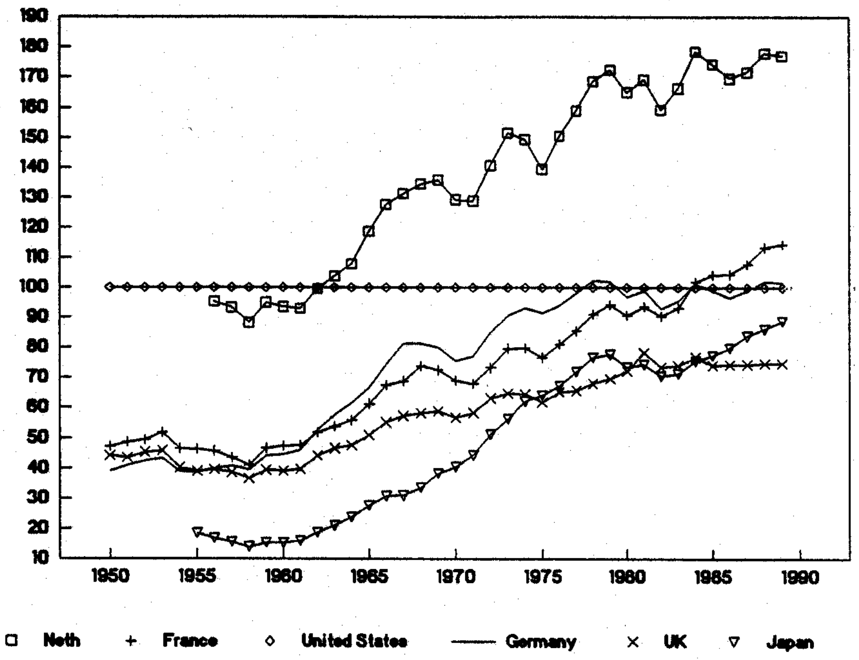
overshoot the US level in 1984. In Japan, capital intensity continued to converge rapidly on the US levels. During the 1980s, British capital-labour ratios stayed well behind those of the other countries which is largely due to the heavy 'shake-out' of large inefficient plants in the past decade.

Table 6.2
Gross Capital Stock, Capital Intensity, Capital Productivity and PPPs for Capital Formation in Manufacturing in 1985

	Gross Capital Stock		Gross Capital Stock per Hour Worked (USA=100)	Census Value Added per Unit of Capital (USA=100)	Fisher PPP for Capitall Formation (national currency/ US$)
	in bln. US$	USA =100.0			
France	326.2	20.7	104.3	74.1	7.50
Germany	535.4	33.9	99.0	87.6	2.44
Japan	804.4	50.9	77.2	100.7	282.94
Netherlands	102.3	6.5	174.3	52.9	2.70
United Kingdom	283.3	17.9	74.0	78.0	0.645
United States	1,578.9	100.0	100.0	100.0	1.000

Source: Capital stock estimates from appendix table VI.4, which were obtained by the perpetual inventory method using official figures on gross capital formation (see appendix table VI.3), and asset life assumptions of 45 years for non-residential structures and 17 years for equipment and vehicles. Assets were assumed to be retired uniformly between 20 per cent below and 20 per cent above the average service life. The Fisher PPPs (with the USA as the base country) are for the expenditure on capital formation on industrial buildings, industry machinery and vehicles. Structures and machinery/vehicles were converted to US dollars separately, and the PPPs shown here are implicitly derived from the value of all assets in manufacturing in national currencies and US dollars. Value added in US dollars and labour input is taken from table 4.1 (for Germany, Japan and the UK) and table 4.9 (for France and the Netherlands) for benchmark years, extrapolated to 1985 with time series from appendix IV.

Graph 6.1
Capital per Hour Worked in Manufacturing (USA=100), 1950-1989



Source: see table 6.2 and appendix table VI.4.

Comparative Measures of Joint Factor Productivity

To determine the productivity of more than one factor input it is necessary to make certain assumptions on the relation between output and the combination of factor inputs, which is expressed in production functions. The most well-known and still most frequently used production function for the purpose of productivity analysis is the Cobb-Douglas function, which expresses output as a combination of labour, capital and a term ‘A’, which for time series analysis can be interpreted as a time variable:

$$Y = AL^{\alpha}K^{\beta} \quad (6.1)$$

with α as the partial elasticity of output with respect to labour and ß as the partial elasticity of output with respect to capital

The Solow-formulation of the production function imposes constant returns to scale on this production function. With the assumption that inputs are paid their marginal products, this implies that the coefficients α and ß correspond to the factor shares and hence sum to one (Solow, 1957). In the original Solow-model the term `A' is interpreted as technical change being entirely 'disembodied' and exogeneous, although Solow later produced an alternative model with embodiment (Solow, 1962).[11]

For the level comparisons of joint factor productivity below, I adopted the Cobb-Douglas version with constant returns to scale. The factor share for labour was obtained from national accounts sources.[12] Equation (6.1) can be reformulated by deducting the logarithmic index of the relative capital-labour ratio of countries X and U (K^X/L^X over K^U/L^U) from that of the corresponding ratio of labour productivity (Y^X/L^X over Y^U/L^U):

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11 The assumptions underlying the Cobb-Douglas production function put certain restrictions on the interpretation of the productivity results. Firstly, the Cobb-Douglas assumes a substitution elasticity between the factor inputs of unity, which implies that a change in the ratio of factor prices leads to a proportional change in the relative factor inputs (K/L) irrespective of the actual factor intensity. Secondly, the coefficients on labour and capital are taken to be constant, which suggest that factor proportions remain unchanged. In other words, the Cobb-Douglas specification assumes neutral technical change. In order to relax these restrictive assumptions, flexible production functions were developed which allow for changing substitution elasticities and non-neutral technical change. One of these flexible functional forms is the transcendental logarithmic production function, which underlies the work of Christensen, Jorgenson and associates. The function is based on a translog index which is derived from the Tornqvist index and described in detail in Christensen, Jorgenson and Lau (1973). Productivity studies based on translog indexes usually lead to results which assign a larger role to capital and a smaller role to 'A' than results from studies based on a Cobb-Douglas function. However these differences in results are largely caused by the definition of output and factor inputs, in particular capital, and not so much by the underlying production functions. The major problem with the use of flexible production functions is that they require much from the data in terms of detail, so that they are difficult to apply. See the debate between Jorgenson and Griliches (1967) and Denison (1969), and a recent comparison of the work by these scholars by Baily and Schultze (1990).

12 The factor shares for labour were obtained from OECD (1991), National Accounts, Detailed Tables, Volume II, 1977-1989, and were defined as the ratio of the compensation of employees to the gross domestic product in manufacturing minus indirect taxes plus subsidies. Apart from wages and salaries, this figure also includes payments for labour input by employers, but not the income of self-employed persons and unpaid family workers. In the national accounts the latter is included with the operating surplus. As a result the contribution of labour input to output is slightly underestimated, though the share of income for self-employed and unpaid family workers in manufacturing labour compensation in advanced countries is very small.

$$\ln\frac{A^X}{A^U} = \ln\frac{Y^X / L^X}{Y^U / L^U} - (1-\alpha)\ln\frac{K^X / L^X}{K^U / L^U} \tag{6.2}$$

with α representing the unweighted average of the share of labour compensation in gross domestic product in country X and country U

Benchmark comparisons of joint factor productivity are made for 1987. The first column of table 6.3 shows estimates of the joint factor productivity level which are based on the factor proportions estimates taken from the national accounts. It has been argued that the returns on capital are substantially larger than capital's share in output. For example, Englander and Mittelstadt (1988) derived a coefficient for capital of 0.4 to 0.5 from a cross-section analysis for OECD countries for the period 1970 to 1985. Column (3) in table 6.3 shows the effects of using a capital coefficient of 0.5, but with constant returns to scale. This adjustment has a small effect on the estimates of joint factor productivity.

Recent work on growth theory has aimed to model situations for which increasing returns to scale can be allowed. In the earliest versions of this kind it was suggested that capital itself could exhibit constant or increasing returns.[13] Column (4) in table 6.2 therefore represents a situation where I imposed constant returns on capital and a coefficient of only 0.1 on labour input (following the suggestion by Romer, 1987). This obviously reduces the productivity gap significantly, and it also affects the ranking of countries. The relatively low capital intensity in Japan and the UK compared to the US narrows their gap in joint factor productivity to only 6 and 10 percentage points respectively, whereas the joint factor productivity gap in capital-intensive Netherlands increases to 32 percentage points. In fact the empirical support for substantially increasing returns to scale is weak. At best there are slightly increasing returns to scale with diminishing returns on each of the individual production factors.[14]

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13 See for example Romer (1986, 1987). In later versions of this 'new growth' theory increasing returns were directly linked to human capital (Lucas, 1988) or to an independent production factor, such as 'design knowledge' (Romer, 1990). The basic idea behind all new growth models is that technological development is derived from an existing stock of knowledge which produces spill-over effects. Economic growth is therefore viewed as an endogeneous process generated by increasing returns. It counteracts the catch-up hypothesis, because the latter assumes diminishing returns to each individual production factor and constant returns to scale, which allows follower countries to catch up with productivity leader.

14 See Crafts (1992) for a review.

Table 6.3
Labour Productivity and Joint Factor Productivity in Manufacturing with Alternative Weights for Factor Inputs (USA=100), 1987

	Value Added per Hour Worked	Joint Factor Productivity		
		Factor Shares Weights[a]	Weights for Capital=0.5 Labour=0.5	Weights for Capital=1.0 Labour=0.1
	(1)	(2)	(3)	(4)
France	73.3	71.7	70.6	80.2
Germany	78.7	79.0	79.2	88.7
Japan	75.5	80.3	82.5	94.1
Netherlands	83.9	70.6	64.0	67.6
United Kingdom	58.0	62.9	67.3	90.2
United States	100.0	100.0	100.0	100.0

[a] The share for labour compensation in GDP in 1987 was 68.3 per cent for France, 70.5 per cent for Germany, 57.2 per cent for Japan, 63.2 per cent for the Netherlands, 72.2 per cent for the United Kingdom and 72.9 per cent for the United States. From OECD (1991), National Accounts, Detailed Tables, Volume II, 1977-1989.
Source: Value added and labour input in manufacturing for benchmarks derived from table 4.1 (for Germany, Japan and the UK) and table 4.9 (for France and the Netherlands). Capital stock from table 6.2.

The joint factor productivity estimates for 1987 are extrapolated forwards to 1989 and backwards to 1950 on the basis of national time series. The relative levels of joint factor productivity are also reproduced in graph 6.2. At first sight it looks as if the comparative trends in joint factor productivity match those of relative labour productivity shown in graph 5.2 in the previous chapter. Indeed there is a strong statistical relation between the two measures.

However, table 6.4 which compares the joint factor productivity level with that of labour productivity, shows that the latter converged more rapidly on the US level than the former. In 1950 the gap in terms of labour productivity was larger than that for joint factor productivity for all countries due to the higher capital intensity in the USA. The catch-up in labour productivity levels until the early 1980s is partly associated with a relative increase in capital intensity as shown above, but other factors (such as technology diffusion) played a role in the catch-up process as well.

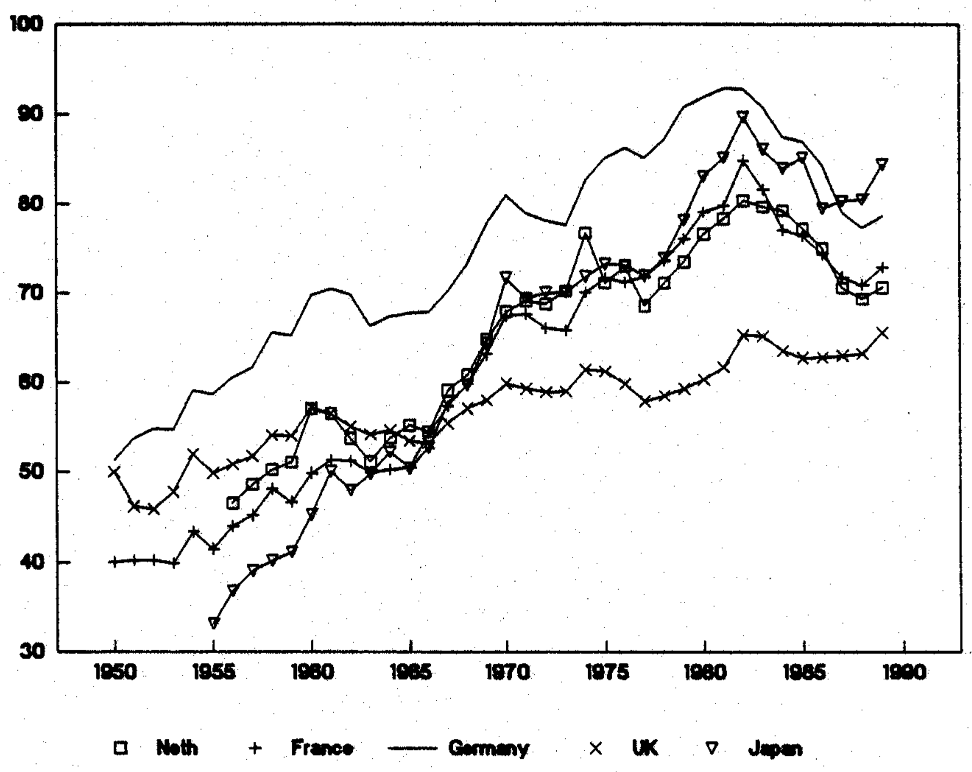
Table 6.4
Joint Factor Productivity (JFP) and Value Added per Hour (LP) in Manufacturing (USA=100), 1950-1989

	1950	1965	1973	1979	1989
France					
Joint Factor Productivity (JFP)	40.1	50.4	65.8	76.0	72.9
Value Added per Hour (LP)	32.1	43.7	61.5	74.7	75.8
JFP-LP	8.0	6.7	4.3	1.3	-2.9
Germany					
Joint Factor Productivity	51.3	67.8	77.6	90.7	78.6
Value Added per Hour	39.3	60.5	75.5	91.3	78.9
JFP-LP	12.0	7.3	2.1	-0.6	-0.4
Japan					
Joint Factor Productivity	33.1[a]	50.4	70.1	78.2	84.4
Value Added per Hour	18.4[a]	32.1	57.4	71.6	80.9
JFP-LP	14.7	18.3	12.7	6.6	3.5
Netherlands					
Joint Factor Productivity	46.5[b]	55.2	70.2	73.5	70.6
Value Added per Hour	42.9[b]	58.3	80.3	87.5	84.7
JFP-LP	3.6	-3.1	-10.4	-14.0	-14.1
United Kingdom					
Joint Factor Productivity	50.0	53.4	59.0	59.3	65.5
Value Added per Hour	40.0	44.4	52.4	53.7	60.5
JFP-LP	10.0	9.0	6.6	5.6	5.0
United States	100.0	100.0	100.0	100.0	100.0

[a] 1955; [b] 1956
Source: Value added per hour worked from appendix table IV.4. Joint factor productivity for benchmark years from table 6.3. Time series for value added and labour input from appendix IV and for the capital stock from appendix table VI.4.

In the early 1980s, catch-up in France, Germany and the Netherlands stopped in terms of labour productivity, but also in terms of joint factor productivity despite a slower increase in relative capital intensity com-pared to the period before. By 1989 the joint factor productivity gap for these countries was even larger than the labour productivity gap. In Japan, the pre-1979 track of catch-up was regained in 1985. The relative level of joint factor productivity in Japan increased from the lowest comparative level in 1950 to a position in 1989 when it was closer to the US level than for any of the other countries. Finally, during the 1980s the UK showed a spurt in joint factor productivity performance compared to the earlier period.

Graph 6.2
Joint Factor Productivity in Manufacturing (USA=100), 1950-1989



Source: see table 6.4

Among the European countries, Germany clearly had a leading posi-tion in joint factor productivity over the Netherlands throughout the period. Despite Germany's deterioration in relative labour productivity during the 1980s, it has not lost its joint factor productivity advantage to the other European countries. The Netherlands appears to have suffered from relatively high capital-output ratios as its joint factor productivity level was among the lowest of the European countries. In the United Kingdom the catch-up in joint factor productivity was not as fast as for the other European countries, but the comparative performance during the 1980s in fact represented a spurt forwards compared to the earlier period. As a result, in 1989 the difference in joint factor productivity between the United Kingdom and the other European countries was less marked than the difference in labour productivity.[15]

The positive relation between the change in comparative levels of capital intensity and joint factor productivity and the consequently faster

15 See also O'Mahony (1992a, pp. 52-53), who shows that differences in capital intensity explains some 8 percentage points of the 21 percentage points labour productivity gap between German and UK manufacturing.

catch-up in labour productivity until the early 1980s is supported by other studies which focussed on the economy as a whole. A recent article by Wolff (1991) shows a strong relationship between capital intensity and total factor productivity growth and levels from 1870 to 1979 for seven OECD countries. Growth rates for capital per hour worked, value added per hour worked and joint factor productivity can also be derived from Maddison's work on the total economy for the six advanced countries considered here (1991, 1992a). Maddison's estimates suggest that, with the exception of the UK, the slowdown in joint factor productivity growth since 1973 has been bigger than for labour productivity, despite a corresponding slowdown in the increase in capital intensity.

The study by Dowrick and Nguyen (1989) on catch-up and convergence for OECD countries provides estimates up to 1985. In contrast to the figures shown above, they find a stable and continuous catch-up in total factor productivity for the whole period, without a statistically significant break in the series for the most recent period. A major shortcoming of their study is that the growth of the capital stock is approximated by investment-output ratios, which effectively assume that capital-output ratios stay constant over time and across countries (Dowrick and Nguyen, 1989, pp. 1016-1017).[16] My figures on capital productivity in table 6.1 show that capital-output ratios were in fact quite different in 1985. Neither did capital-output ratios remain constant over time. Instead they increased at 10 per cent (Netherlands, France, the UK and the USA) to 40 per cent (Germany and Japan) between the early 1950s to 1987.

The study by Dollar and Wolff (1993) is based on a different and more diffuse set of data.[17] Compared to the present study, it provides substantially different levels of comparative productivity in manufacturing,

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16 Dowrick and Nguyen include a sensitivity test comparing their total factor productivity estimates with OECD estimates which use capital stock data. This test showed little difference to the calculations. However, detailed comparisons between capital stock figures and investment-output ratios by Denison show a very imperfect relation (Denison, 1967, p. 121 and 138).

17 In fact Dollar and Wolff use two different sets of data. Their own figures are derived from information on value added and employment from the United Nations' Yearbook of Industrial Statistics. Capital stock for the EEC countries is obtained from Eurostat and for the other OECD countries from national sources. They also apply the OECD sectoral data base (see Meyer-zu-Schlochtern, 1988), which apparently led to similar results. Value added is converted to a common currency with purchasing power parities from OECD for the total economy (see also Dollar and Wolff, 1988). This method obviously leads to different results compared to the present study in particular at disaggregated levels, for which the use of total economy PPPs is less appropriate than the industry UVRs used in this study.

but similar trends as described above. It showed a faster convergence for manufacturing labour productivity than for total factor productivity combined with a narrowing in comparative levels of capital intensity up to 1972. After 1972 TFP convergence slowed down as was also found in this study, and according to Dollar and Wolff further gains in labour productivity (as far as they did occur) were largely the result of capital accumulation.

It appears that at present, capital intensity only plays a minor role in explaining the intercountry differences in productivity gaps. Relative levels of capital intensity in manufacturing are below the US level only in Japan and the UK. The break in the catch-up process in manufacturing since the late 1970s can hardly be explained by the slowdown in capital intensity, as that would have implied a more moderate slowdown for joint factor productivity than for labour productivity which was not confirmed in general.

Augmenting the Factor Inputs

The Quality of Labour Input

Many studies on economic growth have attached considerable importance to the quality of labour input and in particular to the education and training of the labour force. The concept of human capital, as introduced and developed by Schultz (1961), Becker (1964) and Blaug (1965), has now become common ground for most economists.

The by now traditional way of estimating the contribution of human capital to output is to measure schooling levels of cohorts of the labour force which are weighted by wage or earnings differentials (Denison, 1964c and 1967) or by educational costs. Most growth accounting studies measure the quality of the labour force in terms of the average number of years of schooling. For level comparisons this method is less satisfactory, because the organisation of the schooling system is quite different among countries. In particular for manufacturing, the average number of years of schooling is a poor indicator of the quality of the labour force because it lacks information on the actual distribution of skills. The most extreme example is Germany where a large proportion of the labour force has obtained diplomas through an apprenticeship system which is not reflected in the estimates of years of formal schooling.[18]

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18 For a critique of the approach which only looks at years of formal schooling, which is in fact an input- and not an output measure, see Prais (1988).

Some attempts have been undertaken to classify educational systems among advanced countries. For example OECD (1975) provides a classification in terms of primary, general and technical secondary, higher non-university and university education. Studies at the National Institute of Economic and Social Research (NIESR) have shown that education received at technical colleges or through an apprenticeship system, and the possession of vocational certificates are of much greater importance in explaining productivity differentials in manufacturing than the number of years of general schooling.[19] The augmentation of labour input for quality differences therefore requires a careful evaluation of attainment levels between countries.

Table 6.5 shows the distribution of the manufacturing labour force according to levels of vocational qualifications. The basic information is obtained from the labour force and population surveys in each country. For the European countries, I based my estimates on the distribution of qualification levels as suggested in the NIESR studies.[20] For Japan and the United States I compiled my own estimates, which are much cruder than the estimates for Europe, because the statistics in these two countries do not clearly distinguish between vocational and general qualifications at high school level. In the United States, the provision of separate schools for vocational training below college level has traditionally been limited. Neither have apprenticeship systems been of great importance. However, most general high schools have technical subjects on offer from which pupils can choose to integrate into their programme. Estimates from a survey for 1963 show that about 37.5 per cent of the labour force received some kind of vocational training at high school level.[21] There is no evidence that this share has substantially increased in the past three decades. On the assumption that the time spent on vocational subjects by this 37.5 percent of all working people visiting high school was about one third of all education received, I classified 12.5 per cent of the 1987 labour force with high school diplomas to intermediate vocational qualifications.

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19 See, for example, the results from comparisons of 'matched plants' by Daly, Hitchens and Wagner (1985), Steedman and Wagner (1989) and Mason, Prais and van Ark (1992) covering Germany, the Netherlands and the United Kingdom.

20 For Germany see Prais (1981b) and O'Mahoney (1992a); for France, see Steedman (1990); for the Netherlands and the UK, see Mason, Prais and van Ark (1992).

21 See the detailed study of comparison of qualification levels between the United Kingdom and the United States by Daly (1984, p. 236).

Table 6.5
Vocational Qualifications of the Work Force in Manufacturing, 1987-1989

	France (1988)	Germany (1987)	Nether-lands (1989)	United Kingdom (1987)	Japan (1987)	United States (1987)
High degrees[a]	4.0	5.7	12.1	6.7	11.7	17.7
Intermediate degrees	41.2	65.1	47.9	30.7	22.0	23.8
Upper intermediate[b]	4.0	8.4	33.1	4.4		
Lower intermediate[c]	37.2	56.7	12.1	26.3		
No vocational qualifications[d]	54.8	29.3	40.0	62.6	66.2	58.5
Total	100.0	100.0	100.0	100.0	100.0	100.0

[a] Includes university and college degrees and degrees from higher vocational schools as far as these contained elements of technical training.
[b] Includes higher technician certificates.
[c] Includes craft and lower technician certificates.
[d] Includes all non-vocational degrees (excluding university and college).
Source: France from Steedman (1990), table 2 and 3 with adjustments for higher degrees from table 1; Germany from Statistisches Bundesamt, Mikrozensus 1987, with distribution as suggested by Prais (1981); Netherlands from `Enquête Beroepsbevolking 1989', in CBS, Sociaal-Economische Maandstatistiek (1990, no. 4), table 4, with distribution as suggested by Mason, Prais and van Ark (1992) but with 90% of HBO-degrees as `high degrees' and 90% of MBO-degrees as `upper intermediate'. UK from OPCS, Labour Force Survey 1987, with distribution as suggested by O'Mahony (1992a), table 6. Japan from Management and Coordination Agency, 1987 Employment Status Survey, assuming that one third of senior high school degrees could be characterised as `intermediate'. See the text for the derivation of the latter ratio. US from unpublished tabulations from US Dept. of Labor (1987), `Educational Attainments of Workers, March 1987' (October), assuming that 12.5 per cent of all the education received by workers with 1 to 3 or 4 years of high school could be characterised as vocational. For derivation of the latter ratio see the text.

For Japan I used a figure on enrollment in vocational senior high schools from Prais (1987, p. 47), which I recalculated as a percentage of enrollment in all senior high schools in 1984. This 1984 percentage was extrapolated backwards to 1955 with quinquennial estimates of the ratio of enrollment in technical schools to all senior high schools which I obtained from the Japanese Statistical Yearbook (various issues). This showed that between 1955 and 1980 33 per cent of all enrollment in Japanese senior high schools could be classified as vocational.

Table 6.5 shows some important differences in the distribution of qualification levels among the countries. The manufacturing labour force in Japan and the USA is characterised by a large share of university and college degrees, and the Dutch share in this category is also relatively large because of the larger number of qualified technicians from Higher Technical Schools in the Netherlands. In the intermediate category, Germany has the highest share due to the large number of workers who have gone through the German apprenticeship system. Within Europe, the United Kingdom shows the lowest share in the intermediate category, because of the lack of a comprehensive vocational education system. Up to the age of 16 years there is relatively little vocational education in the UK, after which a large number of pupils drop out from the education system and remain unskilled.

