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INVESTMENT, INNOVATION AND COMPETITIVENESS:

SECTORAL PERFORMANCE WITHIN THE TRIAD

BY

ANDREW WYCKOFF

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Executive Summary

This report uses two newly developed OECD databases to examine sectoral performance over the last two decades for a dozen countries which include the United States, Japan, Canada, the four largest European countries as well as the Netherlands and four of the Nordic countries. Performance is evaluated by constructing nearly a dozen indicators which cover four broad areas of economic activity and which correspond to features affected by industrial and technology policy: investment in plant and equipment, investment in R&D, international trade and structural change. The focus of this report is on international comparisons at a sectoral level, because it is at the individual industries such as motor vehicles, computers and aircraft where the economic competition, and the trade friction, is the most keen.

The major findings are summarised below on an indicator by indicator basis, but the following broad trends are evident when the individual pieces are combined into a more complete picture:

- Although the United States still holds a lead position in overall R&D, overall production and the share of export markets in high-technology products, the gap between it and the EC and Japan has narrowed substantially over the past two decades.

- While a convergence has happened between the countries of the triad on aggregate, significant differences remain at the sectoral level – some of which are becoming more pronounced.

- The economies of the Triad are all moving out of low technology industries and into high technology, high wage industries, setting the stage for increased competition and potentially more conflicts.

R&D Shares across the 13 OECD Countries

The United States has been, and continues to be, the largest contributor to OECD-13 R&D performed by business enterprises in the manufacturing sector, responsible for over 46 per cent of the OECD-13 manufacturing business R&D in 1990. Nevertheless, this is a decline of almost ten percentage points from 1973, as other countries, most notably Japan which doubled its share from nine to 18 per cent, have increased their R&D shares. The shares of the six largest European Community countries (the EC-6) remained relatively stable throughout the two decades at 26 percent, with Italy's increase compensating for a decline in the United Kingdom's share. The only EC-6 country to experience dramatic changes was the United Kingdom.

Focusing solely on the high-technology sector, the United States has maintained a dominant position, contributing over half of the 1990 OECD-13 high-technology R&D, a lead of over 20 percentage points on the next largest contributor, the EC-6. But the US's high-tech strength is dependent largely on one industry, aircraft, where it accounted for three quarters of all OECD-13 R&D that was performed in that industry.

The Distribution of R&D within Countries

R&D tends to be concentrated into five industries: aircraft, motor vehicles, communications equipment, computers and pharmaceuticals. These five sectors accounted for 64 per cent of the 1990 OECD-13 manufacturing R&D. The United States had the largest share of its 1990 manufacturing R&D, 73 per cent, clustered in these sectors, while the Nordic-4 and Japan had the least with less than 48 per cent. The EC-6 group had roughly the same profile as the United States, with R&D share levels for 1990 of over 60 per cent for these five industries with the United Kingdom leading the group at 70 per cent while Germany had the lowest share of the group at just over 50 per cent. The structure of sectoral R&D in Japan is distinctive by its rather even distribution of R&D across all manufacturing sectors, resulting in nearly the lowest cross-industry variance of any of the 13 countries.

R&D Intensity

When the R&D performed is divided by the amount of production, it is apparent that the United States has the most R&D intensive manufacturing sector with much of this coming from the high-technology manufacturing industries. Germany and Japan, on the other hand, displayed relatively low levels of intensities in the high-technology industries, even though they were practically tied, behind Sweden, for the third most R&D intensive manufacturing sector. Germany and Japan put relatively more R&D per unit of production into medium technology industries such as industrial chemicals and non-electrical machinery.

Japan and Germany were the only two countries where the R&D intensity increased in nearly every manufacturing industry from 1976-1978 to 1986-1988. With nine out of 22 sectors having a falling R&D intensity, the United Kingdom is the country which exhibited the highest number of sectors with declining intensities.

The Distribution of Investment within Countries

A convergence in the structure of investment has occurred as investment has swung away from low-technology industries (textiles, basic metals, non-metallic mineral products), with the share of these industries in total investment declining from around 55 per cent of the total in the early 1970s to 45 per cent in the late 1980s and into the fabricated metal products and machinery industry, particularly the motor vehicles and the paper industry.

Japan underwent the most significant restructuring of investment, moving from having a higher than average share of investment in low-technology industries in the mid-1970s (55-60 per cent) to a lower than average share at the end of the period (below 40 per cent), as investment was reduced in basic metals and textiles and increased in electronics and related industries. By the end of the 1980s, Japan and Germany had the highest shares of total investment in fabricated metal products and machinery -- 48 and 46 per cent respectively, with Japan increasing its share by over 50 per cent from 1970.

Investment per Employee

High wage, medium-technology and scale intensive industries are linked to high levels of investment per employee while low wage, labour intensive industries are characterized by a relatively low investment per employee activity.

Petroleum refining is the industry which has the highest investment per employee levels, exceeding the manufacturing average by at least a factor of three in every country. Industrial chemicals and non-ferrous metals are the next two industries which typically had investment per employee ratios in the late 1980s that were about twice as high as the manufacturing average.

These sharp interindustry differences propel countries, such as the Netherlands, Canada and Norway where one or more of these industries have a strong presence, to the top of the cross-country rank comparisons of investment per employee in the manufacturing sector. The somewhat surprising presence of Japan and Germany in the bottom half of the list is indicative of the fact that their economies rely more on comparatively less investment intensive industries such as non-electrical and electrical machinery, communication equipment and instruments.

Export Market Shares across the OECD-13 Countries

Germany and the United States dominated the OECD-13 export market in manufactured goods, with Germany slightly increasing its share from 19 per cent to 20 per cent between 1970 and 1990 while the share of the United States fell from 20 per cent to 17 per cent. The biggest gain in total manufacturing export market share was made by Japan whose share rose from 11 to 15 percent.

Much of the Japanese gain in share was in high-technology or high wage industries. In the low-technology and low wage industries, on the other hand, Japan's shares declined dramatically whereas this was the sector where the EC-6 saw strong growth, largely due to Italy's gains in the textile sector.

The share fluctuations in the medium-technology group, for most countries, are being driven by two industries: motor vehicles and non-electrical machinery. In both of these industries, Germany was the leading exporter between 1970 and 1990, with approximately one-fourth of these markets. In motor vehicles, Japan more than tripled its export share, moving from eight per cent to 25 per cent in 21 years, while the shares of the United States, Canada and the United Kingdom fell.

In the high-technology industries, Japan gained seven percentage points between 1970 and 1990 to reach a share of 21 per cent by 1990. This growth enabled Japan to overtake Germany, whose share declined slightly from 18 to 16 per cent. The United States, despite a fall from 31 per cent in 1970 to 26 per cent in 1990, managed to remain the largest exporter in high-technology industries, mainly due to the large role played by the aircraft sector. Nonetheless, the United States' 1970 lead of 14 percentage points was cut to five by the end of the 1980s.

Import Penetration Ratio

Imports of manufactured goods increased as a proportion of domestic demand in the manufacturing sector in every one of the OECD-13 countries during the period from 1970 to the end of the 1980s. The strongest increase by far was in the United States, where manufacturing imports more than tripled as a proportion of domestic demand in the 1970-1989 period. Import intensities doubled in France, Germany and the United Kingdom.

In most countries, high-technology industries are characterized by higher import penetration rates, followed by medium-technology sectors, while the total domestic demand in low-technology industries tends to be mostly satisfied by domestic production.

The profile of import penetration in Japan is strikingly different from that of other 11 OECD countries. Imports accounted for less than six per cent in the total of domestic demand for manufacturing in 1989, a two percentage point increase in 20 years. Little variation is also observable across the three technology groups. The high-technology group of industries has roughly the same degree of import penetration as the medium-technology group, and only marginally lower than the low-technology group.

Production Shares across the OECD-13

Across the OECD-13 during the period from 1970 to 1989 five countries, Japan, Italy, Canada, Finland and Norway, increased their share of total manufacturing production. These gains in share came at the expense of the shares held by United States, the United Kingdom and Germany. In particular, the US lost by almost a factor of two the most share points (-2.6) while Japan gained nearly an equal amount (+3.0), significant exchanges in production share between the United States and Japan occurred in the computer and motor vehicle industries. Nonetheless, the United States was still responsible for almost two-fifths of all production in manufacturing industry of the OECD-13 in 1989, the largest producer by 16 share points.

The EC-6 maintained a relatively stable position, losing one share point over the period; but significant internal changes occurred with the wide differences that existed in the 1970s between Italy, the United Kingdom and France being reduced significantly, resulting in 1989 manufacturing production shares which are very similar.

Manufacturing's Share of GDP

Over the last two decades the share of Gross Domestic Product (GDP) originating in the manufacturing sector declined in every country in our group of 13 OECD countries when measured in current prices. In constant prices a different picture emerged. For those nine countries where constant price data was available, five witnessed a decline, while three (Denmark, Italy and the United States) kept a constant share and one country, Japan, actually experienced an increase in the share. The most precipitous decline in the manufacturing sector's share of GDP, regardless of valuation, occurred in France and the United Kingdom, where the share fell about eight percentage points in each country, over the last two decades.

A pattern of convergence towards a similar share of GDP being contributed by the manufacturing sector is evident when viewed over the past two decades. Countries which had the largest initial share in 1970 were frequently the same countries that experienced the largest decline in share. This is supported by the fact that the variance in manufacturing's share of GDP existing between the countries dropped by a third between 1970 and 1989.

The Sectoral Distribution of Manufacturing Value Added

Within the manufacturing sector, the distribution of value added between industries has changed significantly from the early 1970s to the late 1980s, with most countries moving out of the low-technology, labour and natural resource intensive industries (food, textiles and wood products industries) and into the high and medium-technology, scale intensive and science based industries (fabricated metal products and chemicals).

Japan exhibited the largest amount of structural change from 1970 to 1989 with an index which is nearly twice as large as the next closest country, Denmark. The United States ranked third in the overall rate of structural change from 1970 to 1989 with the bulk of this change occurred in the 1980s where the rate of change was nearly double what occurred in the 1970s.

Relationships between Investment, Output and Competitiveness

When simple correlations were calculated between the various indicators, the following relationships were observed:

R&D v. Investment

- those industries that conduct the largest share of manufacturing R&D are almost purely R&D performers and do not engage in the type of manufacturing which involves heavy investments in capital equipment and structures. The situation in Japan is much different. Here a strong correlation between the two investment indicators exists (R^2=52.5 percent).

Output v. R&D and Investment

- a large share of output is much more directly correlated with those industries which invest in plant and equipment than with those which invest in R&D.

Competitiveness v. R&D and Investment

- by and large the relationship between competitiveness as measured by the two export indicators and tangible investment was weak. A much stronger relationship exists between competitiveness and R&D. The share of manufacturing R&D contributed by an industry is positively correlated with its revealed comparative advantage (RCA) in Japan and the US, while a negative correlation occurred in the EC-6.

Introduction

1. This report deals with factors shaping innovation performance and economic growth within the Triad of the United States, Japan and the European Community. It is a quantitative analysis of the evolution of Triadic industries, seeking to identify the strengths and weaknesses of Triad members, and the trajectories of their competitive positions.

2. Why focus on the Triad? Over the past four decades an important structural realignment has occurred in the world economy, independently of the phases of growth and recession which have tended to preoccupy policy-makers. This structural shift consists of a convergence in economic performance, per capita income and, increasingly, the industry/technology policies used in the economies of the triad.[1] The post World War II dominance by the United States in nearly every industry has slipped to the point where the United States is frequently lagging behind its European and Japanese competitors in certain sectors. Regardless of the position of one country versus another, it is clear that there are certain industries such as computers, electronics, aerospace, pharmaceuticals and motor vehicles which all three members of the triad recognize as being critical sectors not only for ensuring current standards of living, but also because they are perceived as being fundamental building blocks driving technological innovation and international competitiveness which are keys for a high standard of living in the future.[2] For this reason, the nature of competition has changed where the economies of the triad are facing off on a "head-to-head" basis, inevitably leading to heightened competition and political friction.

3. The basis of Triadic dominance of the global economy lies in technological innovation. From the end of World War II, there seem to have been three major processes underlying economic growth. First, there was a process of recovery from the war itself, a period in which growth seems to have owed much to enhanced investment, and to the diffusion of technologies from the United States. Secondly, there has been a sustained process of growth in international trade, particularly in innovation-intensive manufactures. Thirdly, there has been increasing internationalisation, in the sense of cross-border flows of direct investment and technological knowledge (with the knowledge flows taking a wide variety of forms). Growth divergences seem to be closely related to the extent to which economies have been able to participate in these processes of investment and trade which underlie growth. In particular, there are strong grounds for believing that convergence and divergence in economic performance owe much to differences in innovation activity: especially to differences in the capability to create, assimilate and diffuse new technologies.[3] In this area; leadership in the world economy is highly concentrated: the members of the Triad maintain most of the world's science and technology infrastructure, perform most of its research, supply most of its inventions (as measured by patents), and possess most of its high-technology industry.

4. For Europe in the future, therefore, the central competitive challenges within innovation-intensive industries will derive -- as they have in the past -- from other members of the Triad. Understanding the structure of Triadic resources and trends at a detailed sectoral level is therefore a matter of central importance for European policy-makers. This is the *raison d'être* of this study; it seeks to provide a detailed overview of some of the key trends in Triadic manufacturing with respect to output, investment, research and trade. The study uses two new OECD databases -- STAN (Structural Analysis database) and ANBERD (Analytic Business Enterprise R&D) -- which for the first time permit consistent, comparable statistics over time at a disaggregated industry-level for a variety of variables.

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1. Extensive research has been conducted on the topic of convergence and will not be reviewed here. Some of the more recent work includes the papers presented at the MERIT Conference on "Convergence and Divergence in Economic Growth and Technical Change" held in Maastrict, the Netherlands, December 10-12, 1992. For work comparing the triad, see Lester Thurow (1992), Head to Head, (New York, NY: William Morrow & Co.), National Academy of Engineering (1991), National Interests in an Age of Global Technology, (Washington, DC: National Academy Press) and US Congress (1991), Competing Economies: America, Europe and the Pacific Rim, (Washington, DC: Office of Technology Assessment).

2. See Laura D'Andrea Tyson (1992), Who's Bashing Whom: Trade Conflict in High-Technology Industries, (Washington, DC: Institute for International Economics).

3. Jan Fagerberg (1991), "Innovation, Catching-up and Growth" in OECD, Technology and Productivity: the Challenge for Economic Policy (OECD: Paris), pp.37-46.

5. Concretely, the report focuses on the evolution of manufacturing in key Triad economies by:

- dividing the manufacturing sector into industries which are particularly oriented towards international competition or which have a high technology intensity (the "friction prone" sectors);

- using STAN and ANBERD data to construct indicators which reveal relative strengths and weaknesses within these high-tech, high-trade industries, with a particular emphasis on the evolution of competitive strengths over time.

6. The primary focus is on the US, Japan, and the four largest economies of the EC; however other advanced North American and European economies are referred to. The report begins with a description of the basic indicators which are used or constructed are described in detail (usually in boxes) with a discussion of their relevance and fields of application.

7. The report consists of three parts. Part One presents a descriptive overview based on four broad categories of indicators: 1) business enterprise research and development, 2) investment, 3) international trade and 4) production. Part Two employs simple analytical techniques -- such as cross-plots -- to look at the trends and relationships which emerge when indicators are juxtaposed. Finally, an Appendix contains information about the data used to calculate these indicators, the industries used to form the various groupings such as "high-technology," and the countries which compose the various groupings (EC-6, OECD-13, Nordic-4) used in this report.

I. Indicators of Research and Development (R&D), Investment, Structural Change and International Trade

Manufacturing R&D Shares across the OECD-13

8. The United States has been, and continues to be, the largest contributor to OECD-13 R&D performed by businesses in the manufacturing sector (Figure RDSO 1). In 1990, it was responsible for over 46 per cent of the OECD-13 manufacturing business R&D. Nevertheless, this is a decline of almost ten percentage points from 1973, as other countries, most notably Japan, have increased their R&D shares. In 1973, the United States was responsible for 55 per cent of all the manufacturing R&D that was performed, whereas the EC-6 and Japan together only accounted for 42 per cent. This dominant position remained relatively unchallenged until the second half of the 1980s when Japan increased its investment in R&D at twice the rate of the United States causing its share to rise from 13 per cent of the OECD-13 total in 1973 to 22 per cent in 1990 (Table RDSO 1).

Description of the Indicator

R&D shares across the OECD-13 are calculated as business enterprise R&D in a certain industry for a given country or country grouping as a proportion of the business enterprise R&D for the OECD-13 for this industry. This indicator is skewed towards the larger countries which because of their size will dominate R&D shares. On the other hand, in many cases the smaller countries appear to show extremely high growth in their R&D shares, but this is much easier to accomplish starting from their small bases. These shares were calculated using United States purchasing power parities (PPP) for GDP. It should be noted that the results could be significantly different if exchange rates or a PPP specifically for R&D was used.

9. Despite Japan's large increases, it remained behind not only the United States, but also the EC-6. The EC-6's share of the OECD-13 manufacturing R&D moved slightly during these eighteen years, declining only from 29 per cent to 28 per cent. Although within the EC-6, some notable shifting did occur (Figure RDSO 1). The United Kingdom's share fell from 8.3 per cent to 5.7 per cent and Italy's share, while still small, grew at a much faster rate than any other OECD-13 country. The Nordic countries all hold very small R&D shares, but Finland, Denmark and Sweden saw significantly increases.

10. At a detailed sectoral level, the convergence between the United States and Japan is even more pronounced than it is in total manufacturing. In 1973, out of 22 industrial sectors, there were only four in which the US did not have the largest R&D share: textiles, apparel and leather, chemicals excluding drugs, drugs & medicines, and ferrous metals. In these four industries, the EC-6 held the largest share in three of them and Japan performed the most R&D only in ferrous metals. During the course of the 1970s and 1980s, the United States lost R&D shares in 18 of 22 industries, whereas Japan gained R&D shares in all but two industries: shipbuilding and other transportation equipment. The United States remained the R&D leader in most industries, but Japan succeeded in substantially narrowing the gap between itself and the United States, and in five industries: rubber & plastic products, non-metallic mineral products, non-ferrous metals, non-electrical machinery and electrical machinery, it surpassed the United States. The EC-6's R&D shares remained relatively stable throughout the two decades, even at the sectoral level. The only EC-6 country to experience dramatic changes was the United Kingdom. Its R&D shares fell in all but three industries: drugs & medicines, computers and office machinery and other manufacturing.

11. Grouping the 22 industries by their level of technological sophistication, the greatest convergence between the United States and Japan has occurred in the low-technology sector (Figure RDSO 4). In 1973 the difference between the United States' R&D share and Japan's R&D share in the low-technology industries was 23 percentage points, whereas by 1990 the difference in their shares was only three percentage points. In the medium-technology industries the Japanese share is converging towards that of the United States almost as sharply as it does in the low-technology industries. The United States, however, had a larger lead on Japan in the early 1970s in this grouping, and the differences between their shares are thus still large (Figure RDSO 3). The sectors in which there has been the least convergence between these two countries are the high-technology industries (Figure RDSO 2). The United States still maintains a dominant position in R&D shares in the OECD-13 for the high-technology industries. R&D shares in this grouping have been relatively stable and the gap in the R&D shares between the United States and Japan was still 36 percentage points in 1990. In the EC-6, because the shifts in R&D were so well balanced, all three technology groupings were extremely stable. From 1973 to 1990, the EC-6 held a share of about 26 per cent in the high-technology industries and a share of about 33 per cent in the medium-technology industries. Only the low-technology grouping experienced any movement, and that was only from a share of 28 per cent to 24 per cent.

High-technology Industries

12. As with total manufacturing, the United States began the 1970s with an extremely high R&D share in high-technology industries, 63 per cent in 1973. By 1990, its share had fallen to 54 per cent, but still remained more than twice as high as the share of the second largest high-technology R&D performer, the EC-6. The EC-6's share stayed at 26 per cent, as Italy's growth compensated for a decline in the United Kingdom's share. Japan, on the other hand, doubled its share, rising steadily from nine per cent to 18 per cent during these years. Despite this doubling, its share was still only one-third that of the United States' in 1990. The Nordic-4 countries, while still accounting for only 1.5 per cent of the R&D that is done in these industries, all made large gains in this area.

13. The United States' considerable lead in the high-technology industries is largely a result of its sizeable R&D in the aircraft industry. In 1990, the United States accounted for three quarters of all OECD-13 R&D that was performed in the aircraft industry. This was probably due in a large part to the magnitude of the defense and space projects initiated by the United States government. Nearly three-quarters of the R&D performed in this sector was funded by the United States government.[4] France, Germany and the United Kingdom were the only other countries with significant R&D activity in this industry and their sum totalled only 22 per cent of the OECD-13 R&D in 1990. Of the EC-6 countries, Italy showed the most significant increase in aircraft R&D, increasing its share from 0.2 per cent in 1973 to 2.6 per cent in 1990. United Kingdom, on the other hand, saw a decrease from a share of 12 per cent in 1973 to a share of six per cent in 1990.

14. Japan, while only accounting for about one per cent of aircraft R&D, held significant R&D shares in two other industries in the high-technology grouping: electrical machinery and computers and office machinery. In 1990, Japan was responsible for 49 per cent of the OECD-13 R&D that was done in electrical machinery, nearly three times the share it held in 1973. This large gain was achieved at the expense of the United States whose share in this sector dropped from 54 per cent to 13 per cent over the same time period. The EC-6 also benefited from the United States' drop, rising from 27 per cent to 36 per cent. All of the EC-6 countries, except the United Kingdom, saw increases in their shares of electrical machinery, Germany and Italy most significantly. Germany's share rose rapidly, surpassing the United States' share by 1986 and attaining 18 per cent of the OECD-13 R&D by 1990. Italy exhibited extremely strong growth, moving from a share of 0.6 per cent to 4.7 per cent.

15. The other high-technology area in which Japan experienced impressive growth is the computer industry. It jumped from a share of seven per cent in 1970 to 23 per cent in 1990. Nevertheless, in 1990 the United States' R&D share was still almost three times higher than Japan's in this industry. The United States share has declined since 1973, but in 1990, the United States still accounted for a full 60 per cent of the R&D done in this industry. Most of the EC-6 countries saw small increases in this industry, but the overall EC-6 share still fell, driven by France's drop from seven per cent to two per cent.

16. The R&D shares in the pharmaceutical industry have proved to be much more stable throughout the 1970s and 1980s than those in aircraft and the fabricated metal products sectors. The United States and the EC-6 both had shares that hovered about 40 per cent in 1973 and declined only slightly to about 38 per cent in 1990. Within the EC-6, the United Kingdom's increase from 11 per cent to 13 per cent, almost offset the decline in Germany's R&D share. Japan gained slightly in this industry and in 1990 had a share of 19 per cent, up five percentage points from 1973.

Medium-technology Industries

17. In the medium-technology industries there is a much more significant convergence between Japan and the United States than their was in the high-technology industries. The US share declined between 1973 and 1990 from 46 per cent to 36 per cent, while Japan's share rose from 17 per cent to 27 per cent. The EC-6's share remained constant,

4. National Science Foundation (1992), Research and Development in Industry: 1989, NSF 92-307, (Washington, DC), Table A-4, p. 20.

at about 33 per cent, due largely to Germany's consistent share of about 16 per cent (Figure RDSO 3). Japan made gains in six of the seven industries which comprise this grouping. The only medium-technology industry in which it did not increase its R&D share was other transport equipment. In this industry, its share fell from 26 per cent to seven per cent.

18. In motor vehicles, the United States, despite a decline in its share, still held the largest R&D share in 1990. It moved from 56 per cent to 44 per cent, remaining significantly above Japan, who in spite of an increase of 11 percentage points, only obtained a share of only 25 per cent in 1990. The Nordic countries showed a substantial increase, although their share remained small.

19. In rubber and plastics, an extremely large change was evident. Japan's R&D share doubled between 1973 and 1990 whereas the United States's share fell to one-half its 1973 level. The R&D shares of both Japan and the EC-6, were larger than the United States' by 1987. The EC-6's move from 25 per cent to 33 per cent was largely attributable to Germany, which increased its share from 6 to 11 per cent, but was also helped by France, whose share rose from 11 per cent to 14 per cent.

20. Japan also made considerable gains in the non-ferrous metal and the non-electrical machinery industries. In the non-ferrous metal industries, Japan almost doubled its share, increasing from 23 per cent to 42 per cent, and surpassing the R&D share of the United States. At the same time, the United States' share declined sharply, from 43 per cent to 30 per cent. Although the trends were not quite as sharp in the non-electrical machinery industries, Japan moved up sharply to attain the largest R&D share, while the United States share declined sharply. The EC-6 fell slightly, from 22 per cent to 18 per cent, in the non-ferrous metal industries, despite Italy's strong increases. Canada has a relatively large share of the R&D performed in non-ferrous metals. In 1990 it held a share of six per cent, a share which is larger than every other country except Japan and the United States.

21. In the chemical industry, the R&D shares were more stable than in most of the other medium-technology industries. The EC-6 and the United States fell slightly, but still held shares of 41 per cent and 35 per cent in 1990. Japan's R&D increased, but only to a share of 24 per cent of the OECD-13. Nevertheless, this was enough to surpass Germany, whose share stayed stable at 19 per cent.

Low-technology Industries

22. The low-technology industries showed the most dramatic convergence between the United States and Japan (Figure RDSO 4). Japan's share increased from 20 per cent in 1973 to 32 per cent in 1990, to close within four percentage points of the United States, after being more than 24 per cent points behind. The EC-6, although much less dynamic than both Japan and the United States, showed more movement in the low-technology industries than it did in the high and medium ones, falling from 28 per cent to 24 per cent. This drop in the EC-6's share is attributable to the United Kingdom whose share fell sharply from 11 per cent to four per cent.

23. Japan's biggest increase occurred in textiles, apparel & leather. Its share rose from 28 per cent to 50 per cent. This occurred mainly at the expense of the EC-6 whose share fell from 47 per cent to 21 per cent. Again, as with the entire low-technology group, this change was being driven by the United Kingdom, whose share dove from 22 per cent in 1973 to only three per cent in 1990. The United States' share increased slightly rising from 22 per cent to 24 per cent.

Table: RDSO-1
R&D Shares across the OECD-13

ISIC	Industry	Canada		France		Germany		Italy	
		1973	1990	1973	1990	1973	1990	1973	1990
3000	Total Manufacturing	1.0	1.3	6.5	6.5	9.8	10.9	2.2	3.1
3100	Food, beverages & tobacco	2.4	1.8	4.5	7.1	3.1	4.4	0.9	1.4
3200	Textiles, apparel & leather	1.5	3.7	11.5	6.6	6.5	8.5	5.7	1.0
3300	Wood products & furniture	0.9	8.5	3.3	2.1	1.4	15.9	0.0	1.1
3400	Paper products & printing	4.3	5.9	3.2	2.8	1.7	3.5	0.8	0.1
3500	Chemical products	1.0	1.2	7.9	7.8	14.8	13.5	3.4	4.0
3600	Non-metallic mineral products	1.0	0.6	9.5	5.6	5.7	8.1	0.7	1.4
3700	Basic metal industries	3.4	2.8	3.9	6.5	10.1	6.4	1.3	3.4
3800	Fabricated metal products	0.8	1.2	6.2	6.2	9.0	10.7	1.9	2.9
3900	Other Manufacturing	1.3	2.9	3.9	3.4	0.2	2.6	4.7	0.3
	High technology	0.9	1.4	6.4	6.6	8.4	8.5	1.5	2.9
	Medium technology	0.9	0.8	6.6	6.5	14.1	16.6	3.6	3.5
	Low technology	2.0	2.4	6.6	5.9	5.1	7.7	1.6	2.6

		Japan		Nordic-4		United Kingdom		United States	
		1973	1990	1973	1990	1973	1990	1973	1990
3000	Total Manufacturing	12.9	22.2	1.7	1.9	8.3	5.7	55.3	46.6
3100	Food, beverages & tobacco	20.1	32.4	4.0	3.9	16.8	7.8	16.8	35.5
3200	Textiles, apparel & leather	27.8	49.8	1.7	1.8	21.8	2.9	21.7	23.8
3300	Wood products & furniture	12.0	27.0	4.2	5.4	4.0	1.6	72.6	37.0
3400	Paper products & printing	24.9	28.1	8.8	8.8	5.4	4.3	49.1	44.4
3500	Chemical products	16.0	22.4	1.5	1.9	8.5	8.6	43.2	37.6
3600	Non-metallic mineral products	23.6	42.6	2.7	2.1	10.3	3.1	43.9	34.7
3700	Basic metal industries	31.8	52.3	4.0	2.9	9.2	3.1	31.8	18.2
3800	Fabricated metal products	10.6	20.3	1.5	1.7	7.9	5.0	60.3	50.5
3900	Other Manufacturing	20.2	35.1	3.5	5.4	7.1	7.5	58.4	40.9
	High technology	8.9	17.7	1.1	1.5	8.6	6.5	62.5	53.5
	Medium technology	17.4	27.9	1.8	2.3	6.9	4.4	46.2	36.1
	Low technology	20.8	32.5	4.2	3.3	10.6	4.4	44.1	36.5