In Japan and the United States, many more students remain in educa-ti-on after the age of 15 compared to Britain, but in contrast to the other European countries a larger number of them stays in general education rather than in vocational education. As a result according to the present tabulation a greater share of educated workers in Japan and the USA are classified as having no vocational qualifications. A comparison on the basis of the general education level would show a more favourable

Table 6.6
Labour Productivity and Joint Factor Productivity in Manufacturing, Adjusted and Unadjusted for Labour Force Qualifications (USA=100), 1987

	Value Added per Hour Worked	Joint Factor Productivity		
		Unadjusted for Labour Quality	Adjusted for Labour Quality	
			0.6 weight[a]	1.0 weight[b]
France	73.3	71.7	74.4	75.9
Germany	78.7	79.0	79.8	80.2
Japan	75.5	80.3	82.1	83.1
Netherlands	83.9	70.6	70.6	70.6
United Kingdom	58.0	62.9	65.3	66.6
United States	100.0	100.0	100.0	100.0

[a] The adjustment for labour quality is made on the basis of weighting the shares of higher-, intermediate- and 'no vocational-' qualification at 0.6 of the average of relative wage shares for these categories in Germany, the United Kingdom and the United States.

[b] No weight is applied to the relative wage shares.

Source: Value added per hour from appendix table IV.4. Joint factor productivity unadjusted for labour quality see table 6.3. Relative qualification levels from table 6.4. Wage shares for Germany and Britain from O'Mahony (1992b); for the USA from US Dept. of Labor Statistics, unpublished tabulations from the 'Current Population Survey', 1991.

picture for Japan and the United States. Clearly such general qualifications also have something to contribute to productivity. As Daly stated: '(A) more educated workforce may lead to better investment decisions, improved labour relations and greater adaptability to changing economic circumstances' (Daly, 1984, p.241).

Following growth accounting practice, I estimated a differential in labour quality between each country and the United States on the basis of relative wage shares for the higher-, intermediate- and non-vocational categories. For this purpose I used a geometric average of the wage shares in Germany, Britain and the United States. As wage differentials are not only determined by differences in qualifications, but among other things also by ability and social background, I adopted Denison's sugges-tion to reduce the impact of wage differentials on labour quality to 0.6, but by way of sensitivity test I show also the results without such a reduction.[22]

Table 6.6 compares the labour productivity gap with the joint factor productivity gap as estimated above and after an adjustment for differences in labour force qualifications. In all countries except the Netherlands, lower qualification levels (and in particular less college and university degrees) account for part of the lower productivity levels compared to the USA. However, the effects are small due to the relative underrepresentation of workers with intermediate vocational qualifications in the USA.

The Embodiment of Technology in Capital

In the productivity estimates presented above, technology was assumed as disembodied from the capital goods. However it seems implausible that the relative increase in capital intensity of all other countries compared to the USA did not lead to a relative improvement in the quality of the capital stock in the follower countries. Indeed the strong correlation between the rise in capital intensity in the follower countries and the closing of the gap in joint factor productivity suggests the presence of 'embodied' technology.

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22 See Denison (1964c, pp. 36-40) for a detailed account of support for this at first sight somewhat arbitrary assumption. For example, Denison presented a calculation of the change in US real national income between 1930 and 1960, which would be 18.6 percent less than the original estimate if educational levels of 1930 were held constant. According to Denison, this is certainly not an overestimation of the effect of education on growth.

The 'embodiment' issue has been at the forefront of the discussion on growth accounting techniques throughout the postwar period. Salter (1960) and Solow (1962), who pioneered the embodiment hypothesis, argued in favour of a vintage approach. This method implies that investment for each year is blown up by a certain percentage, which represents the increase in production capacity of the assets due to better technology. Denison (1964b, 1967) has been most critical of the embodiment hypothesis, partly because he argued the distinction was artificial and arbitrary and partly because the hypothesis was not supported by changes in average asset lives. Christensen, Jorgenson and associates have probably gone furthest in measuring capital stock inclusive of quality changes. Their approach takes rental rates instead of asset values as weights of the capital stock, as the former are supposed to better represent the service flows of assets. As a result their studies have given a substantially larger weight to capital than any of the other traditional growth accounting studies.[23]

It is important here to separate the issues concerned with the familiar debate on technological change and capital growth from that on comparative levels. Whereas the capital stock in the follower countries may have been of a lower quality several decades ago, so that an embodiment effect should be included, there is less support for this proposition now. Relative levels of capital intensity are now much closer between the follower countries and the United States than at the beginning of the postwar period. As mentioned above, there is no strong evidence on different ages of the capital stock between advanced countries, which one might have interpreted as an indication of different 'states of technology'. Bacon and Eltis (1974) hardly found any difference in age of industrial machinery between the UK and the USA. Prais (1986) finds only a slightly lower average age for British machine-stock (12 years) than for Germany, France and the United States (14-15 years), though the author stresses that this cannot be seen as an indication that British machines are technically more advanced than the machine stock of the other countries.

In recent literature, existing intercountry differences in technology between advanced countries are increasingly related to differences in work practice and shopfloor organisation, such as for example the application of just-in-time inventory methods.[24] These are typical features of disembodied and not of embodied technological change.

23 For a comparison see Norsworthy (1984), Maddison (1987, p. 660) and Baily and Schultze (1990, pp. 385-395).

24 See for example the part on 'Technology and the Organisation of the Firm' in OECD (1991).

In view of these considerations it seems reasonable to assume that the catch-up process in terms of embodied technology in manufacturing is by now largely exhausted, and that existing technological differences between the countries in the sample can be classified entirely as part of the final residual discussed below.

Decomposing the Residual in Level Accounting

The Effect of Structure

Differences in comparative productivity levels between countries can partly be ascribed to a different industry or branch composition of the manufacturing sector. In the literature on structural change and economic growth, Kuznets (1966), Chenery (1979) and Syrquin (1988) in particular emphasised the importance of resource shifts from industries with low levels of productivity to industries with high levels of productivity. In a similar fashion, part of a relatively low productivity level in one country compared to another country may be explained by a relatively strong concentration of employment in low-productivity industries.

The original productivity ratio for total manufacturing as presented in chapter 4, was calculated by converting value added for each branch to a common currency, after which the sum of value added for all branches was divided by manufacturing employment and compared to the other country (compare equations 4.1a and 4.1b in chapter 4):

$$\frac{VA_M^{X(U)} / L_M^X}{VA_m^{U(X)} / L_M^U} = \frac{\sum_{k=1}^{t} \left[VA_K^{X(X)} / UVR_K^{XU(U)} \right] / \sum_{k=1}^{t} L_K^X}{\sum_{k=1}^{t} VA_K^{U(U)} / \sum_{k=1}^{t} L_K^U} \qquad (6.3a)$$

or

$$\frac{VA_M^{X(X)} / L_M^X}{VA_M^{U(X)} / L_M^U} = \frac{\sum_{k=1}^{t} VA_K^{X(X)} / \sum_{k=1}^{t} L_K^X}{\sum_{k=1}^{t} \left[VA_K^{U(U)} * UVR_K^{XU(U)} \right] / \sum_{k=1}^{t} L_K^U} \qquad (6.3b)$$

with VA_k, L_k and UVR_k representing value added, total hours worked and the unit value ratio for branch k; subscripts refer to country X and country U with the subscript between brackets referring to weights of country X or country U.

This procedure does not only take account of the productivity gap for each individual branch, but also of the differences in distribution of the employment among the branches.[25]

The effect of structural differences can be removed by weighting each country's branch productivity by a unique set of labour input weights. The ratio of labour productivity at prices of country U in equation (6.3a) is then adjusted for structural differences by weighting branch productivity in the numerator and the denominator by the labour shares of country X (L_k^x/L_m^x):

$$\frac{VA_M^{X(U)^{L(X)}}}{VA_M^{U(U)^{L(U)}}} = \frac{\sum_{k=1}^{t}\left[(VA_K^{X(X)}/UVR_K^{XU(X)})/L_K^X * \frac{L_K^X}{L_M^X}\right]}{\sum_{k=1}^{t}\left[VA_K^{U(U)}/L_K^U * \frac{L_K^X}{L_M^X}\right]} \tag{6.4a}$$

or by the labour input shares of country U (L_k^u/L_m^u):

$$\frac{VA_M^{X(U)^{L(U)}}}{VA_M^{U(U)^{L(U)}}} = \frac{\sum_{k=1}^{t}\left[\left(VA_K^{X(X)}/UVR_K^{XU(X)}\right)/L_K^X * \frac{L_K^U}{L_M^U}\right]}{\sum_{k=1}^{t}\left[VA_K^{U(U)}/L_K^U * \frac{L_K^U}{L_M^U}\right]} \tag{6.4b}$$

with $VA_m^{L(X)}$ and $VA_m^{L(U)}$ representing the value added weighted by labour input shares of country X and country U respectively

These calculations can be repeated for the labour productivity at prices of country U in equation (6.3b).[26]

Table 6.7 shows the effect of differences in branch structure on the labour productivity ratios in the benchmark year for each direct binary comparison with the USA. As the comparisons with the USA for France and the Netherlands were made indirectly via the United Kingdom, it was not possible to calculate the structure effect adequately. By way of

25 Smith, Hitchens and Davies (1982) named this method the 'standardising' method.

26 An alternative method to adjust for compositional differences is the 'shift-share' method. The productivity gap between two countries is then first calculated on the assumption that the productivity for each individual branch is the same. The aggregate result, which only reflects the productivity due to structural differences, is then deducted from the unadjusted productivity ratio. This method provides similar results to those presented in table 6.7. See also Hitchens, Wagner and Birnie (1990).

Table 6.7
The Effect of Structural Differences on Comparative Productivity Levels in Total Manufacturing in Benchmark Years

Binary Comparisons with United States	Value Added per Hour Worked (USA=100.0)	
	Unadjusted for Structural Differences	Adjusted for Structural Differences
1987		
Germany	78.7	75.5
Japan	75.5	78.8
United Kingdom	58.0	58.1
United States	100.0	100.0

Binary Comparison with United Kingdom	Value Added per Hour Worked (UK=100.0)	
	Unadjusted for Structural Differences	Adjusted for Structural Differences
1984		
France	126.2	127.1
Netherlands	155.4	144.3
United Kingdom	100.0	100.0

Note: The adjustment is made by weighting each country's value added per hour by branch at the labour input shares of one of the two countries. The adjusted figure presented in the table is the geometric average of the four calculations which could be made for each binary comparison (see text).
Sources: Calculated from appendix tables III.12 to III.21.

illustration the bottom panel of table 6.7 therefore shows the structural effect on the France/UK and Netherlands/UK comparisons of labour productivity.

It appears that, on the whole, structural differences account for only a small part of the labour productivity gap. In the case of Germany the adjustment led to a small rise in the productivity gap. Machinery is relatively strongly represented in German manufacturing and shows comparatively high productivity ratios. For Japan the adjustment narrowed the productivity gap because of the relatively strong concentration of

Japanese employment in the low-productive food products branch. As a result the relative positions of Germany and Japan switch after the adjustment for structural effects.

The most substantial adjustment for structure was made for the Netherlands. As already discussed above, Dutch labour input is strongly concentrated in highly capital-intensive industries, in particular chemicals. This higher level of specialisation in the Netherlands is typical for a small and open industrialised economy.

It should be emphasised that the structural elements were removed here only at branch level. There are also structural differences within branches, i.e. at industry and product level. For example, the Dutch chemical industry concentrates more on the relatively capital-intensive production of basic chemicals, whereas its British counterpart manufactures more consumer-type chemical products. This allows for part of the productivity gap between the Netherlands and Britain within the chemicals branch, which is not taken into account by the adjustments made in table 6.7.

However, even if structural effects at product- and industry levels were taken into account, it seems unlikely that structural differences can play a very large role in accounting for the productivity gaps between the advanced countries included in this study.

The Effect of Firm Size

Table 6.8 compares the average size of plants for the six advanced countries in the sample for a recent year. The branch figures are expressed in terms of ‘median size’. The median is the average size where half of all employees are employed in plants which are smaller, and half in plants above this size. This is a more suitable measure for analysing productivity differences than the average number of workers per plant.[27]

For total manufacturing the median plant size is largest in Germany and smallest in France, whereas the Netherlands, the UK and the USA take a middle position, and Japan and France are at the lower end of the size scale. In terms of an arithmetic average the United States, not Germany, has the largest number of employees per plant, namely 49

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27 A plant is defined as a ‘local unit’, which is a producing unit at a single postal address (see chapter 4, p. 56, for census classifications of producing units). The local unit is the most relevant concept for an analysis of the impact of average size on productivity, though certain economies of scale, such as those derived from large scale administrative management, can only be obtained at activity- or legal unit level.

employees. This implies that although more than half of American manufacturing employees work in plants smaller than 263 employees, the USA had more large plants than any of the other countries.

The variation in median size is quite substantial among major branches. For example, the smallest country in the sample, the Netherlands, had the largest median size in chemicals. On the other hand, Germany had the smallest median size in food manufacturing, whereas it had the largest median size for overall manufacturing.

Table 6.8
Median and Average Employment Size of Manufacturing Plants in Advanced Countries in Selected Years

	France 1988	Germany 1987	Japan 1987	Neth. 1985[a]	UK 1988	USA 1987
			Median Size			
Food Products, Beverages and Tobacco	74	31	52	283	346	274
Textiles, Wearing Apparel and Leather Products	110	112	26	96	151	233
Chemicals, Rubber and Plastic Products	274	723	107	1050	306	240
Basic Metals and Metal Products	136	248	48	174	160	208
Machinery, Electrical Engineering and Transport Equipment	347	889	195	199[b]	329	633
Other Manufacturing Branches	47	79	28	228[b]	106	198
Total Manufacturing	146	318	166	254	240	263
			Average Size			
Total Manufacturing	19	30	16	34	30	49

[a] Manufacturing units in the Netherlands refer to legal units instead of plants. However, the total of 8,903 enterprises employing 10 employees or more on 1 January 1985 consisted of 9,073 activity units (see CBS, *Produktiestatistieken*) so that the Dutch estimate is not very much inflated. See also van Ark (1990a).

[b] Electrical engineering included in transport equipment.

Source: France from INSEE, *Annuaire Statistique de la France* 1988; Germany from Statistisches Bundesamt, *Arbeitsstätten und Beschäftigte nach Beschäftigtengrößenklassen* 1987; Japan from MITI, *Census of Manufactures, Report by Industries*, Tokyo; Netherlands from CBS, *Statistiek van het Ondernemingen- en Vestigingenbestand* 1985, Voorburg. UK from BSO, *Size Analyses of United Kingdom Businesses* 1988. USA from US Dept. of Commerce, 1987 *Census of Manufactures, General Summary*.

The result for Germany is perhaps most surprising, because Germany is usually known as a country with relatively many small firms. For example, Prais shows that in the early 1970s, half of manufacturing plants in Germany were in the size category of 1 to 4 employees compared to just over one-third in the USA and just over one-quarter in the UK (Prais, 1981, pp. 15-16). However, the fact that more than half of the employees in the chemicals group and the investment goods group work in very large plants, explains the relatively high median size.

The production censuses used for the benchmark comparisons in this study also include information on the distribution of value added and employment between firm size categories. On the whole, firms with few employees show lower value added per person employed than large firms. Differences in the distribution of the average firm size between countries can therefore play a role in explaining the productivity gap.

Table 6.9 shows the effect of firm size on the relative productivity level for three benchmark comparisons which were directly made with the USA. The adjustment was made in a similar way as for the effect of structure discussed above. Comparative productivity was calculated by plant size for six categories, i.e. from 0 to 20 employees, 20 to 49 employees, 49 to 99 employees, 100 to 499 employees, 499 to 999 employees and for plants of more than 1,000 employees.[28] Productivity for each size category was then weighted by the labour input share of one of the two countries (see equations 6.4a and 6.4b for the comparisons at prices of country X).

The size effect on productivity is strongest in Japan, where it accounts for about half of the productivity gap compared to the USA. For the UK/USA comparison the effect of firm size differences is relatively small. In Germany, the size effect increases rather than reduces the productivity gap. The size effects for France and the Netherlands could not be directly calculated. Table 6.8 shows that France has a similar median size as Japan and that the Dutch median size is close to that of the UK. The size effects for France and the Netherlands can therefore be taken as comparable to those for Japan and the UK respectively.

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28 In the Germany/USA the category 0-20 employees was excluded from the size adjustment. In some cases I put two size categories together, e.g. the 20-49 and 50-99 groups. It should be emphasised that I could only use one unit value ratio for all size ranges. Clearly it may be unrealistic to assume the same price relationship for products from small firms compared to those from large firms, but for comparisons among the advanced countries I think this is a reasonable assumption. The census distribution of value added and employment by size category was insufficient for making a suitable adjustment for the European countries compared to the United Kingdom.

Table 6.9
The Effect of Differences in Firm Size on Comparative Productivity Levels in Total Manufacturing in Benchmark Years

Binary Comparisons with United States	Value Added per Hour Worked (USA=100.0)	
	Unadjusted for Firm Size Differences	Adjusted for Firm Size Differences
1987		
Germany[a]	78.7	73.3
Japan	75.5	88.3
United Kingdom	58.0	56.8
United States	100.0	100.0

[a] excludes adjustment for establishments with less than 20 employees.
Note: The adjustment is made by weighting each country's productivity by size category in absolute terms at the employment shares of one of the two countries. The adjusted figure presented in the table is the geometric average of the four calculations which could be made for each binary comparison.
Sources: production censuses as given for each country in appendix tables III.1 to III.11.

The relation between firm size and economies of scale has been a subject of substantive analytical interest for a long time. The traditional literature claims that under normal circumstances larger firms should have lower average unit costs. On the other hand there may also be diseconomies of scale. Among other things, large firms may realise a lower return on entrepreneurship, they may be more inflexible concerning their market behaviour and have worse labour relations than small firms.[29]

The present comparisons are too aggregated to derive any definitive conclusion concerning differences of economies of scale between the countries. At firm level, scale economies for one and the same product

29 For a review of these kind of factors in relation to the low productivity performance of British manufacturing in comparison to Germany and the USA during the 1970s, see Prais (1981). For an analysis of these factors in a cross-section analysis between the UK and the USA, see Davies and Caves (1987).

may be quite substantial in particular when it concerns typical process products which are made on the basis of mass production techniques. There may also be economies of scope which are related to research and development activities and other ancillary activities of a firm.[30]

Over the past two decades median plant size in manufacturing in all advanced countries has decreased. For example, in the United States median plant size was 356 employees in 1977 compared to 263 employees in 1987. In British manufacturing it was at 400 employees in 1979 compared to 240 employees in 1988 and in French manufacturing it fell from 200 employees in 1979 to 146 employees in 1988. For Germany, Prais (1981, p. 10) suggests a median plant size of 410 employees in 1970 whereas my corresponding estimate for 1987 is 318 employees.

New technologies which were introduced in the 1970s and 1980s, in particular in the area of computers, have radically changed products and production processes, which reduced unit costs to smaller firms. The trend towards concentrating firm activities in core product areas in which it has a comparative advantage has been another development which may account for the decrease in average firm size.

The Final Residual and Technology Levels

Table 6.10 shows the percentage contribution of the factors discussed above to the labour productivity gap compared to the USA. The final residual which remains, represents the part of the labour productivity gap which was not accounted for by these factors.

It appears that the part of the productivity gap which is explained is quite different among the countries. In Japan most of the productivity gap is accounted for by the smaller size of firms. Only 1.8 per cent of the productivity gap remains to be explained by other factors. In France a substantial part of the productivity gap is also explained by firm size difference. For the other three European countries the final residuals are substantially bigger. In Germany, the residual is even somewhat bigger than the original labour productivity gap. The relatively high capital intensity and the apparently low capital productivity in Dutch manufacturing creates a final residual which is as large as that of the United Kingdom.

30 See estimates from, for example, Bain (1966), Scherer et. al (1975) and Pratten (1971). For recent studies focussing on the EC, see for example Owen (1983) and Pratten (1988).

Table 6.10
Effects of Capital Intensity, Labour Quality, Structure and Size on Comparative Levels of Value Added per Hour Worked in Manufacturing (USA=100), 1987

	Value Added per Hour Worked (USA=100)	Percentage Point Contribution to Productivity Gap				
		Capital Intensity	Labour Quality	Structure	Size	Final Residal
France	73.3	-2.0	2.7	(0.7)	(13.4)	11.9
Germany	78.7	0.3	0.8	-3.2	-5.4	28.8
Japan	75.5	4.8	1.8	3.3	12.8	1.8
Netherlands	83.9	-13.2	0.0	(-5.9)	(-1.7)	36.9
United Kingdom	58.0	4.9	2.4	0.1	-1.4	36.0

Note: Figures between brackets are proxies, which are derived as follows: structure effect for France and the Netherlands by linking the adjustment in the binary comparison with the UK to the adjustment for the UK/USA comparison (table 6.7); size effect for France is proxied by using the same percentage explanation in the labour productivity gap as for Japan (table 6.9); size effect for the Netherlands using the same percentage explanation in the labour productivity gap as for the UK (table 6.9). The residual is derived by adding the percentage point contribution for all effects to the ratio of value added per hour worked.
Sources: Value added per hour worker from table 4.1 (for Germany, Japan and the UK) and table 4.9 (for France and the Netherlands). Effects of capital intensity and labour quality from table 6.6, for structure from table 6.7 and for size from table 6.9.

In the calculations I did not account for the existence of interaction effects between the various factors. These may be important in relation to the effects of capital intensity and size in Japan, and for capital intensity and structure in the Netherlands. This implies that the final residual may be somewhat understated for Japan, and overstated for the Netherlands

The final residual in table 6.10 can be further decomposed by estimating the effect of other proximate causes, such as differences in openness of the economy and the effects of energy conservation practices. The final residual which remains after all these adjustments is often referred to as 'changes in technology' or 'advances in knowledge' (e.g. Denison, 1967).

However, it remains to be tested whether the final residual estimated here can be seen as a good proxy of intercountry differences in disembodied technology. Direct measures on disembodied technology are not available, but data on expenditure on research and development at least give an indication of how much input goes into the creation of new technology.

Table 6.11 shows comparative figures of expenditures on research and development in the business sector per employee-hour worked in manufacturing. There clearly is a substantial gap between R&D expenditure per working hour in the United States and the other countries. However, there is no clear relation between these estimates and the size of the final residuals in table 6.10. Surprisingly, there appears to be a very close relationship between the measure of R&D per hour worked and the relative capital intensity in manufacturing (see table 6.2).[31] This would suggest that capital intensity, even without an embodiment adjustment, is a better proxy of relative technology levels than the final residual.

Table 6.11
Expenditure on Research and Development per Employee-Hour and Joint Factor Productivity in Manufacturing, 1975 and 1985

	1975		1985	
	1975 US$	USA= 100.0	1985 US$	USA= 100.0
France	0.58	43.7	1.18	55.2
Germany	0.59	45.1	1.14	53.3
Japan	0.50	38.1	1.11	51.9
Netherlands	0.87	66.2	1.42	66.4
United Kingdom	0.53	40.6	1.03	47.8
United States	1.32	100.0	2.14	100.0

Note: Research and development expenditures includes all expenditures in the business enterprise sector, including contributions by the government. Manufacturing accounts for more than 95 per cent of business expenditure on R&D.
Source: Expenditures on R&D from OECD (1989), *OECD Science and Technology Indicators Report*, No. 3, Paris. Employee hours for benchmarks from appendix III extrapolated with time series from appendix IV.

The estimates in table 6.11 need to treated with caution, as it is questionable whether the R&D measure is the appropriate indicator of relative technology levels. In fact R&D is an input measure and gives no

31 Compare table 6.2 and table 6.9. Pooling the 1975 and 1985 observations together, a regression of R&D expenditure per hour worked on capital per hour worked shows a t-statistic on the regression coefficient of 6.5 (with 8 degrees of freedom) and a correlation coefficient of 0.84.

indication of the return on R&D in terms of generating new and applicable technology and the productivity gains which are derived from it.[32]

Research and development expenditures are also primarily related to the invention and innovation. Diffusion of existing technology to the follower countries in fact saves funds for research and development in the follower countries. When these countries approach the productivity level of the leader they will have to spend more on innovative activities themselves as the potential for further borrowing of technology from the leader disappears.

Even as a measure of input, R&D statistics increasingly understate the efforts to develop new technology. Much of the technological innovation is not developed in laboratories anymore but in design offices and production engineering departments. Moreover an increasing part of technological development is 'outsourced' to the services sector. For example new software is often purchased from software houses instead of developed in-house.

In the past decades the literature on technology has increasingly moved away from the neo-classical framework, where knowledge is assumed to be completely exogeneous and equally accessible to all firms as a public good. Recent models of technological change focus on the searching process of the firm for new techniques in an environment which is characterised by incomplete information (Nelson and Winter, 1977, 1982; Freeman, 1982).[33]

These models also point more clearly in the direction of ultimate causes, such as institutional and organisational factors, which determine

32 On the basis of an alternative measure which is more like an output measure, i.e. the number of patented inventions, Englander, Evenson and Hanazaki (1988) and Evenson (1991) observed a decline in the number of granted patents per scientist/engineer. This decline appears to have been much faster in Germany and France than in the Japan, the United Kingdom and the United States. The main problem with patenting as a measure of technology is that the number of patents applied for and granted strongly depends on a country's market structure and on the legal framework. Moreover the 'technological content' of patents strongly differs between countries, and there are indications that these differences increased over time (see for example Soete and Verspagen, 1991). For a critical review of the use of figures on research and development and patents for productivity analysis, see Griliches (1990).

33 For an extensive survey of the literature on technological change and economic growth, which deals with both the micro-economics of invention and the macro-economics of innovation, see Gomulka (1990). An interesting collec-tion of articles building upon the evolutionary theory of technical change is presented in Dosi et. al. (1988). See also Dosi (1988).

the pace of technological change. Denison listed the following factors as important in explaining the residual in level comparisons:

> 'the lag in the application of knowledge, especially managerial knowledge; the quality of management; less intense competitive pressures; how hard people work; institutional restraints not only against the dismissal of employees and reassignment of their duties but also against a variety of business practices that could raise productivity; and the adequacy of industrial organization, including the efficiency with which financial institutions allocate savings'.
> Denison (1967, p. 292).

These factors bear much resemblance to what Abramovitz referred to as the social capability of a society to adopt and adapt new technology. The search for such 'ultimate causes' is one of the major challenges in the study of comparative productivity levels. Examples of such attempts are the contribution by North and Thomas (1973) on the emergence of new institutions which facilitated the development of the market economy in the Western world, the study by Olson (1982) on the existence of distributional coalitions retarding the process of economic growth and the work by Chandler (1977, 1990) on the role of large businesses and management practices.

Conclusion

The aim of this chapter was to search for factors which could explain the catch-up on the US productivity level in manufacturing during the postwar period for advanced countries, and the reasons for the breakdown in this catch-up process in the past decade.

It was found that the parallel rise in relative capital intensity and joint factor productivity were the underlying forces of the narrowing of the labour productivity gap up to the late 1970s. Since then the positive relation between capital intensity and joint factor productivity disappeared.

The level accounting approach shows that the impact of some of the traditional factors which played an important role in the catch-up and convergence of labour productivity between advanced countries up to the end of the 1970s, have by now become exhausted. Relative levels of capital intensity in manufacturing are only significantly lower compared to the United States in the United Kingdom and Japan, and for the Netherlands an adjustment for capital intensity increases rather than lowers the productivity gap. Vocational qualifications show a different distribution between the countries, but the overall effect on comparative productivity is small. The limited effect of structural differences suggests that not much specialisation has taken place among the countries, except for the Netherlands. Finally, size differences accounted for a significant part of the productivity gaps only in France and Japan.

The level accounting method needs to be further developed before it can be regarded as an accurate tool in explaining intercountry productivity differences. This does not only require that more proximate causes are taken into account. It will also be necessary to assess possible interaction effects between the various factors, such as between capital and size distribution and between capital and industrial structure. Moreover, the theoretical framework which underlies the level accounting approach, which is mainly neo-classical and assumes constant returns to scale, needs to be tested in more detail on its validity.

It appeared that the present final residual shows little relation to the comparative technology levels measured by the intensity of research and development per working hour, but that the latter was more strongly related to capital intensity. If capital intensity would be treated as a proxy to embodied technological change this would imply that there is only substantial scope for further technological catch-up left in Japan and the United Kingdom. However, it was also mentioned that the recent literature on technology suggests that the role of embodied technology has lost ground to disembodied technology, which relates to the increased importance of work practice and shopfloor organisation.

There are also indications which point in the direction of an increased role for ultimate causes to explain the productivity gaps in manufacturing which still exist between advanced countries.[34] For example, whereas the focus in this chapter was primarily on 'common' factors which affect all industries and branches alike, the previous chapter showed that the variation in catch-up and convergence between branches indicate that branch specific factors play an important role as well. These factors are, for example, related to the organisation of the industry, to the degree of international competitiveness in that industry, and to government regulations on quality, safety and environmental standards.

There is also a literature pointing at institutional and socio-political factors which may, for example, explain the 'Eurosclerosis' of the past two decades.[35] Such factors include the effect of differences in macroeconomic and structural policies in Europe, the impact of rent-seeking on the European slowdown, and the role of institutions which may have

34 It needs to be stressed that ultimate causes may also have been important in the earlier phase of catch-up and convergence, but during that phase they largely supported the proximate causes in the analysis, whereas the proximate causes now seem to play a less important role.

35 See Crafts (1992) for a review of the topic and the related literature.

retarded recovery from the oil shocks of the 1970s. It goes beyond the scope of this study to deal with these factors in further detail. Given their complexity and inherent resistance to quantification, it is difficult to establish their impact which was the initial purpose of the level accounting approach. There is also a risk of overemphasising these factors once one turns into a descriptive mode.

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Appendix I
Classification Scheme of Major Branches, Branches and Industries in Manufacturing

Major Branches	Branches		Industries	
1. Food Products, Beverages and Tobacco Products	1.1	Food Products	1.1a	Meat Products
			1.1b	Dairy Products
			1.1c	...
	1.2	Beverages	1.2a	Malt Beverages
			1.2b	...
	1.3	Tobacco Products	1.3a	Tobacco Products
2. Textiles, Wearing Apparel and Leather Products	2.1	Textile Products	2.1a	Broadwoven Cotton Fabrics
			2.1b	Knitting Mills
			2.1c	...
	2.2	Wearing Apparel	2.2a	Men's and Boys Suits, Coats and Overcoats
			2.2b	Women's, Misses and Juniors' Blouses and Shirts
			2.2c	...
	2.3	Leather and Leather Products	2.3a	Leather Tanning and Finishing
			2.3b	Footwear, except Rubber
			2.3c	...
3. Chemicals, Petroleum Refining, Rubber and Plastic Products	3.1	Chemicals and Allied Products	3.1a	Industrial Organic Chemicals
			3.1b	Soap and Detergents
			3.1c	...
	3.2	Petroleum Refining and Related Products	3.2a	Petroleum Refining
			3.2b	Asphalt Paving
			3.2c	...
	3.3	Rubber and Miscellaneos Plastic Products	3.3a	Tires and Inner Tubes
			3.3b	Miscellaneous Plastic Products
			3.3c	...

Appendix I, continued

Major Branches		Branches		Industries	
4.	Basic Metals and Metal Products	4.1	Basic Metals and Metal Products	4.1a	Iron and Steel Works
				4.1b	Fabricated Structural Metal Products
				4.1c	...
5.	Machinery, Electrical Machinery and Transport Equipment	5.1	Machinery and Transport Equipment	5.1a	Farm and Garden Machinery and Equipment
				5.1b	Computer and Office Equipment
				5.1c	Motor Vehicles and Equipment
				5.1d	...
		5.2	Electrical Machinery	5.2a	Electrical Industrial Apparatus
				5.2b	Household and Audio Equipment
				5.2c	...
6.	Other Industries	6.1	Wood Products and Furniture	6.1a	Sawmills and Planing Mills
				6.1b	Household Furniture
				6.1c	...
		6.2	Paper, Printing and Publishing	6.2a	Paper Mills
				6.2b	Newspapers and Periodicals Publishing
				6.2c	Commercial Printing
				6.2d	...
		6.3	Stone, Clay and Glass Products	6.3a	Cement
				6.3b	Structural clay Products
				6.3c	...
		6.4	Other Manufacturing	6.4a	Instrumental Engineering
				6.4b	Toys and Sporting Gear
				6.4c	...

`...' are other industries, not mentioned, in the branch.
Note: Based on International Standard Industrial Classification (ISIC) 1968, but industries and branches were amalgamated where necessary in order to obtain a classification which guaranteed an optimal representativity of unit value ratios within the industries and branches.

Appendix II - Unit Value Ratios, Percentage of Matched Sales and Number of Matched Items

Appendix Table II.1
Unit Value Ratios, Percentage of Matched Sales and Number of Matched Items, Brazil and the United States, 1975

	Unit Value Ratio (Cr./US$)			% of Matched Sales		Number of UVRs
	USA Quantity weights	Brazil Quantity weights	Geometric Average	Brazil	USA a)	
	(1)	(2)	(3)	(4)	(5)	(6)
Food Products	6.69	4.48	5.47	35.94	18.66	26
Beverage Products	6.23	5.71	5.96	30.55	28.72	2
Tobacco Products	4.93	4.38	4.65	90.15	89.76	3
Textiles	10.85	7.29	8.89	50.94	43.90	11
Wearing Apparel	8.21	8.21	8.21	10.08	8.38	1
Wood Products	13.14	11.53	12.31	27.30	18.57	3
Paper Products, Printing and Publishing	10.51	8.77	9.60	19.96	12.83	7
Chemical Products	12.05	10.26	11.12	24.62	41.29	20
Footwear and Leather Products	)	)	)	)		)
Rubber and Plastic Products	9.79)	6.64)	8.06)	41.40)	20.20	17)
Non-Metallic Minerals	7.69	5.17	6.31	29.61	8.59	4
Basic Metals and Metal Products	8.14	6.88	7.48	30.66	15.88	12
Electric Engineering	9.88	9.73	9.80	14.88	4.66	10
Machinery and Transport Equipment	6.65	6.54	6.59	19.04	28.52	13
Other Manufacturing	8.77	6.91	7.79	0.00	0.00	0
Total Manufacturing	8.77	6.91	7.79	27.87	22.94	129

(a) USA refers to 1977

Note: Based on 27 sample industries and 129 product matches; see Maddison and van Ark (1988, updated).

Source: IBGE, *Censo Industrial: Brasil, Produçao Fisica*, Rio de Janeiro, 1981. US Dept. of Commerce, *1977 Census of Manufactures*, Washington D.C., 1981.

Appendix Table II.2
Unit Value Ratios, Percentage of Matched Sales and Number of Matched Items, Germany and the United States, 1987

	Unit Value Ratio (DM/US$)			% of Matched Sales		Number of UVRs
	USA Quantity weights (1)	German Quantity weights (2)	Geometric Average (3)	Germany (4)	USA (5)	(6)
Food Products	1.98	1.92	1.95	44.04	35.92	43
Beverage Products	2.59	2.38	2.49	58.85	38.41	11
Tobacco Products	1.20	1.23	1.21	69.29	82.23	1
Textiles	2.70	2.52	2.61	39.64	59.68	21
Wearing Apparel	2.93	2.90	2.91	56.93	39.71	27
Footwear and Leather Products	2.85	2.76	2.81	64.38	53.14	11
Wood Products	2.81	2.57	2.69	30.76	16.11	13
Paper Products, Printing and Publishing	2.28	2.23	2.26	18.63	23.67	13
Chemical Products	2.66	2.47	2.57	11.80	12.87	17
Petroleum Refining	1.96	1.98	1.97	25.02	76.04	5
Rubber and Plastic Products	2.33	2.32	2.32	7.68	8.78	4
Non-Metallic Minerals	2.09	1.88	1.98	18.94	23.03	13
Basic Metals and Metal Products	2.25	2.16	2.20	46.49	23.89	31
Electric Engineering	2.50	2.49	2.49	13.83	11.56	40
Machinery and Transport Equipment	1.87	1.92	1.90	29.61	20.97	21
Other Manufacturing	2.25	2.16	2.21	0.00	0.00	0
Total Manufacturing	2.25	2.16	2.21	24.36	24.82	271

Note: Based on 36 sample industries and 271 product matches; see Pilat and van Ark (1992).
Source: Statistisches Bundesamt, *Produktion im Produzierenden Gewerbe 1987*, Wiesbaden, 1988; US Dept. of Commerce, *1987 Census of Manufactures*, Washington D.C., 1990.

Appendix Table II.3
Unit Value Ratios, Percentage of Matched Sales and Number of Matched Items, India and the United States, 1975

	Unit Value Ratio (Rs./US$)			% of Matched Sales		Number of UVRs
	USA Quantity weights (1)	India Quantity weights (2)	Geometric Average (3)	India a) (4)	USA b) (5)	(6)
Food Products	8.03	4.38	5.93	44.05	13.46	19
Beverage Products	10.69	10.47	10.58	15.40	28.72	2
Tobacco Products	3.36	3.12	3.23	91.79	91.36	3
Textiles	)	)	)	)	)	)
Wearing Apparel	7.58)	5.23)	6.30)	70.01)	13.55)	9)
Wood Products	9.60	7.97	8.75	53.89	18.57	3
Paper Products, Printing and Publishing	9.69	9.75	9.72	25.98	12.93	7
Chemical Products	14.39	8.76	11.23	15.37	6.74	17
Footwear and Leather Products	)	)	)	)	)	)
Rubber and Plastic Products	10.01)	9.36)	9.68)	42.10)	13.19)	12)
Non-Metallic Minerals	6.21	6.39	6.30	48.22	7.91	5
Basic Metals and Metal Products	6.99	6.20	6.58	45.90	16.66	17
Electric Engineering	12.36	7.32	9.51	4.52	1.08	6
Machinery and Transport Equipment	22.90	11.32	16.10	22.20	10.01	8
Other Manufacturing	12.77	6.70	9.25	0.00	0.00	0
Total Manufacturing	12.77	6.70	9.25	19.44	9.59	108

(a) USA refers to 1977
(b) India refers to 1973/74.
Note: Based on 24 sample industries and 108 product matches; see van Ark (1991).
Source: CSO, *Annual Survey of Industries 1973-74, Census Sector,* New Delhi, 1982; US Dept. of Commerce, *1977 Census of Manufactures*, Washington D.C., 1981.

Appendix Table II.4
Unit Value Ratios, Percentage of Matched Sales and Number of Matched Items, Japan and the United States, 1987

	Unit Value Ratio (Yen/US$)			% of Matched Sales		Number of UVRs
	USA Quantity weights	Japan Quantity weights	Geometric Average	Japan	USA	
	(1)	(2)	(3)	(4)	(5)	(6)
Food Products	360.6	414.4	386.6	13.81	11.21	16
Beverage Products	465.9	396.0	429.5	44.40	30.21	3
Tobacco Products	379.6	411.1	395.0	86.00	80.68	1
Textiles	178.6	184.8	181.7	25.85	38.87	14
Wearing Apparel	185.8	172.9	179.2	21.20	30.38	9
Footwear and Leather Products	212.6	205.3	208.9	34.11	29.30	4
Wood Products	478.2	464.9	471.5	19.52	7.86	2
Paper Products, Printing and Publishing	186.4	189.9	188.1	13.05	15.04	10
Chemical Products	241.3	218.3	229.6	15.49	14.20	31
Petroleum Refining	354.2	276.9	313.2	67.00	76.64	6
Rubber and Plastic Products	125.2	117.6	121.3	7.37	11.44	6
Non-Metallic Minerals	194.2	184.5	189.3	32.97	27.75	9
Basic Metals and Metal Products	193.7	164.4	178.4	24.91	22.94	34
Electric Engineering	153.4	134.1	143.4	11.43	11.17	19
Machinery and Transport Equipment	154.4	94.3	120.7	20.48	17.80	29
Other Manufacturing	218.8	150.6	181.5	0.00	0.00	0
Total Manufacturing	218.8	150.6	181.5	19.98	19.90	193

Note: Based on 38 sample industries and 193 product matches; constructed by Pilat, see Pilat and van Ark (1992).
Source: Ministry of Industry and Trade, *Census of Manufactures 1987, Report by Commodities*, Tokyo, 1989; US Dept. of Commerce, *1987 Census of Manufactures*, Washington D.C., 1990.

Appendix Table II.5
Unit Value Ratios, Percentage of Matched Sales and Number of Matched Items, Korea and the United States, 1987

	Unit Value Ratio (Won/US$)			% of Matched Sales		Number of UVRs
	US Quantity weights	Korean Quantity weights	Geometric Average	Korea	USA	
	(1)	(2)	(3)	(4)	(5)	(6)
Food Products	1,138.0	838.0	976.5	46.7	33.0	29
Beverage Products	601.6	508.2	553.1	21.1	30.3	4
Tobacco Products	757.5	748.4	752.9	98.8	77.4	2
Textiles	770.9	723.8	747.0	39.9	26.3	8
Wearing Apparel	875.1	1,013.9	941.9	29.4	13.5	6
Footwear and Leather Products	587.4	521.6	553.5	55.9	53.4	7
Wood Products and Furniture	1,335.0	1,208.7	1,270.3	39.3	13.9	4
Paper Products, Printing and Publishing	764.1	544.8	645.2	25.0	11.8	6
Chemical Products and Petroleum Refining	1,366.9	965.5	1,148.8	41.4	35.4	46
Rubber and Plastic Products	754.3	830.0	791.2	41.3	10.5	4
Non-Metallic Minerals	460.3	455.4	457.8	47.4	23.3	6
Basic Metals and Metal Products	801.7	600.7	694.0	59.1	24.1	39
Electric Engineering	531.4	454.5	523.9	19.5	5.1	17
Machinery and Transport Equipment	739.5	371.2	491.4	22.4	17.7	14
Other Manufacturing	954.7	644.9	784.7	0.0	0.0	0
Total Manufacturing	848.7	576.8	699.6	36.7	21.0	192

Note: Based on 39 sample industries and 192 product matches; see Pilat (1991b).
Source: Pilat (1991b). Original sources: Economic Planning Board, *Report on Mining and Manufacturing Survey 1987*, Seoul, 1987; US Dept. of Commerce, *1987 Census of Manufactures*, Washington D.C., 1990.

Appendix Table II.6
Unit Value Ratios, Percentage of Matched Sales and Number of Matched Items, Mexico and the United States, 1975

	Unit Value Ratio (Pesos/US$)			% of Matched Sales		Number of UVRs
	USA Quantity weights	Mexico Quantity weights	Geometric Average	Mexico	USA a)	
	(1)	(2)	(3)	(4)	(5)	(6)
Food Products	12.76	7.00	9.45	25.19	18.30	26
Beverage Products	13.34	13.32	13.33	37.33	28.72	2
Tobacco Products	9.35	7.64	8.45	58.53	89.76	3
Textiles	15.54	15.30	15.42	24.54	43.18	6
Wearing Apparel	15.76	15.74	15.75	11.60	8.38	2
Wood Products	22.04	23.42	22.72	27.88	20.34	5
Paper Products, Printing and Publishing	22.99	16.95	19.74	27.57	14.61	10
Chemical Products	13.09	11.82	12.44	57.41	41.82	25
Footwear and Leather Products	)	)	)	)	)	)
Rubber and Plastic Products	23.28)	15.53)	19.01)	27.06)	19.23)	15)
Non-Metallic Minerals	11.29	12.24	11.75	20.01	7.98	3
Basic Metals and Metal Products	12.57	11.25	11.89	33.64	14.72	13
Machinery and Transport Equipment	15.19	13.35	14.24	40.67	27.53	9
Electric Engineering	16.11	21.01	18.40	15.81	4.83	11
Other Manufacturing	15.60	11.97	13.67	0.00	0.00	0
Total Manufacturing	15.60	11.97	13.67	31.76	22.75	130

(a) USA refers to 1977

Note: Based on 27 sample industries and 130 product matches; see Maddison and van Ark (1988, updated).

Source: SPP, *X Censo Industrial 1976, Datos de 1975, Desglose de Productos,* Mexico, 1979; US Dept. of Commerce, *1977 Census of Manufactures*, Washington D.C., 1981.

Appendix Table II.7
Unit Value Ratios, Percentage of Matched Sales and Number of Matched Items, United Kingdom and the United States, 1987

	Unit Value Ratio (pnd/$)			% of Matched Sales		Number of UVRs
	UK quantity weights pnd/US$	US quantity weights pnd/US$	Geometric Average pnd/US$	United Kingdom	United States	
Food Products	0.742	0.855	0.796	19.86	15.56	26
Beverages	0.590	0.586	0.588	25.46	28.55	2
Tobacco Products	0.475	0.477	0.476	101.76	86.58	3
Textiles	0.664	0.708	0.685	38.15	64.12	20
Wearing Apparel	0.721	0.667	0.693	43.63	36.98	27
Footwear and Leather Products	0.583	0.568	0.576	38.86	50.22	7
Wood Products and Furniture	0.788	1.076	0.921	18.41	8.89	8
Pulp, Paper and Printing	0.981	1.119	1.047	9.87	10.90	7
Chemicals	0.597	0.673	0.634	12.37	12.80	22
Petroleum Refining	0.643	0.648	0.645	47.52	72.66	5
Rubber and Plastic Products	0.546	0.553	0.550	7.75	7.85	9
Non-Metallic Minerals	0.652	0.648	0.650	15.95	8.14	7
Basic Metals and Metal Products	0.661	0.677	0.669	21.35	12.36	8
Machinery and Transport Equipment	0.609	0.614	0.611	10.58	16.43	11
Electric Engineering	0.737	0.744	0.740	5.66	4.65	9
Other Manufacturing	0.670	0.748	0.708	0.00	0.00	0
Total Manufacturing	0.670	0.748	0.708	17.61	18.05	171

Note: Based on 40 sample industries and 171 product matches; see van Ark (1992).
Source: BSO, *Business Monitors, Quarterly Statistics 3rd Quarter*, London; US Dept. of Commerce, *1987 Census of Manufactures*, Washington D.C., 1990.

Appendix Table II.8
Unit Value Ratios, Percentage of Matched Sales and Number of Matched Items, France and the United Kingdom, 1984

	Unit Value Ratio (FF/pnd)			% of Matched Sales		Number of UVRs
	French Quantity Weights	UK Quantity Weights	Geometric Average	France	United Kingdom	
	(1)	(2)	(3)	(5)	(6)	(7)
Food Products and Beverages	10.70	11.29	10.99	0.0	0.0	0
Textiles	11.48	11.48	11.48	4.6	6.8	3
Wearing Apparel	16.16	16.84	16.50	18.7	16.6	6
Leather Products	11.36	11.36	11.36	46.7	50.2	23
Wood Products	10.87	10.57	10.72	10.1	6.1	3
Paper Products	7.75	7.75	7.75	40.4	24.4	6
Printing and Publishing	10.70	11.29	10.99	0.0	0.0	0
Chemicals	10.48	10.77	10.62	15.4	13.2	17
Rubber and Plastic Products	10.32	11.85	11.06	17.5	16.9	9
Stone, Clay and Glass Products	12.54	12.98	12.76	13.7	10.0	3
Basic Metals and Metal Products	10.82	10.68	10.75	24.7	20.8	8
Electric Engineering	12.22	12.42	12.32	2.9	3.0	8
Machinery and Transport Equipment	9.88	10.79	10.33	24.3	13.6	16
Instruments and Other Industries	10.70	11.29	10.99	0.0	0.0	0
Total Manufacturing, excl. petroleum refining and tobacco	10.70	11.29	10.99	13.1	9.4	102

Note: Based on 16 sample industries and 102 product matches; see van Ark (1990b)
Source: SESSI, *Enquêtes de Branche 1984*, Paris; BSO, *Business Monitors, Quarterly Statistics 3rd Quarter*, London.

Appendix Table II.9
Unit Value Ratios, Percentage of Matched Sales and Number of Matched Items, Germany and the United Kingdom, 1987

	Unit Value Ratio (DM/pnd)			% of Matched Sales		Number of UVRs
	German Quantity Weights	UK Quantity Weights	Geometric Average	Germany	United Kingdom	
	(1)	(2)	(3)	(5)	(6)	(7)
Food Products, Beverages and Tobacco	3.06	3.12	3.09	33.6	33.5	56
Textiles	4.09	4.45	4.29	41.2	45.1	34
Wearing Apparel and Leather Products	4.06	4.28	4.17	50.0	34.4	40
Wood Products	2.29	3.06	2.65	16.4	13.1	13
Paper Products	2.12	2.15	2.13	42.0	30.0	7
Chemicals	3.36	3.42	3.38	17.6	16.5	37
Stone, Clay and Glass Products	3.18	3.13	3.16	30.6	26.1	10
Basic Metals	2.94	3.06	2.99	34.6	24.5	6
Metal Products	3.57	3.84	3.69	13.8	6.6	5
Machinery	3.22	3.30	3.27	0	0	0
Electric Engineering	4.52	4.58	4.55	4.8	3.0	13
Transport Equipment	3.77	3.89	3.82	48.3	29.7	2
Instruments and Other Industries, incl. Rubber and Plastic Products	3.29	3.31	3.30	13.1	13.2	14
Total Manufacturing, excl. petroleum refining and printing and publishing	3.44	3.56	3.50	21.4	21.9	237

Note: Based on 45 sample industries and 237 product matches. The UVR for machinery, electrical engineering (except consumer goods) and transport equipment was derived from the ratio of 1985-proxy PPPs at European weights for these types of products and that for total manufacturing (Eurostat 1988) which was applied to the UVR for total manufacturing; see O'Mahony (1992a)
Source: O'Mahony (1992a). Original sources: Statistisches Bundesamt, *Produktion im Produzierenden Gewerbe 1987*, Wiesbaden, 1988; BSO, *Business Monitors, Quarterly Statistics 3rd Quarter*, London.

Appendix Table II.10
Unit Value Ratios, Percentage of Matched Sales and Number of Matched Items, Netherlands and the United Kingdom, 1984

	Unit Value Ratio (Dfl/pnd)			% of Matched Sales		Number of UVRs
	Dutch quantity weights	UK quantity weights	geo-metric average	Nether-lands	United Kingdom	
	(1)	(2)	(3)	(4)	(5)	(6)
Food Products and Beverages	3.72	3.94	3.83	29.0	40.0	36
Tobacco	2.50	2.93	2.70	95.1	100.0	3
Textiles	3.81	4.19	3.99	35.0	26.9	8
Wearing Apparel	4.78	5.14	4.96	40.5	29.4	12
Leather and Footwear	5.42	5.67	5.54	47.4	33.7	7
Wood Products	3.79	4.23	4.01	0.0	0.0	0
Paper Products	2.36	2.34	2.35	49.4	32.1	6
Printing and Publishing	3.79	4.23	4.01	0.0	0.0	0
Chemicals	3.74	3.90	3.82	19.6	18.9	20
Rubber and Plastic Products	3.79	4.23	4.01	0.0	0.0	0
Stone, Clay and Glass Products	2.45	2.39	2.42	13.3	7.1	3
Basic Metals and Metal Products	4.40	4.46	4.43	8.8	7.8	5
Electric Engineering	3.79	4.23	4.01	0.0	0.0	0
Machinery and Transport Equipment	4.85	4.96	4.90	1.6	0.8	6
Instruments and Other Manufacturing	3.79	4.23	4.01	0.0	0.0	0
Total Manufacturing	3.79	4.23	4.01	17.5	14.5	106

Note: Based on 22 sample industries and 106 product matches; see van Ark (1990a)
Source: CBS, *Produktiestatistieken 1986*, Den Haag, 1987; BSO, *Business Monitors, Quarterly Statistics 3rd Quarter*, London.