Figure RDSO 1

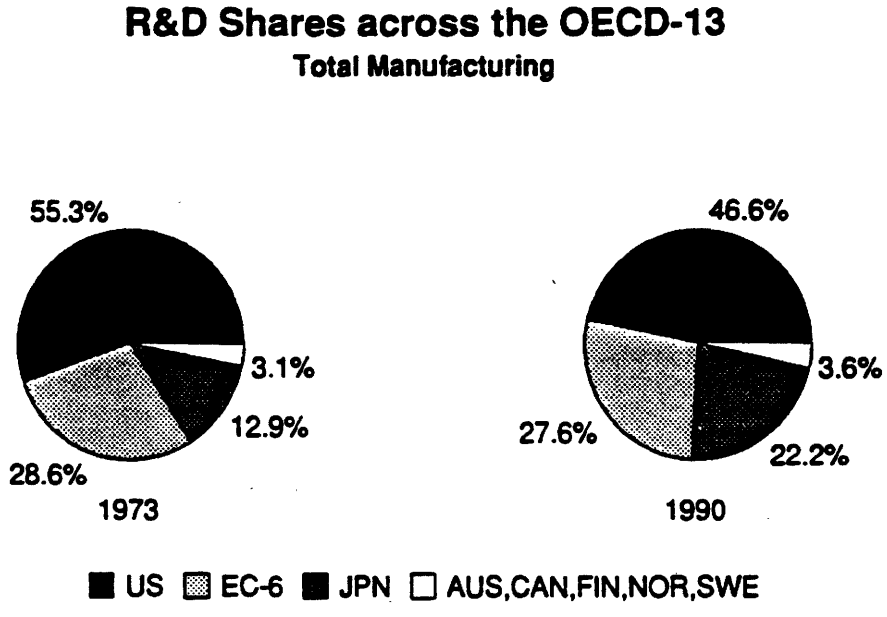


Figure RDSO 2

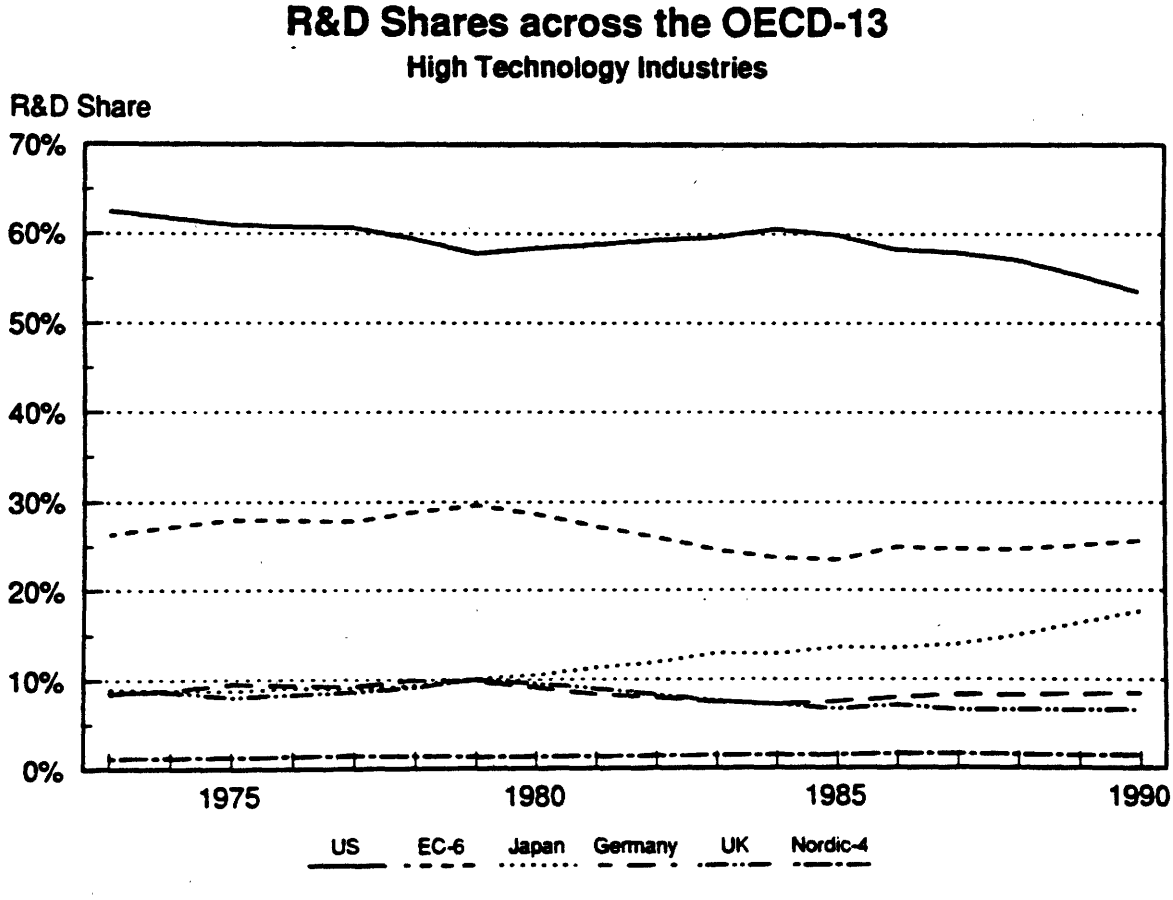


Figure RDSO 3

R&D Shares across the OECD-13

Medium Technology Industries

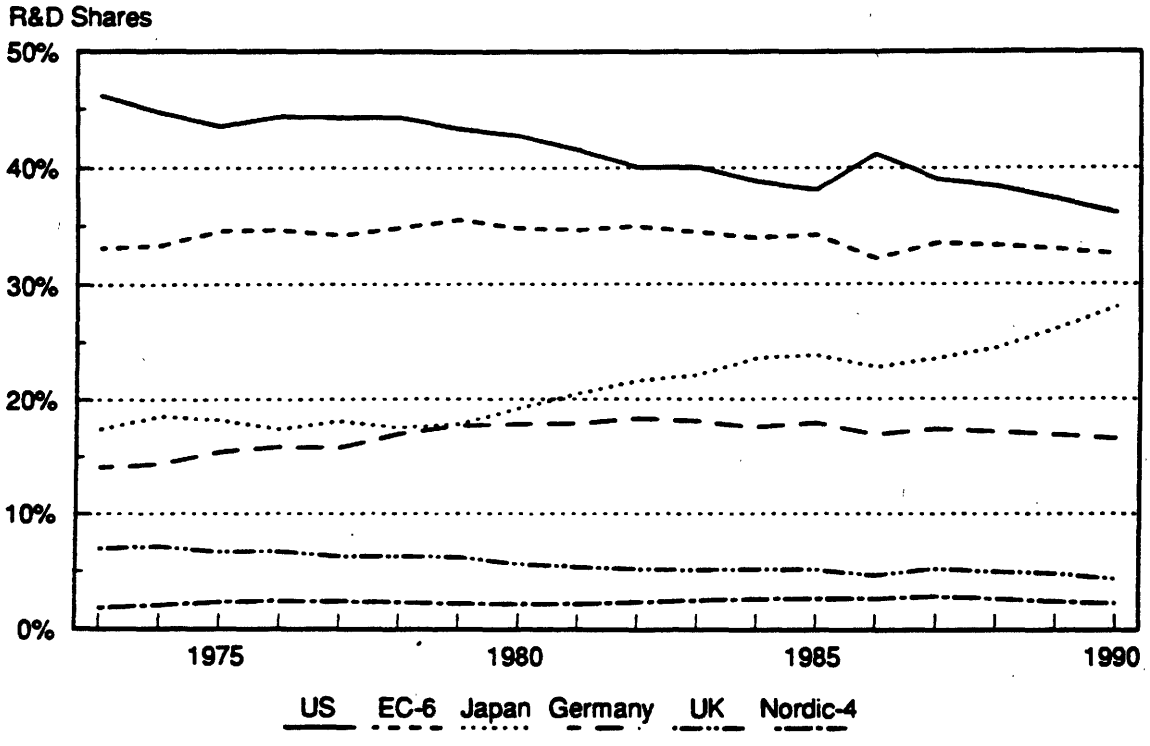
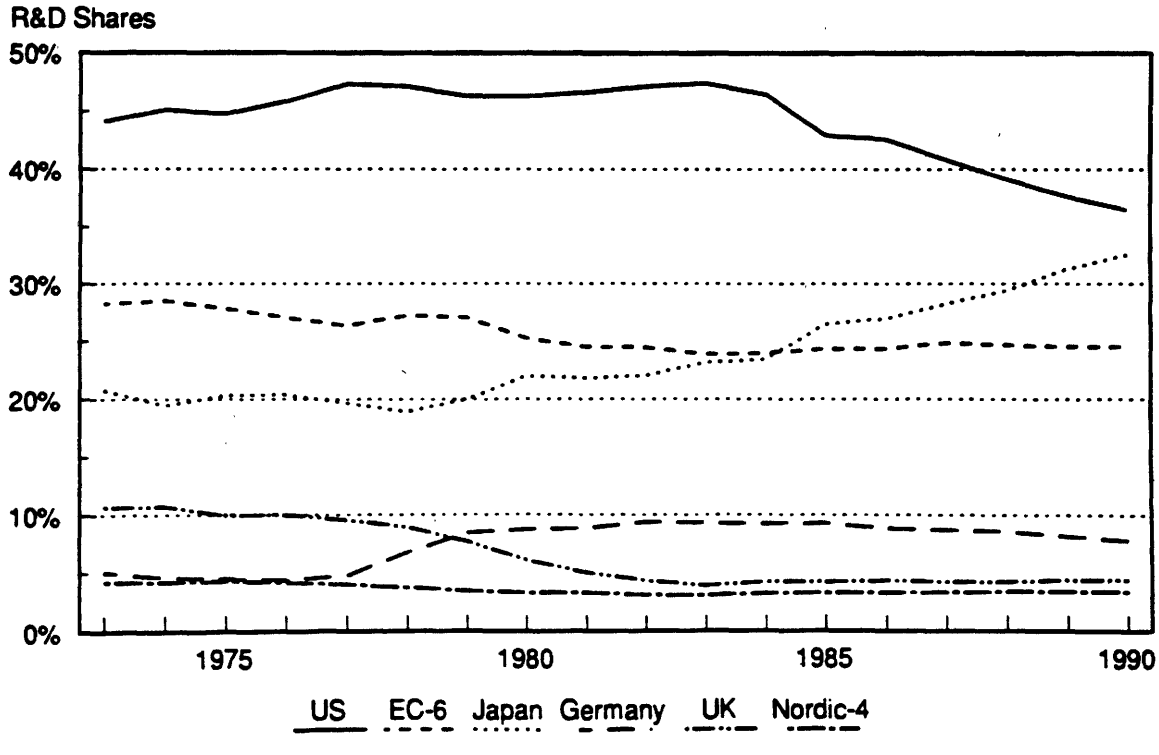


Figure RDSO 4

R&D Shares across the OECD-13

Low Technology Industries



The Distribution of Manufacturing R&D by Sector within a Country

24. The distribution of manufacturing R&D by sector within a country (RDS) reveals that R&D is predominately clustered in five industries: aircraft, motor vehicles, communications equipment, computers and pharmaceutical. These five sectors accounted for 64 per cent of the 1990 OECD-13 R&D. The United States had the largest share of its 1990 manufacturing R&D, 73 per cent, clustered in these sectors, while the Nordic-4 and Japan had the least with less than 48 per cent. The EC-6 group had roughly the same profile as the United States, with RDS levels for 1990 of over 60 per cent for these five industries with the United Kingdom leading the group at 70 per cent while Germany had the lowest share of the group at just over 50 per cent (Figure RDS 1).

A Description of the Indicator

R&D shares (RDS) are calculated by dividing the R&D performed by an industry (or industry group) by the total manufacturing R&D expenditure for that year in a specific country (or group). This allows a clear view of the evolution of both the structure of manufacturing R&D and the evolution of the emphasis placed on an industry over time. This indicator identifies shifts in R&D expenditure from one sector to another within a country, while also permitting international comparisons of this evolution. The main weakness of this indicator is that it relies on current price data and may be affected by inflation which could distort the calculation of shares across manufacturing if the relative inflation of R&D by sector is not constant.

Country Profiles

25. Over the eighteen years between 1973 and 1990, the United States performed roughly one-quarter of its manufacturing business enterprise R&D in the aircraft industry: the largest share for this sector of any of the countries analyzed (Figure RDS 2). Motor vehicles and communications equipment remained at relatively constant levels between 1973 and 1990 with the share held by motor vehicles roughly 10 per cent of the total (Figure RDS 2) while communications equipment held at approximately 14 per cent. R&D performed in the computer industry saw the greatest gain in share over the period, growing by 4.3 share points. These gains were offset by losses of shares in the rubber & plastics and non-electrical machinery and, in particular, the electrical machinery industry which decreased the most, falling from nine per cent in 1973 to one per cent in 1990. As shown in Table RDS 1, the distribution of R&D across sectors in the United States was among the most uneven of any of the countries analyzed.

26. After the United States, France dedicated the largest share of its manufacturing R&D to the aircraft sector, about one-fifth of its total expenditure. But the sector with the largest share of R&D in France was communications equipment with shares consistently above 20 per cent after 1974, peaking at 25 per cent in 1987. France also dedicated a relatively large share to industrial chemicals (10 per cent) and pharmaceuticals (peaking at eight per cent in 1990). In the United Kingdom, the share held by the aerospace industry fell from over time from 26 per cent in 1973 to 14 per cent in 1988 with most of the gain in share coming from the communications equipment industry. Pharmaceuticals also witnessed a large growth in the share of R&D performed, jumping from six per cent, in 1973, to 16 per cent, in 1990.

27. Germany has a different R&D structure, with over 60 per cent of its R&D originating from the industrial chemicals, non-electrical machinery, communication equipment and motor vehicles sector (Table RDS 2). The largest 1990 share of R&D was held by the communication equipment industry whose share fluctuated between 15 per cent and 18 per cent while sector with the second largest 1990 share, motor vehicles, saw a steady increase from 12 per cent in 1975 to 17 per cent in 1990. Although still retaining a large total share of manufacturing R&D, the industrial chemicals industries witnessed a decrease of four share points over the period. Unlike most of the countries where there is a sharp difference in share between the high-technology and medium-technology groups, Germany's R&D was almost evenly split between the two.

28. The motor vehicle industry is the single largest source of R&D performed in Italy with a 1990 share that has climbed back to the same place it held in the early 1980s: 18 per cent. The pharmaceutical industry is the second largest R&D performer in Italy, responsible for about 13 per cent over the sixteen years from 1973 to 1988, with an uptick to 15 per cent in 1989 and 1990. Aircraft has also grown to become a key R&D performer in Italy, increasing from the 1973 level of two per cent to the 1987 level of 15 per cent.

29. The structure of sectoral R&D in Japan is distinguished from the other countries because of its rather even distribution of R&D across sectors. Finland was the only country with a lower cross-industry variance in the shares of manufacturing R&D than Japan in 1990 (Table RDS-1). Only one Japanese industry, communication equipment, had a share of more than 15 per cent of the total manufacturing R&D expenditure. Motor vehicles had the second largest share, fluctuating between 12 per cent and 14 per cent over the period. The computers and office machinery industry saw the greatest increase in share, jumping by a factor of five, from two per cent in 1974 to over ten per cent in 1990.

Table RDS-1: Ranked 1990 Variance in R&D Shares Across Sectors

Canada	45
United States	44
France	43
United Kingdom	41
Netherlands	37
Germany	36
Australia	35
Denmark	33
Sweden	31
Italy	30
Norway	28
Japan	23
Finland	21

30. The Nordic-4 group had a much different distribution of R&D across sectors, where nearly twice as large a share of R&D was dedicated to sectors classified as low-technology as found on average across the OECD-13 countries (Table RDS 2). Low-technology industries typically received less than 12 per cent of total R&D in the OECD-13, whereas the Nordic-4 expenditures ranged anywhere from 27 per.cent to 14 per cent. The share of R&D allocated to shipbuilding, for example, was consistently seven to eleven times higher than that of the OECD-13 and five times that average for paper products. The aircraft industry, on the other hand, contributed a relatively minor share of overall R&D in the Nordic-4 countries with levels between one-third and one-quarter of the OECD-13 average.

Table: RDS-2
1990 Manufacturing R&D Shares by Industry Within a Country

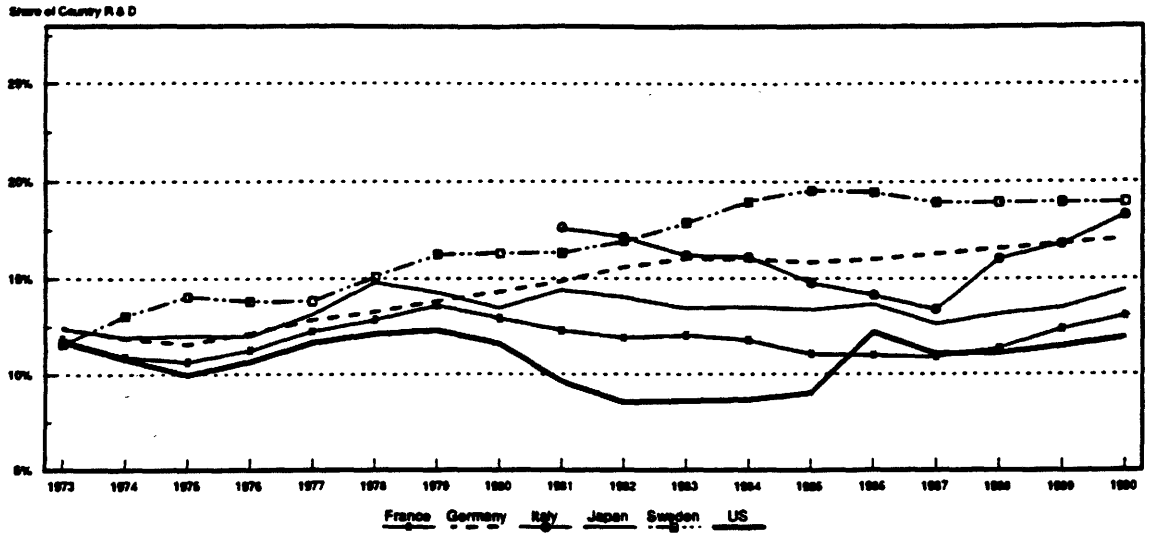
ISIC	Industry	Canada	Denmark	France	Germany	Italy	Japan	United Kingdom	United States	Nordic-4	EC-6
3100	Food group	2.5	7.6	2.0	0.7	0.9	2.6	2.5	1.4	3.7	1.7
3200	Textile group	1.3	0.4	0.4	0.3	0.1	1.0	0.2	0.2	0.4	0.3
3300	Wood group	1.5	0.4	0.1	0.3	0.1	0.3	0.1	0.2	0.7	0.2
3400	Paper group	3.5	0.7	0.3	0.2	0.0	1.0	0.6	0.7	3.6	0.3
3500	Chemical group	17.3	29.5	23.3	24.0	25.4	19.5	29.4	15.6	19.6	25.8
351+352-3522	Industrial Chemicals	6.0	4.1	9.9	16.4	6.4	10.1	11.5	6.8	5.9	12.9
3522	Pharmaceuticals	6.8	24.1	8.1	5.8	15.4	5.8	15.9	5.8	11.6	9.7
353+354	Petroleum Refining	3.9	0.0	2.2	0.3	1.3	1.0	1.4	2.2	1.1	1.4
355+356	Plastic products	0.5	1.3	3.1	1.5	2.3	2.6	0.7	0.8	1.1	1.8
3600	Non-metallic mineral prods.	0.6	2.1	1.1	0.9	0.6	2.4	0.7	0.9	1.4	0.9
3700	Basic metals	4.5	0.7	2.1	1.2	2.4	5.0	1.2	0.8	3.2	1.7
3710	Ferrous metals	0.7	0.3	1.4	0.9	1.7	3.4	0.7	0.3	1.8	1.2
3720	Non-ferrous metals	3.8	0.3	0.7	0.3	0.7	1.6	0.4	0.5	1.4	0.5
3800	Fabricated metal products	67.7	50.3	70.4	72.1	70.5	67.4	64.7	79.7	66.0	68.8
3810	Metal products	1.0	2.7	0.7	2.5	2.5	1.5	0.7	0.8	2.2	1.8
3820-3825	Non-electrical mach.	2.6	12.3	3.3	11.2	6.6	8.9	3.2	3.0	15.1	7
3825	Computers	9.9	3.5	3.7	3.6	7.3	10.1	8.5	12.8	4.1	4.9
3830-3832	Electrical machinery	1.5	6.2	3.4	8.2	7.8	11.2	4.4	1.4	7.2	6.6
3832	Communications equip.	31.8	9.2	24.7	18.7	13.5	16.3	22.4	16.5	15.5	20.1
3841	Ships	na	3.2	0.1	0.1	0.6	0.2	0.1	0.0	1.3	0.3
3843	Motor vehicles	2.6	0.0	13.0	17.1	18.3	14.4	7.1	11.9	11.2	13.4
3845	Aircraft	13.2	0.0	20.0	8.9	12.1	0.9	17.2	26.5	3.8	13.1
3842+3844+3849	Other transport equip.	na	1.6	0.4	0.1	0.7	0.3	0.0	0.6	1.0	0.2
3850	Instruments	1.6	11.6	1.1	1.6	1.0	3.8	1.0	6.3	4.7	1.4
3890	Other manufacturing	1.1	8.2	0.3	0.1	0.0	0.8	0.7	0.4	1.4	0.3
	High wage	42.4	31.8	57.0	52.0	60.8	42.3	61.6	66.0	46.9	55.5
	Medium wage	47.9	43.9	36.5	38.1	29.6	41.5	30.5	30.2	37.0	35.2
	Low wage	9.7	24.4	6.5	9.8	9.6	16.2	7.8	3.8	16.1	9.3
	High technology	64.8	54.6	60.9	46.8	57.2	48.0	69.4	69.2	46.9	55.8
	Medium technology	18.4	27.8	30.8	46.7	35.0	38.6	23.6	23.7	37.0	36.1
	Low technology	16.8	17.5	8.3	6.5	7.8	13.4	7.0	7.1	16.1	8.1
	Resource intensive	12.3	10.4	6.1	2.7	3.5	8.0	5.1	5.2	8.2	4.7
	Labour intensive	3.4	11.4	1.4	3.0	2.7	3.2	1.6	1.5	4.0	2.5
	Scale intensive	16.9	11.2	26.2	36.3	29.9	32.0	20.6	21.1	25.8	30.1
	Specialised supplier	35.9	27.7	31.4	38.1	28.0	36.3	30.0	20.9	37.8	33.6
	Science based	31.4	39.3	32.8	19.9	35.9	20.5	42.6	51.3	24.2	29.1

n.a. = not available

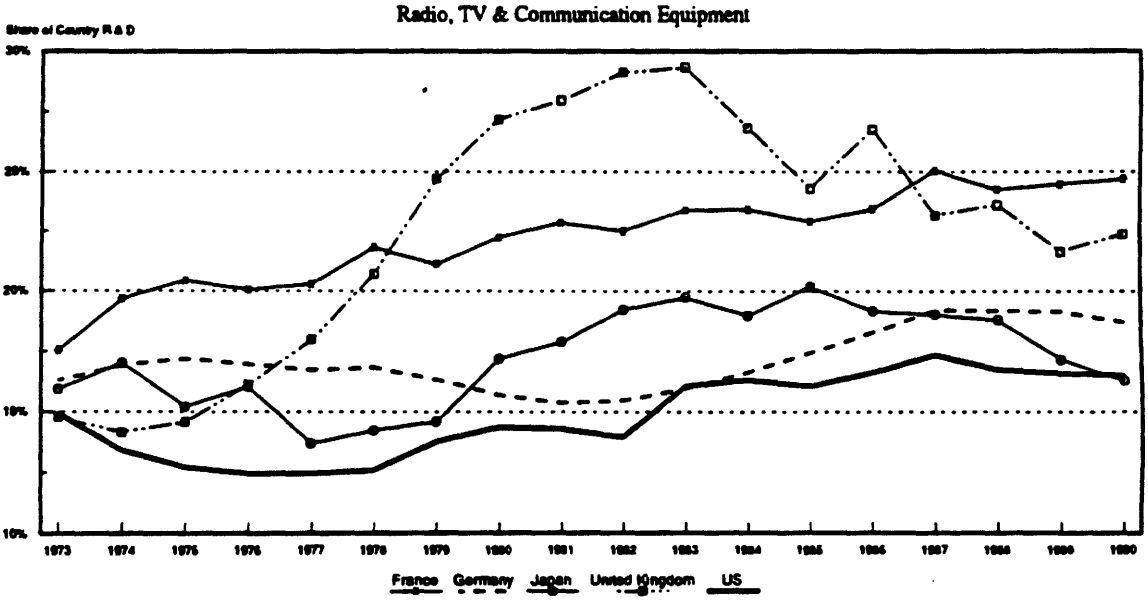
Figure RDS 1

Share of Business Enterprise R&D by country for:

Motor Vehicles



Radio, TV & Communication Equipment



Aircraft

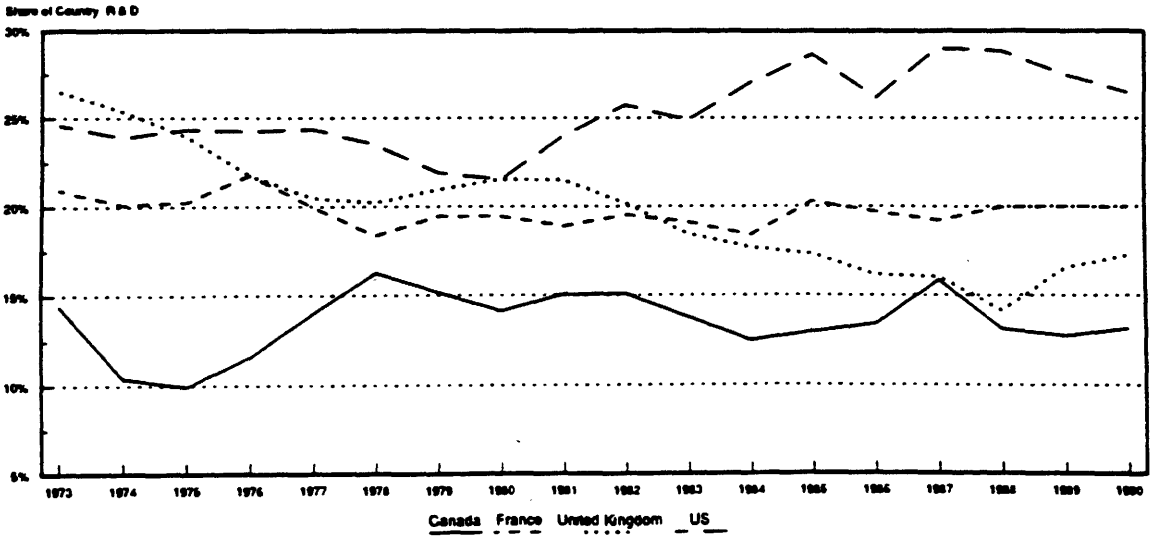
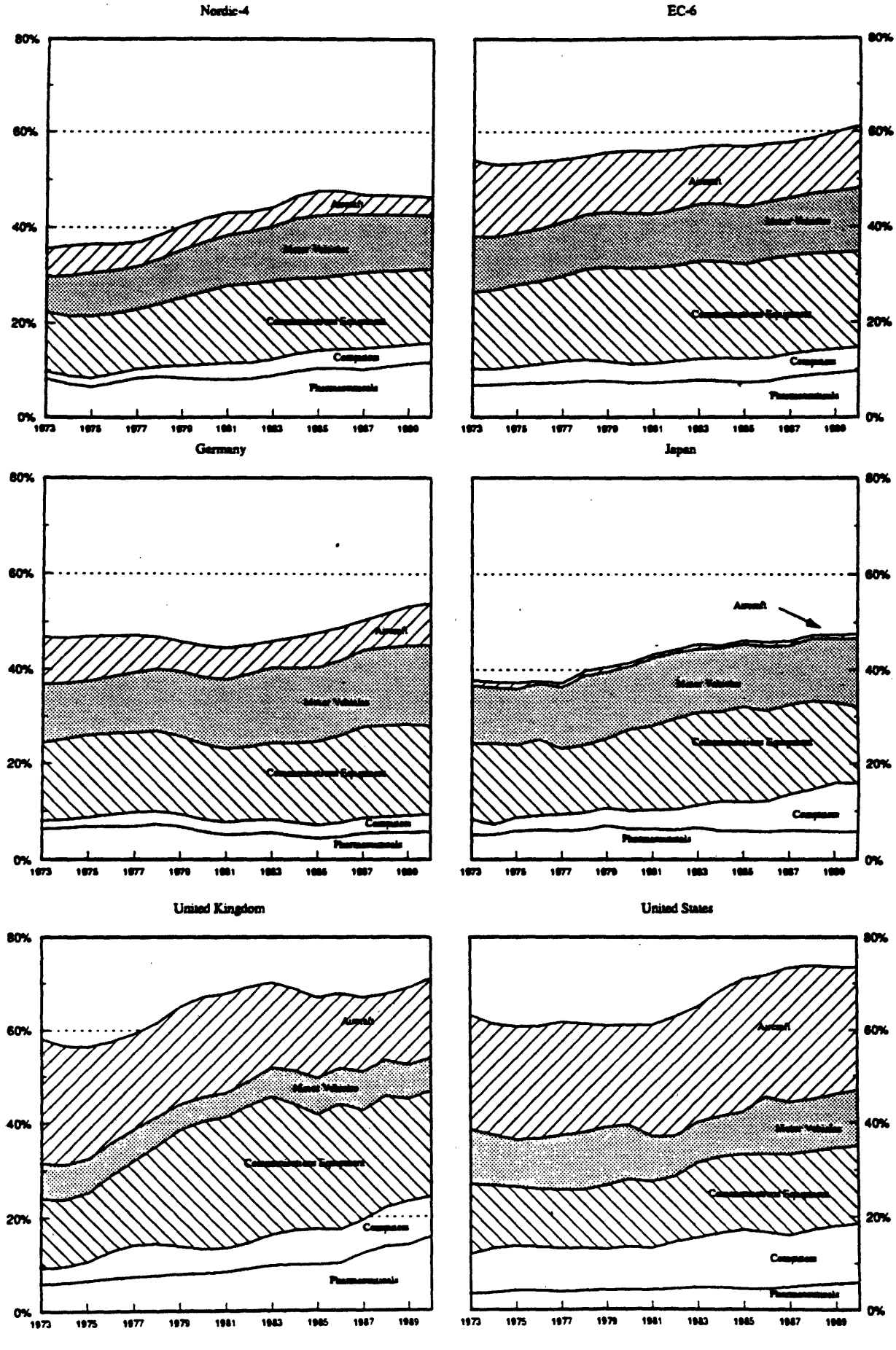


Figure RDS 2

Share of Manufacturing R & D Dedicated to 5 Select Industries



R&D Intensities

31. The amount of R&D performed per unit of production, or the R&D intensity (see box), reveals that from 1973 to 1989 the United States had the highest total manufacturing intensity and the strongest intensities in the high-technology group of industries. Conversely, Germany and Japan displayed relatively low levels of intensities in the high-technology industries, even though they had high total manufacturing R&D intensities. Compared to the other countries, Japan especially exhibited low intensities in what are traditionally considered to be the core high-technology industries -- aircraft, computers, communications equipment and pharmaceuticals -- but had relatively high intensities in the medium-technology group.

Total Manufacturing R&D Intensities

32. As shown in Figure RDI 1, the evolution and levels of total manufacturing R&D intensities differed quite substantially between OECD-13 countries during the period 1973-1989. For that seventeen year span, among the countries with the largest economies, Japan has shown by far the strongest growth in its total manufacturing R&D intensity. Japan's intensity has grown especially rapidly since 1981 (an increase of 1.1 percentage points) allowing it to attain in 1989 a level comparable to Germany's (2.5 per cent). By 1985, Japan's overall R&D intensity for manufacturing had surpassed those of France and the United Kingdom. Nevertheless, when compared to the United States' R&D intensity for manufacturing, Japan's R&D intensity is only three-quarters of the US intensity in 1990 when measured using purchasing power parities (see box). Despite a slight decline from 1985 to 1989, the United States has consistently maintained intensities well above the other OECD-13 countries, being the only country to obtain a total manufacturing intensity ratio exceeding the three per cent level (from 1985 to 1989).

33. Although it was not as large as Japan's increase, Germany also showed an important rise in its total manufacturing intensity over the period. After 1983, Germany had the highest intensity of all of the EC-6 countries, surpassing the United Kingdom in that year. The evolution of the United Kingdom's total manufacturing intensity ratio is rather distinctive as it displayed the strongest growth of OECD-13 countries during the 1977 to 1981 period, achieving a two per cent level in 1981, but has not moved appreciably from this level during the 1980s. The stable level of the United Kingdom's intensity during the 1980s, explains why the United Kingdom registered the lowest increase of all the OECD-13 between 1973 and 1989. On the other hand, France showed steady growth in its total manufacturing intensity throughout this period, attaining a level of 2.2 per cent in 1989. The two remaining Group of Seven (G-7) countries, Canada and Italy, had the lowest intensities of all OECD-13 countries in 1989, at less than one per cent. Their total manufacturing R&D intensities during the 1973-1989 period represented between 30 per cent and 50 per cent, respectively, of the intensities found in the other G-7 countries.