Appendix III - Output, Labour Input and Productivity in Benchmark Years

Appendix Table III.1
Characteristics of Census Data, Brazil, 1975

Country	BRAZIL (1975)
Title:	*Censo Industrial, Serie Nacional*
Agency:	Fundacao Instituto Brasiliero de Geografia e Estatistica, Rio de Janeiro.
Year of Publication:	1981
Number of manufacturing industries with separate output and employment information:	367 `grupos de produtes'
Reporting unit:	legal unit
Statistical unit:	local unit (`estabelecimentos')
Employment size coverage:	all registered units, i.e. excluding `autonomos'
Sample size:	Complete, but firms with less than 5 employees and/or a gross value of output less than 640 times the highest minimum wage (Cr. 532.80) use a simplified census form.
Classification:	Classificacao das Industrias 1970, which excludes certain agriculture-based transformation processes.
Adjustments for present study:	None.
Output concept used:	Census value added (`valor de transformacao'). See Maddison and van Ark (1988) for adjustments from census value added to gross value added.
Employment concept used:	Employees on the payroll in production units. Includes working proprietors and family workers. Excludes head office employees and outworkers.
Relation to national accounts:	Basic source for national accounts estimates. See IBGE (1988), *Novo Sistema de Contas Nacionais, Metodologia e Resultados Provisorios*, Rio de Janeiro, December.

Appendix Table III.2
Characteristics of Census Data, France, 1984

Country	FRANCE (1984)
Title:	*Enquête Annuelle d'Entreprise 1984* and *Enquête Annuelle d'Entreprise 1984, industries agricoles et alimentaires*.
Agency:	Service d'Étude et des Statistiques Industrielles (SESSI); for food processing industry: Service Central des Enquêtes et Études Statistique (SCEES), Ministère de l'Agriculture, Paris.
Year of Publication	1985
Number of manufacturing industries with separate output and employment information:	276
Reporting unit:	`entreprise' = legal unit
Statistical unit:	`entreprise' = legal unit, although a limited amount of information was also available for local units and activity units.
Employment size coverage:	Legal units with 10 or more persons employed
Sample size:	Complete coverage, but legal units 10-19 employees and 20-99 employees receive minimum and simplified questionnaire respectively.
Classification:	Nomenclature d'activités et de produits 1973
Adjustments for present study:	Figures exclude oil refining, tobacco products and some mining activities lumped in with basic metals and non-metallic minerals.
Output-concept used:	Gross value added at factor cost. Total number of employees for activity units (`fractions d'entreprise') with 10 or more persons employed from *Enquêtes de Branche* (SESSI; SCEES) with deduction of employees in legal units from 10 to 19 employees. Gross value added was obtained by multiplying this employment figure with the average value added per employee per legal unit with 20 or more employees.
Employment concept used:	Employees on payroll
Relation to national accounts:	Used as one of the basic sources for the construc-tion of the input-output tables for the French national accounts. See INSEE (1987), *Systeme Élargi de Comptabilité Nationale,*, Les Collection de l'INSEE, No. C 140-141

Appendix Table III.3
Characteristics of Census Data, Germany, 1987

Country	GERMANY (FR) (1987)
Title:	*Kostenstruktur der Unternehmen*, Reihe 4.3.1 to 4.3.3.
Agency:	Statistisches Bundesamt, Wiesbaden
Year of Publication:	1989
Number of manufacturing industries with separate output and employment information:	175
Reporting unit:	`Unternehmen' = legal unit
Statistical unit:	`Unternehmen' = legal unit
Employment size coverage:	Legal units with 20 or more persons employed
Sample size:	In 1987 about 40 per cent of legal units in mining and manufacturing, covering 79 per cent of the employment and 84 per cent of turnover, with almost complete coverage of legals unit with 100 or more persons employed.
Classification:	Systematik der Wirtschaftszweige 1979. Manufacturing excludes publishing.
Adjustments for present study:	Repair activities were taken out. For the comparison with the UK oil refining was also excluded.
Output-concept used:	Census value added (for the comparison with the USA) is calculated as `Nettoproduktionswert' minus net indirect taxes and other industrial services (`Kosten für Sonstige Industrielle/Handwerk-liche Dienstleistungen'). Gross value added at factor cost (for the comparison with the UK) is similar to `Bruttowertschöpfung' which is census value added minus and non-industrial services. See Pilat and van Ark (1991).
Employment concept used:	Employees on payroll, excluding outworkers. Working proprietors are included in comparison with UK but excluded in comparison with USA.
Relation to national accounts:	National accounts estimates for GDP at current prices in manufacturing make directly use of the figures from the *Kostenstrukturerhebung* for legal units with more than 20 persons employed. Based on worksheets provided by Statistisches Bundes-amt, Wiesbaaden.

Appendix Table III.4
Characteristics of Census Data, India, 1975

Country	INDIA (1975-76)
Title:	*Annual Survey of Industries 1975-76, Summary Results for the Factory Sector.*
Agency:	Central Statistical Organisation, New Delhi.
Year of Publication:	1977
Number of manufacturing industries with separate output and employment information:	162
Reporting unit:	legal unit (`ownership unit')
Statistical unit:	local unit (`factory').
Employment size coverage:	Units with 10 or more employees using power, and units with 20 or more employees not using power.
Sample size:	Complete coverage of units with 50 or more employees using power, and units with 100 or more employees not using power (census sector). The non-census sector is surveyd on the basis of an approximately 50%-sample.
Classification:	National Industrial Classification 1970.
Adjustments for present study:	None.
Output concept used:	Census value added was computed by deducting fuels consumed, materials consumed and part of `other inputs' from total output. The part of `other inputs' related to the share `work done by others' and `purchase value of goods sold, etc.' in `other inputs' obtained from the *Annual Survey of Industries 1973-74, Census Sector*. See van Ark (1991).
Employment concept used:	Employees on the payroll, including working proprietors and unpaid family workers. Head office employees connected with the manufacturing activity of the factory are also included.
Relation to national accounts:	After an adjustment for depreciation and bank service charges the net domestic product estimate for manufacturing in the national accounts is identical to the census figure. See CSO (1981), *National Accounts Statistics, Sources and Methods*, New Delhi.

Appendix Table III.5
Characteristics of Census Data, Japan, 1987

Country	JAPAN (1987)
Title:	*Census of Manufactures, Report by Industries*
Agency:	Ministry of International Trade and Industry, Tokyo.
Year of Publication:	1989
Number of manufacturing industries with separate output and employment information:	about 575
Reporting unit:	legal unit
Statistical unit:	local unit
Employment size coverage:	all units.
Sample size:	Complete for units with more 30 employees. Sample surveys for smaller units.
Classification:	Standard Industrial Classification Japan.
Adjustments for present study:	Electronic computing and processing machines were reallocated from electrical engineering to machinery. See Pilat and van Ark (1991).
Output concept used:	Census value added.
Employment concept used:	Employees on the payroll, but excluding working proprietors and family workers. Including head office employees.
Relation to national accounts:	Information mainly from census; for some industries additional information derived from input-output table. See Szirmai and Pilat (1990) and Pilat (1991a).

Appendix Table III.6
Characteristics of Census Data, Korea, 1987

Country	KOREA (1987)
Title:	*Report on Mining and Manufacturing Survey*
Agency:	Economic Planning Board, Seoul.
Year of Publication:	1989
Number of manufacturing industries with separate output and employment information:	about 515
Reporting unit:	legal unit
Statistical unit:	local unit
Employment size coverage:	all units with five or more employees.
Sample size:	Complete.
Classification:	Korean Standard Industrial Classification 1984.
Adjustments for present study:	Information for units with less than five employees was obtained from *Report on Mining and Manufacturing Census 1988*, for which the ratio of output and employment for small firms to large firms was applied to the 1987 information for large firms. See Pilat (1991b, updated).
Output concept used:	Census value added adjusted to factor cost with net indirect taxes from Bank of Korea adjusted for coverage. See Pilat (1991b, updated).
Employment concept used:	Employees on the payroll, working proprietors and unpaid family workers.
Relation to national accounts:	Gross value of output from census; additional information from trade sources and other ministries. See Szirmai and Pilat (1990) and Pilat (1991b, updated).

Appendix Table III.7
Characteristics of Census Data, Mexico, 1975

Country	MEXICO (1975)
Title:	*X Censo Industrial 1976, Resumen General*
Agency:	Secretaria de Programacion y Presupuesta, Mexico.
Year of Publication:	1979
Number of manufacturing industries with separate output and employment information:	239
Reporting unit:	legal unit (`empresa')
Statistical unit:	local unit (`establecimientos')
Employment size coverage:	all units, but excluding unregistered units.
Sample size:	Complete
Classification:	Catalogo Mexicano de Actividades Economicas.
Adjustments for present study:	Census excludes information on petroleum refining, which was taken from the Mexican national accounts, *Sistema de Cuentas Nacionales de Mexico.* See Maddison and van Ark (1988).
Output concept used:	Detailed adjustments had to be made to adjust the `Valor Aggregado Censal Bruto' to a census value added concept. Indirect taxes were taken out on the basis of national accounts information. See Maddison and van Ark (1988).
Employment concept used:	Employees on the payroll, excluding working proprietors and family workers. Excluding head office employees.
Relation to national accounts:	Used as a basic source for the construction of the input-output tables in the national accounts, but substantial upward adjustments are made. See SPP (1981), *Sistema de Cuentas Nacionales de Mexico*, Mexico.

Appendix Table III.8
Characteristics of Census Data, Netherlands, 1984

Country	NETHERLANDS (1984)
Title:	*Produktiestatistieken*
Agency:	Centraal Bureau voor de Statistiek, Voorburg.
Year of Publication:	1985-1986
Number of manufacturing industries with separate output and employment information:	160
Reporting unit:	legal unit (`onderneming')
Statistical unit:	activity unit (`bedrijfseenheid')
Employment size coverage:	Activity with 10 or more employees; since 1985 only 20 or more employees.
Sample size:	Complete survey
Classification:	Standaardbedrijfsindeling 1974
Adjustments for present study:	Information on activity units with less than 20 employees was taken out on the basis of unpubli-shed information from CBS. Petroleum refining is excluded.
Output-concept used:	Gross value added at factor cost.
Employment concept used:	Employees on payroll working at least 15 hours per week and with a compulsory health insurance. Including working proprietors; excluding outworkers.
Relation to national accounts:	Used as primary source in construction of annual input-output tables.

Appendix Table III.9
Characteristics of Census Data, United Kingdom, 1984 and 1987

Country	UNITED KINGDOM (1984 and 1987)
Title:	*Report on the Census of Production, Summary Volume*.
Agency:	Business Statistics Office, London.
Year of Publication:	1989
Number of manufacturing industries with separate output and employment information:	214
Reporting unit:	legal unit
Statistical unit:	1984: activity unit; 1987: `businesses' (=legal unit, unless information can be separated for activities within the legal unit).
Employment size coverage:	1984: all activity units; 1987: all businesses.
Sample size:	1984: full coverage of activity units with 50 or more employees; about 50% sample for units 20-49 employees. 1987: full coverage of businesses with 100 or more employees; about 50% sample for businesses 50-99 employees, and 25% sample for those with 20-49 employees. Estimates for units from 1-19 employees are based on informa-tion from the register of businesses.
Classification:	Standard Industrial Classification 1980
Adjustments for present study:	Information on activity units/businesses with less than 20 employees excluded using unpublished information from BSO. Steelworks for construction are reallocated from machinery to metal products; mining activities included in non-metallic minerals were excluded; petroleum refining is included in the comparison with the USA; tobacco products are excluded in the comparison with France; pu-blishing is excluded in comparison with German y.
Output concept used:	Gross value added at factor cost in comparisons with European countries; census value added (`net output') in comparison with United States.
Employment concept used:	All employees on the payroll, excluding outworkers and casual workers. Working proprietors are included in comparison with Germany, but excluded in comparison with USA.
Relation to national accounts:	Output shares used to allocate total GDP at industry level in base year. Used for 5-year input-output table (1979; 1984). See main text chapter 4.

Appendix Table III.10
Characteristics of Census Data, United States, Non-Census Year, 1975

Country	UNITED STATES (1975)-NON-CENSUS YEARS
Title:	*Annual Survey of Manufactures 1975-1976*
Agency:	US Dept. of Commerce, Bureau of the Census, Washington D.C..
Year of Publication:	1979
Number of manufacturing industries with separate output and employment information:	about 450
Reporting unit:	legal unit
Statistical unit:	local units and auxiliary units
Employment size coverage:	all units
Sample size:	About one-sixth of all local units, including almost all of the largest units.
Classification:	Standard Industrial Classification
Adjustments for present study:	None.
Output concept used:	Census value added
Employment concept used:	Employees on the payroll in production units but excluding auxiliary units. Excluding working pro-prietors.
Relation to national accounts:	Value of shipments used for gross output estimates at current prices. See main text chapter 4.

Appendix Table III.11
Characteristics of Census Data, United States, Census Year, 1987

Country	UNITED STATES (1987) - EVERY FIVE YEARS
Title:	*1987 Census of Manufactures, General Summary*.
Agency:	US Dept. of Commerce, Bureau of the Census, Washington D.C..
Year of Publication:	1991
Number of manufacturing industries with separate output and employment information:	about 450
Reporting unit:	legal unit
Statistical unit:	local units and auxiliary units
Employment size coverage:	all units
Sample size:	Complete coverage of local units with about 20 or more employees (differs by industry). Information for smaller units from Social Security Administra-tion and Internal Revenue Services in conjunction with average by industry for units with more than 20 employees.
Classification:	Standard Industrial Classification
Adjustments for present study:	None.
Output concept used:	Census value added
Employment concept used:	Employees on the payroll in production units and in auxiliary units. Employment in auxiliary units is excluded in the comparison with Korea. Excluding working proprietors.
Relation to national accounts:	Value of shipments used for gross output estimates at current prices. Output and input information also used to construct input-output tables. See main text chapter 4.

Appendix Table III.12
Value Added, Labour Input and Comparative Labour Productivity
Brazil and the United States, 1975

	Brazil			United States			Brazil/USA (%)	
	Census Value Added at Factor Cost (mln. Cr.)	Persons Employed (000s) (a)	Annual Hours Worked per Employee	Census Value Added at Factor Cost (mln. $)	Persons Employed (000s) (b)	Annual Hours Worked per Employee	Census Value Added per Person Employed	Census Value Added per Hour Worked
Food Products	37,658	502.2		39,985	1,321.4	1,876	45.3	
Beverages	5,494	52.1		8,110	203.8	1,876	44.4	
Tobacco Products	3,212	24.0		3,722	66.2	1,802	51.3	
Textiles	18,829	324.7		12,044	835.0	1,853	45.2	
Wearing Apparel	8,418	182.9		14,749	1,214.0	1,664	46.1	
Wood and Furniture	15,053	319.9		16,646	984.0	1,808	22.6	
Paper and Printing	19,033	204.5		42,585	1,659.0	1,804	37.8	
Chemicals and Oil Refining	45,575	158.2		55,476	983.1	1,908	45.9	
Leather, Rubber and Plastic	16,825	250.1		16,786	824.7	1,837	41.0	
Stone, Clay & Glass	19,161	311.4		14,849	588.8	1,891	38.7	
Basic Metals and Metal Products	38,781	429.5		64,570	2,505.8	1,875	46.8	
Machinery and Transport Equipment	51,192	595.6		96,381	3,571.2	1,890	48.3	
Electrical Machinery	17,655	170.4		34,845	1,523.6	1,852	46.2	
Other	10,005	146.3		21,738	893.2	1,830	36.1	
Total Manufacturing	306,891	3,671.7	2,017	442,486	17,173.8	1,848	41.6	38.1

Note: See Appendix I for full definition of the branches. `Census value added' is inclusive of purchases of non-industrial service inputs.

(a) Excludes 152,682 employees in administrative offices and auxiliaries, representing about 4 per cent of all employees in manufacturing.

(b) Excludes 1,228.4 thousand employees in administrative offices and auxiliaries, representing about 4 per cent of all employees in manufacturing.

Source: See appendix tables III.1 and III.10. For hours see table 4.6. See also Maddison and van Ark (1988, updated).

Appendix Table III.13
Value Added, Labour Input and Comparative Labour Productivity
Germany and the United States, 1987

	Germany (a)			United States (a)			Germany/USA (%)	
	Census Value Added at Factor Cost (mln. DM)	Persons Employed (000s)	Annual Hours Worked per Employee	Census Value Added at Factor Cost (mln. $)	Persons Employed (000s)	Annual Hours Worked per Employee	Census Value Added per Person Employed	Census Value Added per Hour Worked
Food Manufacturing	34,201	363.8	1,889	95,349	1,319.6	1,893	66.7	66.8
Beverages	12,020	87.3	1,585	21,961	165.9	1,866	41.8	49.2
Tobacco Products	3,393	16.8	1,585	14,252	63.1	1,853	73.6	86.0
Textiles	15,306	222.0	1,606	24,861	681.1	2,053	72.5	92.7
Wearing Apparel	9,367	171.7	1,557	29,808	1,029.3	1,794	64.7	74.6
Leather Products	3,230	54.6	1,621	4,155	128.0	1,843	65.0	73.9
Wood and Furniture	16,289	214.3	1,728	42,614	1,045.4	1,964	69.2	78.6
Paper and Printing (b)	28,198	293.4	1,666	82,678	1,311.9	1,847	67.6	75.0
Chemicals	82,676	592.6	1,627	116,030	980.1	1,922	46.0	54.3
Oil Refining	6,657	30.9	1,663	17,223	144.6	1,922	91.8	106.1
Rubber and Plastic	27,483	325.7	1,621	42,080	811.2	1,986	70.1	85.8
Stone, Clay and Glass	21,707	239.4	1,726	29,508	479.7	2,003	74.1	86.0
Basic Metals and Metal Products	78,851	973.8	1,587	113,481	2,048.6	1,956	66.4	81.8
Machinery and Transport Equipment	185,304	1,969.5	1,624	244,040	3,690.5	1,905	75.0	87.9
Electrical Machinery	88,401	1,019.4	1,550	93,385	1,636.4	1,877	61.0	73.8
Other	14,667	192.3	1,612	83,080	1,323.3	1,885	55.1	64.4
Total Manufacturing	627,749	6,767.6	1,630	1,054,503	16,858.7	1,909	67.2	78.7

Note: See Appendix I for full definition of the branches. `Census value added' is inclusive of purchases of non-industrial service inputs.
(a) Excluding establishments with less than 20 employees.
(b) Excludes publishing.
Source: See appendix tables III.3 and III.11. For hours see table 4.6, for Germany updated from 1986 to 1987 on the basis of trend from DIW (1991), *Produktionsvolumen und -potential, Produktionsfaktoren des Bergbaus und des Verarbeitendes Gewerbe*, Berlin. See also Pilat and van Ark (1992).

Appendix Table III.14
Value Added, Labour Input and Comparative Labour Productivity
India and the United States, 1975

	India			United States			India/USA (%)	
	Census Value Added at Factor Cost (mln. Rs.)	Persons Employed (000s)	Annual Hours Worked per Employee	Census Value Added at Factor Cost (mln. $)	Persons Employed (000s) (a)	Annual Hours Worked per Employee	Census Value Added per Person Employed	Census Value Added per Hour Worked
Food Manufacturing	7,968.9	1,062.0		39,985	1,321.4	1,876	4.18	
Beverages	448.1	25.8		8,110	203.8	1,876	4.13	
Tobacco Products	1,839.9	198.0		3,722	66.2	1,802	5.11	
Textiles and Wearing Apparel	13,914.0	1,579.2		26,793	2,049.0	1,741	10.70	
Wood and Furniture	511.2	76.1		16,646	984.0	1,808	4.54	
Paper and Printing	3,608.1	234.5		42,585	1,659.0	1,804	6.17	
Chemicals and Oil Refining	13,343.4	368.0		55,476	983.1	1,908	5.72	
Leather, Rubber and Plastic	2,196.3	139.5		16,786	824.7	1,837	7.99	
Stone, Clay and Glass	3,050.7	290.9		14,849	588.8	1,891	6.60	
Basic Metals and Metal Products	12,444.8	669.0		64,570	2,505.8	1,875	10.97	
Machinery and Transport Equipment	11,198.9	697.6		96,381	3,571.2	1,890	3.69	
Electrical Machinery	5,552.1	260.7		34,845	1,523.6	1,852	9.79	
Other	780.8	60.1		21,738	893.2	1,830	5.83	
Total Manufacturing	76,857.2	5,661.4	2,256	442,486	17,173.8	1,848	5.76	4.72

Note: See Appendix I for full definition of the branches. `Census value added' is inclusive of purchases of non-industrial service inputs.

(a) Excludes 1,228.4 thousand employees in administrative offices and auxiliaries, representing about 4 per cent of all employees in manufacturing.

Source: See appendix tables III.4 and III.10. For hours see table 4.6. See also van Ark (1991).

Appendix Table III.15
Value Added, Labour Input and Comparative Labour Productivity
Japan and the United States, 1987

	Japan			United States			Japan/USA (%)	
	Census Value Added at Factor Cost (bln. Yen)	Persons Employed (000s)	Annual Hours Worked per Employee	Census Value Added at Factor Cost (mln. $)	Persons Employed (000s)	Annual Hours Worked per Employee	Census Value Added per Person Employed	Census Value Added per Hour Worked
Food Manufacturing	8,181	1,093.5	2,126	99,018	1,384.9	1,893	27.1	24.1
Beverages	1,733	91.4	2,126	22,585	172.2	1,866	33.6	29.5
Tobacco Products	270	15.1	2,126	14,264	63.5	1,853	37.9	33.0
Textiles	3,366	599.4	2,183	25,660	698.9	2,053	84.2	79.2
Wearing Apparel	1,984	562.2	2,131	32,516	1,113.8	1,794	67.4	56.8
Leather Products	438	78.9	2,148	4,378	135.7	1,843	82.3	70.6
Wood and Furniture	3,135	500.8	2,270	48,975	1,235.1	1,964	33.5	29.0
Paper and Printing	8,328	813.8	2,226	140,651	2,232.9	1,847	86.4	71.6
Chemicals	10,163	392.2	2,021	120,778	1,028.4	1,922	95.8	91.1
Oil Refining	1,340	34.4	2,040	18,518	153.6	1,922	103.3	97.3
Rubber and Plastic	4,962	568.6	2,101	44,437	863.3	1,986	139.7	132.1
Stone, Clay and Glass	4,771	457.1	2,203	33,383	554.3	2,003	91.6	83.2
Basic Metals and Metal Products	13,729	1,315.4	2,185	121,078	2,228.9	1,956	107.7	96.4
Machinery and Transport Equipment (a)	23,169	2,144.4	2,208	255,264	3,966.1	1,905	139.1	120.0
Electrical Machinery (a)	14,518	1,694.2	2,125	95,815	1,689.4	1,877	105.3	93.0
Other	3,625	505.4	2,076	88,428	1,429.9	1,885	63.9	58.0
Total Manufacturing	103,711	10,866.8	2,161	1,165,747	18,950.9	1,909	85.4	75.5

Note: See Appendix I for full definition of the branches. `Census value added' is inclusive of purchases of non-industrial service inputs.

(a) Industry 3051 `Electronic Computing and Processing Machines' reallocated from electrical engineering to machinery.

Source: See appendix tables III.5 and III.11. For hours see table 4.6. Constructed by Pilat, see also Pilat and van Ark (1992).

Appendix Table III.16
Value Added, Labour Input and Comparative Labour Productivity
Korea and the United States, 1987

	Korea			United States			Korea/USA (%)	
	Census Value Added at Factor Cost (bln. Won)	Persons Employed (000s)	Annual Hours Worked per Employee	Census Value Added at Factor Cost (mln. $)	Persons Employed (000s) (a)	Annual Hours Worked per Employee	Census Value Added per Person Employed	Census Value Added per Hour Worked
Food Manufacturing	2,239.2	236.5	2,743	102,873	1,384.2	1,893	13.0	9.0
Beverages	207.6	30.3	2,674	22,703	172.9	1,866	9.4	6.6
Tobacco Products	287.5	10.2	2,796	14,264	63.5	1,853	16.7	11.0
Textiles	4,377.4	466.9	2,830	25,610	698.9	2,053	34.3	24.8
Wearing Apparel	1,695.7	305.3	2,799	32,597	1,113.8	1,794	20.1	12.9
Leather Products	790.8	93.0	2,823	4,378	135.7	1,843	47.6	31.1
Wood and Furniture	583.8	90.3	2,880	48,973	1,235.1	1,964	12.8	8.8
Paper and Printing	1,889.3	144.7	2,634	140,618	2,232.9	1,847	32.1	22.5
Chemicals and Oil Refining	3,891.8	137.9	2,562	139,762	1,182.0	1,922	20.8	15.6
Rubber and Plastic	2,202.0	279.5	2,829	44,418	863.3	1,986	19.3	13.6
Stone, Clay and Glass	1,733.2	127.5	2,850	33,375	554.2	2,003	49.3	34.7
Basic Metals and Metal Products	4,653.0	274.3	2,775	121,147	2,228.9	1,956	45.0	31.7
Machinery and Transport Equipment	5,428.7	391.9	2,698	255,169	3,965.8	1,905	43.8	30.9
Electrical Machinery	5,655.1	467.4	2,733	95,803	1,689.4	1,877	40.7	28.0
Other	1,547.1	207.7	2,705	88,365	1,429.9	1,885	15.4	10.7
Total Manufacturing	37,182.3	3,263.5	2,758	1,170,054	18,950.5	1,909	26.4	18.2

Note: See Appendix I for full definition of the branches. `Census value added' is inclusive of purchases of non-industrial service inputs.
Source: See appendix tables III.6 and III.11. For hours see table 4.6. See Pilat (1991b, updated).

Appendix Table III.17
Value Added, Labour Input and Comparative Labour Productivity
Mexico and the United States, 1975

	Mexico			United States			Mexico/USA (%)	
	Census Value Added at Factor Cost (mln. Ps.)	Persons Employed (000s) (a)	Annual Hours Worked per Employee	Census Value Added at Factor Cost (mln. $)	Persons Employed (000s) (b)	Annual Hours Worked per Employee	Census Value Added per Person Employed	Census Value Added per Hour Worked
Food Manufacturing	29,132	310.4		39,985	1,321.4	1,876	32.8	
Beverages	12,994	69.4		8,110	203.8	1,876	35.3	
Tobacco Products	1,817	8.6		3,722	66.2	1,802	44.3	
Textiles	14,079	138.4		12,044	835.0	1,853	45.7	
Wearing Apparel	5,599	90.6		14,749	1,214.0	1,664	32.3	
Wood and Furniture	4,821	75.1		16,646	984.0	1,808	16.7	
Paper and Printing	12,984	89.5		42,585	1,659.0	1,804	28.6	
Chemicals and Oil Refining	40,166	156.4		55,476	983.1	1,908	36.6	
Leather, Rubber and Plastic	11,605	101.5		16,786	824.7	1,837	29.6	
Stone, Clay and Glass	11,930	100.7		14,849	588.8	1,891	40.0	
Basic Metals and Metal Products	31,280	206.5		64,570	2,505.8	1,875	49.4	
Machinery and Transport Equipment	26,743	178.7		96,381	3,571.2	1,890	38.9	
Electrical Machinery	13,430	114.4		34,845	1,523.6	1,852	27.9	
Other	3,241	34.1		21,738	893.2	1,830	28.7	
Total Manufacturing	219,820	1,674.3	2,026	442,486	17,173.8	1,848	37.4	34.1

Note: See Appendix I for full definition of the branches. `Census value added' is inclusive of purchases of non-industrial service inputs.

(a) Excludes 69,448 employees in administrative offices and auxiliaries, representing about 4 per cent of all employees in manufacturing.

(b) Excludes 1,228.4 thousand employees in administrative offices and auxiliaries, representing about 4 per cent of all employees in manufacturing.

Source: See appendix tables III.7 and III.10. For hours see table 4.6. See also Maddison and van Ark (1988, updated)

Appendix Table III.18
Value Added, Labour Input and Comparative Labour Productivity
United Kingdom and the United States, 1987

	United Kingdom			United States			UK/USA (%)	
	Census Value Added at Factor Cost (mln. pnd)	Persons Employed (000s)	Annual Hours Worked per Employee	Census Value Added at Factor Cost (mln. $)	Persons Employed (000s)	Annual Hours Worked per Employee	Census Value Added per Person Employed	Census Value Added per Hour Worked
Food Manufacturing	11,156	499.2	1,705	99,018	1,384.2	1,893	39.2	43.5
Beverages	3,205	70.3	1,705	22,585	172.9	1,866	59.4	65.0
Tobacco Products	1,091	18.6	1,705	14,264	63.5	1,853	54.8	59.6
Textiles	3,339	226.2	1,475	25,660	698.9	2,053	58.7	81.7
Wearing Apparel	2,636	257.4	1,604	32,516	1,113.8	1,794	50.6	56.6
Leather Products	1,022	78.3	1,664	4,378	135.7	1,843	70.3	77.8
Wood and Furniture	3,610	190.0	1,840	47,927	1,205.0	1,964	51.9	55.4
Paper and Printing	11,974	437.0	1,646	140,651	2,232.9	1,847	41.5	46.6
Chemicals	12,705	297.8	1,742	120,778	1,028.4	1,922	57.3	63.3
Oil Refining	1,590	14.8	1,742	18,518	153.6	1,922	138.0	152.3
Rubber and Plastic	4,733	213.3	1,737	44,437	863.3	1,986	78.4	89.6
Stone, Clay and Glass	5,684	200.6	1,861	33,383	554.3	2,003	72.4	77.9
Basic Metals and Metal Products	9,848	452.6	1,792	122,126	2,259.0	1,956	60.2	65.7
Machinery and Transport Equipment	25,937	1,159.9	1,824	255,264	3,965.8	1,905	56.8	59.4
Electrical Machinery	10,902	541.8	1,754	95,815	1,689.4	1,877	47.9	51.3
Other	2,989	161.5	1,683	88,428	1,429.9	1,885	38.8	43.4
Total Manufacturing	112,420	4,819.3	1,763	1,165,747	18,950.6	1,909	53.6	58.0

Note: See Appendix I for full definition of the branches. `Census value added' is inclusive of purchases of non-industrial service inputs.
Source: See appendix tables III.9 and III.11. For hours see table 4.6, for UK updated from 1984 to 1987 on the basis of trend in total weekly hours worked divided by the number of employees from Dept. of Employment, *Employment Gazette*, various issues. See also van Ark (1992).

Appendix Table III.19
Gross Value Added, Labour Input and Comparative Labour Productivity
France and the United Kingdom, 1984

	France (a)			United Kingdom (a)			France/UK (%)	
	Gross Value Added at Factor Cost (mln. Fr.)	Persons Employed (000s)	Annual Hours Worked per Employee	Gross Value Added at Factor Cost (mln. pnd)	Persons Employed (000s)	Annual Hours Worked per Employee	Gross Value Added per Person Employed	Gross Value Added per Hour Worked
Food Manufacturing and Beverages (b)	71,330	363.5	1,621	8,431	542.6	1,705	114.9	120.8
Textiles	29,813	217.4	1,597	1,996	217.0	1,711	129.9	139.2
Wearing Apparel	17,414	160.2	1,597	1,468	207.9	1,599	93.3	93.5
Leather Products	10,422	82.1	1,622	593	63.5	1,658	119.7	122.3
Wood and Furniture	14,848	112.4	1,633	1,534	142.4	1,829	114.4	128.1
Paper	19,362	96.8	1,619	1,941	147.5	1,732	196.2	209.9
Printing	29,253	143.9	1,606	3,783	227.6	1,615	111.2	111.8
Chemicals (c)	75,705	281.4	1,582	7,298	285.8	1,738	99.1	108.9
Rubber and Plastic	27,815	171.7	1,623	2,379	183.1	1,747	112.7	121.4
Stone, Clay and Glass	30,604	157.7	1,627	3,117	187.4	1,870	91.4	105.1
Basic Metals and Metal Products	88,607	526.1	1,613	6,481	488.8	1,800	118.1	131.9
Machinery and Transport Equipment	174,146	917.9	1,609	15,487	1,103.1	1,812	130.9	147.3
Electrical Machinery	82,580	447.3	1,592	7,360	523.0	1,723	106.5	115.2
Other	19,370	118.1	1,635	1,453	120.8	1,672	124.0	126.8
Total Manufacturing	691,269	3,796.6	1,610	63,320	4,440.5	1,749	116.1	126.2

Note: See Appendix I for full definition of the branches.
(a) Excluding establishments with less than 20 employees.
(b) Excludes tobacco products.
(c) Excludes oil refining.
Source: See appendix tables III.2 and III.9. For hours see table 4.6. See also van Ark (1990b, updated).

Appendix Table III.20
Gross Value Added, Labour Input and Comparative Labour Productivity
Germany and the United Kingdom, 1987

	Germany (a)			United Kingdom (a)			Germany/UK (%)	
	Gross Value Added at Factor Cost (mln. DM)	Persons Employed (000s)	Annual Hours Worked per Employee	Gross Value Added at Factor Cost (mln. pnd)	Persons Employed (000s)	Annual Hours Worked per Employee	Gross Value Added per Person Employed	Gross Value Added per Hour Worked
Food Manufacturing, Beverages and Tobacco	33,876	470.8	1,822	12,155	594.0	1,705	113.8	106.6
Textiles	12,615	223.2	1,606	2,893	228.1	1,475	104.4	95.9
Wearing Apparel and Leather Products	9,904	228.1	1,573	3,148	341.3	1,618	112.9	116.2
Wood and Furniture	12,929	216.2	1,728	3,028	198.3	1,840	147.9	157.4
Paper and Printing (b)	12,387	152.4	1,666	3,087	152.5	1,646	187.8	185.6
Chemicals (c)	60,893	593.2	1,627	10,228	298.1	1,742	88.4	94.6
Rubber and Plastic	25,681	381.9	1,632	5,167	298.1	1,716	113.9	119.8
Stone, Clay and Glass	16,812	235.3	1,726	4,441	202.2	1,861	103.1	111.2
Basic Metals	21,441	301.0	1,555	3,525	142.5	1,793	96.1	110.8
Metal Products	31,968	495.1	1,614	4,406	299.8	1,792	118.6	131.7
Machinery	85,212	1,243.3	1,624	11,234	647.5	1,807	121.1	134.8
Electrical Machinery	77,208	1,020.6	1,550	10,035	544.9	1,754	90.3	102.2
Transport Equipment	74,394	901.9	1,553	9,755	540.2	1,843	119.4	141.6
Other	8,904	138.5	1,619	1,263	83.3	1,704	141.6	149.1
Total Manufacturing	484,222	6,601.5	1,630	84,367	4,570.8	1,763	112.7	121.8

Note: See Appendix I for full definition of the branches.
(a) Excluding establishments with less than 20 employees.
(b) Excludes publishing.
(c) Excludes oil refining.
Source: See appendix tables III.3 and III.9. For hours see table 4.6, for Germany updated from 1986 to 1987 on the basis of trend from DIW (1991), *Produktionsvolumen und -potential, Produktionsfaktoren des Bergbaus und des Verarbeitendes Gewerbe*, Berlin; for UK updated from 1984 to 1987 on the basis of trend in total weekly hours worked divided by the number of employees from Dept. of Employment, *Employment Gazette*, various issues. See also van Ark (1990b, updated). See O'Mahony (1992a).

Appendix Table III.21
Gross Value Added, Labour Input and Comparative Labour Productivity Netherlands and the United Kingdom, 1984

	Netherlands (a)			United Kingdom (a)			Neth./UK (%)	
	Gross Value Added at Factor Cost (mln. Dfl.)	Persons Employed (000s)	Annual Hours Worked per Employee	Gross Value Added at Factor Cost (mln. pnd)	Persons Employed (000s)	Annual Hours Worked per Employee	Gross Value Added per Person Employed	Gross Value Added per Hour Worked
Food Manufacturing and Beverages	9,750	115.9	1,559	8,431	542.6	1,705	140.8	154.0
Tobacco Products	696	7.8	1,159	780	26.7	1,705	113.0	123.6
Textiles	1,270	19.8	1,556	1,996	217.0	1,711	174.3	191.7
Wearing Apparel	467	10.8	1,491	1,468	207.9	1,599	123.1	132.0
Leather Products	255	5.2	1,611	593	63.5	1,658	94.9	97.6
Wood and Furniture	1,054	18.9	1,619	1,534	142.4	1,829	129.3	146.1
Paper	1,878	22.2	1,615	1,941	147.5	1,732	272.8	292.5
Printing	4,117	52.3	1,552	3,783	227.6	1,615	118.2	123.0
Chemicals (b)	11,070	81.8	1,623	7,298	285.8	1,738	139.1	149.0
Rubber and Plastic	1,691	22.2	1,615	2,379	183.1	1,747	146.6	158.6
Stone, Clay and Glass	1,978	26.3	1,603	3,117	187.4	1,870	186.6	217.7
Basic Metals and Metal Products	7,209	88.0	1,591	6,481	488.8	1,800	138.9	157.1
Machinery and Transport Equipment	8,171	124.6	1,636	15,487	1,103.1	1,812	95.2	105.4
Electrical Machinery	8,290	105.3	1,649	7,360	523.0	1,723	139.6	145.8
Other	605	9.7	1,610	1,453	120.8	1,672	129.9	134.9
Total Manufacturing	58,501	710.9	1,611	64,101	4,467.2	1,749	143.1	155.4

Note: See Appendix I for full definition of the branches.
(a) Excluding establishments with less than 20 employees.
(b) Excludes oil refining.
Source: See appendix tables III.8 and III.9. For hours see table 4.6. See also van Ark (1990a, updated).

Appendix IV - Time Series of Output, Labour Input and Comparative Productivity

Appendix Table IV.1
Gross Value Added at Constant Prices in Manufacturing
1950-1990, 1975=100.0

		Brazil	France	Germany	India	Japan	Korea	Nether-lands	United Kingdom	United States
1950	1950	10.0	22.9	23.6	24.1			22.9	42.9	47.1
1951	1951	10.6	25.0	27.5	24.8			20.6	45.0	52.7
1952	1952	11.2	25.1	28.8	24.9			22.0	44.6	54.5
1953	1953	12.3	25.4	31.1	26.0		4.1	25.5	48.7	58.4
1954	1954	13.6	27.3	34.7	28.9		4.8	29.9	53.5	54.2
1955	1955	15.3	29.0	40.1	32.4	11.8	6.0	32.0	57.6	59.9
1956	1956	16.2	31.3	42.6	36.0	13.9	7.0	34.6	58.3	60.4
1957	1957	17.1	33.8	44.5	37.7	15.4	7.6	37.1	60.4	60.7
1958	1958	20.6	35.3	45.7	38.8	15.9	8.2	37.0	60.6	55.4
1959	1959	23.6	36.1	49.4	42.7	17.9	9.0	40.9	65.1	61.7
1960	1960	26.4	39.8	55.9	48.0	21.1	9.7	47.8	71.4	61.9
1961	1961	29.7	42.7	59.2	52.4	25.6	10.0	49.7	72.6	62.0
1962	1962	32.4	45.8	62.0	57.5	27.7	11.4	51.4	73.9	67.3
1963	1963	32.3	49.4	63.3	64.0	33.0	13.3	53.6	77.6	72.6
1964	1964	34.0	53.9	68.9	69.3	38.5	14.2	60.8	84.4	77.7
1965	1965	32.5	56.6	74.1	71.6	40.3	17.0	66.9	86.6	84.5
1966	1966	36.8	61.8	75.4	71.7	45.6	20.0	67.9	87.8	90.9
1967	1967	37.6	64.7	73.7	69.3	53.5	24.5	72.5	88.1	90.7
1968	1968	43.8	68.3	81.4	74.0	61.3	31.1	77.8	94.0	95.3
1969	1969	49.4	76.6	90.9	86.9	71.0	37.8	85.3	97.6	98.0
1970	1970	56.0	82.2	95.5	88.9	82.1	44.7	89.0	98.2	92.6
1971	1971	63.6	88.1	96.5	90.5	86.2	52.7	94.6	97.8	94.2
1972	1972	74.0	92.3	99.6	93.4	95.0	59.7	97.9	100.1	102.5
1973	1973	88.7	99.2	106.0	98.0	107.0	76.9	106.0	108.4	113.5
1974	1974	96.2	102.5	105.0	99.0	103.8	89.3	111.6	106.6	108.1
1975	1975	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1976	1976	112.1	105.0	107.7	112.5	109.8	123.6	105.5	101.4	109.7
1977	1977	114.7	109.4	109.6	120.0	113.9	142.2	101.3	102.9	117.8
1978	1978	121.7	111.4	111.7	133.1	119.0	172.1	104.3	103.9	123.1
1979	1979	130.0	114.0	117.3	130.3	128.9	190.0	107.7	103.8	126.2
1980	1980	141.9	114.3	115.0	128.2	136.4	188.6	108.2	94.8	119.4
1981	1981	127.1	112.5	113.9	138.1	142.7	207.3	108.2	89.1	120.3
1982	1982	126.9	113.6	109.9	151.4	149.0	221.1	106.8	89.2	112.5
1983	1983	119.5	113.5	111.4	173.6	155.5	255.2	108.6	91.7	119.5
1984	1984	126.9	112.1	114.6	188.3	168.7	299.4	114.9	95.5	133.3
1985	1985	137.4	112.6	118.6	192.7	180.6	320.7	117.9	98.3	138.1
1986	1986	153.0	112.6	120.3	203.8	175.7	379.4	121.2	99.6	142.3
1987	1987	154.4	113.2	117.9	218.8	188.6	450.6	121.6	104.7	151.0
1988	1988		117.0	121.7	239.5	206.0	511.0	127.3	111.8	162.5
1989	1989		121.8	125.5		222.5	529.8	133.1	116.2	164.6
1990	1990			131.2		238.9		138.3	115.4	167.3

Source: see below

Appendix Table IV.2
Number of Persons Employed in Manufacturing
1950-1990, 1975=100.0

	Brazil	France	Germany	India	Japan	Korea	Netherlands a)	United Kingdom	United States
1950	38.8	83.6	72.6	48.9				98.0	83.8
1951	39.0	86.2	77.0	50.0				106.7	90.4
1952	39.2	86.2	77.6	51.1				104.5	92.0
1953	39.5	84.4	80.7	52.1		17.2		105.5	96.5
1954	39.7	84.7	84.7	53.3				107.8	89.9
1955	39.9	85.5	91.2	54.4	56.2	17.2		110.4	92.9
1956	40.2	86.9	94.9	55.6	59.8			110.7	94.7
1957	40.4	89.8	97.7	56.7	63.4			111.0	94.2
1958	40.6	90.8	99.0	58.0	66.7	20.2		109.3	87.0
1959	42.3	88.7	100.5	59.2	66.6			109.6	90.9
1960	44.1	89.4	105.8	60.5	70.3	21.8		113.9	91.6
1961	46.6	90.2	108.9	63.6	75.1	23.6		115.1	89.2
1962	49.3	91.2	109.4	67.1	79.2	25.4		113.5	92.2
1963	49.0	93.4	108.6	71.9	82.3	27.2		111.7	92.8
1964	51.7	95.3	108.7	76.6	83.9	28.9		113.3	94.4
1965	48.9	94.8	110.6	79.0	85.4	35.0		114.4	98.6
1966	48.6	95.4	109.4	78.5	87.5	37.8		114.5	104.9
1967	48.9	94.8	103.5	77.9	93.0	46.3		110.9	106.2
1968	52.6	93.4	104.3	77.5	97.0	53.1		110.0	108.0
1969	52.4	95.4	108.6	80.6	99.9	55.9		111.4	110.3
1970	69.0	97.5	111.2	83.2	102.3	58.2		111.1	105.7
1971	70.5	98.6	110.5	88.6	102.7	60.6		107.4	101.1
1972	75.5	99.7	108.4	89.7	102.7	65.5		103.7	103.6
1973	84.6	101.8	109.1	90.8	107.2	80.5		104.4	109.4
1974	95.8	102.9	106.5	95.5	106.0	91.2		105.1	109.3
1975	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0
1976	103.7	98.9	97.7	106.7	99.9	121.5		96.8	103.8
1977	109.1	98.4	98.1	110.0	99.6	126.9		97.4	107.8
1978	120.4	97.1	97.9	112.5	98.5	136.8		97.0	112.5
1979	125.0	95.3	99.1	120.2	99.0	141.8		96.6	115.3
1980	128.9	93.9	100.0	122.6	101.6	134.8		92.4	111.4
1981	126.9	90.9	98.2	121.0	102.9	129.7		82.9	110.8
1982	126.4	89.7	95.3	115.5	102.5	137.6		78.1	103.3
1983	120.3	87.9	92.1	119.7	104.5	148.1		73.5	101.3
1984	121.4	85.2	91.7	121.3	106.8	151.8		71.9	106.3
1985	127.5	82.7	92.8	116.2	107.9	158.9		71.4	105.7
1986	143.9	81.1	94.3	115.2	107.2	173.5		69.6	104.2
1987	144.7	79.0	94.4	120.5	105.9	200.3		68.7	104.5
1988		77.5	94.2		108.1	211.7		69.5	106.8
1989		77.5	95.5		110.2	219.5		69.6	107.0
1990			98.3		111.8			69.1	105.7

(a) No separate figures are available for persons engaged; appendix table IV.3 shows the total number of hours worked.

Source: see below

Appendix Table IV.3
Average Annual Hours per Employee in Manufacturing
1950-1990, 1975=100.0

	Brazil	France	Germany	India	Japan	Korea	Netherlands a)	United Kingdom	United States
1950	96.6	110.9	134.7	108.9			88.2	115.3	110.1
1951	96.7	111.9	134.3	108.9			89.6	116.7	110.4
1952	96.9	110.0	133.9	108.9			87.1	115.8	110.5
1953	97.0	109.9	134.4	108.9		106.8	89.4	116.7	110.0
1954	97.2	110.7	135.0	108.9		106.8	94.1	118.0	108.1
1955	97.3	111.3	133.4	108.9	118.0	106.8	96.8	119.2	105.8
1956	97.5	112.8	131.9	108.9	121.8	106.8	98.6	118.4	105.2
1957	97.6	113.8	127.2	108.9	120.9	106.8	99.5	118.3	104.0
1958	97.8	112.4	122.6	108.9	120.0	106.8	97.7	117.0	102.8
1959	97.9	111.8	122.0	108.9	122.0	106.8	99.6	117.9	105.0
1960	98.1	113.3	121.5	108.9	123.4	106.8	104.0	116.9	103.8
1961	98.2	113.8	119.3	108.9	121.2	106.8	106.4	115.3	103.8
1962	98.4	113.5	116.3	108.9	118.2	106.8	109.1	114.2	104.9
1963	98.5	113.4	114.6	108.9	117.3	110.0	110.2	114.0	105.1
1964	98.7	113.4	114.8	108.9	116.6	103.7	111.8	115.0	105.4
1965	98.8	112.2	114.2	108.9	114.3	107.5	112.6	113.5	106.3
1966	99.0	109.0	112.7	104.0	115.0	106.8	112.2	112.0	106.5
1967	99.1	108.2	109.7	105.9	115.6	104.4	109.3	110.2	105.0
1968	99.3	104.9	110.9	107.8	115.0	110.2	108.9	110.3	104.4
1969	99.4	108.1	111.1	103.0	113.2	108.6	110.4	109.4	103.9
1970	99.5	107.2	110.4	101.1	111.7	105.8	110.7	107.2	101.5
1971	99.7	106.9	107.8	102.5	109.8	103.1	109.0	104.2	101.6
1972	99.8	106.0	106.7	102.5	109.2	102.4	105.4	103.9	103.2
1973	100.0	104.4	106.3	102.5	108.5	101.8	103.9	105.7	103.2
1974	100.0	103.0	103.2	102.5	103.2	99.0	103.5	102.2	101.1
1975	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1976	101.6	100.5	103.2	97.2	103.6	103.6	96.0	101.1	101.0
1977	101.6	99.7	101.6	97.5	103.8	104.3	93.5	102.0	101.4
1978	102.1	98.6	100.2	95.7	104.4	104.4	91.2	101.4	101.6
1979	102.1	98.4	99.8	95.0	105.7	102.4	90.3	99.6	101.4
1980	101.6	98.5	98.4	94.7	105.8	104.7	89.3	93.5	100.5
1981	100.0	97.4	96.8	94.7	105.3	105.8	85.9	92.9	100.9
1982	101.6	93.1	96.2	99.3	105.0	105.9	82.7	93.4	99.4
1983	102.1	92.6	96.8	105.0	105.5	107.2	79.2	96.4	101.9
1984	103.7	92.6	97.2	103.5	106.9	107.0	78.3	99.1	103.0
1985	104.2	92.1	96.5	104.6	106.4	106.0	79.8	100.8	103.0
1986	102.6	92.2	95.6	106.4	105.4	107.9	81.4	99.9	102.9
1987	101.6	92.6	94.2	107.0	105.8	106.5	82.0	100.8	103.4
1988		93.0	94.3		107.0	106.8	82.7	101.2	104.2
1989		93.1	93.6		106.0	106.8	84.2	100.3	104.2
1990			92.5		104.4		85.8	100.5	103.7

(a) Total number of hours worked.
Source: see below

Appendix Table IV.4
Value Added per Hour Worked in Manufacturing
1950-1990, USA=100

	Brazil	France	Germany	India	Japan	Korea	Nether-lands	United Kingdom	European Four(a)	USA
1950	20.0	32.1	39.3	4.2			40.3	40.0	38.0	100.0
1951	20.2	32.5	41.8	4.1			34.5	36.8	37.6	100.0
1952	20.9	32.7	43.0	3.9			37.4	36.9	38.2	100.0
1953	22.3	32.9	43.2	3.9		4.9	41.0	38.5	39.1	100.0
1954	24.1	34.6	45.2	4.2			45.1	40.4	41.1	100.0
1955	24.6	33.1	44.9	4.2	18.4	6.4	42.9	38.5	39.8	100.0
1956	26.0	35.0	46.6	4.6	19.7		45.8	39.3	41.3	100.0
1957	26.7	35.4	47.9	4.6	20.4		47.5	39.8	42.1	100.0
1958	31.9	37.0	50.4	4.7	20.2	7.4	48.3	41.0	43.9	100.0
1959	33.6	37.3	51.7	4.8	21.3		50.2	41.8	44.8	100.0
1960	35.8	40.0	55.5	5.3	23.4	7.8	55.8	44.2	47.9	100.0
1961	36.9	41.2	56.6	5.3	26.3	7.2	55.2	43.8	48.4	100.0
1962	36.6	42.2	58.2	5.3	26.7	7.3	53.6	44.0	49.2	100.0
1963	34.3	41.5	56.7	5.2	28.8	7.2	51.7	43.9	48.4	100.0
1964	32.5	42.3	58.7	5.0	31.6	7.3	55.1	44.5	49.7	100.0
1965	31.8	43.7	60.5	4.9	32.1	6.8	58.3	44.4	51.6	100.0
1966	35.8	48.4	62.4	5.1	34.9	7.3	58.9	45.2	53.8	100.0
1967	36.4	51.4	66.3	4.9	38.4	7.5	64.5	47.5	57.1	100.0
1968	37.9	54.7	69.1	4.9	40.7	7.6	66.9	49.2	59.6	100.0
1969	42.2	57.5	73.1	5.8	46.0	8.8	71.4	50.2	62.4	100.0
1970	36.0	60.4	74.8	5.8	52.2	10.1	73.7	51.2	64.2	100.0
1971	37.6	60.3	73.3	5.1	52.2	11.1	74.9	51.1	63.7	100.0
1972	39.0	60.3	74.6	5.0	55.4	11.2	76.7	51.9	64.5	100.0
1973	39.7	61.5	75.5	4.9	57.4	11.2	80.3	52.4	65.5	100.0
1974	39.1	65.5	81.0	4.9	60.8	12.2	87.2	54.4	69.6	100.0
1975	38.1	66.3	83.0	4.7	62.7	12.0	79.1	53.6	69.8	100.0
1976	38.8	67.0	84.7	4.9	63.6	11.3	83.2	53.2	70.6	100.0
1977	36.6	68.6	84.7	4.9	64.1	12.0	79.5	51.6	70.3	100.0
1978	35.0	71.6	87.8	5.4	67.3	13.5	84.0	52.6	72.8	100.0
1979	36.0	74.7	91.3	5.0	71.6	14.6	87.5	53.7	75.4	100.0
1980	38.7	76.8	91.0	4.9	74.6	15.1	89.9	55.2	76.5	100.0
1981	35.5	78.3	92.6	5.3	76.8	16.9	92.6	57.7	78.3	100.0
1982	34.4	82.4	90.9	5.7	79.3	16.7	93.3	60.0	79.4	100.0
1983	32.0	79.9	89.6	5.6	76.5	16.7	93.8	60.0	78.3	100.0
1984	31.5	77.4	87.7	5.8	76.1	18.2	95.4	59.1	76.7	100.0
1985	31.1	77.3	86.7	5.9	77.8	18.1	92.2	57.7	75.7	100.0
1986	29.7	75.2	83.5	5.9	73.5	18.4	88.8	57.8	73.8	100.0
1987	28.6	73.3	78.7	5.7	75.5	18.2	83.9	58.0	71.2	100.0
1988		73.6	77.8		76.4	18.6	83.4	58.3	71.0	100.0
1989		75.8	78.9		80.9	18.4	84.7	60.5	72.7	100.0
1990			78.4		84.0		83.5	58.3		100.0

(a) The average figure for the European countries was obtained by weighting the country series at their labour input for the following subperiods: 1950-65 at 1960 weights; 1965-80 at 1975 weights; 1980-89 at 1985 weights.
Source: appendix tables IV.1 to IV.3 and tables 4.1 and 4.9 (for France and Netherlands).