34. Among the medium- and small-size economies, Sweden has the highest total manufacturing R&D intensity. During the period from 1973 to 1989, Sweden's R&D intensity was higher than all OECD-13 countries, except for the United States. It attained a level of almost three per cent in 1987, but has since that time decreased 0.3 percentage points, falling below the three per cent level in 1990. The Netherlands' total manufacturing intensity stayed rather stable between 1973 and 1985, but showed rapid growth from 1985 to 1987, attaining a level of 2.2 per cent in 1987. However, from 1987 to 1989, like the Swedish case, the Netherlands intensity declined notably, falling below the two per cent level. It is interesting to note that Finland showed the strongest increase of all OECD-13 countries from 1973 to 1989 in its total manufacturing intensity, growing at an average annual growth rate of 6.4 per cent during the period. This rate of increase permitted Finland to exceed in 1989 the intensities of Australia, Denmark, Norway, Canada and Italy. One could argue that Finland's considerable growth is just a reflection of a small starting point in 1973. Nonetheless, all countries which were surpassed by Finland had intensities similar to Finland's in 1973. Despite having been surpassed by Finland in the late 1980s, Denmark's total manufacturing intensity has also increased strongly between 1973 and 1989, more than doubling. Norway is the Nordic-4 country for which total manufacturing R&D intensity demonstrated the weakest growth. It increased only by 0.3 percentage points from 1973 to 1989, just barely reaching the one per cent level in 1989. Australia had a 1989 total manufacturing intensity of only one per cent, but it attained this level by exhibiting a very rapid growth from 1983 to 1989, increasing at average annual growth rate of 14 per cent.

A Description of the Indicator

R&D intensities have been calculated as the ratio of business enterprise R&D expenditure performed in a manufacturing industry over the production (gross output) of that industry for a given country or country groupings. They were calculated with current national currencies data except for the country groupings where the data is expressed using United States purchasing power parities (PPPs) for GDP. It should be noted that the R&D intensities for country groupings could be significantly different if exchanges rates had been used.

R&D intensities try to reflect the technological sophistication of a particular industry. Despite their wide use, R&D intensities have many shortcomings as they account for only one (the need for a strong R&D effort) of the characteristics usually attributed to industries considered as belonging in the high-technology category. Other characteristics of high-tech industries are the presence of high-risks, large capital investment, very rapid product and process obsolescence, strategic importance for governments and a high degree of international co-operation or competition in R&D. In addition, by focusing exclusively on the R&D expenditures in a particular industry no consideration is given to the fact that some industries often do little R&D themselves while acquiring embodied technology through the purchase of technologically sophisticated capital goods. Technology may also be acquired through purchases of patents, technological feedback by users of the industry's products or improved management and information systems. In certain industries, these alternative methods of acquiring technology may be more important than direct R&D expenditures. In such cases, R&D intensity ratios may be a poor proxy for technological intensity. Moreover, simple international comparisons based on them are distorted by differences in the industrial structure of countries. As an example, if a country's economy is biased towards sectors involved in the extraction of natural resources, a low R&D intensity may simply reflect the importance of these sectors, which are typically considered as not being R&D-intensive.

This indicator uses business enterprise R&D expenditure (BERD) which allocates that portion of R&D that is performed by the business sector as opposed to where the funding for the R&D comes from. In this sense, it includes R&D funded by the non-business sector such as government, but performed by industry. Given that the role of government funding differs widely across countries, R&D intensities based on BERD should not be strictly interpreted as a measure of the financial involvement of business enterprises in R&D activities. The general unavailability of R&D data at a detailed industrial-level precludes the separation of R&D by source of funds.

Another caveat associated with this indicator is the lack of internationally comparable R&D price deflators, making it necessary to use current price data which limit accurate historical comparisons. As a result of using current price data, some of the fluctuations in R&D intensity could simply be a reflection of relative price changes, not a change in true R&D investment. Lastly, the R&D intensities presented here are based on a flow, rather than a stock, concept. Thus, they fail to reflect accumulated R&D expenditures. Nevertheless, by calculating the intensities over a 17 year period, a rough idea of the accumulated stock can be obtained.

Sectoral R&D Intensities

35. Given the diversity that exists between manufacturing industries, R&D intensities at the sectoral level vary significantly between the OECD-13 countries. This is evident in Table RDI 1 which presents the average R&D intensity ratios calculated for two time periods (1976 to 1978 and 1986 to 1988). R&D intensities are given for nine manufacturing sectors (two-digit ISIC) as well as for the high, medium and low-technology groupings. It can be seen that the intensities of the high-technology industries are in every OECD-13 country significantly higher than the intensities found in the medium and low-technology industries. The United States exhibited by far the highest intensities in the high-technology sectors during both time periods, being the only country to exceed the ten per cent level in 1986 to 1988. France and the United Kingdom, with high-technology intensities of respectively 8.7 per cent and 8.5 per cent in 1986 to 1988, followed the United States. Although Canada is in the middle of the R&D intensity of the high-technology group is ranked, it displayed the strongest asymmetry of intensities between the high-technology and medium-technology sectors, with the high-technology intensity being ten times as large as the medium-technology intensity.

Value Added or Production as an Output Measure in R&D Intensity?

In order to examine if the ranking of industries according to their R&D intensity varies using a measure of net output, sensitivity tests were carried with value added as the output factor instead of production (gross output). This analysis reveals that depending on the measure used, the R&D intensity for certain industries increased faster than others. Nonetheless, the choice of which measure to use as a value of output had little affect on the overall ranking of industries.

Those industries which were most sensitive to the use of value added as opposed to production were petroleum refining, non-ferrous metals, ferrous metals and motor vehicles. This is because of the importance of intermediate inputs to these industries which are included in production data, but not in value added data.

36. The most interesting feature of the table is that countries, such as Germany and Japan, which showed a high total manufacturing intensity in 1986-88 do not necessarily display a strong intensity in the high-technology group during

that same period. Japan's level of R&D intensity in the high-technology sectors during the 1986-88 period was below every OECD-13 country, except for Italy (3.6 per cent). In this sense, there is not necessarily a strong link between high levels of total manufacturing intensities and an R&D intensive high-technology sector. Rather, a stronger correlation exists between the R&D intensity of the medium-technology group and the overall intensity of total manufacturing. A simple Spearman rank correlation indicates a correlation of 0.68 between the total manufacturing R&D intensity and the medium-technology intensity while the same correlation with the high-technology group is 0.38.

37. In the low-technology sectors, because of the very low intensities (all below one per cent), the countries are grouped much more closely than in the high and medium-technology industries. Japan had in 1986 to 1988 the highest intensity (0.7) in the low-technology sectors, followed by the United States (0.5 per cent). In particular, Japan showed the highest intensity in three (the food group, the textile group and non-metallic mineral products) out of the five low-technology sectors (Table RDI 1). As for the paper group and the wood group industries, Japan displayed intensities comparable to the ones exhibited by Canada and the Nordic-4 countries where the paper and wood group industries hold a very important place in their industrial structures.

R&D Intensity Profile of Countries

38. Table RDI 1 showed that countries with high levels of total manufacturing R&D intensities are not necessarily the countries which displayed the strongest intensities in the high-technology sectors. Figures RDI-2, 3 and 4 provide further detail by showing the individual R&D intensities of all 22 manufacturing industries for the United States, Japan, the EC-6, Germany, France and the United Kingdom. Each graph presents R&D intensities calculated over two time periods (1976 to 1978 and 1986 to 1988) for every manufacturing sector, presented from left to right following the standard OECD classification of industries according to their technological intensity (ranging from high to low-technology industries).[5]

39. A striking feature of the graphs is that the R&D profiles do not fall uniformly from left to right. There are differences over time within an individual country as well as between countries. The most apparent divergence is the one noted above on a broader scale: the relatively low R&D intensity in Japan of what are traditionally considered to be high-technology industries. In every country but Japan, four industries (aircraft, computers, communications equipment and pharmaceuticals) have very high intensities that undoubtedly set them apart from the other industries. These very high intensities unquestionably make them belong to the high-technology group. Compared to the other countries, it is clear that the R&D intensity profile of Japan exhibits less of a bias towards high-technology industries as the R&D intensities do not drop so markedly as one moves from high to low-technology sectors. R&D resources in Japan are less concentrated in the high-technology industries and more evenly distributed across the high and medium-technology industries as described in Table RDI 1.

40. Another feature of the graphs is that not all the R&D intensities have increased from 1976-1988 to 1986-1988. In the case of the United Kingdom, the R&D intensity ratios of two high-technology sectors (aircraft and computers) have decreased over time. The intensity of the aircraft sector suffered the most significant decline of all manufacturing sectors in the United Kingdom, decreasing by five percentage points between 1976 to 1978 and 1986 to 1988. At the same time, the R&D intensities of the communications equipment and pharmaceuticals industries have significantly increased, making pharmaceuticals in 1986 to 1988 the most R&D intensive industry in the UK with a R&D intensity of 13.2 per cent. With nine out of 22 sectors showing a fall in their R&D intensities, the United Kingdom is the country which exhibited the highest number of sectors with declining intensities.

5. OECD (1986), OECD Science and Technology Indicators, No.2, Paris.

41. The United States displayed declines in five industries, most significantly in electrical machinery whose R&D intensity decreased from 5.4 per cent to 1.7 per cent.[6] Nevertheless, the United States showed notable increases in the R&D intensities of the communications equipment, pharmaceuticals, motor vehicles and other transport sectors. The communications equipment industry showed the greatest increase in its R&D intensity in terms of percentage points, rising from 7.8 per cent to 13.2 per cent. This increase was not large enough for it to exceed the intensity of the aircraft sector which was in 1986-1988 had a R&D intensity of 20.8 per cent: the most R&D intensive manufacturing industry in the United States. In France, the aircraft industry also had the highest R&D intensity in 1986-1988, at 15 per cent. France exhibited important increases in the R&D intensity of the communications equipment, pharmaceuticals, chemicals and other transport industries. However, it is striking that the R&D intensity of the computers industry has declined by two percentage points from 1976-1978 to 1986-1988.

42. In Japan and Germany, the R&D intensity profiles reveal an unequivocal increasing trend from 1976-1978 to 1986-1988 with nearly every industry showing an increase in its R&D intensity ratio. In Japan, the strongest rises occurred in the aircraft, instruments, computers, pharmaceuticals, chemicals and other transports industries. With an increase in its R&D intensity of 2.4 percentage points, the pharmaceuticals industry has become the most R&D intensive industry in Japan, surpassing in 1986-1988 the intensity of the aircraft sector. In Germany, the R&D intensities of only two sectors (aircraft and non-ferrous metals) have fallen. Despite a large decline of almost seven points, the aircraft sector was still the industry with the highest R&D intensity ratio in Germany (1986-1988). The strongest R&D intensity increases in Germany occurred mainly in the communications equipment, motor vehicles and non-electrical machinery sectors.

43. As for the EC-6 countries taken as a whole, the movements in their R&D intensities reflect the intensity fluctuations observed in France, Germany and the United Kingdom. The decreases in the R&D intensity of the aircraft and computers industries reflect declines in the intensity of the aircraft sector in Germany and the United Kingdom, as well as decreases in the intensity of the computers industries in France and the United Kingdom. At the same time, the R&D intensity of the communications equipment and pharmaceuticals industries has risen significantly, reflecting the R&D intensity increases of these sectors in Germany, France and the United Kingdom. These gains in the communications equipment and pharmaceuticals industries meant that they exceeded the R&D intensity ratio of the computer industry in 1986-1988.

6. Some of this decline could be due to the fact that the United States data is strictly classified on an enterprise basis while efforts have been made to convert many of the other countries' data to more of an establishment or product basis. Because the US data is on an enterprise basis, it is possible that a change in the classification of a large enterprise from one industry to another could result in such a shift. For example, if General Electric (GE) was re-classified out of the electrical machinery industry.

Table: RDI-1
Average R&D Intensity Ratios

ISIC	Industry	Canada		Denmark		France		Germany		Italy	
		1976-78	1986-88	1976-78	1986-88	1976-78	1986-88	1976-78	1986-88	1976-78	1986-88
3000	Total Manufacturing	0.58	1.04	0.76	1.30	1.42	2.17	1.49	2.40	0.44	0.93
3100	Food group	0.15	0.20	0.17	0.33	0.11	0.21	0.08	0.17	0.02	0.06
3200	Textiles group	0.08	0.27	0.16	0.07	0.16	0.18	0.09	0.24	0.09	0.01
3300	Wood group	0.05	0.14	0.09	0.11	0.04	0.06	0.05	0.38	0.01	0.01
3400	Paper group	0.25	0.31	0.07	0.03	0.08	0.11	0.10	0.17	0.03	0.01
3500	Chemical group	0.86	0.98	1.54	2.46	1.72	2.77	2.31	2.95	N.A.	N.A.
3600	Non-metallic mineral products	0.16	0.23	0.65	0.80	0.69	0.71	0.29	0.80	0.03	0.06
3700	Basic metals	0.61	0.59	0.19	0.60	0.46	0.67	0.37	0.50	0.08	0.30
3800	Fabricated metal products	1.08	2.25	1.47	2.27	2.96	4.25	2.52	3.81	0.85	2.00
3900	Other Manufacturing	0.17	0.66	N.A.	N.A.	0.39	0.32	0.09	0.72	0.53	0.05
	High technology	4.73	8.43	N.A.	6.98	7.14	8.72(1)	5.54	7.21	1.64	3.63(2)
	Medium technology	0.45	0.57	N.A.	1.96	1.51	2.03(1)	2.02	2.89	0.71	1.04(2)
	Low technology	0.24	0.30	0.22	0.30	0.25	0.36	0.15	0.40	0.07	0.13

		Japan		Nordic-4		United Kingdom		United States		EC-6	
		1976-78	1986-88	1976-78	1986-88	1976-78	1986-88	1976-78	1986-88	1976-78	1986-88
3000	Total Manufacturing	1.12	2.26	1.21	1.94	1.37	2.04	2.11	3.36	1.22	1.93
3100	Food group	0.27	0.56	0.23	0.31	0.30	0.24	0.19	0.34	0.15	0.20
3200	Textiles group	0.18	0.48	0.17	0.26	0.34	0.13	0.10	0.18	0.16	0.11
3300	Wood group	0.12	0.22	0.12	0.14	0.06	0.04	0.22	0.14	0.04	0.13
3400	Paper group	0.18	0.30	0.40	0.43	0.15	0.13	0.34	0.24	0.09	0.11
3500	Chemical group	1.66	3.13	1.68	2.85	1.51	2.63	1.84	2.73	1.61	2.60
3600	Non-metallic mineral products	0.92	2.15	0.67	0.83	0.57	0.39	0.80	1.46	0.35	0.45
3700	Basic metals	0.46	1.17	1.17	1.11	0.43	0.47	0.53	0.63	0.38	0.55
3800	Fabricated metal products	1.99	3.36	2.52	4.03	2.74	4.02	4.43	6.77	2.33	3.59
3900	Other Manufacturing	0.82	1.33	N.A.	N.A.	1.47	1.22	1.28	1.19	0.72	0.70
	High technology	3.49	5.34	N.A.	9.35	6.96	8.49	9.76	11.81	N.A.	6.95(1)
	Medium technology	1.60	2.55	N.A.	2.78	1.13	1.66	1.74	2.54	N.A.	2.08(1)
	Low technology	0.34	0.72	0.39	0.47	0.32	0.26	0.39	0.52	0.22	0.32

(1): 1986
(2): 1985-87

Figure RDI 1

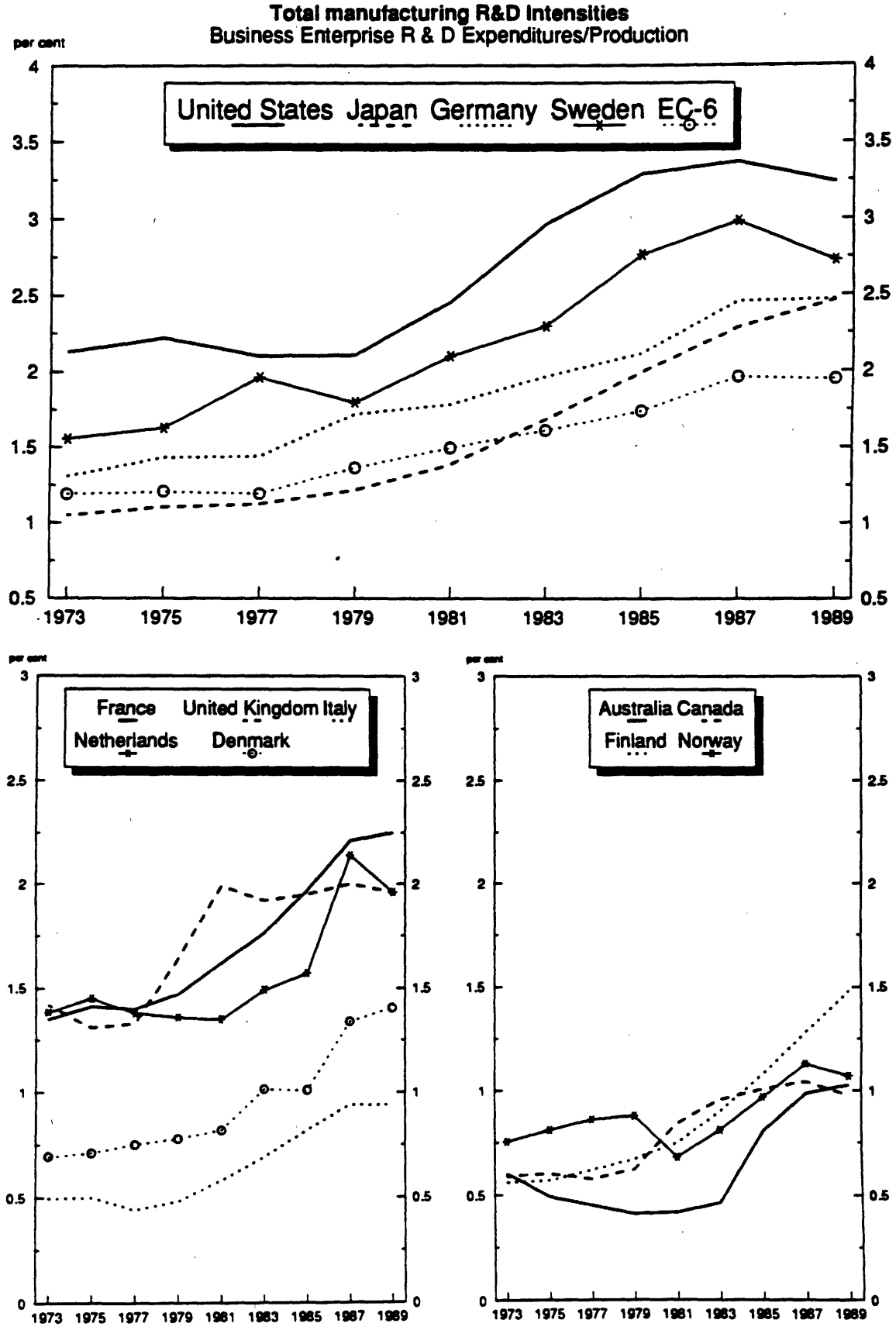

Total manufacturing R&D Intensities
Business Enterprise R & D Expenditures/Production
per cent
United States Japan Germany Sweden EC-6
France United Kingdom Italy
Netherlands Denmark
Australia Canada
Finland Norway
1973 1975 1977 1979 1981 1983 1985 1987 1989

Figure RDI 2

R & D Intensity Profiles

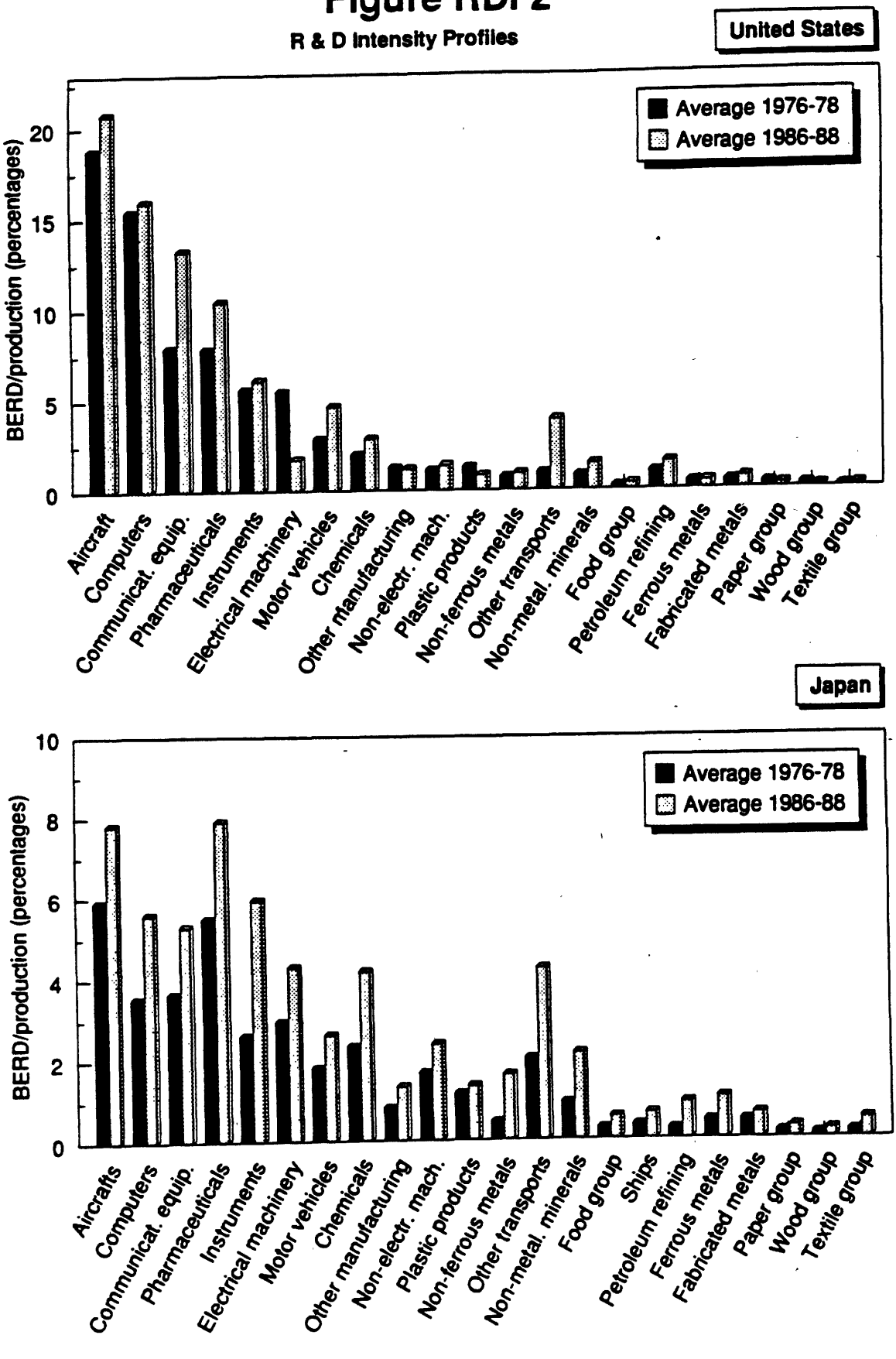


Figure RDI 3

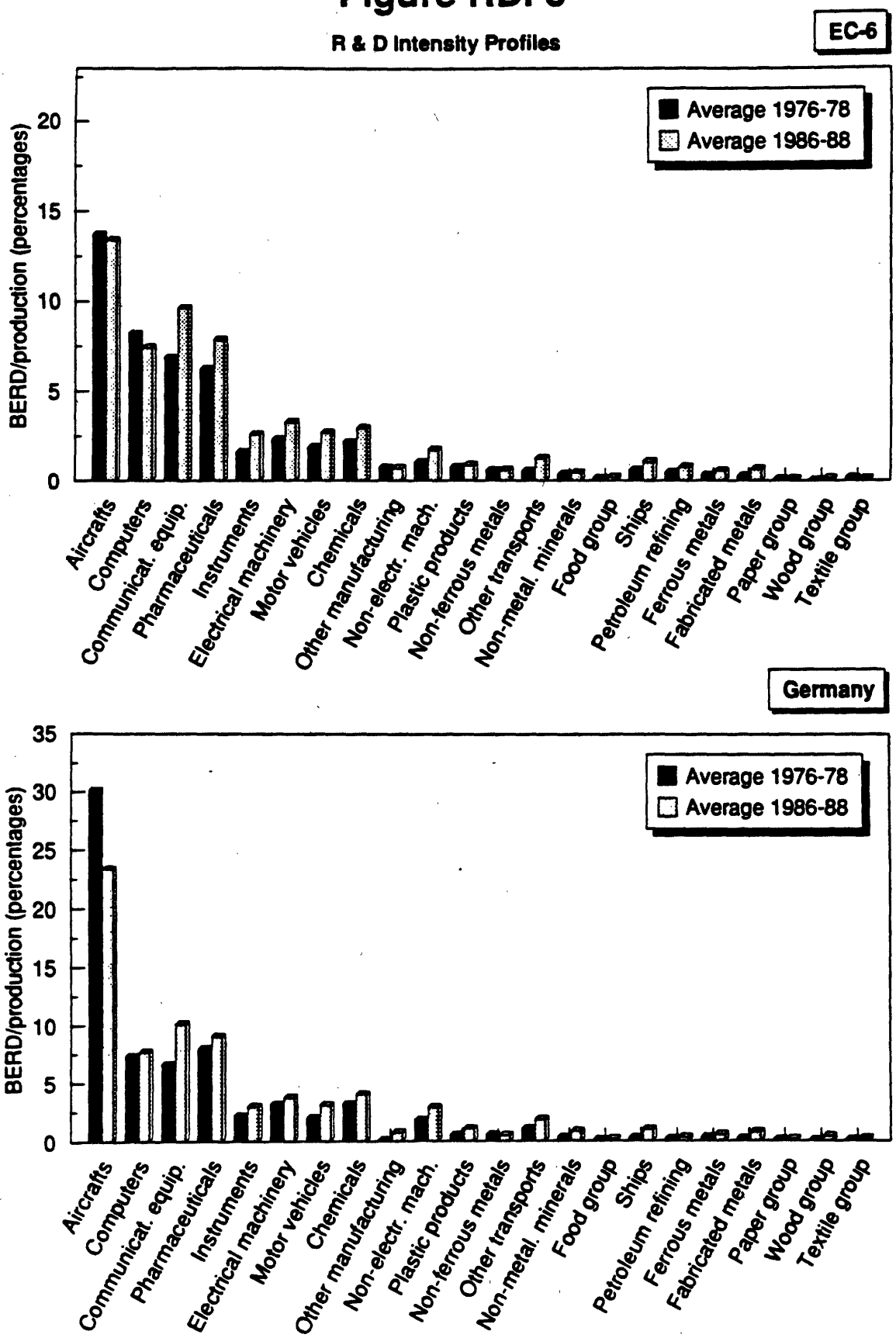
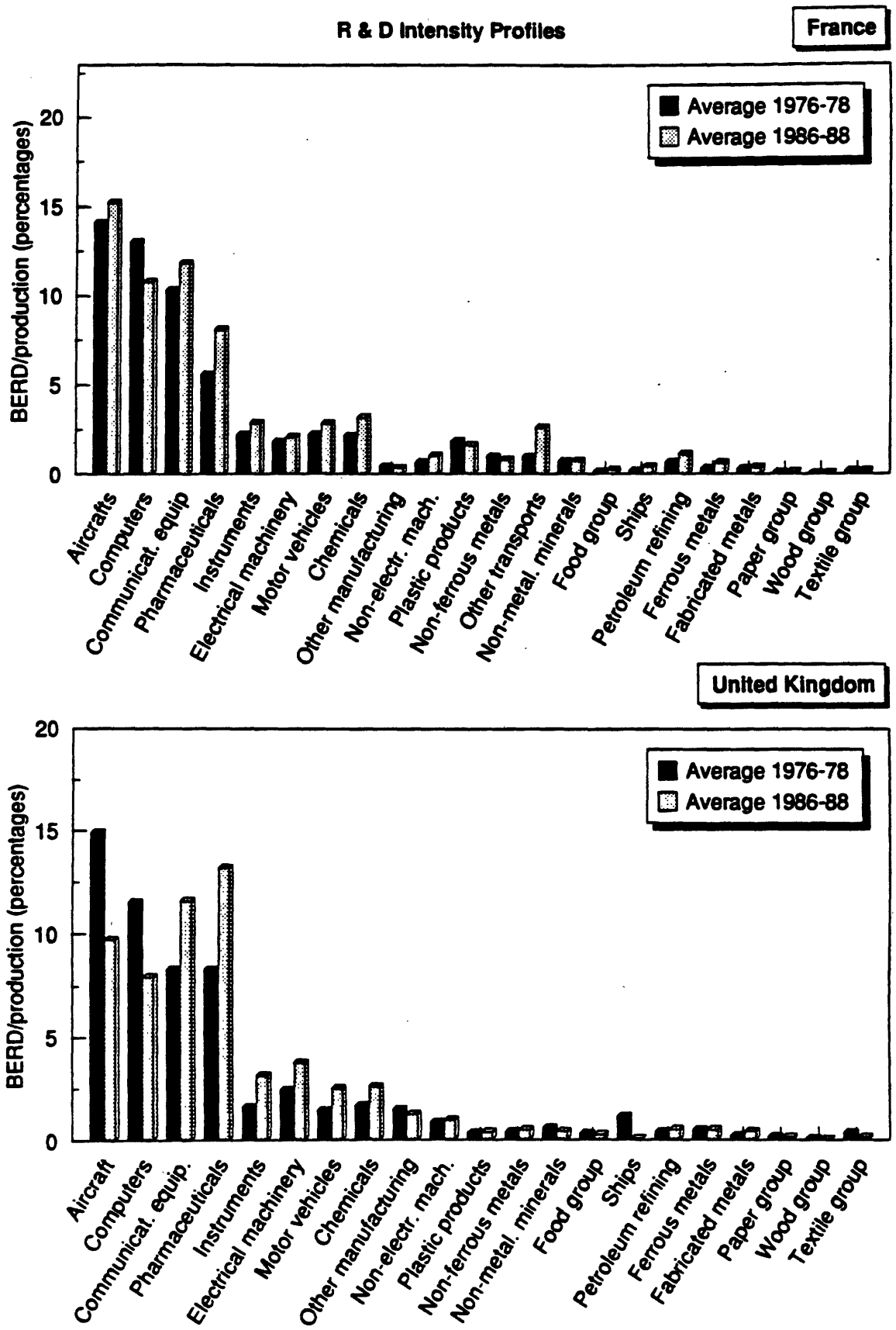

R & D Intensity Profiles
EC-6
Average 1976-78
Average 1986-88
BERD/production (percentages)
0
5
10
15
20
Aircrafts
Computers
Communicat. equip.
Pharmaceuticals
Instruments
Electrical machinery
Motor vehicles
Chemicals
Other manufacturing
Non-electr. mach.
Plastic products
Non-ferrous metals
Other transports
Non-metal. minerals
Food group
Ships
Petroleum refining
Ferrous metals
Fabricated metals
Paper group
Wood group
Textile group
Germany
Average 1976-78
Average 1986-88
BERD/production (percentages)
0
5
10
15
20
25
30
35
Aircrafts
Computers
Communicat. equip.
Pharmaceuticals
Instruments
Electrical machinery
Motor vehicles
Chemicals
Other manufacturing
Non-electr. mach.
Plastic products
Non-ferrous metals
Other transports
Non-metal. minerals
Food group
Ships
Petroleum refining
Ferrous metals
Fabricated metals
Paper group
Wood group
Textile group

Figure RDI 4


R & D Intensity Profiles
France
Average 1976-78
Average 1986-88
BERD/production (percentages)
0
5
10
15
20
Aircrafts
Computers
Communicat. equip
Pharmaceuticals
Instruments
Electrical machinery
Motor vehicles
Chemicals
Other manufacturing
Non-electr. mach.
Plastic products
Non-ferrous metals
Other transports
Non-metal. minerals
Food group
Ships
Petroleum refining
Ferrous metals
Fabricated metals
Paper group
Wood group
Textile group
United Kingdom
Average 1976-78
Average 1986-88
BERD/production (percentages)
0
5
10
15
20
Aircraft
Computers
Communicat. equip.
Pharmaceuticals
Instruments
Electrical machinery
Motor vehicles
Chemicals
Other manufacturing
Non-electr. mach.
Plastic products
Non-ferrous metals
Non-metal. minerals
Food group
Ships
Petroleum refining
Ferrous metals
Fabricated metals
Paper group
Wood group
Textile group

Investment Shares within a Country

44. Movements in investment shares capture the annual changes in the flow of investment into different manufacturing industries, giving a picture of broad structural shifts that are taking place in manufacturing (see box for definition and discussion of investment shares). From this perspective, it is evident that there has been a steady swing away from investment in low-technology (low R&D-intensity) industries, with the share of these industries in total investment declining from around 55 per cent of the total in the early 1970s to 45 per cent in the late 1980s and into the machinery and fabricated metal products industry, particularly the motor vehicles industry (Figure IS 1). Despite differences among countries in investment specialisation, most moved out of, and into, the same industries. Nearly every country increased or maintained investment shares in machinery and fabricated metal products and in paper and printing. Almost all moved out of textiles, apparel and leather, basic metals, and non-metallic mineral products. Chemicals remained flat or declined in most cases.

Investment in Low-technology Industry

45. Low-technology industries account for one-half of total manufacturing investment in most OECD countries. These industries, particularly process industries such as food, paper products, petroleum refineries, non-metallic minerals (building materials) and iron and steel, are capital-intensive and have continued to take a large share of all physical investment in OECD countries through the period 1970-1990. However this share declined significantly in most countries from an average around 55 per cent in the early and mid-1970s to around 45 per cent at the end of the 1980s, although there were some signs of an upturn in the share of investment at the end of the period (Figure IS 2). The decline has been associated with shifts away from capital-intensive heavy industry (e.g. iron and steel, heavy engineering) towards technology-intensive industry in most countries, coupled with structural adjustment and scrapping of surplus capacity in heavy industries.

46. Germany and Japan had the lowest shares of investment in low-technology industries (around 40 per cent) at the end of the 1980s. However their investment experience has been different. Germany has consistently had a lower than average share of investment in these industries. Japan shifted resources rapidly from having a higher than average share of investment in low-technology industries in the mid-1970s (55-60 per cent) to a lower than average share at the end of the period (below 40 per cent), as investment was reduced in basic metals and textiles and increased in electronics and related industries.

47. Resource-based OECD economies maintained relatively large shares of investment in low-technology industries. Of all countries for which data is available, Finland, Denmark and Norway have the highest shares of investment in low-technology industries. In the

Description of the Indicator

"Investment" is gross fixed capital formation (GFCF) as defined in the System of National Accounts. The investment shares indicator is calculated by dividing annual GFCF investment expenditures in each individual industry by total GFCF for all of manufacturing for each country or group of countries. The total for all manufacturing sums to one.

The indicator shows the relative distribution of annual investment expenditures. It illustrates shifts in investment over time in individual countries, and differences between countries in the distribution of investment. It is an important indicator of structural change, as different industries invest at different rates to increase capacity and expand (capital-widening), or change production methods and become relatively more capital-intensive (capital-deepening). In conjunction with employment shares and R&D shares the indicator shows changes in key inputs into production. This indicator also shows variations in national industrial specialisation, reflecting natural and acquired comparative advantages.

The main weakness of the indicator is that annual values for a few years may not reflect long-term trends in the capital stock, and hence the capital intensity of production. Capital stock data give a more reliable picture of the use of capital in different industries. But capital stocks are difficult to construct, because scrapping rates and economic lifetimes of capital assets change both over time and among industries, and can change dramatically over short periods, e.g. when large parts of national industries such as steel and ship building become un-economic and close.

Furthermore, the investment cycle varies among industries, and annual comparisons among industries should be treated with caution. For example process industries producing intermediate goods such as chemicals and basic metals have a similar investment cycle, but one which is different from other investment-intensive process industries such as paper pulp. These are different again from industries more closely linked to consumer demand such as construction materials or consumer products such as motor vehicles or consumer electronics, or industries producing investment goods.

The investment cycle also differs among countries, despite convergence of economic cycles. The United States went into recession well ahead of continental Europe and Japan in the current economic cycle. Smaller economies are much more likely to show large annual changes in the distribution of their investment due to the impact of large projects in capital-intensive industries with "lumpy" investment behaviour.

Nordic countries the low-technology share of total investment was 65 per cent or more at the end of the 1980s, except in Sweden where it was around 55 per cent throughout the 1980s, and in Canada where it was over 55 per cent at the end of the 1980s. The paper, wood and food groups were particularly important and consistent investors in capital equipment in these countries. Australia has maintained relatively high shares of investment (around 55 per cent) in low-technology industries particularly in food processing, paper products and basic metals. In Italy, textiles and apparel, non-metallic minerals, and the share of total investment in low-technology industries showed a rising trend.

Investment in Different Industries

48. The machinery and fabricated metal products industry has consistently held the largest share of total investment for the OECD-13 as a whole. On an individual country basis, it was the leader in eight of these thirteen countries, was the alternating leader with other industries in two countries, and was the second most important sector of investment in the other three countries.

49. The chemical industry is the next most important investing industry, being the lead source of investment in two countries (the Netherlands and Norway), the second most important investing industry in six other countries and the third in four countries. The food, beverages and tobacco industries are the second most important sources of investment in Denmark and occupy third position in five other countries. A small number of other industries each count among the most important investors in a few countries. These include paper, printing and publishing in Finland, Canada and Sweden, and basic metals in Australia (particularly non-ferrous metals). Basic metals were also important during the early part of the 1970-1990 period in Sweden and Germany. Textiles, apparel and leather goods are important investors in Italy.

50. The broad fabricated metal products and machinery industry increased in importance as a source of fixed investment in most countries over the two decades. Japan and Germany had the highest shares of total investment in machinery and fabricated metals at the end of the period -- 48 and 46 per cent respectively, with Japan increasing its share by over one-half from 32 to almost 50 per cent from 1970 through to the end of the 1980s (Table IS 1). Of other countries, only the United States and Sweden had investment shares greater than 40 per cent in this industry at the end of the 1980s. The only exceptions to this general trend were found in the United Kingdom, Denmark, Norway and Australia, but declines in the share of investment were not particularly important and may well have been cyclical.

51. The motor vehicle industry was the most important investing industry within the broad machinery and fabricated metal products industry at the end of the 1980s. Motor vehicles were particularly important investors in Germany, Japan and Canada at the end of the period. In both Germany and Japan they ranked just behind the broad chemical products industry. And in Canada, motor vehicles was a more important investor than chemicals at the end of the 1980s. The motor vehicle industry was also the most important of the machinery and fabricated metal products industries in Australia, France, the United Kingdom and the United States at the end of the 1980s, surpassing other industries in this sector such as computers, electrical machinery and aircraft.

52. Of the other industries within machinery and fabricated metal products, non-electrical machinery (including office and computing equipment) was particularly important in Denmark, Finland and Norway, fabricated metal products in Italy and the Netherlands, and electrical machinery in the United States. In Japan there was also considerable investment in the radio, TV and communication equipment industry (comprising consumer electronics, communications equipment and semiconductors) towards the end of the period as Japanese industry invested heavily in export-oriented industries.

53. Within the broad chemical industry, industrial chemicals was the key source of investment, but the pattern of investment fluctuated widely due to the bunching of large-scale investments in major plants in this industry.

54. The paper products and printing industry had the most significant increase in its share of investment. This industry had the largest increase in its investment share for eight of the thirteen countries and had significant increases in two others. Machinery and fabricated metal products had the second most important increase in investment share, having

the largest percentage share increase for three countries. These two industries had by far the most important increases in investment shares.

55. Basic metal industries had the largest declines in their share of investment (from around 15 per cent to around seven per cent). These industries (particularly iron and steel) experienced the most important drop in the share of investment in eight countries, and significant declines in their share in three other countries. Textiles and apparel had the second largest relative declines in investment shares (from around 5 to around 3 per cent). They had the most important decline in share in three countries, and there was an important decline in share in eight other countries. The non-metallic mineral products industry is the other major industry to significantly lose its share of investment with declines in eight countries.

56. Industries retaining a stable share of total investment were the consumer industries of food, beverages and tobacco (around one tenth of total investment) and wood products and furniture (two to three per cent of total investment), and the intermediate chemical products industry (slight declines from a little over 20 per cent to a little less than 20 per cent of the total).

Country Specialisation

57. By country there was a wide variation in the specialisation of industrial investment, and considerable differences in the speed with which countries changed the structure of their investment. Japan had the most noticeable changes in the pattern of investment, away from basic metal industries (particularly iron and steel), textiles clothing and leather, and to a lesser extent chemicals and towards the machinery and fabricated metal products industries (and paper and printing), noticeably towards motor vehicles and radio, TV and communications equipment. France and Germany also changed their investment structures markedly, with France moving out of basic metals, textiles, building materials and chemicals, and towards the machinery and fabricated metal products industries. Although Germany had somewhat smaller changes in its structure of investment, it too moved away from basic metal industries and textiles towards machinery and fabricated metals and paper and printing.

58. Despite differences among countries in their areas of specialisation, of more interest is the clustering effect as most countries moved out of investing in the same industries, towards investing in the same set of industries. Nearly all the countries increased or maintained their investment share in machinery and fabricated metal products and in paper and printing. Almost all moved out of textiles, apparel and leather (with the exception of Italy which increased its share), basic metals (no country increased its share), and non-metallic mineral products. Chemicals remained flat or declined in importance in all countries except Norway.

Figure IS 1

Investment Shares Across the OECD-13

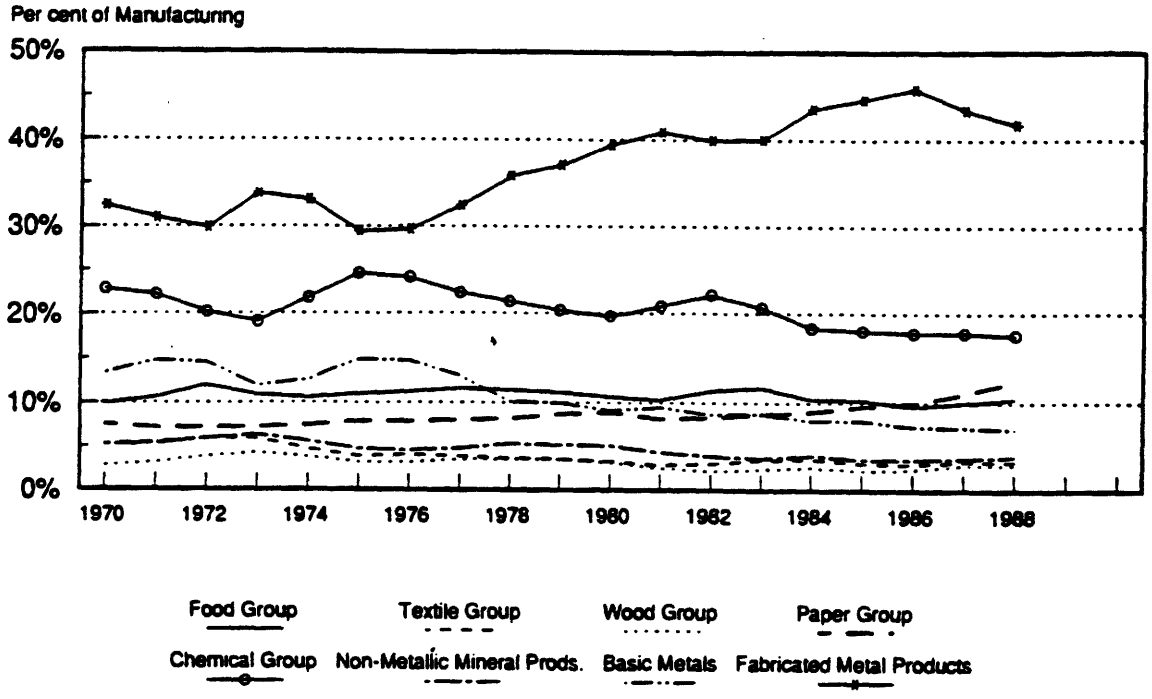
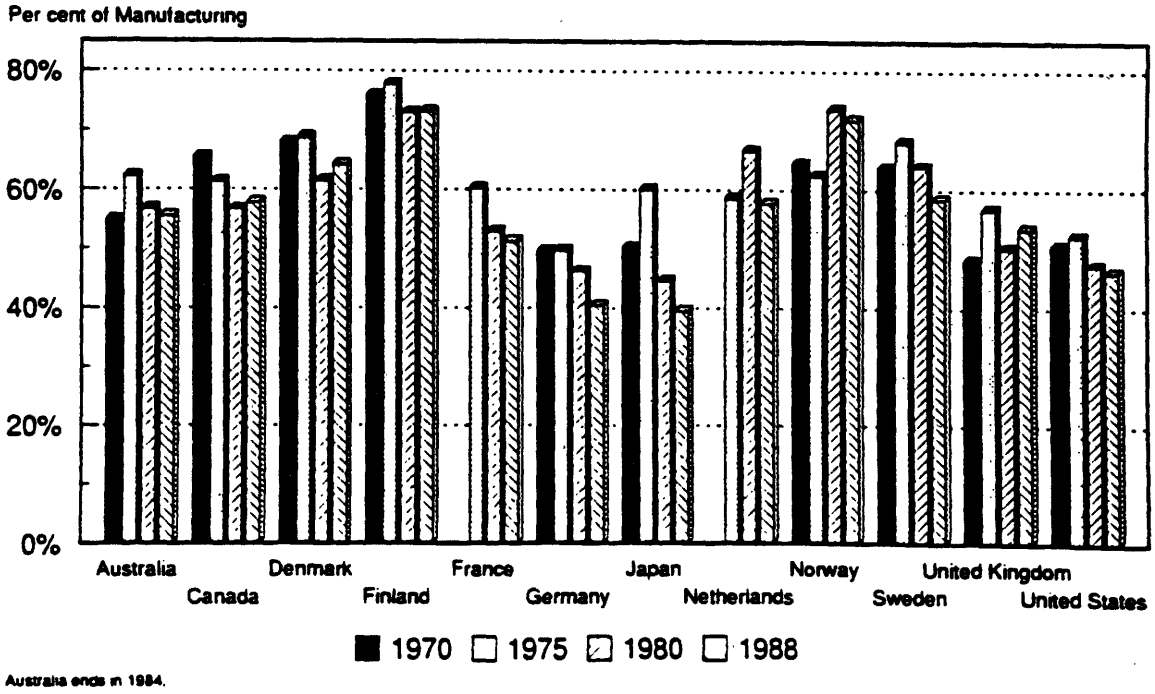


Figure IS 2

Low-Tech



Australia ends in 1984.
France in 1986.

Table: IS-1
Investment Shares within a Country

ISIC	Industry	Australia 1970	Australia 1984	Canada 1970	Canada 1988	Denmark 1970	Denmark 1988	Finland 1970	Finland 1988	Germany 1970	Germany 1988	Italy 1970	Italy 1986	France 1970	France 1989
3100	Food, beverages & tobacco	14 54	17.36	10 90	8.75	20.81	22.09	12.84	10 00	10.61	9.30	6.81	9.70	13.47	12 72
3200	Textiles, apparel & leather	4.78	5.43	3.19	2.03	7.87	4.00	5.62	0.24	5.30	3.14	10.88	14.03	6.35	4.32
3300	Wood products & furniture	3 09	3.70	5.56	6.73	6.54	4.62	8.82	5.26	3.09	2.38	0.00	0.00	2 85	3.62
3400	Paper products & printing	6.92	9.89	20.69	25.73	9.19	12.28	24.63	39.70	5.47	7.28	4.22	8.05	4.90	10.31
3500	Chemical products	13.77	13 44	18.88	14.55	16.23	17.14	15.76	15 55	21.63	19.20	n.a.	n.a.	24.99	18.84
3600	Non-metallic mineral products	5.66	5.36	4.77	2.88	12.72	8.20	4.61	4 10	6.11	4.59	8.31	6.91	7.97	5.63
3700	Basic metal industries	26.94	21.42	15.24	10.31	1.32	0.96	9.31	7 44	12.09	7.05	8.44	8.12	10.56	7.91
3800	Fabricated metal products	23.53	22 98	19 43	27.66	24.59	28.43	17.89	17.15	35.28	46 45	25.25	33.96	28.91	36.66
3900	Other Manufacturing	0.76	0.41	1.35	1.35	0.72	2.28	0.52	0.56	0.41	0.61	n.a.	n.a.	0.00	0 00 *

ISIC	Industry	Japan 1970	Japan 1988	Netherlands 1970	Netherlands 1988	Norway 1970	Norway 1988	Sweden 1970	Sweden 1988	United Kingdom 1970	United Kingdom 1988	United States 1970	United States 1988	OECD-12** 1970	OECD-12** 1984
3100	Food, beverages & tobacco	7 82	9.00	16.05	18.07	18.94	18.34	11.07	8.93	12.06	14.78	9.29	10.45	10.39	10.87
3200	Textiles, apparel & leather	5 24	3.16	4.01	2 45	3.07	0.90	3.01	1.82	5.93	4.38	5.02	3.11	5.21	3 52
3300	Wood products & furniture	1 79	1.11	2 45	2 26	7.59	5.13	5.89	6 72	1.58	2.69	3.42	3.51	2.96	2 86
3400	Paper products & printing	6.39	9.11	7.33	11.86	11.84	12.00	21.87	23.50	6.41	13.81	9.44	14.69	7.99	9 51
3500	Chemical products	22.56	16 59	31.14	31.42	12.79	35.30	11.14	11.75	23.59	19.43	23.01	17.12	22.46	18 52
3600	Non-metallic mineral products	4.59	3.63	7.10	4.10	4.37	4.35	4.07	2.82	6.12	7.10	3.98	2.77	5.28	4 01
3700	Basic metal industries	18.80	8.85	9.56	3.17	18.35	7.18	12.50	5.90	10.24	5.31	11.21	5.23	13.43	8.01
3800	Fabricated metal products	32.07	47.67	21.84	25.98	22.58	16.36	29.99	38.20	33.25	31.85	33.56	42.30	31.55	42.01
3900	Other Manufacturing	1.35	1.35	0.51	0 69	0.46	0.44	0.45	0.37	0.81	0.64	1.07	0.81	n.a.	n.a.

* For France other manufacturing is included in wood products and furniture
** an OECD-12, which excludes Italy, is used here to allow for the calculation of chemical products.

Investment per Employee

59. Gross investment per employee (IE) is the amount of annual expenditures on plant and equipment in an industry divided by the number of employees in that industry (see box for details). Generally, high wage, medium-technology and scale intensive industries are positively correlated to the IE indicator, while low wage, labor intensive industries are characterized by a relatively low investment per employee activity.

60. In terms of the OECD-13 total manufacturing average, IE has increased steadily since 1970, except in 1971-1972 (minus 0.3 per cent) and in 1982-1983 (minus eight per cent), to end up in 1987 three times higher than the 1970 level. To a large degree this increase is a reflection that the investment indicator is calculated using current prices and thus includes a large element of inflation. Nevertheless, this smooth increase in the average OECD-13 indicator contrasts with the fluctuating path followed by most countries, a dissimilarity which seems to go beyond the obvious statistical effect. Three factors contribute to such a phenomenon: 1) the mismatch among short-term economic cycles between countries; 2) differences in national macro-economic policies, and 3) the existence of international capital flows. These factors reflect the fact that national variations in investment behavior are not exclusively a domestic affair, but are frequently affected by the existence of a global economic system.

Major Groupings: Wages, Technology and Orientation

61. Figure IE 1 illustrates the IE indicator aggregated by wage levels, technology intensity, and orientation for the 1985-1987 average for those countries where the data is available. IE is positively correlated to wage levels. In terms of technology, the medium group generally ranks first, except in the United States, where it is preceded by the high-technology group, and in Norway, where it comes immediately after the low-technology group. Only for the United States, Germany, and Japan did the high-technology group clearly exceed the low-technology group in terms of investment per employee.

62. The sectoral grouping based on orientation also displays a rather common pattern, with minor exceptions in the profiles of Norway and Japan. The scale intensive group is always associated with the highest IE values, the science based and the resource intensive groups constantly appear in the second or third position, and the specialized supplier and labor intensive groups regularly rank fourth and fifth, respectively. The two countries mentioned above also conform to this general pattern, although Japan shows an above average IE value in the specialized supplier group, and Norway records a below average IE value in the scale intensive groups.

Description of the Indicator

Gross investment per employee (IE) is calculated as the gross fixed capital formation in a certain industry divided by the number engaged in that industry for a specific country or country grouping.

The gross fixed capital formation values have been converted to U.S. dollars by using the purchasing power parities for capital formation. This conversion allows international comparisons, with the limitation that time-series are expressed in current rather than constant values.

The IE indicator is built using measures of the traditional factor inputs, capital and labor. As regards the former, capital stock would be the ideal measure, but the lack of reliable capital stock data in most OECD countries forces the use of investment flow data. As a result, IE is not so much a proxy for the degree of capital versus labor intensity, as a weighted measure of investment activity.

IE captures basic structural trends in investment, but because investment behavior depends to a large degree on interest rates, business confidence and previous investments, the trends can be quite volatile, especially in capital intensive industries and in small economies. Given the sensitivity of this indicator and its sometime erratic behavior, moving averages are presented to smooth the movements so that a more general trend can be discerned.

Industry Profiles

63. Regularities and exceptions just described are accounted for by the underlying country by industry profiles presented in Figure IE 2, where the industry IE values have been normalized by the total manufacturing IE value.

64. From these figures, it is clear that petroleum refining is the industry which has the highest IE values, exceeding the manufacturing average by at least a factor of three in every country. After petroleum refining, industrial chemical and non-ferrous metals are the next two industries which typically had investment per employee ratios in the late 1980s that were about twice as high as the manufacturing average. Other sectors which frequently had an investmen

per employee ratio that exceeded the manufacturing average are motor vehicles, pharmaceuticals and the paper group. Textiles, apparel and leather was the sector which consistently had the lowest compensation per employee when compared to the manufactuuring average, usually about one-half of the average. The wood group, metal products industry and non-electrical machinery industry also consistently had ratios below the manufacturing average. The industries that remain -- the food group, plastic products, ferrous metals, computers, electrical machinery and communications equipment -- all tend to have investment per employee ratios which were roughly in line with the manufacturing average.

65. These variations reveal that the Norway's high investment per employee in the natural resource intensive group is mainly due to the presense of a high petroleum refining ratio. The industrial chemicals, non-ferrous metals and motor vehicle industries pull up the overall ratio for the medium-technology group with motor vehicle investment the factor behind the high Canadian level in this group. The higher cross-country variance in the IE values for computers, pharmacuticals and aircraft industries explain the different country levels for the high-technology and science based groups.

Changes in Investment per Employee Over Time

66. As regards the relative change in the IE indicator by industry over the period late-1970s to late-1980s, only six industries adhered to a consistent trend across countries: the food and wood industries, which decreased their IE intensity, and the paper, chemicals, plastic products and ferrous metals industries which increased, with very few local exceptions.

Table IE-1: Ranked 1986 Investment per Employee
US Dollars

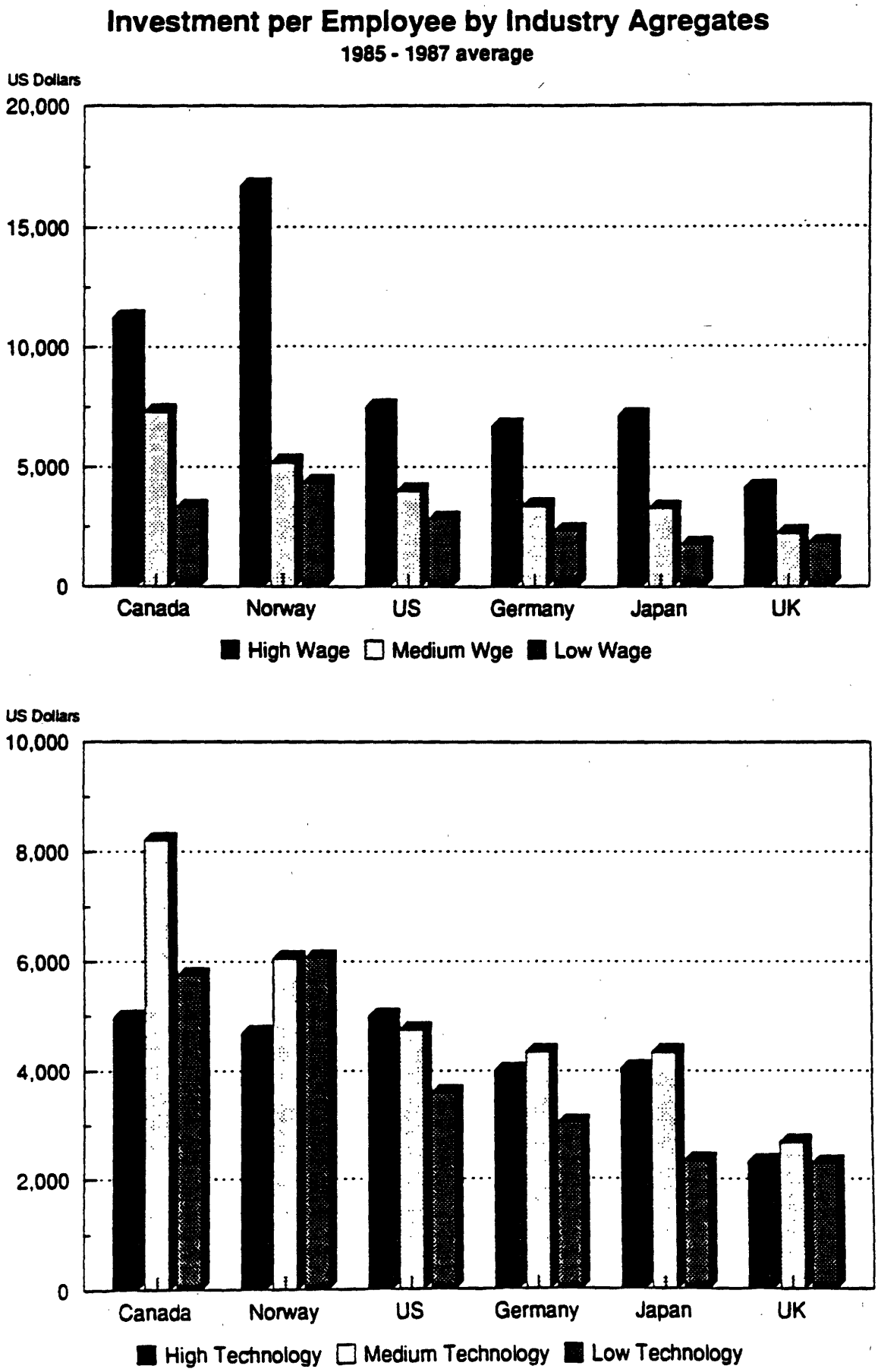
	PPPs	Exch Rate
the Netherlands	7167	7839
Canada	6718	5675
Norway	6076	6779
Finland	5239	5279
France	4829	4986
Italy	4209	4305
Sweden	4164	4853
Australia	4117	4073
United States	4073	3442
Denmark	4102	4774
Germany	3671	4027
Japan	3383	4464
United Kingdom	2331	2383

67. The individual country changes in the ratio of investment per employee relative to the manuafcturing average reflect the structural changes underway in that country. Australia was characterized by a sharp decline in petroleum refining and motor vehicles, accompanied by a large jump in non-ferrous metals. Canada exhibited the biggest decrease in chemicals, offset by a considerable increase in motor vehicles. Denmark increased its already above average position in chemicals, non-metallic mineral products, and ships. Finland appeared to deepen its investment in paper and ferrous metals, and recorded a significant increase in chemicals. France registered a slight deterioration in the petroleum refining and non-ferrous metals industries, but maintained a high IE in non-metallic mineral products. Germany has a decreasing ratio of investment per employee in petroleum refining and computers, although the latter remains particularly high. The profile in Italy shows it to be specialized in the textile, ferrous metals and computers industries, with a jump in non-ferrous metals. Japan has above average ratios in the chemical, motor vehicles, aircraft, petroleum refining and ferrous metals industries, although the latter two have declined over time. Both the Netherlands and Norway offset a reduction in chemicals with an increase in petroleum refining. Sweden has a high ratio in the paper industry, and shows no significant shifts in the overall trend. The United Kingdom is characterized by above average chemicals, pharmaceuticals, and non-metallic mineral products; the decrease in ferrous metals is offset by the increase in computers. The United States records a significant improvement in the pharmaceuticals, computers, electrical machinery, communications equipment, and aircraft industry, while registering a falling ratio in chemicals and petroleum refining.

Country Rankings

68. These sectoral differences are the driving force behind the country rankings shown in table IE-1. Regardless of whether the investment flows were converted to a common currency using purchasing power parities (PPPs) or US dollars, the ranking for the countries with the most investment per employee in the manufacturing sector does not change. The prominence of the Netherlands, Canada and Norway in this top group is a reflection of the large petroleum refining, industrial chemicals and non-ferrous metals sectors within these countries. Likewise, the somewhat surprising presence of Japan and Germany in the bottom half of the list is indicative of the fact that their economies rely more on less investment intensive industries such as non-electrical and electrical machinery, communication equipment and instruments.