Appendix Table IV.5
Value Added per Hour Worked in Manufacturing
1950-1990, UK=100

	France	Germany	Nether-lands	United Kingdom
1950	76.7	88.8	96.1	100.0
1951	84.1	96.7	89.3	100.0
1952	84.5	105.3	96.6	100.0
1953	81.6	103.5	101.7	100.0
1954	82.2	101.7	107.0	100.0
1955	82.5	104.7	106.9	100.0
1956	85.3	107.8	111.8	100.0
1957	85.2	109.7	114.5	100.0
1958	86.5	111.7	112.9	100.0
1959	85.6	112.2	115.3	100.0
1960	86.8	112.7	121.2	100.0
1961	90.3	115.7	120.9	100.0
1962	92.1	118.4	117.1	100.0
1963	90.7	114.5	113.0	100.0
1964	91.3	118.0	118.9	100.0
1965	94.8	122.0	126.5	100.0
1966	103.3	123.0	125.8	100.0
1967	104.6	123.5	131.3	100.0
1968	107.1	124.0	131.0	100.0
1969	110.4	129.0	137.2	100.0
1970	113.8	129.1	138.7	100.0
1971	113.9	126.7	141.3	100.0
1972	112.0	126.6	142.4	100.0
1973	113.3	126.8	147.8	100.0
1974	116.1	131.5	154.5	100.0
1975	119.0	137.0	142.1	100.0
1976	121.5	141.4	150.8	100.0
1977	128.1	146.0	148.6	100.0
1978	131.0	147.8	153.7	100.0
1979	134.1	151.0	157.0	100.0
1980	134.1	149.1	156.8	100.0
1981	130.5	142.4	154.4	100.0
1982	132.1	134.5	149.7	100.0
1983	128.2	132.7	150.5	100.0
1984	126.2	132.0	155.5	100.0
1985	128.8	133.8	153.6	100.0
1986	125.1	127.8	147.7	100.0
1987	121.5	121.8	139.0	100.0
1988	121.2	119.5	137.3	100.0
1989	120.4	117.4	134.6	100.0
1990		121.1	137.5	100.0

(a) excluding petroleum refining. Where possibile the time series from appendix tables IV.1 to IV.3 were also adjusted to exclude petroleum refining.
Source: appendix tables IV.1 to IV.3 and table 4.1.

Appendix Table IV.6
Gross Value Added at Constant Prices by Major Branch, 1973-1989, 1975=100.0

Food Products, Beverages and Tobacco Products

	France	Germany	Japan	Nether-lands	United Kingdom	United States
1973	90.7	101.5	98.3	98.7	103.1	106.1
1974	93.5	102.5	98.0	97.2	102.5	97.5
1975	100.0	100.0	100.0	100.0	100.0	100.0
1976	97.3	104.1	99.0	102.5	102.5	105.2
1977	97.0	102.9	108.9	95.8	104.0	104.5
1978	96.3	108.7	100.3	101.2	106.2	113.5
1979	94.2	112.5	111.1	105.1	107.9	118.5
1980	97.6	112.8	108.6	106.6	107.2	118.5
1981	97.0	113.1	112.2	110.3	105.3	117.5
1982	105.5	105.5	117.1	111.5	106.8	120.0
1983	97.8	106.7	121.6	111.5	108.3	120.7
1984	98.3	110.0	116.1	115.2	109.3	119.3
1985	101.8	109.8	117.5	112.4	108.8	121.2
1986	101.7	106.3	113.9	119.9	109.8	124.0
1987	101.0	101.6	110.5	112.2	112.4	122.8
1988	97.8	101.5	114.4	115.8	114.0	122.1
1989	105.2	101.3	116.0	118.6	114.9	125.3

Textiles, Wearing Apparel and Leather Products

	France	Germany	Japan	Nether-lands	United Kingdom	United States
1973	98.6	105.7	90.8	118.1	111.2	111.2
1974	104.0	101.8	99.7	106.9	103.5	103.3
1975	100.0	100.0	100.0	100.0	100.0	100.0
1976	99.1	101.9	98.8	103.7	100.8	113.0
1977	99.7	100.3	96.1	89.8	101.6	123.1
1978	95.6	99.3	96.7	89.2	101.3	122.5
1979	97.0	99.3	100.4	88.2	100.1	121.1
1980	97.4	97.2	102.7	83.1	84.8	119.1
1981	95.7	91.8	104.8	77.0	78.6	115.4
1982	98.8	86.6	103.8	76.1	77.4	107.7
1983	98.5	84.9	105.7	74.2	80.2	114.2
1984	93.9	85.4	102.6	78.1	83.2	114.0
1985	91.5	86.6	101.6	79.8	86.6	110.8
1986	89.5	84.7	96.0	75.2	87.2	115.9
1987	91.8	83.5	96.2	72.4	89.8	120.8
1988	89.2	83.4	95.7	73.6	88.3	119.9
1989	89.4	84.6	87.8	76.0	85.2	119.7

Chemicals, Oil Refining, Rubber and Plastics

	France	Germany	Japan	Nether-lands	United Kingdom (a)	United States
1973	108.3	113.1	102.5	120.1	107.4	111.1
1974	109.2	112.5	89.7	144.4	110.4	103.3
1975	100.0	100.0	100.0	100.0	100.0	100.0
1976	106.2	114.3	123.7	111.3	111.1	111.3
1977	112.0	116.5	130.5	104.4	114.1	122.9
1978	118.7	119.4	155.9	108.3	114.9	126.0
1979	127.2	129.2	132.6	113.2	117.9	131.9
1980	122.5	122.1	137.7	110.7	105.4	119.1
1981	122.2	120.7	156.2	119.0	103.6	125.8
1982	124.7	117.7	170.8	117.1	103.5	128.9
1983	131.9	126.6	169.8	134.0	110.7	144.7
1984	134.9	131.3	186.1	146.0	117.1	160.9
1985	137.4	132.8	198.4	157.1	120.6	162.9
1986	136.9	137.9	152.5	161.3	122.5	172.4
1987	140.9	128.0	200.9	168.9	130.3	187.5
1988	150.4	136.1	196.2	178.0	136.8	197.8
1989	156.7	138.6	224.3	186.0	142.6	197.7

Basic Metals and Metal Products

	France	Germany	Japan	Nether-lands (b)	United Kingdom	United States
1973	111.3	104.6	136.1		118.4	128.1
1974	112.6	102.7	113.8		112.3	123.8
1975	100.0	100.0	100.0		100.0	100.0
1976	112.0	100.2	106.7		102.0	108.5
1977	116.6	105.8	102.4		104.1	112.4
1978	119.6	107.5	116.3		102.9	120.1
1979	127.2	110.4	142.0		103.3	122.9
1980	123.2	108.7	145.2		82.7	115.2
1981	116.8	106.5	131.2		80.3	117.2
1982	109.7	99.0	132.6		79.8	92.3
1983	108.3	96.6	125.1		81.1	87.9
1984	105.5	99.0	146.0		84.6	99.8
1985	106.3	103.0	155.9		84.9	100.5
1986	110.4	105.2	149.0		84.7	98.4
1987	108.3	102.6	158.8		89.5	106.0
1988	116.5	108.1	174.0		98.4	117.6
1989	119.7	112.7	182.1		100.2	116.2

Appendix Table IV.6 (continued) - Value Added

	Machinery, Transport Equipment and Electrical						Other Manufacturing Industries					
	France	Germany	Japan	Netherlands (b)	United Kingdom	United States	France	Germany	Japan	Netherlands	United Kingdom	United States
1973	94.3	102.5	95.7	102.4	102.2	112.8	101.0	111.0	115.0	106.3	114.7	109.9
1974	99.8	102.8	106.8	111.7	103.9	108.3	102.8	106.8	107.6	104.8	109.5	106.0
1975	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1976	108.4	109.5	117.0	111.4	97.3	110.5	103.1	108.0	109.8	95.3	103.6	109.7
1977	114.6	111.9	126.6	110.8	98.3	122.7	110.2	109.1	110.6	91.2	105.3	116.5
1978	118.3	113.7	130.3	112.7	99.0	129.6	111.1	109.9	113.1	94.6	108.2	119.0
1979	118.3	120.1	150.1	116.6	96.7	131.8	115.8	114.8	120.7	96.7	109.7	122.3
1980	120.5	118.9	176.0	119.1	91.8	125.1	116.4	113.1	122.5	96.5	98.2	115.3
1981	121.3	120.3	192.2	120.2	84.3	125.3	111.0	107.8	129.5	88.1	90.5	114.9
1982	121.2	119.4	201.2	118.8	85.3	114.6	112.0	102.1	136.1	84.5	89.3	111.5
1983	123.1	120.0	221.4	117.2	87.1	126.6	111.3	102.8	144.8	85.4	92.0	117.4
1984	120.3	123.6	255.6	125.4	90.3	150.9	110.8	105.6	149.7	87.9	96.4	127.5
1985	120.5	133.4	283.9	130.3	94.6	164.1	109.0	103.0	158.7	88.0	97.6	128.3
1986	120.6	135.3	293.9	130.8	95.0	169.0	107.4	105.3	159.9	93.8	101.3	133.5
1987	121.5	135.7	313.6	128.6	98.2	181.1	107.9	106.5	167.1	101.7	110.4	139.9
1988	126.0	138.6	364.1	133.8	106.4	203.4	113.4	110.0	179.9	109.0	121.6	146.2
1989	132.3	148.1	406.1	142.3	114.4	212.3	116.2	110.5	189.8	112.7	126.5	142.6

(a) UK series used for comparisons with France, Germany and the Netherlands exclude oil refining.

(b) `Basic Metals and Metal Products' included in `Machinery, Transport equipment and Electrical Engineering'.

Source: see below

Appendix Table IV.7
Number of Persons Employed by Major Branch, 1973-1989, 1975=100.0

	Food Products, Beverages and Tobacco Products						Textiles, Wearing Apparel and Leather Products					
	France	Germany	Japan	Netherlands (a)	United Kingdom	United States	France	Germany	Japan	Netherlands (a)	United Kingdom	United States
1973	101.2	106.4	105.2		103.6	103.5	109.3	121.3	112.8		111.6	115.9
1974	101.2	104.7	103.0		105.3	103.3	105.9	109.1	106.0		108.3	110.8
1975	100.0	100.0	100.0		100.0	100.0	100.0	100.0	100.0		100.0	100.0
1976	98.8	98.6	104.9		98.3	101.4	96.6	96.1	101.2		95.8	106.3
1977	99.5	99.8	104.9		98.1	102.8	94.1	91.4	100.1		96.7	105.7
1978	100.7	101.4	105.2		97.2	103.8	90.3	90.5	101.0		93.3	106.3
1979	100.5	102.1	105.5		97.5	104.1	87.5	89.0	99.0		91.4	103.5
1980	99.9	102.4	105.3		96.3	102.6	84.2	87.9	93.6		81.7	100.0
1981	100.2	101.1	109.4		90.8	101.0	78.0	82.2	97.2		70.0	98.3
1982	101.3	98.7	109.1		87.0	99.0	75.8	76.3	96.8		65.6	90.8
1983	101.6	96.6	107.8		81.9	96.9	73.6	71.3	98.8		62.3	89.7
1984	101.6	95.4	110.4		79.8	96.8	70.3	69.8	95.2		62.4	90.5
1985	100.8	94.3	119.5		78.8	96.1	67.4	68.0	94.1		62.8	84.5
1986	100.3	93.0	111.3		76.2	96.4	65.1	66.6	95.2		63.3	83.1
1987	99.8	92.2	114.8		75.5	96.8	61.9	64.5	92.1		62.0	83.6
1988	98.3	90.2	118.3		75.4	97.6	58.2	62.5	92.8		62.6	83.5
1989	97.5	89.7	118.1		75.3	97.8	56.0	61.0	93.8		59.5	82.6

	Chemicals, Oil Refining, Rubber and Plastics						Basic Metals and Metal Products					
	France	Germany	Japan	Netherlands (a)	United Kingdom (b)	United States	France	Germany	Japan	Netherlands (a)	United Kingdom	United States
1973	100.9	104.9	105.4		99.7	104.7	100.8	108.5	105.5		104.2	111.4
1974	102.9	104.9	103.9		102.0	105.9	102.7	106.3	106.5		104.1	112.1
1975	100.0	100.0	100.0		100.0	100.0	100.0	100.0	100.0		100.0	100.0
1976	99.3	97.7	102.3		98.2	104.4	98.1	95.9	94.1		94.9	102.5
1977	98.9	98.7	98.1		99.5	110.1	98.3	98.3	93.5		97.2	106.2
1978	98.6	98.0	97.2		100.8	113.8	95.5	96.9	89.5		95.2	110.9
1979	97.5	100.4	96.6		101.0	116.3	92.2	96.4	90.1		93.0	113.9
1980	97.7	102.3	98.1		97.4	112.8	90.3	97.0	93.7		86.9	106.3
1981	95.0	101.6	97.4		89.0	113.8	86.7	94.1	93.1		72.2	104.6
1982	93.0	100.9	98.7		84.4	108.9	84.2	91.4	91.0		66.7	90.7
1983	90.6	99.0	101.2		78.8	107.8	81.6	86.1	92.0		58.9	84.6
1984	89.8	100.0	104.4		78.0	111.4	77.1	85.5	92.7		54.7	89.3
1985	88.6	102.0	103.7		77.2	110.9	74.1	86.2	92.3		53.9	87.7
1986	88.4	104.0	104.2		74.6	109.4	72.3	87.3	91.2		50.9	83.8
1987	87.5	105.6	103.5		73.1	110.9	70.0	86.2	89.7		49.7	82.5
1988	87.4	107.9	106.7		73.4	113.4	68.7	85.2	91.6		49.5	84.5
1989	88.5	108.5	108.3		73.8	115.0	69.7	87.7	95.0		52.1	85.1

Appendix Table IV.7 (continued) - Employment

	Machinery, Transport Equipment and Electrical						Other Manufacturing Industries					
	France	Germany	Japan	Netherlands (a)	United Kingdom	United States	France	Germany	Japan	Netherlands (a)	United Kingdom	United States
1973	99.3	106.8	106.1		102.9	109.4	102.3	111.6	106.5		104.9	109.8
1974	101.7	106.2	108.0		104.3	111.2	103.8	107.9	104.6		106.1	109.1
1975	100.0	100.0	100.0		100.0	100.0	100.0	100.0	100.0		100.0	100.0
1976	99.9	98.5	97.7		96.7	103.3	99.0	98.2	100.7		97.5	104.7
1977	99.5	99.2	97.7		97.2	108.8	98.8	98.1	98.9		97.3	109.5
1978	98.4	99.0	94.7		97.8	116.6	98.4	98.6	98.7		97.4	114.3
1979	96.5	101.2	95.5		97.9	122.9	97.4	99.9	98.1		97.9	116.6
1980	95.3	102.5	102.5		94.9	119.0	96.4	101.2	97.9		94.2	112.9
1981	92.6	101.9	105.3		85.7	119.2	93.8	99.1	95.2		86.2	112.2
1982	91.9	99.8	105.5		79.9	110.1	92.4	94.7	93.8		82.8	107.0
1983	90.3	97.5	109.8		75.1	106.2	90.3	91.0	92.7		80.5	108.5
1984	87.9	97.3	116.4		72.7	115.5	86.6	90.4	92.5		80.7	113.8
1985	85.4	100.6	119.1		71.9	116.6	83.0	89.9	90.4		80.8	114.6
1986	83.2	104.6	120.1		69.6	113.4	82.0	89.3	89.7		80.0	115.3
1987	80.2	105.5	117.7		68.1	112.5	81.2	89.4	89.0		80.4	117.4
1988	78.1	105.8	120.0		68.8	115.6	81.4	89.5	91.0		82.5	120.2
1989	77.8	107.8	124.5		68.9	115.8	82.5	91.5	91.0		83.2	120.3

(a) No separate figures are available for persons engaged; table 4A.5 shows the total number of hours worked.
(b) Series used for comparisons with France and the Netherlands exclude oil refining.
Source: see below

Appendix Table IV.8
Average Annual Hours per Employee by Major Branch, 1973-1989, 1975=100.0

	Food Products, Beverages and Tobacco Products						Textiles, Wearing Apparel and Leather Products					
	France	Germany	Japan	Nether-lands (a)	United Kingdom	United States	France	Germany	Japan	Nether-lands (a)	United Kingdom	United States
1973	103.4	102.0	102.1	104.7	100.5	100.3	104.0	102.0	105.6	125.5	104.8	102.9
1974	102.8	100.3	99.6	103.1	101.0	100.2	102.8	100.9	100.5	114.3	100.2	100.3
1975	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1976	99.3	100.8	100.6	95.9	99.0	100.4	101.4	102.5	101.9	89.8	100.9	101.7
1977	97.9	97.6	100.7	94.3	99.8	99.3	100.5	100.9	101.2	82.7	100.7	101.6
1978	96.7	96.9	101.1	92.2	97.3	99.0	100.1	99.7	102.8	75.5	101.3	102.5
1979	96.1	95.8	101.1	92.2	96.8	99.8	100.2	98.5	103.6	70.4	104.8	102.8
1980	95.6	94.9	100.7	90.7	92.5	99.7	99.8	97.3	103.1	66.3	96.6	103.6
1981	94.4	94.3	100.4	89.1	92.5	100.2	98.6	95.0	103.2	58.2	100.9	104.4
1982	90.0	94.4	100.9	86.5	92.3	98.9	95.2	95.6	103.1	52.0	104.3	99.7
1983	89.7	94.6	100.7	83.9	96.9	98.8	95.2	97.6	103.0	48.0	103.5	105.4
1984	90.0	95.7	100.7	83.9	97.0	98.6	95.5	98.1	104.0	46.9	103.4	106.0
1985	89.2	93.1	100.8	83.9	98.5	99.3	95.1	97.4	104.0	46.9	101.1	104.6
1986	89.1	92.6	100.3	83.9	99.5	100.1	95.2	96.2	103.7	48.0	99.3	106.6
1987	89.2	92.5	100.9	83.9	100.2	100.3	95.8	95.7	104.2	48.0	101.1	109.0
1988	89.2	92.3	100.2	83.9	100.5	100.7	96.2	95.7	104.9	46.9	98.9	108.1
1989	89.2	90.9	98.7	84.5	100.2	101.5	96.1	94.4	103.3	46.9	99.6	107.8

	Chemicals, Oil Refining, Rubber and Plastics						Basic Metals and Metal Products					
	France	Germany	Japan	Nether-lands (a)	United Kingdom (b)	United States	France	Germany	Japan	Nether-lands (c)	United Kingdom	United States
1973	103.9	106.8	107.5	97.5	108.3	102.3	105.6	108.6	111.5		108.3	104.6
1974	102.3	104.4	103.0	102.5	104.1	101.3	103.9	105.4	105.6		104.1	102.7
1975	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0
1976	100.8	104.2	102.3	96.7	103.0	101.7	100.9	103.1	104.6		103.0	101.9
1977	100.3	103.0	103.0	95.9	103.7	102.2	101.0	100.7	105.1		103.7	102.7
1978	99.7	101.8	103.7	93.4	103.1	102.4	98.8	99.6	105.6		103.1	103.1
1979	99.6	100.9	105.2	91.8	99.6	101.8	99.2	99.8	108.0		99.6	102.1
1980	99.8	99.4	105.6	91.8	94.8	100.2	99.5	98.6	108.4		94.8	100.2
1981	99.0	98.8	104.9	91.0	94.2	100.7	98.0	96.7	107.1		94.2	100.4
1982	94.8	98.7	104.5	89.3	94.1	98.0	93.5	95.2	107.3		94.1	96.0
1983	93.9	99.7	105.2	89.3	96.3	100.8	92.6	95.4	107.1		96.3	101.3
1984	94.3	99.5	107.1	88.5	99.1	102.8	92.6	97.5	108.9		99.1	103.9
1985	93.5	98.7	107.4	91.0	101.3	101.8	92.3	96.1	108.6		101.3	103.8
1986	93.7	97.8	106.3	94.3	100.3	101.7	92.5	94.5	107.7		100.3	103.5
1987	94.0	97.1	107.1	95.9	99.2	102.9	93.0	93.5	107.9		99.2	104.4
1988	94.6	97.2	108.0	98.4	98.6	103.2	93.6	94.3	110.4		98.6	107.2
1989	94.6	95.9	107.6	100.8	98.8	103.4	93.7	93.4	110.1		98.8	106.0

Appendix Table IV.8 (continued) - Hours

	Machinery, Transport Equipment and Electrical						Other Manufacturing Industries					
	France	Germany	Japan	Nether- lands (a)(c)	United Kingdom	United States	France	Germany	Japan	Nether- lands (a)	United Kingdom	United States
1973	104.1	107.1	110.7	100.4	104.8	103.8	105.1	106.4	107.5	104.4	108.3	103.1
1974	102.7	103.2	104.4	101.7	101.3	101.4	103.7	103.0	102.4	103.5	104.1	101.8
1975	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1976	100.3	103.7	105.3	96.7	99.7	101.8	100.2	103.3	103.1	96.9	103.0	102.0
1977	99.4	102.5	106.1	93.7	101.1	103.0	99.2	102.0	103.4	95.6	103.7	102.4
1978	98.3	100.6	106.3	91.1	100.6	102.8	98.2	100.7	104.6	96.1	103.1	102.6
1979	97.9	100.7	108.1	90.2	98.7	101.4	97.8	99.8	105.5	96.5	99.6	102.1
1980	98.4	98.9	109.1	89.6	91.2	99.6	97.5	98.4	104.9	96.1	94.8	100.8
1981	97.7	97.4	108.7	87.4	89.4	99.6	96.0	96.0	104.1	89.5	94.2	101.0
1982	92.9	96.6	107.7	83.5	90.0	97.7	92.4	95.4	104.7	87.7	94.1	99.6
1983	92.2	96.9	108.6	79.3	94.3	101.2	92.0	96.9	105.6	82.9	96.3	102.6
1984	91.8	96.8	110.5	78.0	98.2	102.9	92.2	96.9	106.6	82.0	99.1	103.9
1985	91.5	97.2	109.8	80.4	100.6	102.7	91.7	95.1	106.5	83.3	101.3	103.9
1986	91.6	96.3	108.1	82.2	99.4	101.5	91.8	94.7	105.9	85.1	100.3	104.1
1987	92.1	94.1	108.9	82.4	102.2	101.2	92.2	93.9	106.3	86.8	99.2	104.2
1988	92.6	94.0	110.7	82.4	104.6	104.3	92.6	94.1	107.1	89.0	98.6	104.2
1989	92.7	93.7	109.7	83.3	101.8	103.7	92.7	93.1	105.7	93.0	98.8	104.5

(a) Total number of hours worked.
(b) UK series used for comparisons with France and the Netherlands exclude oil refining.
(c) `Basic Metals and Metal Products' included in `Machinery, Transport equipment and Electrical Engineering'.

Source: see below.