Figure IE 1


Investment per Employee by Industry Agregates
1985 - 1987 average
US Dollars
20,000
15,000
10,000
5,000
0
Canada
Norway
US
Germany
Japan
UK
High Wage
Medium Wge
Low Wage
US Dollars
10,000
8,000
6,000
4,000
2,000
0
Canada
Norway
US
Germany
Japan
UK
High Technology
Medium Technology
Low Technology

Investment per Employee by Industry Agregates

1985 - 1987 average

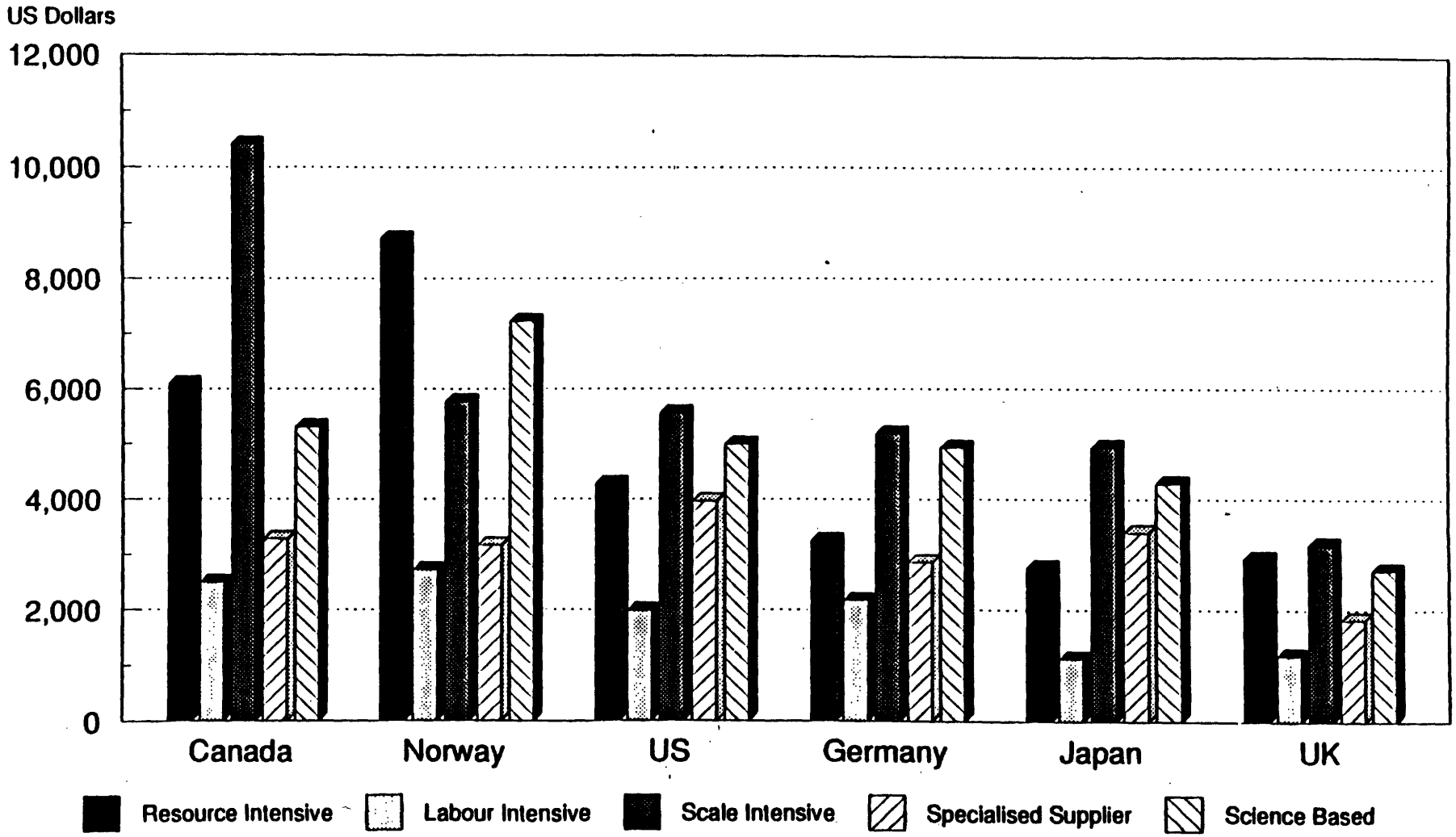
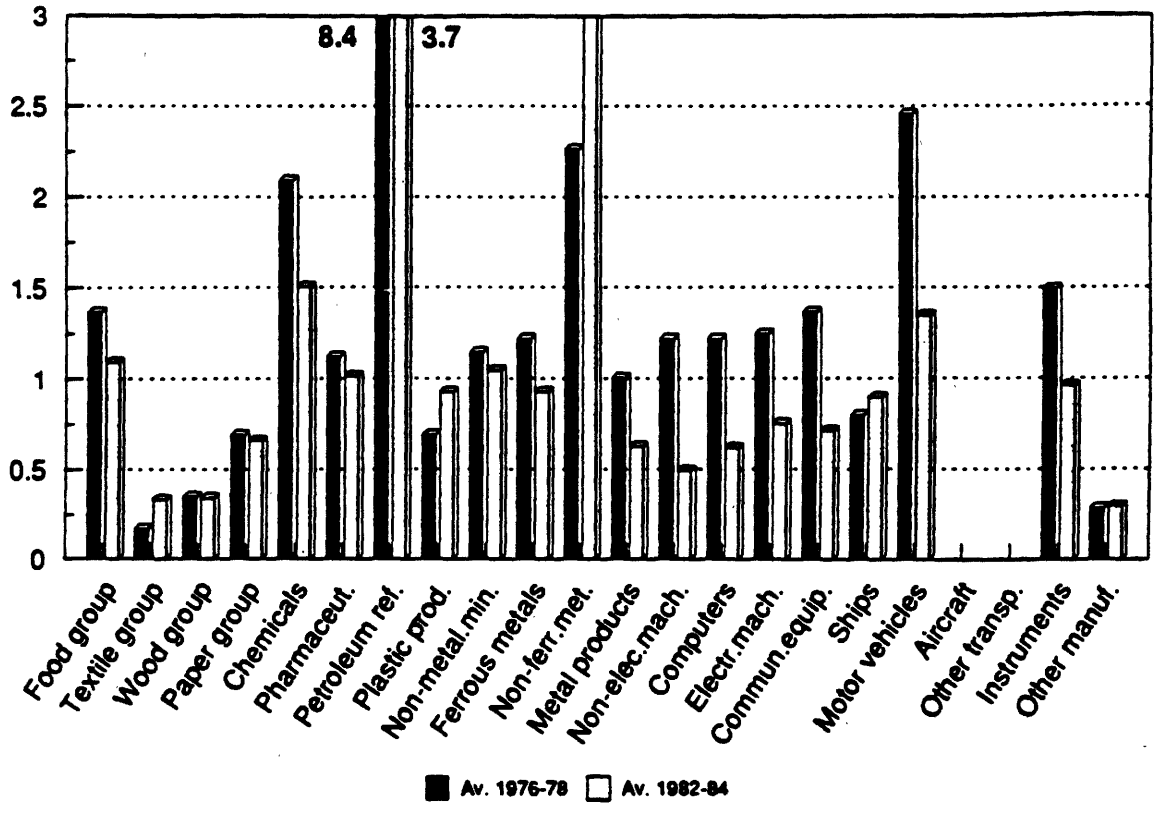


Figure IE 2

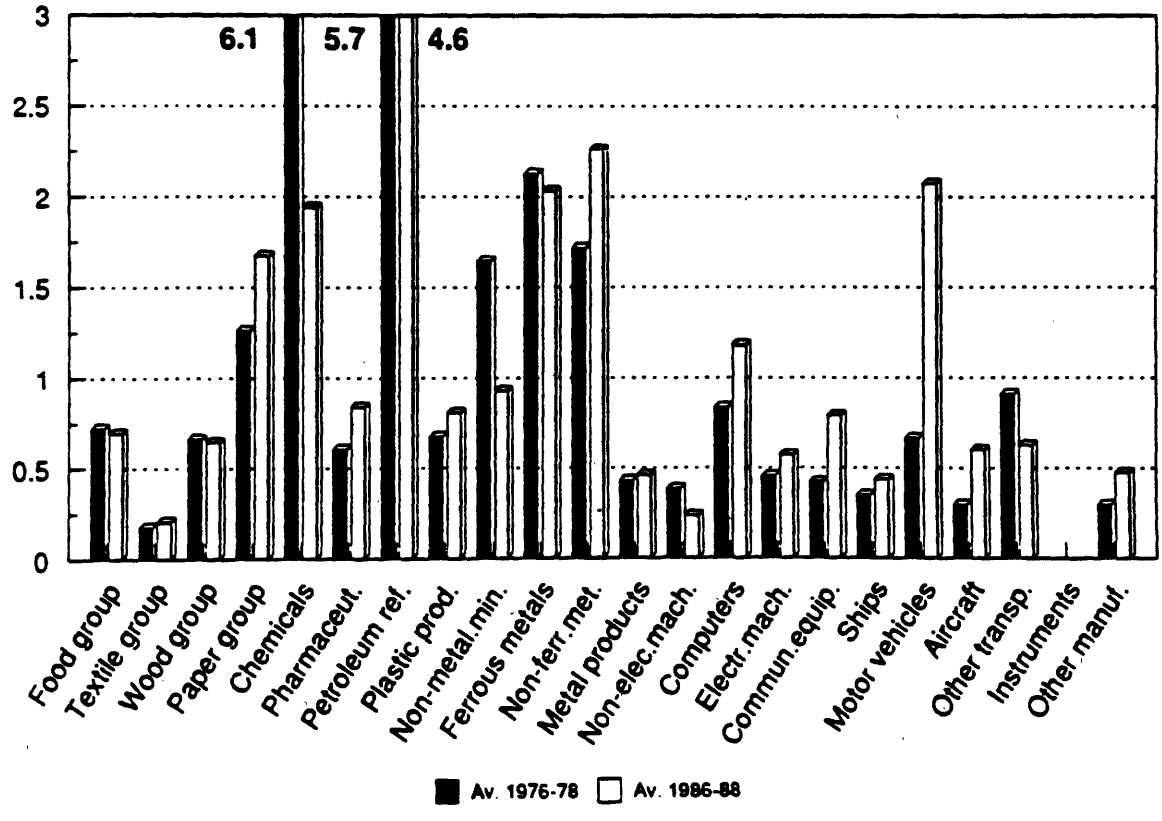
Investment per Employee

Industry / Manufacturing

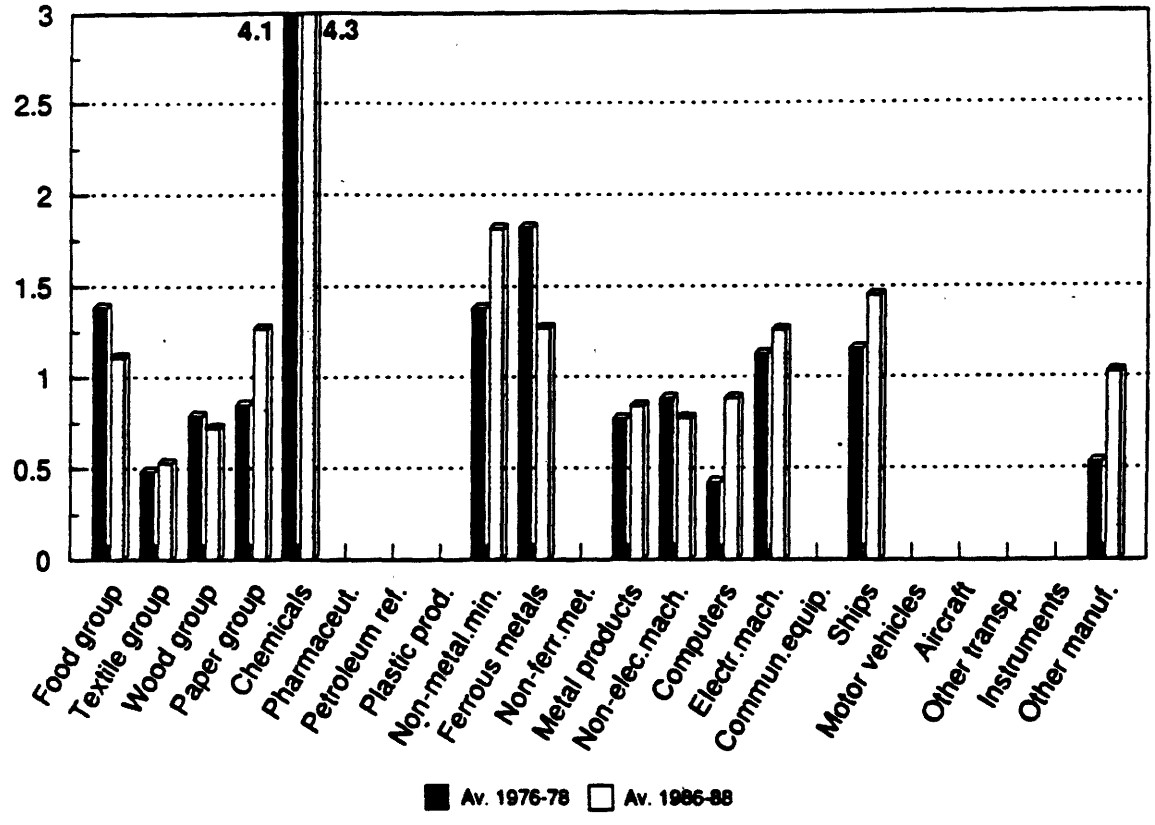
Australia



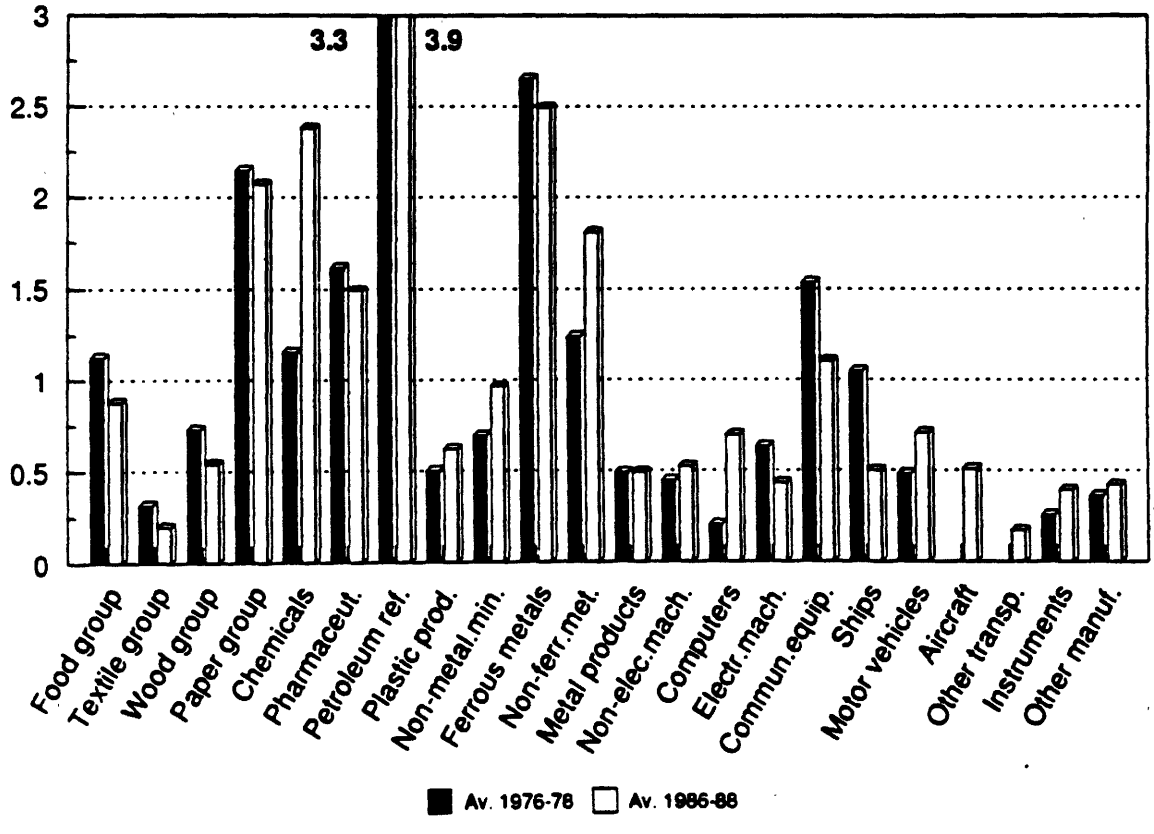
Canada



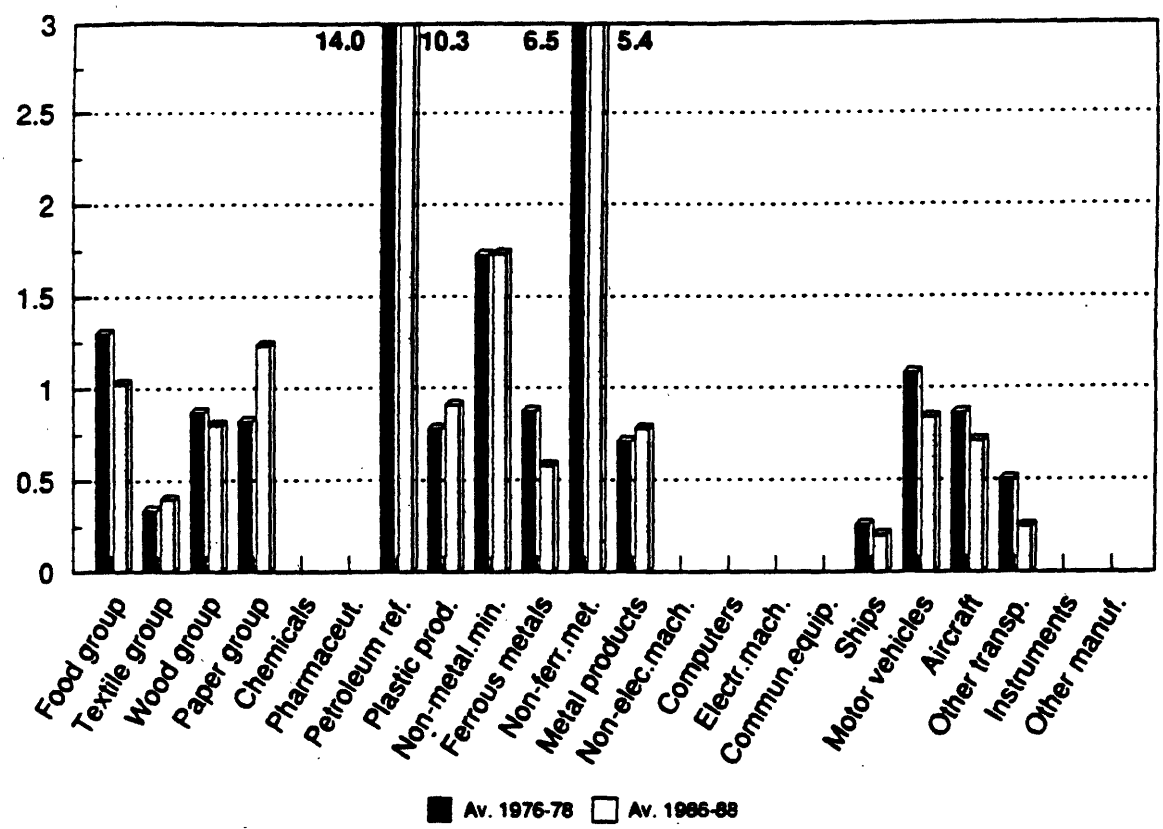
Denmark



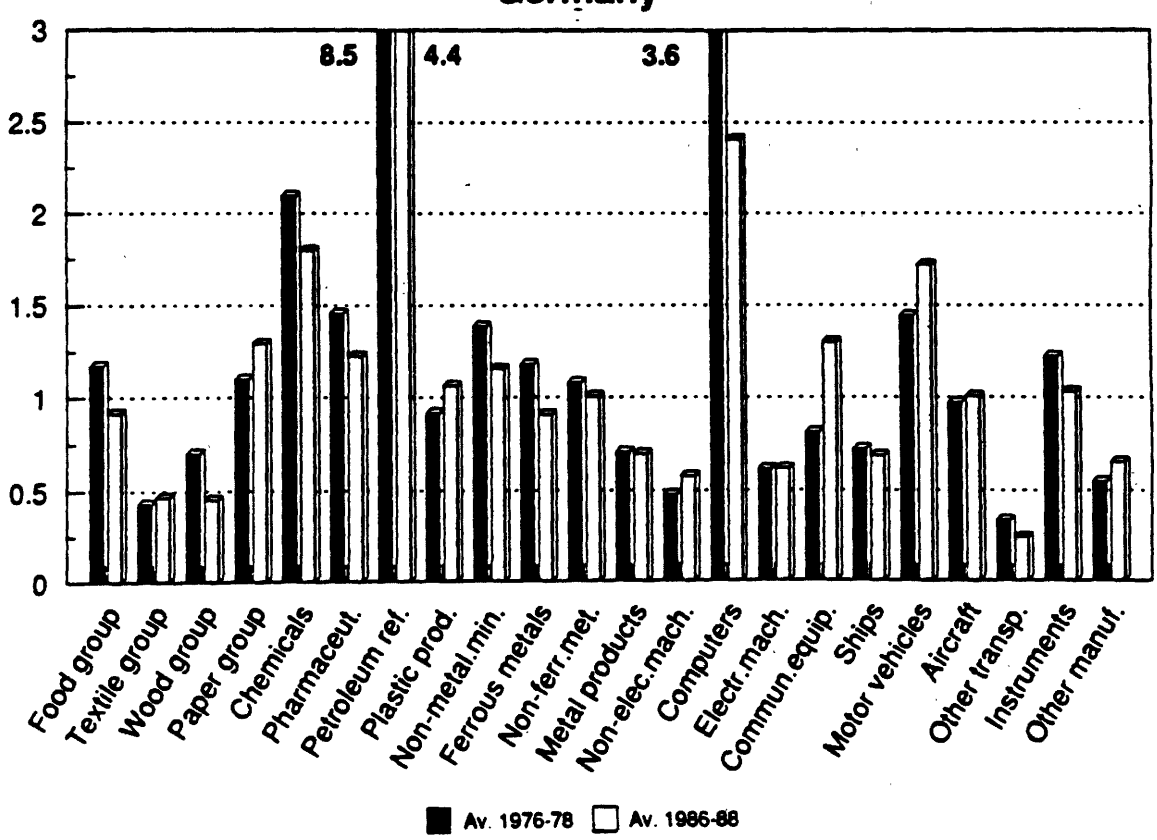
Finland



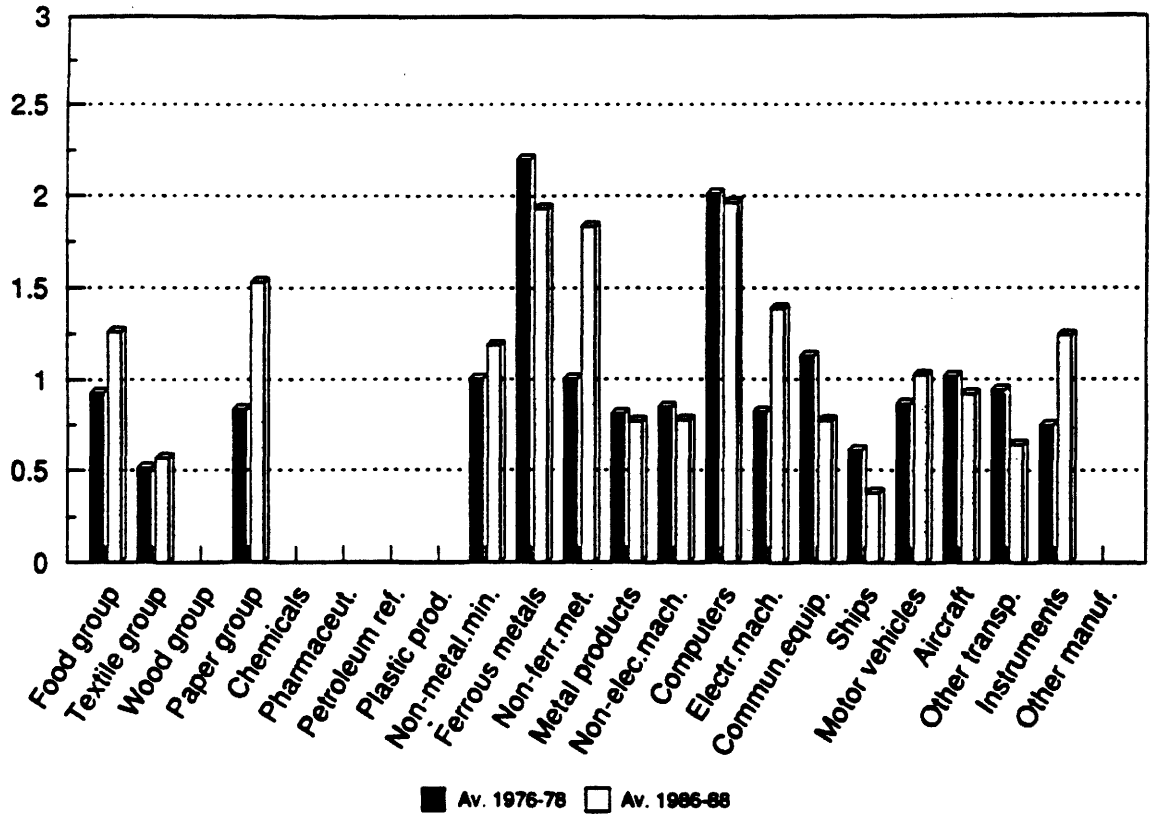
France



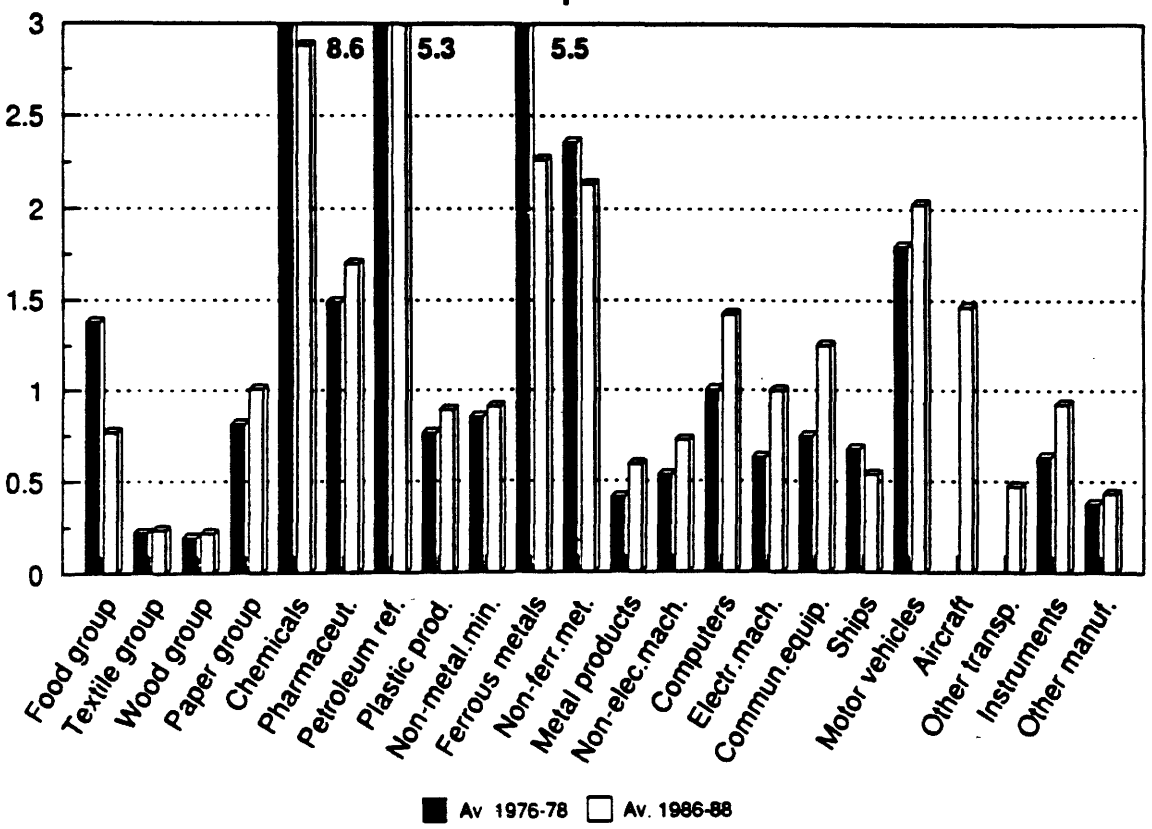
Germany



Italy


3
2.5
2
1.5
1
0.5
0
Food group
Textile group
Wood group
Paper group
Chemicals
Pharmaceut.
Petroleum ref.
Plastic prod.
Non-metal.min.
Ferrous metals
Non-ferr.met.
Metal products
Non-elec.mach.
Computers
Electr.mach.
Commun.equip.
Ships
Motor vehicles
Aircraft
Other transp.
Instruments
Other manuf.
Av. 1976-78
Av. 1986-88

Japan


3
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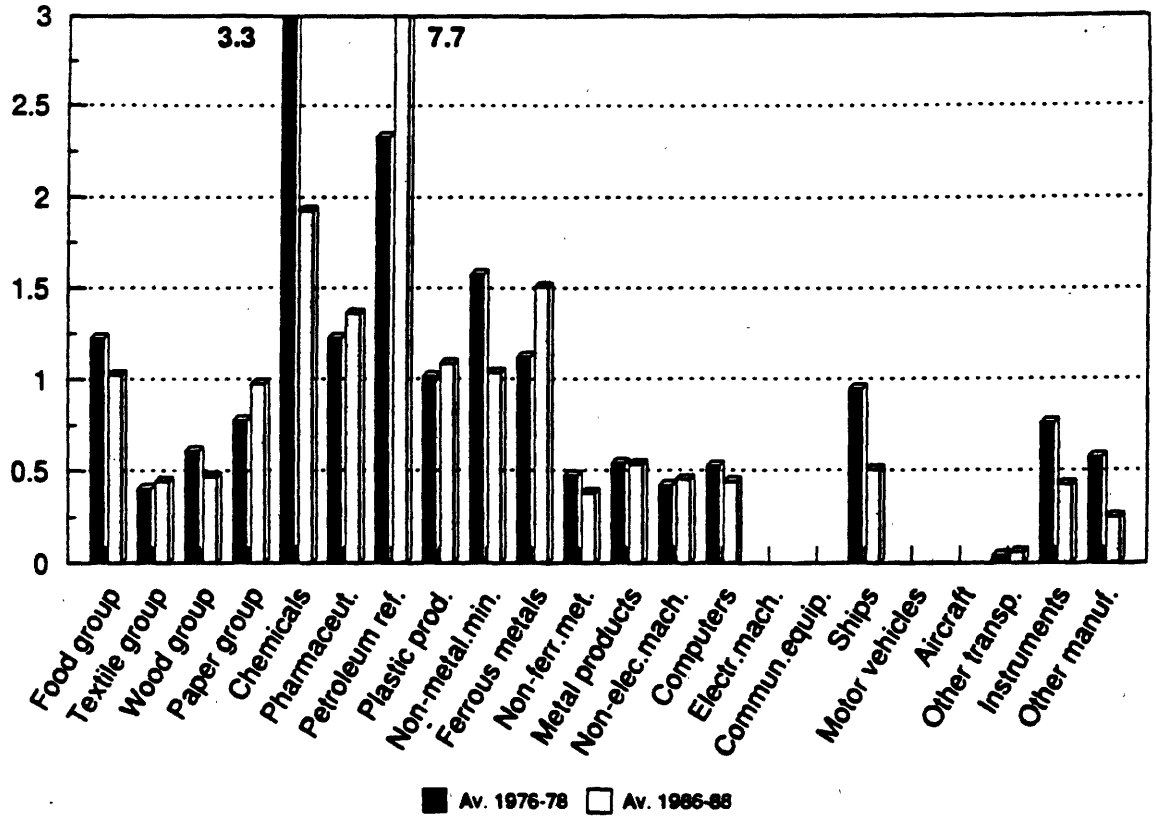
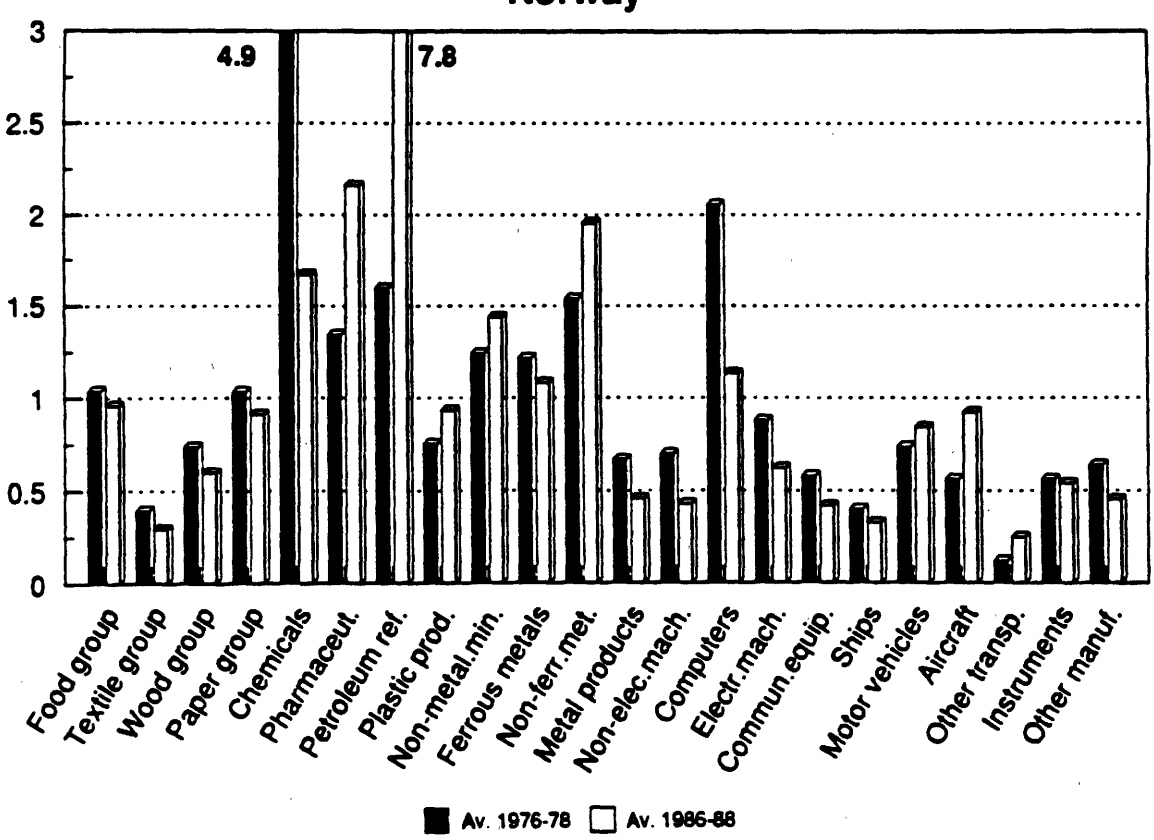
8.6
5.3
5.5
Food group
Textile group
Wood group
Paper group
Chemicals
Pharmaceut.
Petroleum ref.
Plastic prod.
Non-metal.min.
Ferrous metals
Non-ferr.met.
Metal products
Non-elec.mach.
Computers
Electr.mach.
Commun.equip.
Ships
Motor vehicles
Aircraft
Other transp.
Instruments
Other manuf.
Av 1976-78
Av. 1986-88