Appendix Table IV.9
Value Added per Hour Worked by Major Branch, 1973-1989, USA=100

	Food Products, Beverages and Tobacco Products				Textiles, Wearing Apparel and Leather Products			
	Germany	Japan	United Kingdom	United States	Germany	Japan	United Kingdom	United States
1973	63.8	28.0	39.5	100.0	75.9	75.2	61.9	100.0
1974	72.3	31.7	41.8	100.0	82.3	92.5	62.2	100.0
1975	69.8	31.2	40.8	100.0	82.8	91.9	60.6	100.0
1976	70.7	28.4	41.6	100.0	81.9	84.3	60.5	100.0
1977	71.9	31.4	42.3	100.0	78.6	76.1	55.1	100.0
1978	69.8	26.7	41.5	100.0	81.1	76.2	57.8	100.0
1979	70.4	28.6	40.9	100.0	82.4	79.1	55.7	100.0
1980	70.0	27.6	42.4	100.0	81.8	85.0	56.6	100.0
1981	71.3	27.5	44.1	100.0	86.6	85.5	60.0	100.0
1982	64.4	27.1	44.2	100.0	82.6	80.4	57.6	100.0
1983	64.7	27.8	44.2	100.0	83.6	79.0	62.4	100.0
1984	67.2	26.1	46.1	100.0	86.9	80.1	65.8	100.0
1985	68.7	24.0	45.1	100.0	86.4	76.2	66.0	100.0
1986	67.0	24.8	46.0	100.0	83.7	68.4	64.3	100.0
1987	65.7	23.6	48.0	100.0	84.6	69.5	65.5	100.0
1988	68.4	24.2	49.4	100.0	86.9	68.1	65.2	100.0
1989	68.6	24.6	49.3	100.0	90.6	62.0	64.9	100.0

	Chemicals, Oil Refining, Rubber and Plastics				Basic Metals and Metal Products			
	Germany	Japan	United Kingdom	United States	Germany	Japan	United Kingdom	United States
1973	85.0	68.9	64.5	100.0	63.9	76.2	42.5	100.0
1974	93.2	68.8	72.7	100.0	67.4	68.0	42.9	100.0
1975	87.4	79.0	67.3	100.0	79.1	72.3	44.5	100.0
1976	93.6	89.1	70.4	100.0	77.1	75.4	44.6	100.0
1977	91.7	93.4	68.1	100.0	82.0	73.0	44.6	100.0
1978	96.7	112.9	68.7	100.0	83.9	84.7	44.4	100.0
1979	100.1	92.5	70.8	100.0	85.9	99.9	47.0	100.0
1980	99.5	99.7	72.8	100.0	83.0	95.5	41.3	100.0
1981	95.7	110.0	75.7	100.0	82.9	85.2	47.1	100.0
1982	85.5	108.2	72.6	100.0	84.9	92.7	53.4	100.0
1983	84.1	94.5	73.6	100.0	90.7	89.5	62.1	100.0
1984	81.9	93.5	72.5	100.0	87.4	97.2	64.6	100.0
1985	79.9	97.6	71.9	100.0	89.2	101.9	62.7	100.0
1986	76.5	70.2	71.1	100.0	88.9	96.7	65.0	100.0
1987	66.3	87.1	73.5	100.0	81.8	96.4	65.7	100.0
1988	67.1	79.6	75.2	100.0	82.0	96.0	69.1	100.0
1989	70.0	91.5	79.1	100.0	84.4	97.7	67.3	100.0

Appendix Table IV.9 (continued) - Value Added per Hour Worked (USA=100)

	Machinery, Transport Equipment and Electrical Equipment				Other Manufacturing Industries			
	Germany	Japan	United Kingdom	United States	Germany	Japan	United Kingdom	United States
1973	87.4	57.5	61.2	100.0	65.6	40.4	45.9	100.0
1974	94.6	69.2	65.7	100.0	68.6	41.1	45.8	100.0
1975	96.9	70.2	64.2	100.0	68.2	39.1	44.1	100.0
1976	98.9	75.9	61.6	100.0	70.6	40.2	44.3	100.0
1977	97.4	78.2	58.6	100.0	71.5	40.7	44.3	100.0
1978	102.2	83.8	59.7	100.0	74.3	42.2	46.8	100.0
1979	108.0	96.4	60.8	100.0	76.4	44.3	48.4	100.0
1980	107.6	104.6	64.4	100.0	76.4	46.0	47.9	100.0
1981	111.3	111.6	66.9	100.0	76.1	50.3	48.5	100.0
1982	112.7	116.6	71.5	100.0	73.7	51.8	48.4	100.0
1983	104.5	110.6	67.0	100.0	75.3	54.7	49.6	100.0
1984	100.2	109.9	64.0	100.0	76.1	55.0	49.3	100.0
1985	96.5	111.2	61.3	100.0	76.2	59.7	48.8	100.0
1986	88.7	108.2	60.0	100.0	76.2	59.2	50.1	100.0
1987	83.2	107.8	56.9	100.0	75.6	60.3	53.4	100.0
1988	78.9	112.4	55.4	100.0	77.2	62.5	57.2	100.0
1989	80.4	117.9	59.1	100.0	77.9	67.9	59.8	100.0

Source: Appendix Tables IV.6 to IV.8.

Appendix Table IV.10
Value Added per Hour Worked by Major Branch, 1973-1989, UK=100

	Food Products, Beverages and Tobacco Products				Textiles, Wearing Apparel and Leather Products			
	France	Germany	Nether-lands	United Kingdom	France	Germany	Nether-lands	United Kingdom
1973	138.9	125.6	149.6	100.0	101.0	104.1	123.3	100.0
1974	147.7	134.6	153.7	100.0	111.1	112.4	122.2	100.0
1975	158.6	132.9	157.1	100.0	110.8	115.9	124.6	100.0
1976	149.3	132.1	159.5	100.0	107.6	115.0	138.1	100.0
1977	148.7	132.2	150.2	100.0	111.9	120.9	129.8	100.0
1978	139.7	130.9	153.6	100.0	109.3	119.1	137.3	100.0
1979	135.3	133.7	156.5	100.0	117.1	125.5	149.3	100.0
1980	134.8	128.4	153.6	100.0	119.6	122.7	145.3	100.0
1981	129.8	125.8	155.0	100.0	124.0	122.6	148.4	100.0
1982	138.1	113.2	152.2	100.0	134.1	121.7	161.2	100.0
1983	124.6	113.8	152.8	100.0	125.5	113.8	155.1	100.0
1984	120.8	113.4	152.6	100.0	120.2	112.2	160.9	100.0
1985	128.1	118.7	150.0	100.0	116.0	111.1	155.2	100.0
1986	124.6	113.3	154.9	100.0	115.4	110.6	140.9	100.0
1987	121.2	106.6	141.3	100.0	119.7	109.5	131.2	100.0
1988	117.6	107.8	144.0	100.0	123.7	113.1	136.8	100.0
1989	125.8	108.3	144.8	100.0	127.8	118.5	140.3	100.0

	Chemicals, Rubber and Plastics				Basic Metals and Metal Products			
	France	Germany	Nether-lands	United Kingdom	France	Germany	Nether-lands (a)	United Kingdom
1973	117.1	143.0	199.0	100.0	138.8	150.1		100.0
1974	111.9	141.9	216.3	100.0	141.8	156.7		100.0
1975	111.1	141.6	158.3	100.0	139.3	177.4		100.0
1976	106.6	150.1	164.7	100.0	151.2	172.3		100.0
1977	111.9	153.6	153.7	100.0	158.2	183.6		100.0
1978	118.7	157.4	162.2	100.0	168.5	188.5		100.0
1979	121.5	161.0	162.9	100.0	173.8	182.7		100.0
1980	119.2	149.8	162.8	100.0	190.4	200.8		100.0
1981	111.8	139.9	160.1	100.0	162.1	175.8		100.0
1982	116.0	130.7	153.2	100.0	152.6	158.9		100.0
1983	113.6	131.0	156.7	100.0	139.6	145.9		100.0
1984	112.4	129.9	165.8	100.0	131.9	135.0		100.0
1985	114.5	128.3	169.8	100.0	139.3	142.0		100.0
1986	107.2	120.3	158.1	100.0	138.8	136.5		100.0
1987	100.0	107.6	146.5	100.0	127.4	124.3		100.0
1988	101.0	107.0	143.1	100.0	125.4	118.5		100.0
1989	99.6	107.2	139.9	100.0	131.0	125.3		100.0

Appendix Table IV.10 (continued) - Value Added per Hour Worked (UK=100)

	Machinery, Transport Equipment and Electrical Equipment				Other Manufacturing Industries			
	France	Germany	Netherlands (a)	United Kingdom	France	Germany	Netherlands	United Kingdom
1973	111.4	121.6	113.0	100.0	101.0	145.0	236.6	100.0
1974	112.4	122.7	119.5	100.0	104.5	151.9	224.3	100.0
1975	115.7	128.6	109.2	100.0	108.5	156.7	210.9	100.0
1976	124.0	136.8	122.4	100.0	109.4	161.7	193.9	100.0
1977	134.0	141.7	127.1	100.0	116.9	163.7	182.2	100.0
1978	140.7	145.9	131.9	100.0	115.7	160.9	181.9	100.0
1979	144.6	151.3	149.8	100.0	117.3	160.3	177.6	100.0
1980	140.3	142.3	136.6	100.0	122.1	161.8	181.0	100.0
1981	141.0	141.8	132.0	100.0	120.0	159.4	172.5	100.0
1982	138.3	134.3	127.0	100.0	124.1	154.5	168.9	100.0
1983	138.9	132.8	125.4	100.0	122.6	154.0	173.1	100.0
1984	136.4	133.5	131.5	100.0	125.0	156.7	174.8	100.0
1985	136.4	134.2	129.2	100.0	130.3	158.4	166.9	100.0
1986	133.6	126.0	120.6	100.0	122.6	154.4	173.8	100.0
1987	134.9	124.7	114.4	100.0	113.0	143.7	183.3	100.0
1988	136.3	121.3	113.0	100.0	109.2	137.0	185.7	100.0
1989	130.2	115.8	110.1	100.0	107.2	132.2	177.5	100.0

(a) `Basic Metals and Metal Products' included in `Machinery, Transport equipment and Electrical Engineering'.
Source: Appendix Tables IV.6 to IV.8.

Sources Appendix IV:
Comparative productivity in benchmark years from appendix II, with extrapolation on the basis of the following time series:
Brazil: Value added for 1950-1985 from M.A. Gusmão de Veloso (1987), `Brazilian National Accounts, 1947-85', IBGE, Rio de Janeiro, processed; 1985-1987 updates provided by IBGE. Employees for 1970, 1975 and 1980 and 1985 on comparable basis from IBGE, *Censos Economicos Industria* for 1975, 1980 and 1985. Intermediate years interpolated by trends in number of employees ILO, *Yearbook of Labour Statistics*, various issues. 1985-87 extrapolated forwards from 1985 by trend in employees from ILO. 1950-70 extrapolated backwards from 1970 by trend in number of employees obtained from United Nations, *Statistical Yearbook*, various issues. Hours for 1975-1987 derived from monthly hours provided by Federacao das Industrias do Estado de Sao Paulo, October 1988; 1970 hours as for 1975. 1950-70 derived by geometric interpolation of annual hours for total economy for 1950 and 1973 from Angus Maddison (1990), `Growth and Slowdown in Latin America: A Long Run Comparative Perspective', Groningen, processed. This interpolated trend was linked to the 1970 estimate for manufacturing.

France: Value added for 1950-1959 from INSEE (1979), *Comptes Trimestriels 1949-1959*, Paris. 1959-1970 from INSEE (1978), *Retropolation des Comptes Nationaux dans le Nouveau Systeme de Comptabilité Nationale Francaise, Series 1959-1970*, Paris. 1970-1989 `valeur ajoutée' from INSEE, *Rapport sur les Comptes de la Nation 1989*, excluding U03 `Énergie'. Employment for 1950-1959 are `effectifs' from INSEE (1979); 1959-1970 are `effectifs employés' from INSEE, *Rapport Sur les Comptes de la Nation* (1965, 1969 and 1972); 1970-1989 is `emploi interieur total' from INSEE, *Rapport sur les Comptes de la Nation 1989*. Hours for 1950-1962 are weekly hours from INSEE (1979); 1962-1970 refer to average hours worked per year for the total economy from A. Maddison (1980), `Monitoring the Labour Market: A Proposal for a Comprehensive Approach in Official Statistics', *Review of Income and Wealth* (June). 1970-1989 is `durée annuelle effective' from INSEE, *Rapport sur les Comptes de la Nation 1989*.

Germany: Value added for 1950-1959 from production index from W.G. Hoffmann (1965), *Das Wachstum der Deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts*, Berlin, table 76 reweighted to exclude public utilities and construction; link 1959-60 taken from production index in Statistisches Bundesamt, *Lange Reihen zur Wirtschaftsentwicklung 1988*. 1960-1970 value added from *Volkswirtschaftliche Gesamtrechnungen, Revidierte Ergebnisse 1950-1990*; 1970-1990 from *Volkswirtschaftliche Gesamtrechnungen, Konten und Standardtabellen 1991*, 1992). Employees 1950-1959 are `beschäftigte' from Hoffmann (1965), table 15; 1959-60 link from Statisches Bundesamt, *Lange Reihen*; 1960-1970 are `erwerbstätige' from H. Kohler and L. Reyher (1988), *Arbeitszeit und Arbeitsvolumen in der Bundesrepublik Deutschland, 1960-1986*, Institut für Berufsforschung, Nürnberg; 1970-1990 from Statistisches Bundesamt, *Volkswirtschaftliche Gesamtrechnungen*, as above. Hours for 1950-1960 are `geleistete Arbeitsstunden' from Statisches Bundesamt, *Lange Reihen*; 1960-70 is `tatsächliche jahrliches arbeitszeit' from Kohler and Reyher (1988); 1970-1990 from Deutsches Institut für Wirtschaftsforschung (1991), *Produktionsvolumen und -potential, Produktionsfaktoren des Bergbaus und des Verarbeitendes Gewerbe*, Berlin.

India: 1950-1980 gross value added in registered manufacturing from CSO (1989), *National Accounts Statistics, 1950/51-1979/80*, New Delhi; 1980 to 1988 from CSO (1991), *National Accounts Statistics 1991*, New Delhi. Persons engaged in registered manufacturing for 1965-1987 from CSO, *Annual Survey of Industries*, annual issues. 1960-1965 derived by using estimates on persons employed in manufacturing for 1960 and 1970 from CSO (1981), *National Accounts Statistics, Sources and Methods*, the 1960-1965 trend in employees from ILO, *Yearbook of Labour Statistics 1970* and the 1965 figure as derived above. 1950-1960 interpolated from 1950 estimate from *Final Report of the National Income Committee* (1954) and the 1960 estimate as derived above. Hours are based on man-days worked divided by the number of workers from CSO, *Annual Survey of Industries*, various issues, assuming each man-day is equivalent to 8 hours. 1950-1965 assumed constant at 1965 level.

Japan: See Pilat (1991a, updated) and Pilat and van Ark (1992). Gross value added from Economic Planning Agency (1991), *Report on National Accounts from 1955 to 1989*, Tokyo. 1990 from printout of national accounts. Employment from Statistics Bureau, *Labour Force Survey*, various issues. Branch level estimates from Economic Planning Agency (1991). Sectoral breakdown adjusted with information from MITI, *Census of Manufactures, Report by Industries*, various issues. Hours from Ministry of Labour, *Monthly Labour Survey*, various issues. Sectoral breakdown adjusted with information from MITI, *Census of Manufactures*, various issues.

Korea: See Pilat (1991b). 1953-1970 from Bank of Korea (1975), *National Income in Korea 1975*, Seoul. 1970-1988 from Bank of Korea (1990), *National Accounts 1990*, Seoul. Employment from Economic Planning Board, Bureau of Statistics, *Economically Active Population Survey*, Seoul, various issues. Hours see Pilat (1991b) with benchmark estimates of hours for 1967, 1975 and 1987, and interpolated by trends from Economic Planning Board, Bureau of Statistics, *Economically Active Population Survey*, Seoul, various issues, and Ministry of Labour, *Report on Monthly Labour Survey*, Seoul.

Netherlands: value added at current prices for 1950-1968 from CBS, *Nationale Rekeningen* (1960, 1965 and 1970); 1969-1977 at current prices from CBS (1987) *Nationale Rekeningen, Tijdreeksen 1969-1984*; deflated at producer prices indexes from CBS (1989), *Negentig Jaren Statistiek in Tijdreeksen 1889-1989*, Voorburg. 1977-1984 at constant prices also from CBS (1987) *Nationale Rekeningen, Tijdreeksen 1969-1984*, Voorburg; 1984-1990 from CBS (1987 and 1990), *Nationale Rekeningen*, Voorburg. Figures on total hours for 1950-1966 from CBS (1967), *Arbeidsvolume en Geregistreerde Arbeidsreserve 1947-1966*, The Hague; 1966-1969 from CBS, *Nationale Rekeningen 1970*; 1969-1984 from CBS (1987); from 1984 onwards from CBS, *National Rekeningen*, annual issues.

United Kingdom: net output at current prices for 1950-1970 from BSO (1978), *Historical Record of the Census of Production 1907-1970*, and for 1971-1973 from *Report on the Census of Production*, various issues, deflated by producer price index for total manufacturing from *Annual Abstract of Statistics*; 1952, 1953, 1954-57, 1959-63 and 1964-67 interpolated on the basis of manufacturing GDP trend from CSO, *National Income and Expenditure Accounts*, various issues. 1973-1990 GDP at constant factor cost from CSO, *National Income and Expenditure Accounts*, London various issues. Employment for 1950-1973 from BSO (1978), *Historical Record of the Census of Production 1907-1970*; 1952, 1953, 1954-57, 1959-63 interpolated with series from C.H. Feinstein (1972), *Statistical Tables of National Income, Expenditure and Output of the UK 1855-1965*; 1973-1989 are `employees in employment' in manufacturing in United Kingdom as provided by Department of Employment. Hours for 1950-1956 are average weekly hours of manual men (full-time) from *British Labour Statistics 1886-1968*, tables 43 and 44. 1956-1968 hours worked refer to actual hours worked per operative during monthly reference weeks, from *Dept. of Employment Gazette* (various issues), table 1.12; 1968-1971 hours based on October Survey as calculated by O'Mahony (1992a); 1971-1989 hours based on index of total hours from *Employment Gazette* divided by the number of employees.

United States: gross national product in manufacturing for 1950-1977 from US Dept. of Commerce (1986), *National Income and Product Accounts 1929-1982*, Washington D.C.; 1977-1989 from *Survey of Current Business*, January and April 1991. 1989-1990 production index from US Dept. of Commerce, *Statistical Abstract of the United States 1991*. Full-time and part-time employees plus self-employed persons 1950-1982 from US Dept. of Commerce (1986), *National Income and Product Accounts 19291982*, Washington D.C.; 1982-1990 from *Survey of Current Business*, July issues. Hours based on benchmark estimates of hours actually worked for 1987 (table 4.6), 1975 (table 4.5) and 1967 (Pilat, 1991b); the intermediate years are interpolated, and the figures for the period 1950-1967 and 1987-1989 are extrapolated with trends of hours per employee from US Dept. of Commerce (1986), *National Income and Product Accounts of the United States, 1929-1982* and Survey of Current Business, recent issues.

Appendix V - Regression Results in Convergence Analysis

Y_M = estimated annual compound growth rate for manufacturing (M).
A_M = comparative level of value added per hour worked (USA =100) for manufacturing.
Y_G^X and Y_G^U = estimated annual compound growth rate for major groups of manufacturing branches (G) in country X and country U respectively.
A_G^X = comparative level of value added per hour worked in country X (regressions (4) to (7) with USA=100.0 and regressions (8) to (11) with UK=100.0) in initial year of the period for major groups of manufacturing branches (G).
Figures between brackets are standard errors.

1) Sample for total manufacturing for advanced countries (France, Germany, Japan, Netherlands, the United Kingdom and the United States) for 1950-73, 1973-79 and 1979-1989.

$$Y_M = \underset{(1.11)}{19.1} - \underset{(1.35)}{8.45} \log(A_M) \qquad N=18 \qquad R^2=0.71$$

2) Sample for total manufacturing for all countries (Brazil, India, Korea, France, Germany, Japan, Netherlands, the United Kingdom and the United States) for 1950-73, 1973-79 and 1979-1989.

$$Y_M = \underset{(2.16)}{6.7} - \underset{(0.95)}{1.74} \log(A_M) \qquad N=27 \qquad R^2=0.13$$

3) Sample for total manufacturing for all countries, but with interaction dummy variable (D_d) representing the initial productivity level (USA= 100.0) for developing countries (Brazil, India, Korea) for 1950-73, 1973-79 and 1979-1989.

$$Y_M = \underset{(1.96)}{9.6} - (\underset{(1.03)}{3.14} + \underset{(0.84)}{2.11}\, D_d) \log(A_M) \qquad N=27 \qquad R^2=0.28$$

4) Sample for major groups of manufacturing branches for Germany, Japan, United Kingdom and United States for 1973-1979.

$$Y_G^X - Y_G^U = -\underset{(2.46)}{6.9} + \underset{(4.51)}{5.21} \log(A_G^X) \qquad N=18 \qquad R^2=0.08$$

5) Sample for major groups of manufacturing branches for Germany, Japan, United Kingdom and United States with interaction dummy variables (D_T; D_C; D_B; D_I; D_O) for major groups of branches other than food (T=textiles; C=chemicals; B=basic metals; I=machinery, electrical and transport equipment; O=other manufacturing) for 1973-1979.

$$Y_G^X - Y_G^U = -\underset{(2.36)}{6.28} + (\underset{(6.39)}{4.42} - \underset{(1.36)}{0.94}\, D_T + \underset{(1.36)}{0.65}\, D_C + \underset{(1.25)}{1.27}\, D_B +$$
$$\underset{(1.32)}{1.27}\, D_I + \underset{(1.19)}{0.27}\, D_O) \log(A_G^X) \qquad N=18 \qquad R^2=0.42$$

6) Sample for major groups of manufacturing branches for Germany, Japan, United Kingdom and United States for 1979-1989.

$$Y_G^X - Y_G^U = 11.5 - 6.11 \log(A_G^X)$$
(1.98) (3.00) N=18 R^2=0.20

7) Sample for major groups of manufacturing branches for Germany, Japan, United Kingdom and United States with interaction dummy variables (D_T; D_C; D_B; D_I; D_O) for major groups of branches other than food (T=textiles; C=chemicals; B=basic metals; I=machinery, electrical and transport equipment; O=other manufacturing) for 1979-1989.

$$Y_G^X - Y_G^U = 13.4 - (8.07 + 0.85\,D_T + 0.67\,D_C + 1.44\,D_B +$$
(2.11) (4.80) (1.12) (1.20) (1.14)

$$0.92\,D_I + 1.61\,D_O) \log(A_G^X)$$
(1.20) (1.05) N=18 R^2=0.38

8) Sample for major groups of manufacturing branches for France, Germany, the Netherlands and the United Kingdom for 1973-1979.

$$Y_G^X - Y_G^U = 35.58 - 15.91 \log(A_G^X)$$
(1.52) (3.82) N=17 R^2=0.54

9) Sample for major groups of manufacturing branches for France, Germany, the Netherlands and the United Kingdom with interaction dummy variables (D_T; D_C; D_B; D_I; D_O) for major groups of branches other than food (T=textiles; C=chemicals; B=basic metals; I=machinery, electrical and transport equipment; O=other manufacturing) for 1973-1979.

$$Y_G^X - Y_G^U = 30.00 - (13.80 + 0.57\,D_T - 0.11\,D_C + 1.58\,D_B +$$
(1.07) (3.39) (0.45) (0.41) (0.46)

$$1.09\,D_I + 0.38\,D_O) \log(A_G^X)$$
(0.44) (0.41) N=17 R^2=0.85

10) Sample for major groups of manufacturing branches for France, Germany, the Netherlands and the United Kingdom for 1979-1989.

$$Y_G^X - Y_G^U = 25.03 - 12.34 \log(A_G^X)$$
(1.08) (4.36) N=17 R^2=0.35

11) Sample for major groups of manufacturing branches for France, Germany, the Netherlands and the United Kingdom with interaction dummy variables (D_T; D_C; D_B; D_I; D_O) for major groups of branches other than food (T=textiles; C=chemicals; B=basic metals; I=machinery, electrical and transport equipment; O=other manufacturing) for 1979-1989.

$$Y_G^X - Y_G^U = 9.22 - (4.85 + 0.44\,D_T - 0.61\,D_C - 0.76\,D_B -$$
(0.91) (-1.02) (1.23) (-1.77) (-1.78)

$$0.32\,D_I - 0.02\,D_O) \log(A_G^X)$$
(-0.91) (-0.05) N=17 R^2=0.69

Appendix VI - Standardised Estimates of Capital Stock

The perpetual inventory method (PIM) is based entirely on the availability of series on gross investment in constant prices and assumptions concerning the retirement of the assets. These assumptions concern the average life and the retirement pattern of assets. For estimates of net capital stock, one should make further assumptions about the depreciation pattern.

Gross versus Net Capital Stock
For productivity comparisons the `gross concept' of capital is preferable to the `net concept'. Depreciation as practised by firms is largely determined by the financial life time of an asset and it is to a large extent influenced by taxing practices. The gross stock-concept assumes that the productive capacity of assets remains constant over time, which is not unrealistic in particular when maintenance and repair are effective and when the capital market is sufficiently competitive and flexible to prevent assets being left idle for very long.

The Level of Disaggregation
In this study my estimates are based on aggregate investment series for manufacturing for two different asset types, i.e. non-residential structures and equipment including vehicles. There are two elements of compositional differences between countries which may not come out from these capital stock estimates. Firstly, the assets can be further disaggregated into types for which separate asset lives can be applied. Secondly, the various asset types can be distributed in different proportions among the branches and industries in manufacturing.