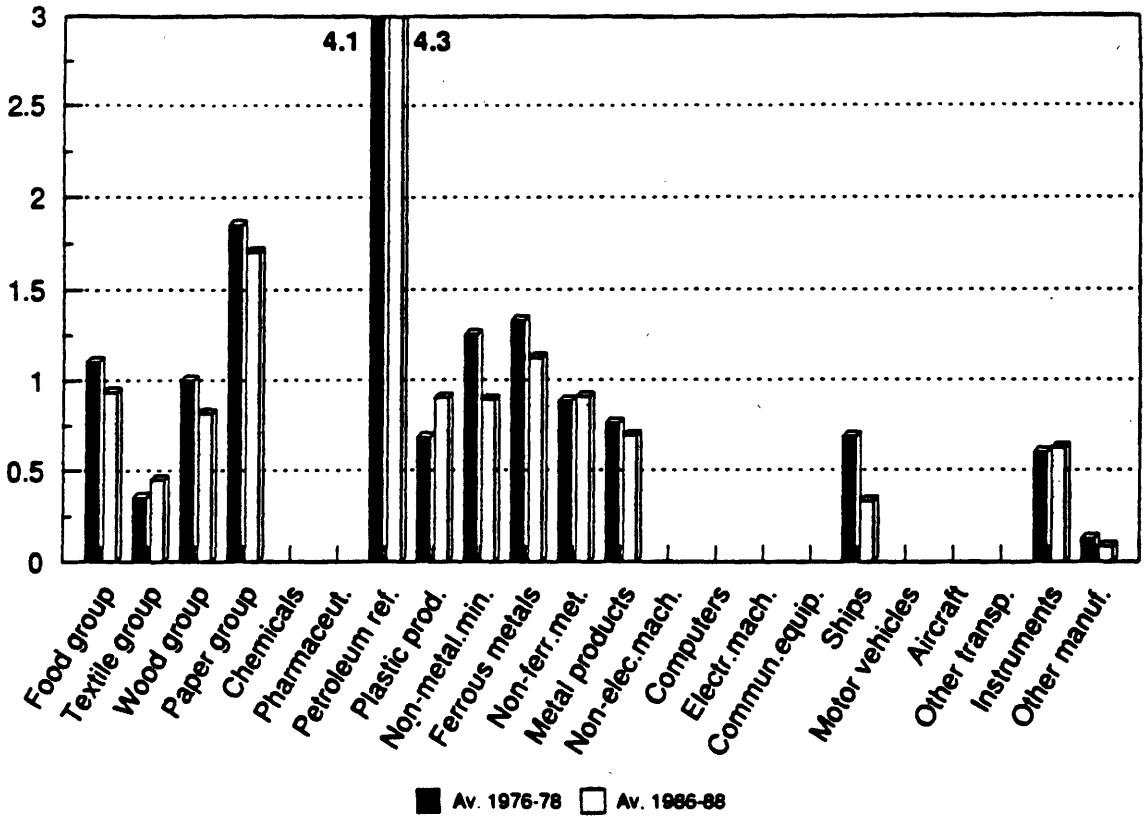
Netherlands



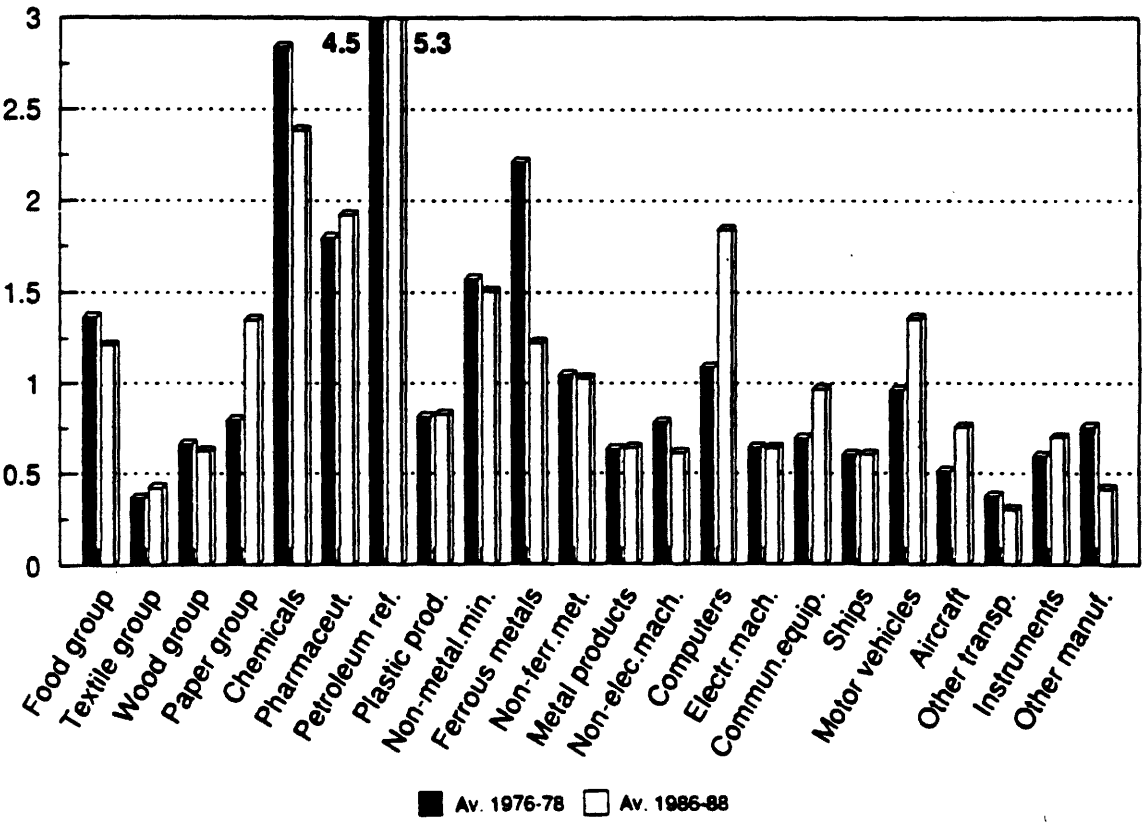
Norway

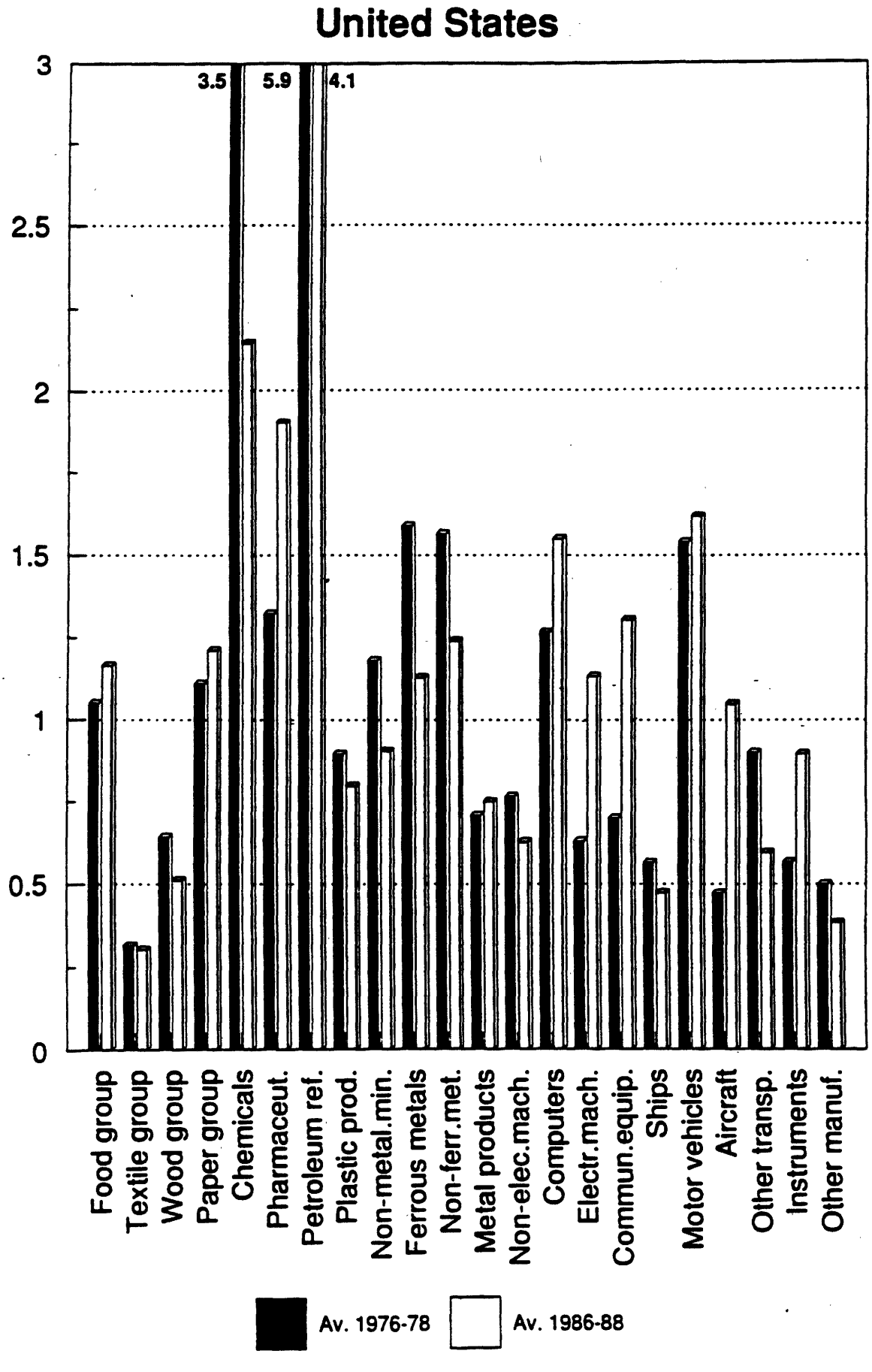


Sweden



United Kingdom




United States
3
2.5
2
1.5
1
0.5
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3.5
5.9
4.1
Food group
Textile group
Wood group
Paper group
Chemicals
Pharmaceut.
Petroleum ref.
Plastic prod.
Non-metal.min.
Ferrous metals
Non-ferr.met.
Metal products
Non-elec.mach.
Computers
Electr.mach.
Commun.equip.
Ships
Motor vehicles
Aircraft
Other transp.
Instruments
Other manuf.
Av. 1976-78
Av. 1986-88

Export Market Shares across the OECD-13

Total Manufacturing

69. Germany and the United States dominated the export market in manufactured goods, with a combined share of about 38 per cent through the 1970s and 1980s (Figure XMSO 1). Germany's share of OECD-13 total manufacturing exports was slightly higher than the United States in the 1970s and again in the late 1980s, but in the early 1980s, the United States led for several years. Over the twenty-one year period from 1970 to 1990, the export market share held by Germany increased slightly, rising from 19 per cent to 20 per cent, whereas the share of the United States fell from 20 per cent to 17 per cent (Table XMSO 1). The biggest gain in total manufacturing export market share was made by Japan. It's share rose from 11 per cent in 1970, peaking in the mid-1980s at 18 per cent, and although it's share declined through the late 1980s Japan still maintained a share of 15 per cent in 1990. The majority of the EC-6 countries also increased their export market shares. Italy in particular had its export market share rise from seven to nine per cent, but France's and the Netherlands' shares also grew. The countries, in addition to the United States, whose export market shares declined, include most of the Nordic countries as well as the United Kingdom and Canada. (See the box for a complete description of this indicator.)

70. Below the aggregate of total manufacturing, the share movements among countries were much more volatile. Japan gained export market shares in more industries than the United States and most of the European countries. Most of these industries in which it gained shares were in high-technology or high wage industries. In the low-technology and low wage industries, on the other hand, Japan's shares declined dramatically whereas export shares from the European countries and the United States showed strong growth.

Description of the Indicator

Export market shares are calculated as exports in a certain industry for a given country or country grouping as a proportion of exports to the world for the OECD-13 in this industry. This indicator is limited by the inclusion of only 13 countries. It does not try to make any adjustment for intra-firm trade or sales made by a foreign owned company operating in another country.

The export market shares could have been much more volatile in some cases had data for other countries, such as the dynamic asian economies been included. For purposes of converting to a common currency, exchange rates were used, and it should be noted that the results could be significantly different if purchasing price power parities had been used.

Low-technology Industries

71. Low-technology exports are a shrinking part of OECD-13 manufacturing exports, falling from 39 per cent in 1970 to 31 per cent in 1990. In these low-technology industries, Germany dominated the OECD-13 export market. Its share between 1970 and 1990 was at least two percentage points higher than any other country, and by the late 1980s this lead had stretched to five percentage points (Figure XMSO 1). This lead reflects strong export shares in every low-technology industry. The position of second largest exporter in low-technology industries, has been held by the United States, Japan, France and Italy in various years. Through most of the 1970s, Japan was exporting substantially more than all of the other countries, except Germany. In 1977, however, Japan's export market share began to decline in the low-technology industries, and by 1990, after its share had fallen by almost one-half, it was exporting less than five of the European countries, and the United States. Japan's export share was falling most sharply in the wood, food and textile groups. The United States' share remained relatively constant. Despite a small drop in the early 1970s, it had 13 per cent of the export market in 1990, just as it did in 1970. The country that gained significantly was Italy. Italy increased its export market share from eight to 12 per cent between 1970 and 1990 and by 1985 it had overtaken every country except Germany. It accomplished this mainly through its preeminent position and large growth in the textile, apparel and leather and non-metallic mineral products industries. In particular, Italy strengthened its lead as the lead textile group exporter with its export share rising from 19 to 29 per cent over the period.

72. In the food, beverages and tobacco industry, Japan has seen a significant decline with its share falling from four to 1.2 per cent between 1970 and 1990. The United States, while still holding the largest share in this food group, with about 19 per cent of the export market, fell, but only slightly. The largest increases in this food group occurred in the European countries. Germany and Italy more than doubled their respective export shares. France, the United Kingdom and the Netherlands' also displayed small increases in their export shares.

73. In the wood and paper groups, Canada maintained its position as the largest exporter, despite a fall in its shares from 25 per cent to 19 per cent and 25 to 17 per cent, respectively between 1970 and 1990. These are the only industries, in 1990, in which Canada held the largest export market share. In wood products and furniture, Germany, Italy and the United States were approaching the same level of exports as Canada, with export shares of 16, 15 and 14 per cent in 1990. Of these three countries with increasing market shares, Italy had the most remarkable growth. Its export share rose from only six per cent in 1970 to 16 per cent in 1990. Sweden and Finland both experienced a large decline in this industry. In 1970, Finland had a larger export share in this industry than it held in any other, and Sweden's export market share in the wood group was second only to the share it held in the paper group. Although these countries shares declined, from 11 to 6 per cent for Finland and 14 to nine per cent for Sweden, the wood and paper groups remained the dominant export industries.

74. The petroleum refining industry is unique in that it is the only low-technology industry which is also a high wage industry. In addition, the export market shares in this industry do not exhibit the same trends as most of the other low-technology industries. It is the only low-technology industry in which Japan notably increased its export share and it is the only low-technology industry in which Italy lost export market share. Italy fell from being the second largest exporter in the petroleum refining industry in 1970, behind only the Netherlands, to the fifth largest exporter behind the Netherlands, the United States, the United Kingdom and Germany. The Netherlands' leading position in the petroleum refining industry is striking. This is the only industry in which the Netherlands is the largest exporter, and in 1990, its export share of 22 per cent was a full five percentage points over the second largest exporter, the United States.

Medium-technology Industries

75. The medium-technology industries accounted for 44 per cent of exports in 1990, just as they did in 1970. Germany was the largest exporter in these industries, just as it was in the low-technology ones, maintaining 21 to 26 per cent of the export market between 1970 and 1990 (Figure XMSO 2). Unlike in the low-technology industries, Japan gained export market shares in the medium-technology group while the United States lost share. The United States was responsible for 22 per cent of medium-technology exports in 1970, but in 1990 had a share of only 15 per cent. Japan more than doubled its export market shares from eight to 16 per cent during the same time. Most of the European countries increased their export shares slightly, with the exception of the United Kingdom whose share declined from 12 to eight per cent in the medium-technology industries.

76. The changes in the medium-technology group, for most countries, are being driven by two industries: motor vehicles and non-electrical machinery. In both of these industries, Germany was the leading exporter between 1970 and 1990, with approximately one-fourth of these markets. In motor vehicles, Japan more than tripled its export share, moving from eight per cent to 25 per cent in 21 years, while the shares of the United States, Canada and the United Kingdom fell. The United States' decline was the largest as it moved from 19 to 12 per cent. Canada lost six percentage points, and the United Kingdom's export share was cut in half. As a result, Japan moved from exporting less than three of the European countries as well as the United States and Canada in 1970, to being the second largest motor vehicle exporter, behind only Germany in 1990. Most of the Nordic countries also increased their export market shares in motor vehicles, although their combined share in 1990 was still less than four per cent. In the non-electrical machinery industry, the United States has maintained its position as the second largest exporter, despite losing one-third of its market share. Japan on the other hand, increased its export share from six to 16 per cent, attaining the third largest export market share behind only Germany and the United States.

High-technology Industries

77. The high-technology industries are a growing part of OECD-13 exports. In 1970 they accounted for 17 per cent of exports and by 1990 they accounted for 24 per cent. Japan's increases in export market shares were equally strong in the high-technology industrial grouping as they were in the medium-technology grouping (Figure XMSO 2). Japan gained seven percentage points in the high-technology industries between 1970 and 1990 to reach a share of 21 per cent by 1990. This growth enabled Japan to overtake Germany, whose share declined slightly from 18 to

16 per cent. The United States, despite a fall from 31 per cent in 1970 to 26 per cent in 1990, managed to remain the largest exporter of high-technology industries, although its lead of 14 percentage points was cut to five.

78. The United States' commanding lead in the high-technology grouping is mainly attributable to the aircraft industry. In 1970 it was responsible for 62 per cent of the exports from this industry. By 1990, the United States' export market share had fallen to 48 per cent, but it maintained a lead of 35 percentage points over its closest competitor, Germany. Its decline was counterbalanced by increases in exports shares of three European countries, Germany, France and Italy. These countries shares rose from three to 13 per cent, seven to 12 per cent and two to four per cent, respectively between 1970 to 1990.

79. Exports from the office and computing machinery industry were also dominated by the United States, although its position in this industry was not nearly as stable as it was in the aircraft industry. In 1970, the United States' exports were more than twice as high as any other country. During the 1970s, the United States' gained a larger share of the export market than any other country, but this trend was dramatically different in the late 1980s. From 1984 to 1990, the United States' export share fell from 38 per cent to 28 per cent. Meanwhile, from the early 1970s on, Japan's share had been slowly increasing, and by 1990 its export share of 25 per cent was three times higher than it had been in 1970. Germany and Italy, like the United States, declined as Japan rose, their shares fell five and four percentage points, respectively. The United Kingdom, on the other hand, managed to increase its export share, from nine to 13 per cent. It was the only high-technology industry in which the United Kingdom gained significant export market share.

Triad

80. By excluding the intra-EC trade for the EC-6 countries and comparing this EC-6 block to the United States and Japan, it is clear that the EC-6 dominates exports from the OECD-13 to the world. In the total manufacturing sector, from 1970 to 1990 intra-EC-6 trade accounted for between 36 and 43 per cent of EC-6 exports. Excluding this intra-EC-6 trade from the overall sum of trade of the 13 OECD countries, the total manufacturing exports from the EC-6 were larger than the sum of the exports from Japan and the United States combined from 1970 until the mid-1980s. Although this was no longer true after 1986, due to Japan's strong increase, the sum of the United States and Japan's export shares were only one percentage point higher than EC-6's in 1990.

81. The movements in the shares of total manufacturing exports between the EC-6, Japan, and the United States change when the EC-6 is examined as a block and not simply as the sum of its countries. During the period from 1970 to 1990, intra-EC trade was rising faster than exports from the EC-6 countries to non-EC-6 countries. In fact, the intra-EC-6 exports were increasing so quickly that when the export shares of the EC-6 countries are summed, the sum rises over the two decades, whereas the shares of the EC-6 block remain constant over this time, at 42 per cent. Japan's share of total manufacturing exports grew from 14 to 20 per cent, and the United States' share fell from 25 to 23 per cent during the same period.

82. The EC-6 dominance is not merely evident at the total manufacturing level, but also in almost all of the detailed sectors. In 1990, in all but three industries, the EC-6 exported more than every other country. The three industries in which it did not lead the OECD-13 in exports are communications equipment, aircraft and other transport equipment. Japan had the leading share in the communication and other transport industries, with 42 and 48 per cent of the export market in 1990, while the United States exported the most from the aircraft industry this year with 58 per cent of the market.

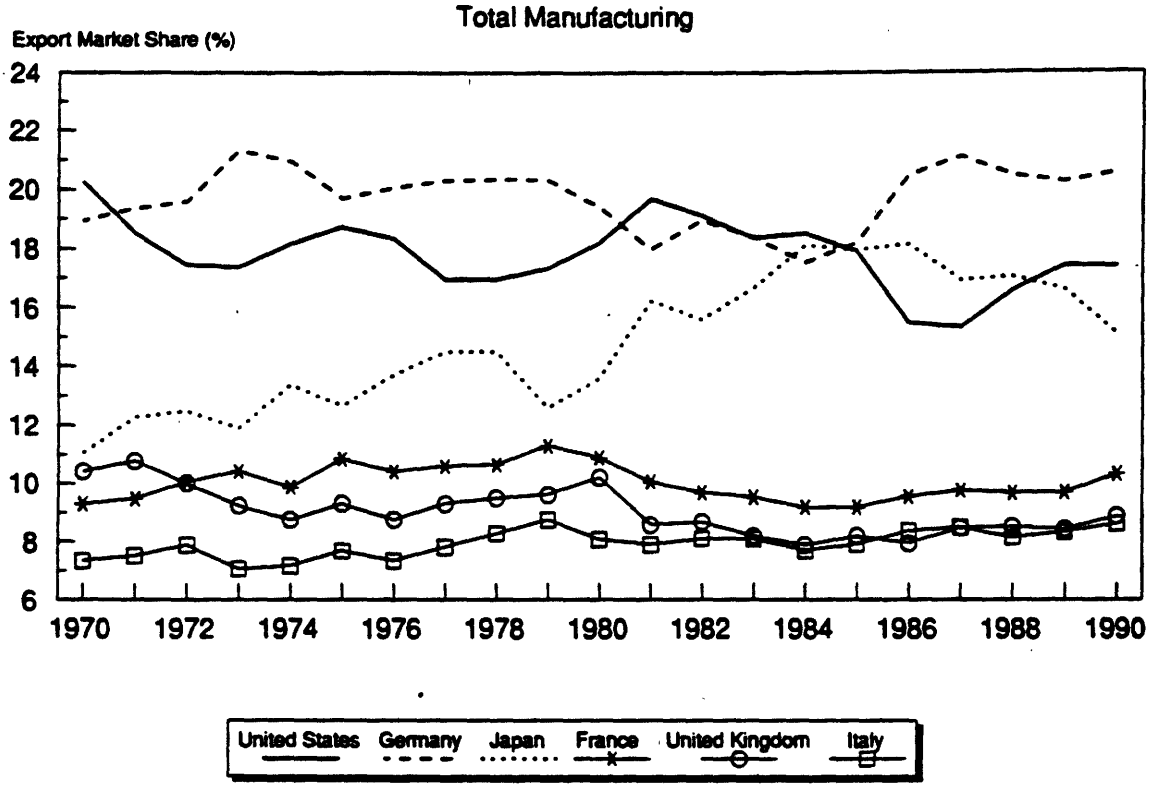
83. At a sectoral level, intra-EC-6 trade ranges from 26 and 57 per cent of the exports from the EC-6 block. In general, and in contrast to exports from most of the other countries, the percentage of trade between the EC-6 countries is higher in lower technology industries than in the higher technology ones. One notable exception is the office computers and machinery industry. In this high-technology industry, intra-EC-6 trade is at its highest level, accounting for 57 per cent of all EC-6 exports.

84. It is these same lower technology industries, in which the EC-6 block is gaining the most of the OECD-13 export market. The EC-6 shares increased substantially in the food group, the textile group, the wood group, the paper group, the non-metallic mineral products and basic metals. In the food group the EC-6 held over 50 per cent of the world export market, and in the textile group the EC-6 attained 68 per cent of the market in 1990.

85. In the slightly higher technology industries of chemicals and fabricated metal products, the EC-6's export share declined slightly between 1970 and 1990. It's shares in these industries fell from 52 to 50 per cent and from 42 to 38 per cent respectively. The largest drops occurred in petroleum refining, aircraft and communications equipment.

Figure XMSO 1

Export Market Shares Across the OECD-13
Total Manufacturing



Export Market Shares Across the OECD-13
Low technology industries

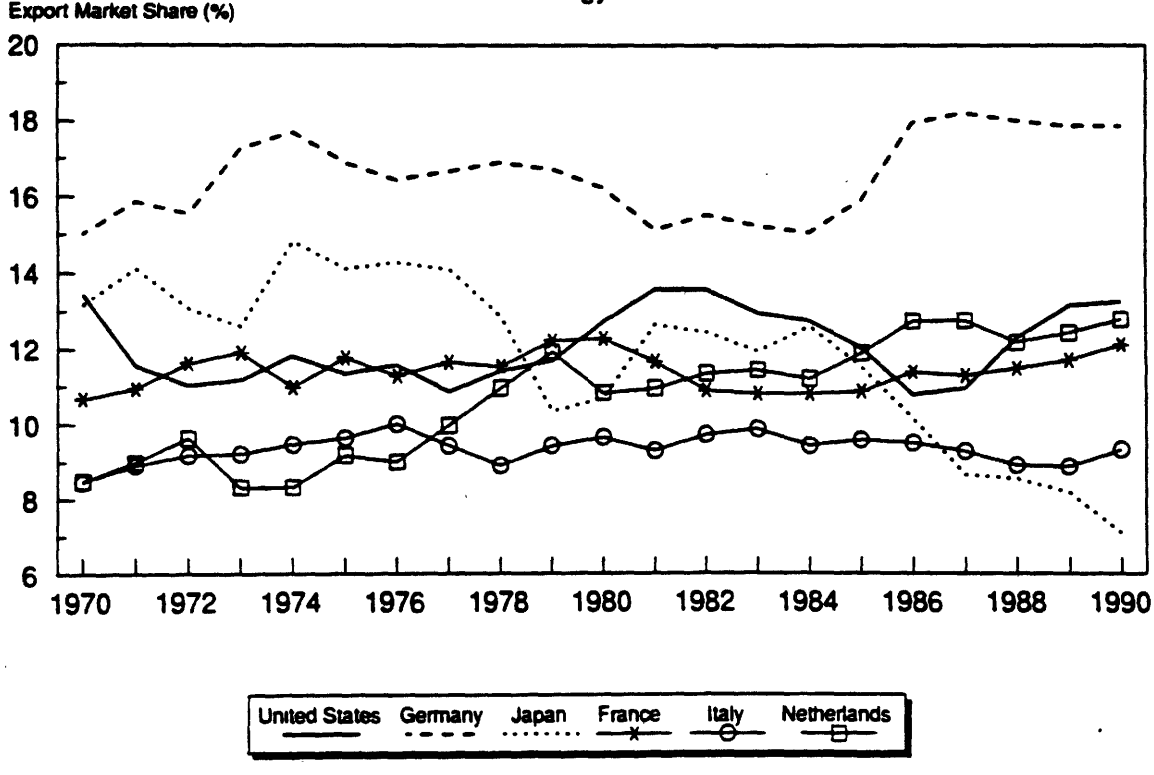


Table: XMSO-1
Export Shares across the OECD-13

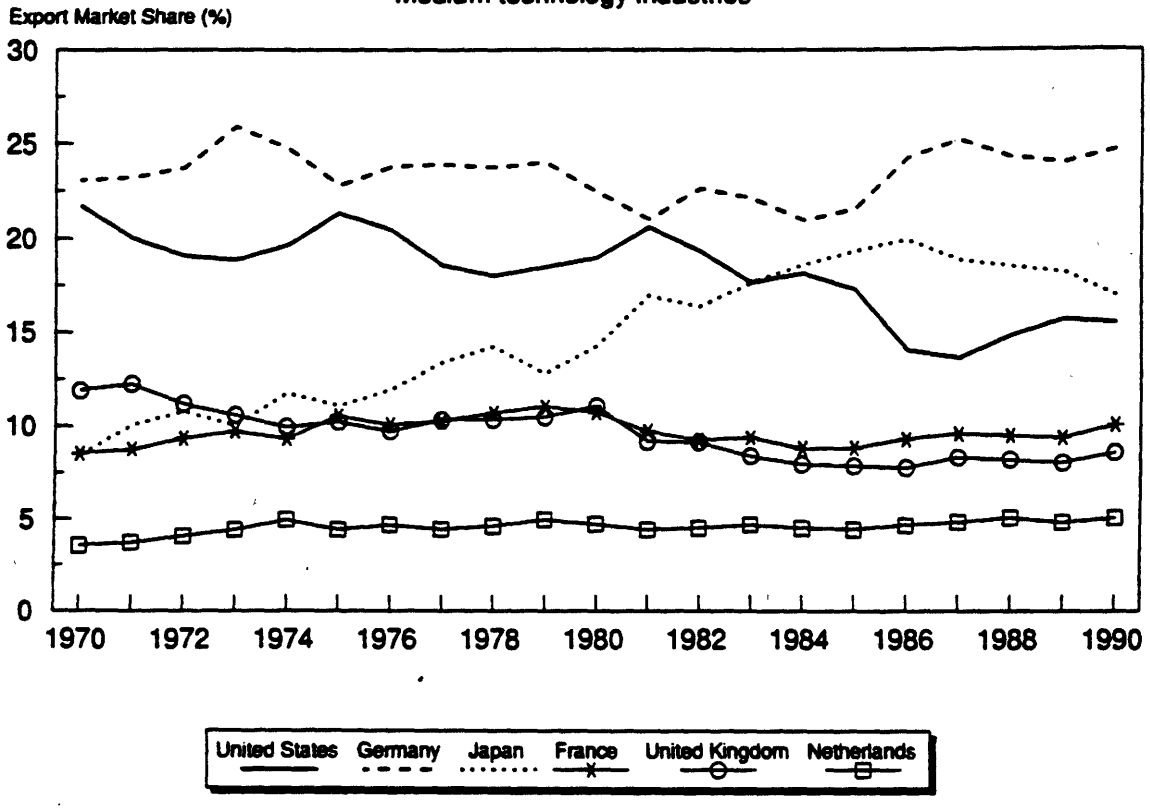
ISIC	Industry	Australia		Canada		Denmark		Finland		France		Germany		Italy	
		1970	1990	1970	1990	1970	1990	1970	1990	1970	1990	1970	1990	1970	1990
3000	Total Manufacturing	1.6	0.9	7.3	5.2	1.7	1.6	1.3	1.4	9.3	10.3	18.9	20.6	7.3	8.6
3100	Food, beverages & tobacco	10.5	4.3	5.4	4.1	7.8	6.4	0.6	0.5	13.3	17.3	6.8	13.4	4.3	6.6
3200	Textiles, apparel & leather	0.9	1.4	1.5	0.9	1.6	1.7	1.1	0.9	13.3	12.6	16.6	20.5	18.9	29.4
3300	Wood products & furniture	0.2	0.1	25.5	19.2	3.0	4.9	11.2	5.6	5.3	7.1	11.4	16.0	6.1	15.5
3400	Paper products & printing	0.3	0.3	25.3	17.1	0.6	1.0	11.2	10.7	5.0	7.7	7.4	15.4	2.9	4.2
3500	Chemical products	1.1	0.6	3.0	3.8	1.4	1.4	0.4	0.6	10.0	12.3	21.6	21.6	8.2	8.5
3600	Non-metallic mineral products	0.4	0.4	2.0	2.6	1.5	1.9	0.5	1.0	12.3	14.0	24.2	21.9	14.0	21.9
3700	Basic metal industries	2.6	3.4	11.1	7.6	0.4	0.7	0.6	2.0	11.1	12.4	18.6	21.5	3.4	7.1
3800	Fabricated metal products	0.4	0.3	6.9	4.7	1.2	1.1	0.5	0.9	8.0	8.6	21.7	21.6	6.7	7.0
3900	Other Manufacturing	0.9	0.6	1.7	1.3	1.2	0.6	0.5	0.5	7.1	8.9	16.3	14.6	11.1	18.7
	High technology	0.3	0.3	3.9	2.8	1.2	1.2	0.2	0.7	7.7	8.7	17.7	16.2	5.5	5.1
	Medium technology	1.0	0.6	6.9	5.9	1.0	1.0	0.5	0.9	8.5	10.0	23.1	24.7	7.1	7.7
	Low technology	2.7	1.7	7.0	6.1	2.7	2.9	2.7	2.6	10.7	12.1	15.0	17.9	8.5	12.6