In a study of five OECD countries, O'Mahony (1992b) shows that the difference between an estimate of the capital stock based on investment series for the economy as a whole compared to a disaggregated estimate constructed on the basis of investment in eight sectors is some two to three per cent both for equipment and for structures. Given the greater similarity of production processes within the manufacturing sector, one may assume that the difference between my aggregated estimates for the manufacturing capital stock and more disaggregated estimates at branch level is even less than suggested by O'Mahony.

Asset Lives

Assumptions on asset lives are very different between countries, as can be seen from appendix table VI.1 which is taken from Blades (1989). Asset life assumptions are clearly highest for the United Kingdom and lowest for Japan, though I do not have estimates for structures in Japanese manufacturing. The `OECD-figure' is an unweighted average of lives used in the individual member countries as far as information was available. The average for machinery and vehicles and the average for structures were used for the capital stock estimates of this study.

Appendix Table VI.1
Assumptions for Asset Lives in Manufacturing Compared to Arithmetic Average for OECD Countries

	France	Germany	Japan	UK	USA	OECD Average
Machinery	18	[a]	11	26	17	19[b]
Vehicles	16	[a]	5	16	18	14[c]
Average	--	15	--	--	--	17[d]
Structures	37	41	[a]	60	32[e]	45[f]

[a] not separately available
[b] average for 14 OECD countries
[c] average for 10 OECD countries
[d] own calculation
[e] excluding engineering construction
[f] average for 12 OECD countries
Source: OECD (1993), tables 1 to 5.

The asset life assumptions are the predominant force behind the actual level of the capital stock estimates in this study. Appendix table VI.2 compares relative levels to the USA in 1985 based on alternative assumptions, which either reflect the long British life assumptions (column 2) or the relatively short American life assumptions (column 3).

Retirement Patterns

Different types of retirement patterns, such as simultaneous retirement of all assets at the end of the average life time and bell-shaped retirement patterns around the end of the average life time (e.g. Winfrey curves) are discussed by Blades (1989, 1991) and O'Mahony (1992b). For the present study I used a `delayed linear' retirement pattern, which assumes that assets are retired uniformly between 20 per cent below and 20 per cent above the average service life.

Appendix Table VI.2
Estimates of Manufacturing Capital Stock in 1985 Based on Alternative Assumptions Concerning Asset Lives of Equipment and Vehicles and Structures (1985 billion US$)

	45[a]& 17[b] years	60 & 24 years	32 & 15 years
France	326	389	284
Germany	535	635	483
Japan	804	911	762
Netherlands	102	122	92
United Kingdom	283	354	250
United States	1,579	1,817	1,433

[a] structures; [b] equipment and vehicles;
Source: Calculations on the basis of the perpetual inventory method.
See text and appendix table VI.1.

As a matter of fact the different assumptions on retirement patterns do not make much difference to the series. For all countries the spread in retirement led to a slightly higher level of capital stock compared to rectangular retirement, but on average the difference for all observations (six countries times up to 40 annual estimates) was less than 2 per cent. In some cases when the investment figures for the countries did not go back quite far enough to apply the delayed linear retirement pattern, I used the results based on rectangular scrapping for the Netherlands (1955-1964), France (1950) and Japan (1950-1959).

War-damage adjustment
Not all investment survived until the end of their life time due to war damage during the period 1914-1918 and I followed the assumptions on war-damage to investment made before the first and second world war as put forward by Maddison (1992b), except for the Netherlands. The adjustments were as follows: France: 16 per cent of all investment done before 1919 and 8 per cent of investment between 1919 and 1945; Japan: 25.7 per cent of all investment before 1946; United Kingdom: 3 per cent of all investment before 1945. For Germany the war-damage adjustments were already worked into estimates by Kirner (1968). Netherlands: 17 per cent of all investment before 1945 (Van Zanden and Griffiths, 1989, p. 186);

Investment in Structures and Equipment and Vehicles in Manufacturing

The investment figures in this study are for non-residential structures and depreciable assets in manufacturing. Land, inventories and intermediate inputs are excluded. Postwar investment figures are largely taken from the national accounts, taking the 1985 figures in 1985 prices as the starting point. Like in the case of output indexes the comparability over time of these estimates is usually better guaranteed when based on the natinal accounts than with other direct sources, such as production censuses, industry surveys and tax records from companies. Most national accounts apply a commodity flow method to derive investment, which is based on input-output tables which make extensively use of the various other sources in conjunction with each other.

In the case of Japan, Dean, Darrough and Neef (1990) have argued strongly in favour of using investment data from the census over those from the Economic Planning Agency's national accounts, as in particular the deflation procedure in the latter source seems very crude. However, the problems with the census series are also substantial most importantly the need for to adjust for investment by the smallest establishments. By applying the perpetual inventory method (using my assumptions described above) to the census- and the EPA investment figures, I found that the capital stock resulting from the first source was about 33 per cent below the national accounts-based estimate in 1985. This indicates that the census probably underestimates manufacturing investment substantially.

In two instances, i.e. France and Netherlands (in the latter case only for buildings), there were no appropriate independent series on manufacturing investment available for the prewar period. In these two cases I compiled a proxy estimate of the trends in prewar investment, which I linked to the 1950 investment level. The assumption was that the trend in the investment/employment ratio for the total economy was representative for manufacturing. For this purpose I used gross investment at constant prices and employment estimates for the total economy from Maddison (1991; 1992b). Manufacturing employment was then taken from other historical sources (see below). The manufacturing investment figures which resulted from this approach for benchmark years were then interpolated for intermediate years with trends of gross investment for the total economy.

Appendix Table VI.3
Gross Investment in Manufacturing Structures and Equipment (incl. Vehicles), 1890-1989, 1985=100.0

	France		Germany		Japan		Netherlands		United Kingdom		United States	
	Struc-tures	Equip-ment	Struc-tures	Equip-ment	Struc-tures	Equip-ment	Struc-tures	Equip-ment	Struc-tures	Equip-ment	Struc-tures	Equip-ment
1890			13.6						14.8			
1891			14.1						15.1			
1892			16.4						20.8			
1893			17.5						20.6			
1894			19.2						26.5			
1895			23.2						25.1		22.3	
1896	30.1		24.3						17.9		28.9	
1897	31.1		25.5						36.7		23.3	
1898	33.0		26.6						35.1		17.7	
1899	34.1		25.5						41.0		17.7	
1900	35.2		20.4						44.3		14.3	
1901	35.5		17.5						42.8		16.4	
1902	34.9		18.7						47.8		27.9	
1903	34.2		24.9						57.0		26.4	
1904	34.9		29.4						40.8		17.6	
1905	36.1		29.4		0.6	0.6			36.6		18.2	
1906	35.9		30.6		0.8	0.4		6.9	38.0		23.8	
1907	35.7		25.5		0.9	0.5		6.9	30.8		24.9	
1908	37.3		17.5		0.8	0.7		6.9	30.8		25.3	
1909	39.4		14.1		0.8	0.5		6.9	25.7		29.1	
1910	41.5		20.4		1.3	0.4	38.2	6.9	41.3		29.4	
1911	44.2		24.9		1.6	0.4	38.2	6.9	36.6		33.7	
1912	47.3		23.2		0.9	0.7	41.6	6.9	46.2		40.5	
1913	47.2		17.5		0.7	0.7	43.7	6.9	40.8		35.6	
1914	42.9		17.0		0.9	0.5	41.9	6.6	38.6		24.1	
1915	34.0		13.0		0.6	0.4	44.0	6.9	44.3		22.9	
1916	28.8		11.9		0.6	0.6	45.8	7.1	38.5		24.9	
1917	28.4		12.5		0.7	0.7	42.3	6.6	40.5	7.2	28.7	
1918	17.5		7.4		0.6	0.7	39.2	6.1	30.9	6.5	27.9	
1919	20.2		4.5		1.0	1.0	49.9	7.7	75.2	4.3	37.4	
1920	23.3		13.6		1.0	0.9	52.1	8.0	94.2	12.1	82.2	
1921	26.8		23.2		1.3	1.0	55.6	8.6	65.9	15.9	44.2	8.1
1922	30.9	12.8	26.6		1.6	0.9	48.6	7.9	52.1	12.3	37.3	9.5
1923	38.1	11.9	17.0		1.2	0.6	47.0	6.3	43.7	12.5	45.3	13.9
1924	47.7	16.1	17.0		2.2	0.6	47.4	7.2	46.2	12.0	33.6	10.5
1925	45.8	13.9	23.2		2.2	0.5	48.5	8.1	65.9	15.4	31.1	11.7
1926	54.9	15.6	19.8	5.2	2.2	0.4	56.6	9.0	54.4	14.3	45.3	11.5
1927	44.5	12.6	23.8	7.0	2.6	0.5	62.0	9.5	46.8	14.9	48.5	11.1
1928	50.2	17.2	26.0	7.7	2.1	0.6	68.8	10.9	39.3	17.8	56.3	11.8
1929	59.4	17.8	19.8	5.7	2.7	0.8	76.9	10.9	63.2	16.8	67.5	14.6
1930	64.0	19.5	15.3	4.5	2.2	0.7	84.6	13.2	58.7	13.6	40.9	12.3
1931	58.6	15.8	9.1	2.7	2.3	0.4	90.9	8.9	35.5	13.8	19.1	8.7
1932	50.5	11.5	5.1	1.4	2.5	0.6	80.5	5.1	30.6	14.0	6.2	5.7
1933	45.9	12.5	7.9	1.8	2.8	1.0	71.2	5.6	33.2	13.1	17.4	6.7
1934	40.8	11.8	13.0	3.6	3.8	1.9	71.5	5.7	35.8	20.9	18.3	8.6
1935	38.1	11.5	20.9	5.3	4.5	2.3	68.6	4.9	41.8	20.0	14.0	11.0
1936	38.2	12.5	27.2	7.0	4.2	2.4	64.3	5.5	65.0	26.4	23.9	14.6
1937	36.5	14.9	33.4	9.3	5.5	2.5	65.1	7.8	99.0	28.3	38.0	17.3
1938	32.6	12.0	43.0	12.1	5.3	4.7	75.8	9.6	90.0	29.2	16.5	12.4
1939	32.6	12.0	49.8	14.6	9.4	6.4	80.8	10.9	121.7	31.7	18.9	14.0
1940	13.8	5.1	53.8	16.4	4.6	7.9	45.4	6.1	182.6	62.0	33.5	17.9
1941	11.0	4.0	54.3	17.4	4.8	8.2	32.7	4.4	156.3	48.4	65.2	20.4
1942	9.8	3.6	53.8	18.5	4.0	6.9	18.6	2.5	119.3	35.5	23.1	18.2
1943	9.3	3.4	47.0	16.2	5.0	8.6	14.9	2.0	74.9	20.6	8.3	16.4
1944	8.1	3.0	32.8	11.4	5.0	8.6	0.0	0.0	41.8	12.7	10.3	23.2
1945	8.8	3.2	9.6	2.8	2.5	4.3	0.0	0.0	21.2	11.8	32.6	29.8
1946	26.7	9.8	13.0	3.2	4.1	2.2	28.0	5.5	38.0	15.6	78.8	34.5
1947	36.2	13.3	18.1	3.8	4.1	2.2	60.0	11.7	83.5	27.5	58.9	42.5
1948	49.9	18.3	45.8	8.2	4.6	2.4	75.1	13.5	71.7	35.0	42.1	39.0
1949	51.5	18.9	68.5	12.9	4.6	2.4	79.4	18.1	82.0	39.1	31.1	28.0

Appendix Table VI.3 (continued) - Investment

	France		Germany		Japan		Netherlands		United Kingdom		United States	
	Struc-tures	Equip-ment	Struc-tures	Equip-ment	Struc-tures	Equip-ment	Struc-tures	Equip-ment	Struc-tures	Equip-ment	Struc-tures	Equip-ment
1950	51.9	19.1	86.0	16.1	5.0	2.6	81.2	19.8	91.9	43.8	33.2	29.3
1951	52.7	21.2	90.5	20.2	5.6	3.0	79.9	17.5	87.7	47.5	59.1	36.5
1952	48.5	19.8	83.2	22.4	6.6	3.5	71.7	16.8	90.7	44.5	62.2	36.9
1953	49.0	20.2	83.2	26.8	7.6	4.0	69.4	15.1	92.8	43.4	58.0	37.2
1954	45.8	20.5	93.9	31.9	7.9	4.2	75.6	18.4	104.4	47.7	55.8	37.1
1955	50.1	24.3	131.3	38.5	6.5	3.8	98.9	21.8	133.6	50.6	58.2	37.3
1956	55.8	28.5	141.5	38.4	9.3	5.4	94.9	25.5	165.0	56.4	88.2	45.2
1957	62.5	33.5	125.1	39.1	14.9	8.5	109.3	28.1	166.5	60.0	83.6	45.0
1958	66.2	33.9	122.8	39.6	15.6	8.9	92.5	22.6	148.2	58.9	57.0	33.3
1959	68.2	33.3	141.5	41.7	16.5	10.1	102.7	25.7	139.7	58.9	49.9	33.4
1960	74.9	37.6	177.7	49.9	27.8	14.0	94.2	33.2	164.3	70.0	72.5	37.5
1961	91.4	44.5	187.7	55.8	37.2	19.8	138.4	39.0	200.3	82.0	72.8	36.1
1962	94.4	50.6	159.3	59.6	46.9	23.0	141.0	40.4	189.9	75.6	71.6	39.8
1963	89.3	53.9	148.1	57.8	44.1	23.0	136.9	41.1	148.8	68.2	76.2	41.9
1964	90.5	57.3	148.0	64.2	49.0	24.6	153.0	43.0	171.3	76.4	82.7	50.3
1965	89.4	57.3	153.8	71.4	47.2	25.1	137.3	43.7	197.2	88.0	120.3	62.3
1966	95.2	63.4	154.1	71.5	37.3	23.4	152.6	51.7	185.8	91.2	151.8	71.5
1967	100.1	65.0	116.4	63.1	50.1	33.9	160.2	55.4	160.1	88.6	142.9	68.2
1968	100.7	67.6	103.0	69.0	73.7	44.7	146.0	58.1	168.5	96.8	123.8	67.0
1969	106.8	84.1	143.7	87.5	87.8	55.4	132.9	65.0	200.2	103.1	127.5	70.0
1970	121.6	92.2	189.1	101.9	103.5	65.3	180.2	78.3	199.8	109.0	115.3	68.2
1971	138.1	96.8	189.8	101.7	106.6	67.7	142.5	70.2	174.5	101.0	95.9	62.2
1972	153.4	96.2	157.1	92.8	93.2	63.1	111.7	63.1	142.1	89.1	89.5	68.6
1973	152.5	106.5	142.3	85.4	85.1	64.4	128.9	67.9	136.7	97.9	92.9	75.5
1974	144.9	95.9	123.1	78.6	93.4	60.2	147.2	78.8	135.0	109.8	113.0	91.4
1975	126.0	77.0	100.1	75.6	80.0	52.1	129.5	59.7	124.4	99.6	92.9	82.6
1976	122.5	86.7	99.5	80.8	68.7	58.5	94.3	57.0	102.4	98.0	94.4	83.9
1977	131.5	88.5	115.0	83.4	66.4	59.9	108.4	69.0	110.9	102.2	91.1	91.9
1978	125.7	89.2	108.1	84.8	59.9	55.1	123.2	77.5	124.5	107.9	104.1	102.3
1979	134.7	88.3	120.1	93.5	59.9	59.3	126.9	81.5	127.1	112.6	123.7	105.4
1980	131.6	96.0	131.2	100.3	63.5	64.2	126.8	80.7	101.8	98.8	114.3	109.1
1981	111.8	90.2	115.3	94.4	76.9	73.5	99.4	72.2	77.0	74.6	117.0	104.5
1982	103.7	86.1	102.5	86.1	80.6	76.8	92.6	69.1	65.0	73.7	112.6	93.1
1983	104.3	85.0	93.3	89.2	74.4	81.1	79.8	73.3	56.8	76.3	83.8	77.3
1984	97.5	89.1	96.4	86.6	79.5	89.4	90.8	86.1	83.6	90.3	92.7	90.6
1985	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1986	106.7	106.2	124.1	106.0	91.3	98.9	114.6	106.8	90.0	98.9	86.8	89.8
1987	116.0	113.9	133.7	111.1	76.8	90.0	138.2	109.8	103.2	105.4	83.2	89.6
1988	129.9	127.6	129.0	114.2	87.4	103.8	141.0	116.7	119.4	116.9	88.5	100.2
1989	140.2	137.8	141.3	124.4	111.8	119.4	153.6	120.3	111.8	124.6	104.4	114.1

Sources Table 6A.3

France: 1980-1989 total investment in manufacturing at constant prices were derived from INSEE, *Rapport sur les Comptes de la Nation 1989*, including food products and excluding energy industries. 1970-1980 from OECD (1989), Flows and Stocks of *Fixed Capital, 1962-1987*, Paris. These figures correspond with those from INSEE. The shares of structures and equipment from the OECD source were used for the 1980-1989 series. 1960-1970 investment in structures and equipment/vehicles was taken from B. Siedel (1981), *Berechnung des Industriellen Brutto-Anlagevermögens in den EG-Ländern unter Anwendung einheilicher Definitionen, Abgrenzungen und Verfahren*, Deutsches Institut für Wirtschaftsforschung, Berlin. These investment series are based on unpublished national accounts from INSEE. 1950-1960 investment in manufacturing at constant prices were taken from J.J. Carré, P. Dubois en E. Malinvaud (1972), tableau annexe XI, with shares for selected years from p. 150.
1896-1950 investment in structures and 1922-1950 investment in equipment was derived from the ratio of investment to employment for the total economy from Maddison (1992b) (see above). Maddison's figures for gross investment at constant prices were extrapolated backwards on the basis of J.J. Carré, P. Dubois en E. Malinvaud, *op. cit.*, p. 652. Manufacturing employment was taken from L.A. Vincent (1965), `Population Active, Production et Productivité dans 21 Branches de l'Économie *française*', *Études et Conjuncture*, February.
Germany: 1960-1988 from Statistisches Bundesamt, *Volkswirtschaftliche Gesamt-rechnungen, Revidierte Ergebnisse 1950-1990. 1989 and 1990 from Volkswirtschaftliche Gesamt-rechnungen*, recent issues. Investment in structures (1890-1960) and equipment/vehicles (1926-1960) from W. Kirner (1968), *Zeitreihen für das Anlagevermögen der Wirtschaftsbereiche in der Bundesrepublik Deutschland*, Deutsches Institut für Wirtschaftsforschung, Berlin.
Japan[1]: 1965-1989 total manufacturing investment (excluding construction in progress) from Economic Planning Agency (1991), *Gross Capital Stock of Private Enterprises*. 1954-1965 investment in structures and equipment/vehicles at current prices derived from MITI, *Census of Manufactures* (various issues) with adjustments for establishments with less than 20 employees (1963-1965) and less than 4 employees (1954-62). These figures were deflated at producer price indexes from Bank of Japan, *Price Indexes Annual*. The real investment figures from the census were also estimated for the period 1965 to 1989, from which the shares for structures and equipment/vehicles were applied to the EPA series referred to above; 1940-1954 real investment are approximated on the basis of the trend in non-residential investment in the private sector from K. Ohkawa and H. Rosovsky (1973), p. 293. The 1946 to 1953-shares of assets were assumed to be the same as those for 1954. For 1941 to 1945 I used the 1940-asset shares; 1905-1940 total manufacturing investment in mining and manufacturing from Ohkawa and Rosovsky, *op. cit.*, p. 294. Shares for structures and equipment/vehicles were derived from a series on the gross domestic capital formation (excluding dwellings) in the nonprimary industry from K. Ohkawa and M. Shinohara (1979), *Patterns of Japanese Economic Development*, Yale University Press.

[1] I am very grateful to Dirk Pilat who provided me with figures and advice on using the information on Japanese investment.

Netherlands[2]: 1963-1989 investment at current prices from CBS, *Nationale Rekeningen*, various issues, including *Nationale Rekeningen, Tijdreeksen 1969-1984* (1987). Investment at constant prices from the same sources. As the latter series included mining, public utilities and construction, the implicit deflator was applied to investment in manufacturing at current prices to obtain a constant-price series for manufacturing only.
The manufacturing series at constant prices for the period 1969 to 1984 was divided up into structures and equipment and vehicles as follows. Current price figures on investment in structures and equipment/vehicles from CBS, *Investeringen in Vaste Activa door de Nijverheid* (various issues) were deflated at a price index for dwellings and a producer price index for machinery respectively. The shares of structure and equipment/vehicles in constant prices were applied to the national accounts figures on real investment derived above.
1906-1963 investment in equipment and vehicles at constant prices were derived from H. den Hartog and H.S. Tjan (1979), *A Clay-Clay Vintage Model Approach for Sectors of Industry in the Netherlands*, Central Planning Bureau, Occasional Papers, No. 17, appendix table 7.1.
1950-1963 investment in structures at constant prices were derived from total manufacturing investment at current prices from CBS, *Nationale Rekeningen*, various issues, which, after an adjustment for the share of structures were deflated at the price index for dwellings.
1910-1950 investment in structures were derived from the ratio of investment in structures to employment for the total economy (Maddison, 1991; 1992b; see above). Manufacturing employment was derived from Maddison (1991) by applying labour force shares for census years from CBS (1966), *13e Algemene Volkstelling 31 mei 1960, Deel 10.C, Vergelijking van de uitkomsten van de beroepstellingen 1849-1960* to Maddison's employment figures.

United Kingdom: Postwar investment figures are from CSO, *United Kingdom National Accounts*, various issues. Figures from 1987 backwards are taken from unpublished sources from the Central Statistical Office. Some detail on the origin of thee sources is given in CSO (1985), *United Kingdom National Accounts: Sources and Methods*, London. For the postwar period CSO largely uses information from production censuses and company accounts. For the CSO estimates of investment for the period 1938 to 1948 and the period before 1920 use has been made of G.A. Dean (1964), `The Stock of Fixed Capital in the United Kingdom', *Journal of the Royal Statistical Society*, Series A, pp. 327-358. For 1920 to 1938 they use C.H. Feinstein (1965), *Domestic Capital Formation in the United Kingdom 1920-1938*, Cambridge. See Maddison (1992b) and O'Mahony (1992b) for a critique of the CSO estimates, in particular those concerning the pre-1920 period.

United States: 1895-1985 manufacturing investment in structures and equipment from US Dept. of Commerce (1986), *Fixed Reproducible Tangible Wealth in the United States*, Washington D.C.. Recent years from BEA Wealth Data Tape.

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[2] See also H-J. Brinkman and J. Schiphorst (1987), `An Estimation of the Gross Tangible Fixed Capital Stock in the Netherlands for the period 1951-1973', *Research Memorandum No. 212*, Institute of Economic Research, Groningen.

Appendix Table VI.4
Gross Capital Stock in Manufacturing in 1985 US dollars, 1950-1989

	Germany	Japan	France	Nether-lands	United Kingdom	United States
1950	85.9		67.0		99.0	499.0
1951	91.7	41.4	68.9		103.1	517.9
1952	97.9	42.7	70.8		107.0	541.6
1953	104.3	44.3	72.6		110.1	564.7
1954	111.7	46.1	74.6		113.0	586.1
1955	121.0	47.4	77.1		116.1	606.4
1956	131.7	48.3	80.4	30.2	120.2	631.2
1957	142.1	50.2	84.8	31.7	125.1	659.8
1958	152.3	52.9	89.9	33.3	130.3	680.6
1959	163.4	56.3	95.2	34.8	135.5	693.0
1960	177.1	61.1	100.8	36.6	141.6	705.7
1961	193.6	70.3	107.5	38.9	149.8	719.0
1962	211.1	82.9	115.1	41.7	158.8	731.8
1963	228.1	96.8	123.1	44.4	166.5	745.8
1964	245.3	111.4	131.1	46.9	173.8	762.8
1965	264.0	127.1	139.1	51.0	182.3	788.7
1966	283.2	143.0	147.3	53.6	191.3	826.7
1967	299.8	162.1	155.9	56.6	199.6	868.1
1968	314.3	188.3	164.7	59.6	207.6	906.1
1969	331.2	222.4	174.7	62.6	216.5	943.4
1970	352.9	263.9	186.7	66.2	226.1	979.6
1971	376.4	307.4	199.8	70.0	235.1	1,009.6
1972	397.6	348.4	213.3	73.0	242.2	1,037.5
1973	415.2	388.8	227.5	75.7	248.5	1,069.9
1974	429.5	428.5	241.2	78.9	255.5	1,112.2
1975	441.0	464.4	251.7	81.8	261.9	1,157.2
1976	451.5	497.2	260.8	83.7	267.0	1,198.1
1977	462.4	529.2	270.2	85.6	271.8	1,241.6
1978	473.1	557.6	279.4	88.1	276.8	1,291.3
1979	484.1	585.4	288.2	90.9	282.2	1,346.1
1980	496.5	618.2	297.0	93.5	286.3	1,401.2
1981	508.4	654.4	305.2	95.7	287.2	1,452.8
1982	517.3	690.8	311.6	97.3	285.9	1,495.9
1983	524.1	725.8	316.8	98.6	284.1	1,524.0
1984	529.7	762.3	321.3	100.2	283.0	1,547.6
1985	535.4	804.4	326.2	102.3	283.3	1,578.9
1986	543.2	847.3	331.6	104.9	283.9	1,608.1
1987	552.5	886.6	337.6	107.8	284.7	1,630.6
1988	562.4	928.3	345.0	111.0	286.6	1,654.8
1989	573.4	981.7	354.3	114.4	289.5	1,687.6

Source: investment from appendix table VI.3. For method of calculation see text above.

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