ISIC	Industry	Japan		Netherlands		Norway		Sweden		United Kingdom		United States		EC-6	
		1970	1990	1970	1990	1970	1990	1970	1990	1970	1990	1970	1990	1970	1990
3000	Total Manufacturing	11.0	15.0	5.6	6.3	1.3	1.0	3.7	2.9	10.4	8.9	20.3	17.4	42.1	42.3
3100	Food, beverages & tobacco	3.9	1.2	16.6	16.9	1.9	1.3	1.0	0.6	8.3	8.5	19.3	18.7	40.5	51.7
3200	Textiles, apparel & leather	17.6	5.9	7.5	6.6	0.5	0.3	1.7	1.1	11.7	8.2	6.9	10.6	57.1	67.9
3300	Wood products & furniture	5.7	1.2	2.7	3.6	1.0	1.3	13.6	8.4	2.6	2.7	11.6	14.1	18.7	34.3
3400	Paper products & printing	2.7	3.1	3.9	5.4	3.6	2.0	14.4	10.9	5.4	6.5	17.4	15.7	17.2	25.4
3500	Chemical products	6.3	9.1	10.7	11.5	1.1	1.3	1.6	2.2	11.1	10.6	21.1	17.6	51.9	49.9
3600	Non-metallic mineral products	12.7	10.9	4.1	5.1	0.6	0.7	2.0	1.7	12.1	7.9	13.3	10.1	55.3	59.5
3700	Basic metal industries	17.6	14.0	3.6	5.3	3.6	3.6	4.3	4.1	9.7	9.0	12.6	9.0	34.6	40.2
3800	Fabricated metal products	11.2	21.0	3.4	3.7	0.6	0.5	3.6	2.6	10.6	8.5	24.6	19.2	41.9	39.0
3900	Other Manufacturing	17.6	15.4	2.6	3.0	0.2	0.3	1.3	1.1	24.0	20.4	15.5	14.2	55.0	59.5
	High technology	13.2	21.1	5.5	4.7	0.4	0.4	2.6	2.3	10.5	10.2	31.1	26.3	37.6	32.6
	Medium technology	6.5	16.9	3.6	5.0	1.1	0.6	3.0	2.6	11.9	8.5	21.7	16.4	45.3	43.7
	Low technology	13.2	7.1	6.5	6.3	1.6	1.7	5.0	3.9	6.9	6.5	13.4	13.3	40.6	46.5

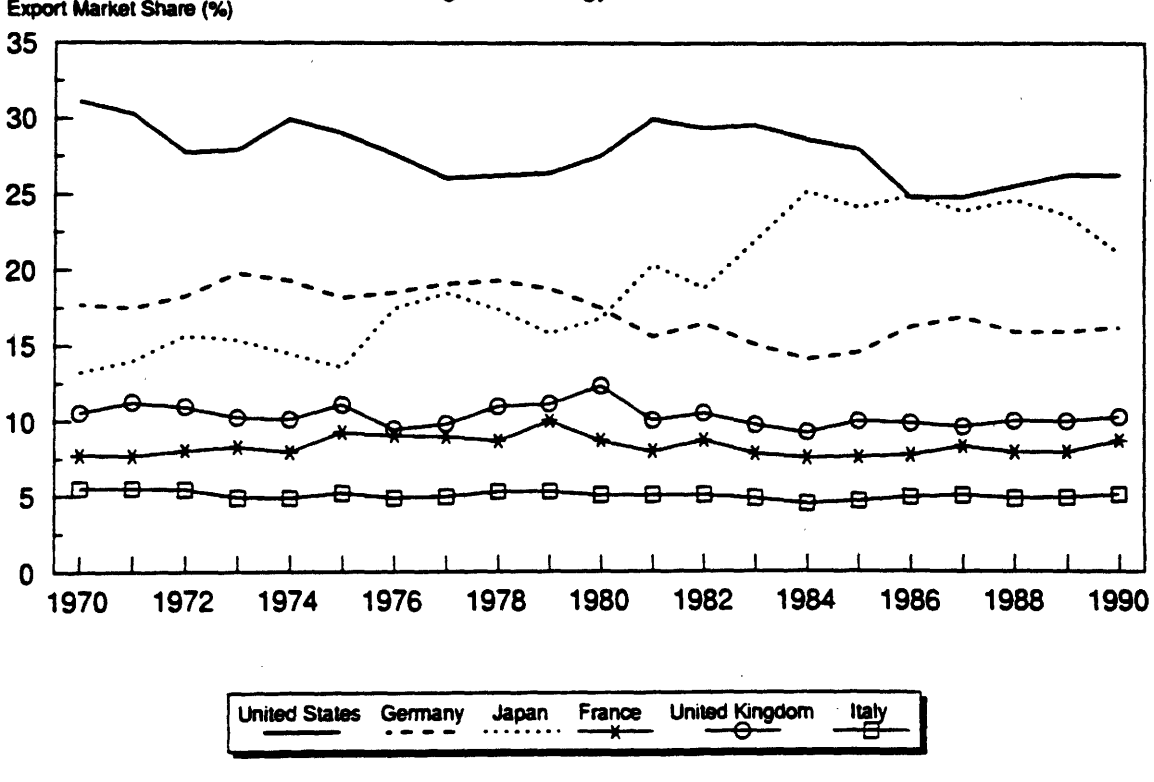
*EC-6 share excludes intra-EC-6 trade and is not on the same basis as the other shares in the table, which have been calculated to sum to 100 per cent.

Figure XMSO 2

Export Market Shares Across the OECD-13
Medium technology industries



Export Market Shares Across the OECD-13
High technology industries



Revealed Comparative Advantage

86. With the exception of Japan, the indices of revealed comparative advantage (RCA) were relatively stable from 1970 to 1990 reflecting the fact that the distribution of each countries' exports moved in the same direction as the shifts that occurred on average across the OECD-13 countries. In 1970 only three countries: Japan, the United Kingdom and the United States, had a high-technology RCA over the OECD average, 1.00 (Table RCA 2). The same was true in 1990. The individual Nordic-4 countries and Australia kept, for the same time period, an RCA well over the average of the OECD-13 countries in the low-technology and resource intensive industries. Conversely, it was mainly EC-6 countries and Canada that maintained, or exceeded, the average RCA level in the medium-technology group of industries. The exception to this general trend of relative stability occurred in Japan where the mix of exports relative to the OECD-13 average changed significantly over the two decades as Japan's RCA in the high wage and high-technology groups increased while the figure for the low-technology and low wage groups dropped. The box describes the characteristics of this index in greater detail.

87. The United States had in 1970, 1980 and still retained in 1990, in terms of RCA, a very competitive position in the high-technology industries, a situation mainly attributable to its strength in the aircraft and computer industries, which in some cases exceeded the OECD-13 average by a factor of three. (Computers and office machines had 1970, 1980 and 1990 RCA's respectively of 1.9, 2.0 and 1.6 while aircraft had 3.1, 2.9 and 2.8.) In the medium-technology industries, the US's RCA slowly but steadily declined from 1970 to end, in 1990, slightly under the OECD-13 average at 0.89. Two industries were particularly important in this decline, non-electrical machinery and motor vehicles with respective RCA indices of 1.3 and 1.0 in 1970 and 1.0 and 0.7 in 1990. The other industries which make up the medium-technology group had a stable RCA over the same time period. RCA in food, textiles, wood products and petroleum refining increased from its 1970 level causing the low-technology RCA to rise from 0.7, to a nonetheless below OECD-13 average level of 0.8 in 1990. The United States was one of the few countries to experience a gain in the RCA of the low wage group and a loss in the high wage group; nonetheless, the United States still retained a 1990 RCA for the high wage group which was the second highest of the countries analysed.

A Description of the Indicator

The most distinct feature of the revealed comparative advantage index is that it equalizes for the size of each country, giving the same relative weight to small and large countries.

The calculation of RCA shows the proportion of a country(j) or area's exports in an industry(i) over total exports for that country(j), divided by the OECD-13 proportion of exports of that same industry as a fraction of the OECD-13 total exports. If the RCA indicator is greater than one, then the given country's share of exports originating from that industry is greater than the average share for that industry for the 13 OECD countries in our group; if it is less than one, that country has a lower share of exports coming from that industry than the average; and if it equals one, that industry is the source for the same share of exports as the average.

The indicator of revealed comparative advantage reflects a country's natural resource endowments, domestic consumption patterns, level of development and competitive strengths and weaknesses. RCA shows how a given country compares to a broader area which is particularly useful for cross country comparisons and the analysis of structural changes in an economy. RCA has limitations though, one of which is intra-firm exchanges which transcend national borders. Today, different stages of production and assembly of certain goods, such as semiconductors, are often carried out in different countries by the same firm. Shifts in these intra-firm exchanges are not necessarily a reflection of changes in an country's competitiveness but may rather reflect a change in business strategy or reflect an event (i.e. a merger). A further limitation is the fact RCA is calculated in current prices. Thus an increase in RCA could be attributed to the rising price of an industries product relative to other industries. In spite of these limitations RCA still provides a good indication of performance, competitiveness and trends in a comparative manner over a large area. Care should be taken when using RCA to describe trends in a given country. These trends should be examined in a relative, and not in an absolute, sense.

88. Japan saw its RCA grow in both the high and medium-technology industries while its RCA in low-technology decreased significantly. The high-technology RCA index increased from 1.2 to 1.4, mainly due to the fact that communication equipment consistently remained over 2.0, peaking at 2.7 in 1980. Contrary to the established Japanese high-technology trend, in 1990, the RCA indices in aircraft and pharmaceuticals were 0.06 and 0.25 respectively, lagging far behind the US and the EC-6 . The equivalent index for medium technologies grew from 0.8 to 1.1, this was largely due to the advance of the Japanese motor vehicle industry, from 0.7 in 1970 to 1.6 in 1990. The most outstanding movement, however, was in the low-technology industries. Between 1970 and 1990 the food group dropped from an RCA of 0.4 to 0.08, the textiles group from 1.6 to 0.4 and the wood group from 0.5 to 0.08.

As a group, the low-technology index dropped from 1.2 to 0.5. In terms of wages, Japan saw a significant change in its RCA over the two decades as the RCA for the low wage group fell to the lowest level of any of the countries analysed while its high wage RCA grew, surpassing the OECD-13 average.

89. The United Kingdom managed to maintain and improve its relative competitiveness in high-technology industries. This was mainly a result of the aircraft, pharmaceuticals and computer industries registering RCAs of 1.3, 1.8 and 1.4 respectively, in 1990. Both low-technology and medium-technology remained under or close to the average 1.0 mark, however they moved in opposite directions, low-technology increasing and medium-technology decreasing. The largest drops in medium-technology industries occurred in non-ferrous metals and motor vehicles, falling 0.2 and 0.4 RCA points respectively, in 21 years.

90. The EC-6 has traditionally had an RCA hovering around the average in the medium and low-technology industries. Slight gains occurred in the low-technology sector while the RCA index in the high-technology industries suffered minor losses in almost all industries. The EC-6 group displayed a constant above average RCA index in food, textiles and chemicals. In aircraft, although the RCA remained below average, the EC-6 made considerable advances. This was particularly notable in France where there was an increase from 0.8, in 1970 to 1.2, in 1990. As is the case for many of the European countries studied here, France and Germany had relatively stable RCAs in a great majority of the manufacturing industries. In these two countries it was mainly the chemicals group and its components which performed above average, with rubber & plastics remaining above 1.4 in France and industrial chemicals staying close to 1.2 in Germany. In 1990, Germany's comparative advantage resided in motor-vehicles and non-electrical machinery, two medium-technology industries. The EC-6's high averages in the low-technology group were boosted by the relative strengths of Italian low-technology industries. Textiles and non-metallic mineral products are two industries in this group where Italy consistently had a RCA exceeding 2.5.

91. The Nordic-4 group had a distinct specialization in low-technology and resource intensive industries with RCA indices close to, or above, 1.5. Shipbuilding and wood industries were exceptionally high, with the Norwegian shipbuilding RCA exceeding 5.0 and Finnish paper group RCA above 3.0. Australia and Canada were also countries with uncommonly high resource intensive group RCA levels. Australia concentrated its exports industries such as food and basic metals with non-ferrous metals growing rapidly from 3.4, in 1970, to 11.6, in 1986. Canada had a particularly high comparative advantage in four industries, wood products, paper products, non-ferrous metals and motor vehicles with averages two, three or four times the OECD-13 levels.

92. Table RCA 1 presents a "snap-shot" of RCA indices at a detailed sectoral level for all 13 OECD countries in 1990. As of 1990, it is quite clear that there is a wide diversity in the structure of exports across the countries with Australia, Denmark and the Netherlands having an export orientation towards the food group, that is two to five times the OECD-13 average, while Japan's RCA for this group is less than a tenth of the average. Similarly, Italy's RCA for the textile group stands out while in the wood and paper groups Canada and the Nordic countries are the leaders. The other sectors with large, cross-country differences tend to be natural resources intensive sectors such as petroleum refining (Norway and the Netherlands) and non-ferrous metals (Australia and Norway). Industries that are R&D intensive do not exhibit the same large differences, but nevertheless reveal pockets of specialization for particular countries. In pharmaceuticals, Denmark, France, Sweden and the United Kingdom have RCAs which are significantly higher than the average while in aircraft, the United States, and to a lessor extent France and the UK, are the leaders. Communications equipment is led by the Japanese who are also have a strong export orientation in computers, equal to that of the United States. Japan also had a relatively high RCA in motor vehicles, as does Germany, but both of these countries are surpassed by the motor vehicle RCA of Canada which is twice the OECD average.

Table: RCA-1
1990 Revealed Comparative Advantage by Industry

ISIC	Industry	Australia	Canada	Denmark	Finland	France	Germany	Italy	Japan	Netherlands	Norway	Sweden	United Kingdom	United States
3100	Food group	4.96	0.78	3.95	0.33	1.68	0.65	0.77	0.08	2.70	1.35	0.29	0.96	1.07
3200	Textile group	1.61	0.17	1.03	0.62	1.22	1.00	3.42	0.39	1.05	0.26	0.38	0.93	0.61
3300	Wood group	0.14	3.72	3.04	3.97	0.69	0.78	1.80	0.08	0.60	1.37	2.85	0.31	0.81
3400	Paper group	0.35	3.31	0.64	7.58	0.75	0.75	0.49	0.21	0.86	2.03	3.69	0.73	0.91
3500	Chemical group	0.74	0.74	0.89	0.57	1.20	1.06	0.75	0.60	1.84	1.37	0.74	1.22	1.02
351+352-3522	Industrial Chemicals	0.42	0.64	0.57	0.57	1.23	1.16	0.59	0.68	1.71	1.01	0.50	1.19	1.10
3522	Pharmaceuticals	0.82	0.17	3.09	0.40	1.51	1.09	0.73	0.24	0.97	0.35	1.84	1.85	0.96
353+354	Petroleum Refining	2.71	1.48	0.87	0.69	0.73	0.47	0.95	0.22	3.66	4.55	1.27	1.25	0.96
355+356	Plastic products	0.34	0.80	1.37	0.54	1.36	1.11	1.49	0.80	1.11	0.56	0.79	0.99	0.71
3600	Non-metallic mineral prods.	0.44	0.49	1.14	0.68	1.36	1.06	2.54	0.73	0.81	0.76	0.58	0.89	0.58
3700	Basic metals	3.97	1.50	0.42	1.45	1.20	1.04	0.83	0.93	0.84	3.91	1.41	1.02	0.52
3710	Ferrous metals	1.30	0.61	0.52	1.48	1.39	1.16	1.04	1.30	0.83	1.66	1.76	0.96	0.31
3720	Non-ferrous metals	7.94	2.81	0.27	1.39	0.92	0.87	0.51	0.38	0.85	7.23	0.88	1.11	0.81
3800	Fabricated metal products	0.33	0.91	0.70	0.64	0.84	1.05	0.81	1.40	0.59	0.56	0.95	0.96	1.10
3810	Metal products	0.59	0.68	1.56	1.05	1.11	1.28	1.60	0.67	0.97	0.85	1.25	0.87	0.69
3820-3825	Non-electrical mach.	0.30	0.39	1.04	1.02	0.70	1.29	1.34	1.06	0.55	0.54	1.24	0.96	0.99
3825	Computers	0.30	0.52	0.34	0.30	0.61	0.52	0.58	1.63	0.96	0.42	0.58	1.45	1.64
3830-3832	Electrical machinery	0.32	0.36	0.79	0.73	1.00	1.22	1.02	1.36	0.64	0.44	0.86	0.87	0.94
3832	Communications equip.	0.21	0.69	0.63	0.77	0.60	0.60	0.38	2.39	0.63	0.32	0.87	0.91	1.25
3841	Ships	0.77	0.12	2.26	3.02	0.49	0.48	0.31	1.90	0.45	8.57	0.84	2.66	0.43
3843	Motor vehicles	0.29	2.03	0.19	0.25	0.97	1.28	0.58	1.65	0.30	0.14	0.99	0.62	0.69
3845	Aircraft	0.24	0.88	0.40	0.04	1.21	0.61	0.52	0.06	0.54	0.35	0.40	1.26	2.77
3842+3844+3849	Other transport equip.	0.19	1.23	0.22	1.22	0.80	0.62	1.47	2.60	0.53	0.26	0.51	0.41	0.57
3850	Instruments	0.34	0.33	0.95	0.52	0.72	1.02	0.43	1.22	1.05	0.55	0.85	1.28	1.40
3900	Other manufacturing	0.91	0.26	0.39	0.37	0.87	0.72	2.18	1.03	0.48	0.26	0.37	2.30	0.81

Table: RCA-2
Revealed Comparative Advantage by Major Industrial Group: 1970 and 1990

	Australia		Canada		Denmark		Finland		France		Germany		Italy	
	1970	1990	1970	1990	1970	1990	1970	1990	1970	1990	1970	1990	1970	1990
High wage	0.47	0.49	1.24	1.22	0.42	0.48	0.16	0.36	0.99	1.03	1.11	1.03	0.88	0.60
Medium wage	0.56	0.86	1.00	0.94	0.77	0.94	1.42	1.72	0.86	0.85	1.07	1.02	0.88	1.00
Low wage	2.54	2.20	0.68	0.77	2.21	2.04	1.25	0.85	1.26	1.24	0.74	0.89	1.43	1.72
High technology	0.17	0.30	0.54	0.55	0.71	0.74	0.19	0.50	0.83	0.84	0.93	0.79	0.75	0.59
Medium technology	0.65	0.74	1.22	1.14	0.61	0.59	0.36	0.63	0.92	0.97	1.22	1.20	0.97	0.89
Low technology	1.73	1.94	0.96	1.19	1.57	1.81	2.08	1.97	1.15	1.18	0.79	0.87	1.16	1.49
Resource intensive	3.92	3.98	1.48	1.54	2.49	2.51	1.43	1.05	1.10	1.26	0.60	0.72	0.91	1.08
Labour intensive	0.56	1.17	0.27	0.35	0.92	1.12	0.72	0.73	1.23	1.13	1.00	1.05	2.06	2.63
Scale intensive	0.48	0.45	1.43	1.48	0.48	0.52	1.50	1.41	1.04	1.07	1.07	1.13	0.69	0.67
Specialised suppliers	0.19	0.28	0.48	0.47	0.93	0.88	0.42	0.89	0.76	0.73	1.27	1.08	1.12	1.01
Science based	0.17	0.34	0.62	0.55	0.64	0.77	0.05	0.28	0.86	0.91	0.82	0.72	0.70	0.54

	Japan		Netherlands		Norway		Sweden		United Kingdom		United States		EC-6	
	1970	1990	1970	1990	1970	1990	1970	1990	1970	1990	1970	1990	1970	1990
High wage	0.61	1.06	0.99	1.05	0.40	0.72	0.63	0.78	1.04	1.04	1.30	1.17	1.01	0.95
Medium wage	1.22	1.14	0.69	0.75	1.51	1.41	1.39	1.37	0.98	1.00	0.95	0.91	0.94	0.95
Low wage	1.09	0.58	1.62	1.40	0.76	0.76	0.71	0.68	1.02	0.96	0.68	0.87	1.12	1.18
High technology	1.20	1.41	0.95	0.75	0.28	0.40	0.71	0.78	1.01	1.16	1.54	1.51	0.90	0.82
Medium technology	0.77	1.12	0.61	0.80	0.88	0.86	0.82	0.89	1.14	0.96	1.07	0.89	1.03	1.01
Low technology	1.19	0.47	1.45	1.49	1.45	1.71	1.34	1.32	0.85	0.95	0.66	0.76	1.01	1.13
Resource intensive	0.42	0.22	2.05	2.09	2.12	2.66	0.79	0.88	0.93	0.94	0.82	0.93	1.01	1.11
Labour intensive	1.47	0.58	1.07	0.94	0.43	0.46	0.63	0.67	1.30	1.11	0.51	0.67	1.25	1.31
Scale intensive	1.21	1.13	0.75	0.89	1.26	1.05	1.33	1.20	0.87	0.92	0.87	0.80	0.92	0.97
Specialised suppliers	1.01	1.49	0.69	0.59	0.40	0.46	1.05	1.06	1.08	0.93	1.18	1.05	1.05	0.92
Science based	0.65	0.91	0.70	0.85	0.14	0.42	0.54	0.71	1.11	1.39	2.00	1.87	0.85	0.85

Import penetration

Overall trends and structure

93. The weight of imported manufactured goods in the total domestic demand for goods in manufacturing industry varies significantly from country to country across the OECD-13 group (Table MPEN 1). The highest import penetration can be found in the Netherlands, where imports represented 70 per cent of total domestic demand in the manufacturing sector in 1989. A number of small European economies such as Finland, Norway and Sweden follow, with import penetration rates between 40 per cent and 50 per cent at the end of the 1980s. Canada and Denmark had import penetration rates between 30 per cent and 40 per cent in 1989, followed by all four large European countries, as well as Denmark and Australia, with imports representing between 20 and 30 per cent of their domestic demand. Import penetration for the United States was 13 per cent in 1989, while it was the lowest of all OECD-13 countries in Japan (six per cent).

94. Despite these large cross-country differences, imports of manufactured goods increased as a proportion of domestic demand in the manufacturing sector in every one of the OECD-13 countries during the period from 1970 to the end of the 1980s. The strongest increase by far was in the United States, where imports more than tripled as a proportion of domestic demand in the 1970-1989 period. Import intensities doubled in France, Germany and the United Kingdom. In general, the share of imports in domestic demand increased most in countries where import intensities were low initially. The exceptions are the Netherlands and Japan; import penetration rose sharply from a very high base in the Netherlands, while hardly changing in Japan. In 1970, Japan had an import penetration rate equal to that of the United States (four per cent), but at the end of the 1980s had a rate only half as high as that of the United States.

95. These trends in import penetration at the level of total manufacturing conceal important differences in industry groupings with different technological characteristics (Table MPEN 2). In most countries, high-technology industries are characterized by higher import penetration rates, followed by medium-technology sectors, while the total domestic demand in low-technology industries tends to be mostly satisfied by domestic production. There are some exceptions: medium-technology industries in France, Italy, the Netherlands and the United States are more import intensive than high-technology sectors.

96. There is also a clear ranking in terms of import penetration between the five industry groupings that are constructed on the basis of the main factors that are believed to affect competitiveness. The science-based industries are the most-import intensive group in all countries, while resource-intensive industries are the least import-intensive. The exception to this rule is in Japan, where the import penetration in resource-intensive industries, although low compared to other countries (10 per cent in 1989), is the highest of any of

Description of the Indicator

Import penetration is calculated as the ratio of imports to total domestic demand (production plus imports minus exports) for the total manufacturing sector, industry groupings or individual industries sectors in the group of OECD-13 countries. Expressed in percentage terms, the value of the indicator ranges between zero and 100. When it approaches zero, imports are a negligible part of total domestic demand, which is satisfied entirely by domestic production. As it approaches 100, imports account for almost all of the total domestic demand of a given sector or industry grouping.

Data problems have not allowed the calculation of import penetration rates for certain 3-digit and 4-digit industries in some of the OECD-13 group of countries. This is due to the lack of complete compatibility of data on exports and imports and data on production. The analysis in the text is thus limited to those countries/industries for which the indicator can be calculated with confidence.

The import penetration ratio is an indicator of import intensity and outward orientation of countries or industries. It can reflect a number of quite different factors. The size of a country will influence the indicator: larger countries with significant domestic markets will as a rule have a lower import penetration ratio than smaller countries. Countries that belong to some trade area such as the EC will tend to import a large fraction of the goods necessary to satisfy domestic demand. Countries that are geographically removed from the centre of world trade will tend to have lower penetration rates than those for which transportation costs are low. At the level of individual industries, import penetration rates reflect the nature of products being traded, with some manufacturing products in general more tradeable than others.

Like any individual indicator, import penetration should be interpreted with caution and its limits should be understood. A low rate of import penetration for particular industries in certain countries does not for example necessarily imply that there are barriers to entry into these industries. It may instead reflect superior productivity or lower prices of domestically produced products. Nor is a very high import penetration rate necessarily a cause for concern. Advanced economies gain through trade by specialising in certain industries or products and importing others. An analysis of international competitiveness of countries and industries needs to be based on the examination of a number of indicators, such as export performance or the evolution of unit labour costs and the existence of tariff and non-tariff barriers.

the five industry groupings, and is followed by import penetration in science-based industries. The high (relative to other industries) share of imports in the total domestic demand of the petroleum refining industry (17 per cent in 1989) accounts for this.

97. Countries are more diverse in the three other industry groupings. The specialized-supplier (differentiated products) group tends to be the second most import-intensive group of industries in most countries, although with important exceptions. In the labour-intensive industry grouping, Germany, Norway and the United Kingdom all tended to import a larger share of total domestic demand than in the differentiated-products industries, while scale-intensive industries in France and the Netherlands have higher import penetration rates than either labour-intensive or differentiated-products industry groups.

98. In terms of individual industries, import penetration is high across the OECD-13 countries in scientific instruments, aircraft, computers, communications equipment and motor vehicles (Figure MPEN 1). In the scientific instruments sector, imports account for more than half of total domestic demand in eight out of the 13 OECD countries in the database. The outliers are the United States and Japan, with import penetration rates of seven per cent and 14 per cent, respectively in 1989. The US is also the exception in aircraft, where its import penetration rate of eight per cent for 1989 contrasts sharply with the high import-intensity of that industry in the other countries. In computers, all countries for which the indicator can be calculated have import penetration rates exceeding 50 per cent, with the exception of the United States (35 per cent in 1990) and Japan (seven per cent in 1989). A similar situation occurs in communications equipment, with Japan the only real outlier (an import penetration of four per cent in 1989), and imports satisfying more than 40 per cent of total domestic demand in the remaining countries (30 per cent for the US and Germany, 25 per cent for France). The variance of import penetration rates in motor vehicles is higher, with imports accounting for more than 40 per cent of total domestic demand in eight out of 13 countries, between 25 and 40 per cent in Australia, Germany, Italy and the US, and two per cent in Japan. .

99. Industries such as textiles, pharmaceuticals, petroleum refining, ferrous and non-ferrous metals, and electrical and non-electrical machinery typically have lower import penetration rates than the previous group and a higher variance by country. In textiles, for example, four countries had import penetration rates ranging between 10 and 30 per cent, three countries between 30 and 40 per cent, and six countries rates exceeding 50 per cent. In pharmaceuticals, the United States and Japan have import penetration rates which are less than 10 per cent, six more countries have rates between 10 and 30 per cent, and the remaining have rates ranging from 40 per cent to 65 per cent.

100. A final group of industries are characterized with imports accounting for a small fraction of total domestic demand in most countries. They include food, beverages & tobacco, paper & printing, non-metallic mineral products, and fabricated metals. In the food industries, the highest import penetration rate can be found in the Netherlands (near 40 per cent), with imports accounting for less than 20 per cent of domestic demand in all other countries (26 per cent in Denmark in 1990). A similar distribution occurs in the paper & printing and stone, clay & glass industries. Finally, in fabricated metals, Norway and the Netherlands have import penetration rates around 40 per cent, seven countries have rates between 10 and 30 per cent, while imports in 1899 were eight per cent of total domestic demand in the US and two per cent in Japan.

Country profiles

101. In the United States for 1989, imports made up 14 per cent of total domestic demand for manufactured goods. This low penetration ratio reflects in large part the size of the US domestic market; nevertheless, its more than tripling since 1970 is testimony to the increased outward orientation of the US economy. Imports are twice as important in the high- and medium-technology industries taken as groups (import penetration rates of 18 per cent in 1989) than in low-technology industries (nine per cent). Specialized-supplier and labour-intensive industries have the highest import penetration rates; at about 20 per cent, imports in these industries have increased five-fold as a share of domestic demand since 1970. Import penetration rates in scale-intensive and in science-based industries were around 13 to 14 per cent in 1989, while the lowest import penetration rates were in resource-intensive industries (eight per cent).

102. In terms of individual industries, import penetration rates are highest in computers and in communications equipment. Imports in these two sectors accounted in 1989 for more than 30 per cent of the total domestic demand of each industry, five times their importance in 1970. They are also high in motor vehicles (27 per cent) and in the textiles industry (24 per cent in 1989). They are particularly low in pharmaceuticals, paper & printing, in food, drink & tobacco (less than five per cent in 1989), as well as in shipbuilding, instruments, fabricated metal products and aircraft industries. Of all manufacturing industries, imports as a proportion of domestic demand increased most between 1970 and 1989 in the electrical machinery sector, while shipbuilding is the only industry that registered a decline in its import penetration rate (from eight per cent in 1970 to five per cent in 1989).

103. Import penetration in the manufacturing industry in Canada has increased by 10 percentage points since 1970 to reach 35 per cent in 1989. Imports tend to be very important in high- and medium-technology industries (import penetration rates of 63 and 53 per cent in 1989), and less so in low-technology manufacturing (17 per cent). As a resource-based economy, Canadian imports into resource-intensive industries tend to be low relative to total domestic demand (13 per cent in 1989). In contrast, nearly three-quarters of domestic demand in science based sectors and more than 60 per cent in specialized suppliers industries tend to be satisfied by imports. Imports in labour-intensive and in scale-intensive industries accounted for 25 per cent and 40 per cent of total domestic demand respectively in 1989. Motor vehicles, aircraft, non-electrical machinery and semiconductors are some of the industries where import penetration is high (exceeding 60 per cent in 1989), while imports satisfy a small fraction of total domestic demand (between 10 and 15 per cent in 1989) in the food, drink and tobacco, wood, and paper & printing industries.

104. The profile of import penetration in Japan is strikingly different from that of other OECD countries. Imports accounted for less than six per cent in the total of domestic demand for manufacturing in 1989, a two percentage point increase in 20 years. Little variation is also observable across the three technology groups. The high-technology group of industries has roughly the same degree of import penetration as the medium-technology group, and only marginally lower than the low-technology group. Of these three groups, only low-technology imports have increased as a proportion of domestic demand since 1970 (from three per cent to seven per cent). Imports tend to be particularly unimportant in the scale-intensive and the specialized-suppliers group of industries (import penetration rates of four per cent in 1989). They are more important in resource-intensive, labour-intensive and science-based sectors, where they accounted in 1989 for nearly 10 per cent of total domestic demand. While labour-intensive imports more than tripled as a share of domestic demand in the period since 1970, imports of science-based industries declined from 14 per cent to nine per cent.

105. Aircraft is the only industry in Japan where imports represent a significant share of total domestic demand. The 33 per cent import penetration rate of that industry in 1989, however, is only half of the 1970 level. Petroleum refining, non-ferrous metals, textiles, wood and scientific instruments are the only other manufacturing industries where imports account for more than 10 per cent of domestic demand. At the other end of the spectrum, imports of fabricated metal products, motor vehicles, electrical machinery, rubber & plastics, non-metallic mineral products and ferrous metals accounted in 1989 for between two and three per cent of total domestic demand in these industries. In most industrial sectors, import penetration increased since 1970. In addition to aircraft, the other two exceptions to this are non-electrical machinery, where the import penetration rate declined marginally, and computers, where imports halved as a proportion of domestic demand between 1970 and 1989.

106. The four large EC economies of France, Germany, Italy and the United Kingdom have broadly similar profiles of import penetration at the level of total manufacturing. They all started with import penetration rates of around 15 per cent in 1970 and in 1989 had rates ranging from 21 per cent in Italy to 27 per cent in Germany and 30 per cent in France and the United Kingdom. At a more disaggregated level, however, the import penetration profile of these four economies is quite distinct to each.

107. Variation by broad industry grouping in terms of import penetration is not large in France. Imports tend to be a lower share of domestic demand in the low-technology industry group than in medium- or high-technology industries. Of the latter two, medium-technology sectors were in 1970 less import-intensive than high-technology sectors, but the situation has been reversed since the mid-1970s. Resource-intensive industries have a relatively low import penetration rate (19 per cent in 1990), while the labour-intensive, scale-intensive and specialized-supplier groups all have roughly similar rates of around 30 per cent in the late 1980s, with the sharpest increase in the importance of imports recorded in the labour-intensive group. Imports account for nearly 40 per cent of total domestic demand in the science-based group

of industries. In terms of individual industries, import penetration is particularly high in computers (over 80 per cent, up from 60 per cent in 1970), and in instruments (58 per cent in 1990, up from 43 per cent in 1970). It is relatively low (less than 20 per cent in 1990) in petroleum refining, shipbuilding, food, drink & tobacco, paper & printing, non-metallic mineral products and in pharmaceuticals. Import penetration has increased in every manufacturing industry in France.

108. Imports have doubled as a proportion of domestic demand in manufacturing as a whole in Germany between 1970 and 1989. The largest increase has been in high-technology industries, which have become since the mid-1970s more import-intensive than the medium-technology group of industries. Of the three technology groups, low-technology industries had in 1990 the lowest import penetration with 20 per cent. In terms of the alternative classification of five broad industry groupings, science-based industries have the highest import-intensity by far; imports in this group increased from 33 per cent of total domestic demand in 1970 to nearly 70 per cent in 1989. The other four groupings all started with import penetration rates around 12 to 13 per cent in 1970; they ended up with rates between 25 per cent and 30 per cent in 1989, with the exception of the resource-intensive group, where imports in 1989 accounted for only 18 per cent of total domestic demand. Import penetration is very high in aircraft, computers and instruments; it is low in fabricated metal products (less than 10 per cent in 1989), petroleum refining, food, drink & tobacco and shipbuilding (around 15 per cent in 1989).

109. Import penetration in Italy is the lowest of the four large EC countries and has not increased much since 1970. The medium-technology group of industries remains the most import-intensive of the three technology groups, with about 30 per cent of total domestic demand in the industries belonging to this group in the late 1980s satisfied through imports. Import penetration tends to be relatively high (exceeding 40 per cent) in industries such as instruments, computers, communications equipment and non-ferrous metals. Italy is also the only of the large EC countries where import penetration has declined significantly in a number of industrial sectors during the period from 1970 to 1989. The proportion of total domestic demand accounted for by imports declined in basic metals industries as well as in non-electrical and electrical machinery.

110. Imports account for about 40 per cent of total domestic demand in both high-technology and medium-technology industries in the United Kingdom, showing a sharp rise in import penetration during the 1970s and 1980s. Low-technology imports represent 20 per cent of the total domestic demand in these industries. In terms of the five industry groupings constructed on the basis of the factors thought to affect competitiveness, imports account for half of all domestic demand in science-based industrial sectors, about 35 per cent in labour-intensive and specialized-supplier industries, around 30 per cent in scale-intensive sectors, and less than 20 per cent in resource-intensive industries. Computers and scientific instruments are the two industries where import penetration rates exceed 75 per cent (starting from 25 per cent in 1970 for instruments), while import penetration is around exceeds 40 per cent in communications equipment, textiles, non-ferrous metals and in the motor vehicles industry.

Table MPEN-1
Import Penetration in Manufacturing

Country	1970	1980	1989
Australia	15.6	19.2	24.8
Canada	24.6	30.7	35.1
Denmark	41.1	43.7	50.2 *
Finland	27.9	27.8	31.4 *
France	14.5	21.3	29.9 *
Germany	13.4	19.8	26.8
Italy	15.7	20.0	21.3 *
Japan	4.0	5.5	6.3
Netherlands	42.0	53.0	70.2
Norway	39.8	38.7	42.9
Sweden	29.5	35.9	41.3 *
United Kingdom	14.6	22.9	30.0
United States	4.4	8.7	13.9

* 1990

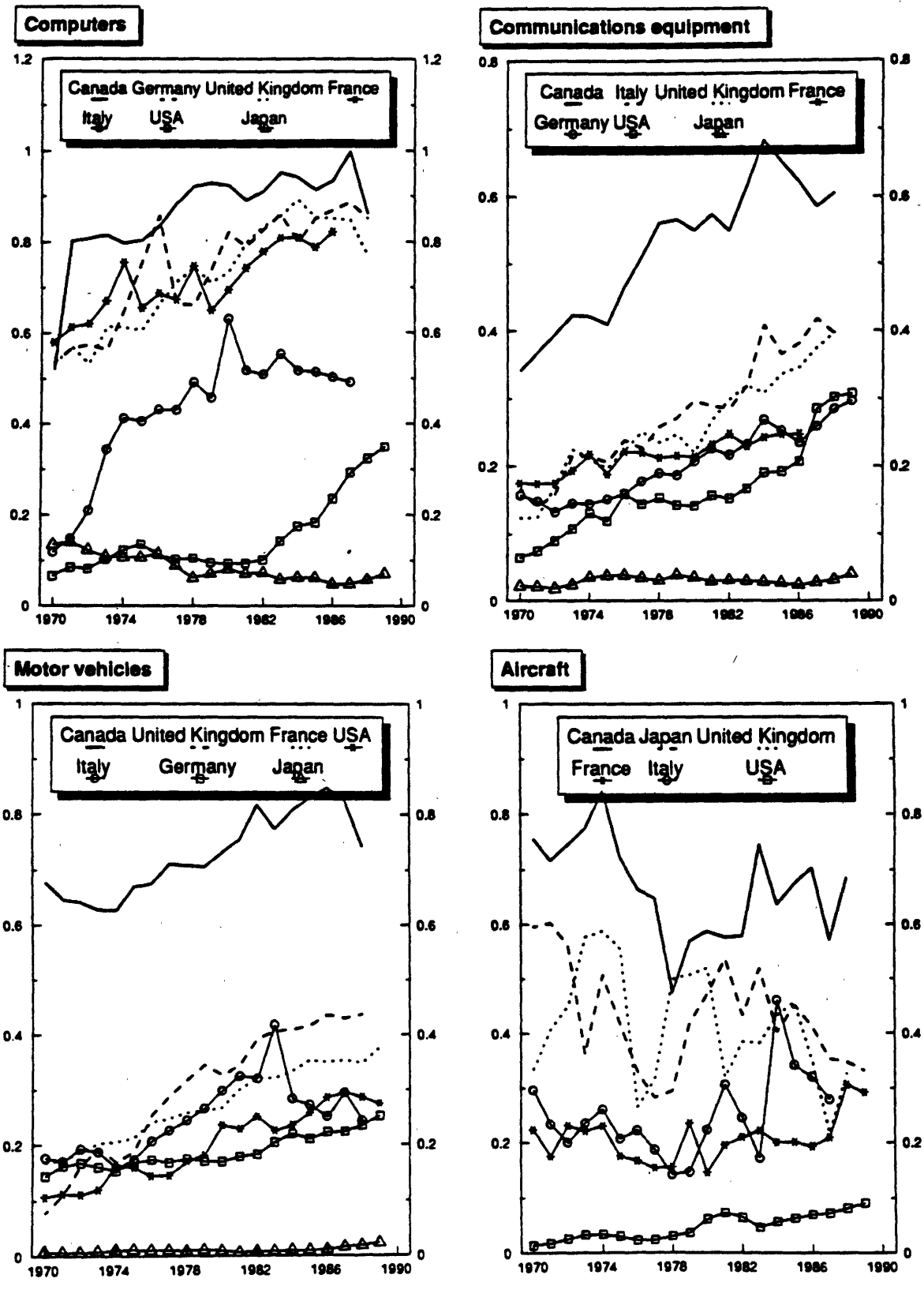
Table MPEN-2
Import Penetration by Industry Gouping

	High technology	Medium technology	Low technology	Resource intensive	Labour intensive	Scale intensive	Specialised supplier	Science based
United States								
1970	4.2	5.6	3.8	4.1	4.1	5.3	4.4	3.1
1980	8.9	12.9	6.2	6.5	9.8	10.3	10.1	6.3
1989	18.4	18.5	8.8	7.6	19.0	13.9	20.8	13.3
Canada								
1970	42.2	42.9	12.1	8.9	15.6	33.8	45.0	65.0
1980	55.0	51.5	13.1	10.7	21.5	39.4	56.2	72.3
1988	63.4	53.3	16.8	13.1	24.8 *	44.1	61.2	72.5
Japan								
1970	5.2	4.5	3.0	5.9	2.7	2.0	3.1	14.1
1980	5.4	5.0	5.5	8.2	6.6	2.6	3.1	10.5
1989	5.4	5.9	6.6	9.6	9.3	3.7	3.5	9.4
France								
1970	21.6	19.7	10.7	10.6	10.9	16.2	18.9	29.5
1980	24.7	30.0	15.8	14.5	22.7	25.7	24.4	28.1
1990	31.6 **	34.1 **	21.4	18.8	31.3	33.5	27.9 **	36.9 **
Germany								
1970	14.9	17.2	11.1	12.3	13.4	12.7	12.4	32.9
1980	23.5	22.6	16.8	15.5	25.8	19.0	17.6	41.1
1989	37.0	29.5	20.9	17.9	29.3	27.0	24.9	68.7
Italy								
1970	16.2	23.6	11.6	16.1	7.3	16.5	27.3	15.1
1980	20.7	28.2	14.9	20.0	11.8	21.4	22.6	23.7
1987	22.8	28.9	15.7	18.4 *	14.4 *	22.2	24.6	27.5
United Kingdom								
1970	17.4	..	12.4	17.2	12.3	-1.0	13.4	28.8
1980	32.6	32.0	15.9	17.1	31.3	21.6	21.9	49.1
1988	42.4	39.4	19.8	17.1	37.4 *	31.2	35.3	50.3

*: 1989
**: 1986

Figure MPEN 1

Import Penetration Rates in Selected Manufacturing Industries



Production Shares Across the OECD-13

111. Across the OECD-13 during the period from 1970 to 1989 five countries -- Japan, Italy, Canada, Finland and Norway -- increased their share of total manufacturing production. These gains in share came at the expense of the shares held by United States, the United Kingdom and Germany. In particular, the US lost by almost a factor of two the most share points (-2.6) while Japan gained nearly an equal amount (+3.0).

112. Nonetheless, the United States was still responsible for almost two-fifths of all production in manufacturing industry of the OECD-13 in 1989 (Table PSO 1). Although the US's lead of 22 percentage points above Japan in 1970 was cut to 16 percentage points by 1989, the US has a dominant position in terms of manufacturing production. This convergence was evident especially at the end of the 1970s and at the beginning of the 1980s. The share of the EC-6 decreased by one percentage point, down from a high achieved in 1974 to 1976.

Description of the Indicator

Production shares across the OECD-13 have been calculated as production in a certain industry for a given country or country grouping as a proportion of production for the OECD-13 in this industry. This indicator was calculated using production data which was converted to a common currency using US purchasing power parities for GDP. The term production refers to the gross output, not the value added of an industry. In this respect, production shares are roughly synonymous with sales shares, regardless of whether the sales were domestic or foreign (exports). Because production (gross output) data includes the cost of purchased inputs as well as the value added generated by a industry, production shares can be influenced by the level of specialisation and out sourcing conducted by an industry.

The interpretation of this indicator is not always straightforward: the production shares of an industry in a country can increase, not because of an increase in that industry's production, but rather because of a general decline of that industry's production across the remaining OECD-13 countries. As in the case of export market shares, the globalization of industrial activity means that for some countries a significant share of production is actually carried out by foreign-owned firms operating in that country. In this indicator the output produced by such firms would be assigned to the country where the production occurred, regardless of ownership.

113. Germany, despite a drop of one share point, retained the position of the third largest contributor to the total manufacturing production of the OECD-13. The only country which notably increased its rank was Italy which jumped from position number six in 1970 to number four in 1989, surpassing France and the United Kingdom. The United Kingdom experienced the largest decline among countries when the decline is compared to the initial share of this country. This was especially evident from 1974 to 1981 when the UK reduced its production share in more industries than any other country (except for the United States) and became the fifth largest producer among the OECD-13. Due to these changes in production shares, the wide differences that existed in the 1970s between Italy, the United Kingdom and France were reduced significantly, resulting in 1989 production shares which are nearly identical.

114. Canada saw the largest increase in share if its gain is compared to its initial, 1970 share, even though its ranking among the 13 countries did not change. The Netherlands, Australia and Sweden formed a group of countries with a share greater than one but not exceeding two per cent of total manufacturing production. Each of these countries experienced a small decline in their shares. Finland, Denmark and Norway make up a final group of countries who contribute less than one per cent to the OECD-13 total. Nevertheless, the 1989 share held by Norway and Finland represented an increase over their 1970 shares.

High-technology Industries

115. In high-technology industries, the United States was the leading producer in all industries. An exception to this rule occurs when the six EC countries are combined into a block where the EC-6 block holds a leading position in electrical machinery and pharmaceuticals (Table PSO 2). As can be seen from the length of the bar, the most significant high-technology shifts occurred in the instruments and computer industries, while pharmaceuticals were relatively stable (Figure PSO 1). The highest share in any one industry is held by the United States in the aircraft industry, the only high-technology industry where the United States was not followed by Japan but by France and the United Kingdom. Nevertheless, the US is losing share in this sector as the combined share of France and the UK countries increased from 12 per cent in 1970 to 17 per cent in 1986. In this industry only two other countries besides the United States decreased their production shares (Sweden and Australia).

116. Only in production of instruments did the United States strengthen its position as the leading producer starting with approximately half of the total manufacturing production of the OECD-13 in 1970 and ending with over two-thirds of the OECD-13 total by 1988. This US gain was counter balanced by a decline in the EC-6's share from 36 per cent to 18 per cent with most of the decrease coming from the United Kingdom and Italy (loss of seven share points respectively), but also in Germany, France and Japan (the only Japanese high-technology industry with a loss).

117. In the production of computers and communications equipment the United States despite a decline still held the largest shares as of 1986, although its closest competitor, Japan, made substantial gains.[4]

Medium-technology Industries

118. The United States managed to remain the largest producer in all medium-technology industries when ranked by countries, but its share declined in every single industry. If compared to the EC-6 as a block the share of the United States was overtaken by this group of countries in chemicals, non-electrical machinery and motor vehicles. Motor vehicles, non-ferrous metals and other transportation equipment went through larger shifts than other medium-technology industries (Figure PSO 2). As of the late 1980s, the sectors where the countries other than the US, Japan or the EC-6 had a significant share of production, all tended to be rather resource intensive: non-ferrous metals, the wood and paper groups, other transportation equipment and ship building. In general over the two decades, the group of other countries (Australia, Canada, Finland, Norway and Sweden) collectively improved their production share in every medium-technology industry with the exception of the plastic products.

119. The share of production in the motor vehicle industry declined the most in the United States (from 40 per cent in 1970 to its final share of 33 per cent in 1988), but also in the United Kingdom (from 9 per cent to 5 per cent). The biggest gain was made by Japan (from 19 per cent to 24 per cent), but gains were also registered by Germany, Italy and Canada, while France's share remained relatively stable.

120. In the chemical industry, the United States continued to hold the largest share: 39 per cent in 1987 after sustaining a loss of five percentage points from 1970. The increase of the EC-6 in this period from 37 per cent to 40 per cent was partly attributable to the growing share of Italy which grew quickly in the first half of the 1970s. Despite this, Italy remained the fifth largest producer behind the United States, Japan, Germany and United Kingdom.

Low-technology Industries

121. In the low-technology group by the end of the 1980s, the United States had a larger share of low-technology production than the EC-6 or Japan in petroleum refining, wood, paper and food groups, while Japan gained leadership in ferrous-metals and EC-6 was the leader in the rest of the low-technology industries. Nevertheless, it was the countries other than the US, Japan and the EC-6 which experienced an increase in share in every industry in the low-technology group with the exception of shipbuilding (Figure PSO 3) where the United States doubled its production share. As a result of this gain, the US share in shipbuilding approached nearly the same level as the EC-6 (37 per cent) and moved from being the second largest producer in 1970 to the leading position with a share of 35 per cent in 1987. Off setting this gain in share was a loss of share by the Japanese whose share fell from 33 per cent to 18 per cent. This gain in the OECD-13 share of ship production is undoubtedly due to the construction of military vessels for the US Navy which undertook "...the largest combatant ship construction program in peacetime history" during the 1980s where nearly 100 billion dollars was appropriated.[5] When just the merchant shipbuilding industry is examined, Japan had the largest share of the market in 1992, followed by South Korea and Denmark.[6]

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[4] Due to the availability of data, these trends are base on a limited time series: computers, 1980 to 1986, communication equipment from 1970 to 1986, and pharmaceuticals from 1970 to 1987.

[5] US Department of Commerce (1993), US Industrial Outlook 1993, (Washington, DC: US Government Printing Office), p.21-2.

[6] IBID, p.21-1.

122. The make up of the top-five producers in the textile, apparel and leather industry changed significantly as Italy increased its share from 11 in 1970 to 20 per cent by 1988, surpassing Japan (17 per cent in 1988) and Germany (eight per cent). Although losing three share points, the US retained its leading role with 34 per cent of the OECD-13 production in 1988. By 1988, the United Kingdom (seven per cent) had lost its fifth position to France (eight per cent). Across the 13 countries, only Italy, France, Australia and Canada increased their production share in this industry.

123. The United States and the EC-6 decreased their production shares in the food group (US from 42 to 38 per cent, EC-6 from 40 to 37 per cent), while Japan increased its share from 10 to 16 per cent, moving from the fourth position to the second as its share became higher than the shares of Germany (10 per cent) and the United Kingdom (nine per cent.

Table PSO 1
Total Manufacturing Production Shares
(Ranked by 1970 Share)

	1970	1980	1989	1989 -1970	1989/ 1970	min	year	max	year
USA	39.8	37.9	37.2	-2.6	0.94	35.9	1974	40.2	1972
Japan	17.8	19.8	20.9	3.0	1.17	17.4	1978	20.9	1989
Germany	12.0	11.4	11.0	-1.0	0.92	11.0	1989	12.0	1970
United Kingdom	9.1	7.3	7.4	-1.7	0.81	6.7	1981	9.7	1974
France	7.2	7.2	6.8	-0.3	0.95	6.8	1988	7.8	1974
Italy	5.7	7.6	7.7	2.0	1.35	5.7	1970	7.9	1976
Canada	2.4	3.0	3.3	0.9	1.37	2.4	1970	3.3	1988
Netherlands	1.9	1.7	1.7	-0.2	0.89	1.6	1988	2.0	1974
Australia	1.6	1.5	1.5	-0.1	0.93	1.4	1977	1.7	1971
Sweden	1.1	1.0	1.1	-0.1	0.96	1.0	1978	1.2	1975
Finland	0.5	0.7	0.6	0.0	1.08	0.6	1971	0.7	1982
Denmark	0.5	0.5	0.5	-0.0	0.90	0.5	1989	0.5	1986
Norway	0.4	0.4	0.4	0.1	1.11	0.4	1973	0.5	1986
EC6	36.4	35.7	35.1	-1.3	0.96	34.9	1988	39.2	1974

Table PSO 2
Production Share By Industry

	Year	USA	Japan	EC6	others*
High technology					
pharmaceuticals	1987	34.5	20.3	40.8	4.4
computers	1986	46.4	28.3	21.4	3.9
electrical machinery	1986	28.0	26.4	41.1	4.5
communications equipment	1986	38.7	31.1	27.3	3.0
aircraft	1986	71.0	1.9	24.2	2.9
instruments	1988	69.3	11.7	17.6	1.4
Medium technology					
chemicals	1987	38.5	15.7	39.9	5.9
plastic products	1988	35.5	24.5	34.7	5.3
non-ferrous metals	1988	34.6	21.5	29.4	14.4
non-electrical machinery	1986	35.3	20.9	38.4	5.4
motor vehicles	1988	33.1	24.4	34.7	7.8
other transport equipment	1987	42.3	12.4	33.8	11.5
other manufacturing	1988	40.1	24.0	28.4	7.6
Low technology					
food group	1988	38.0	16.2	37.5	8.3
textile group	1988	33.7	17.0	43.8	5.5
wood group	1988	40.9	14.9	32.4	11.8
paper group	1988	45.3	17.1	26.5	11.1
petroleum refining	1988	47.3	12.7	33.8	6.1
non-metallic mineral products	1988	29.0	19.9	44.1	7.0
ferrous-metals	1988	23.1	36.6	33.6	6.7
metal products	1988	34.2	19.6	38.3	8.0
ships	1987	35.3	18.0	36.6	10.2

* Australia, Canada, Finland, Norway and Sweden

Figure PSO 1

CHANGES IN PRODUCTION SHARES

Total manufacturing + High-Technology Industries

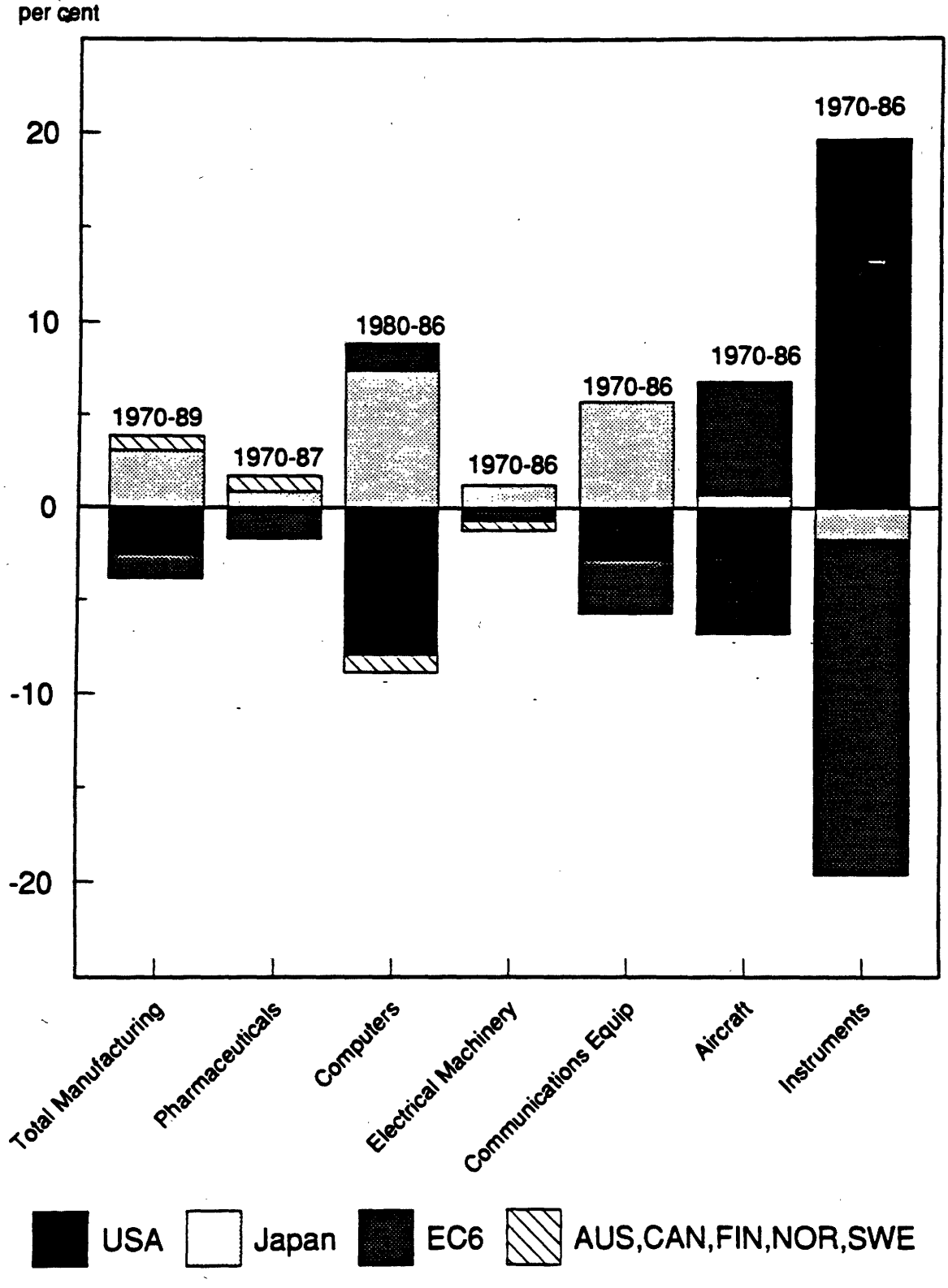


Figure PSO 2

Medium-Technology Industries

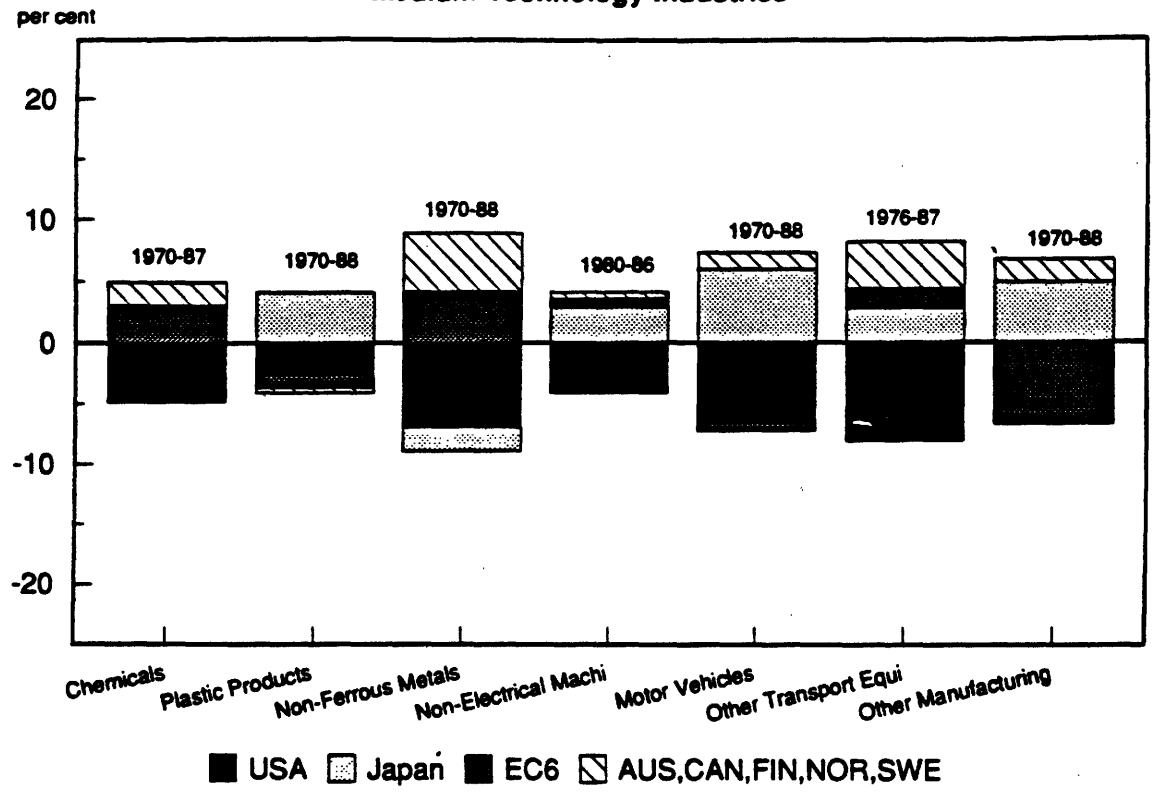
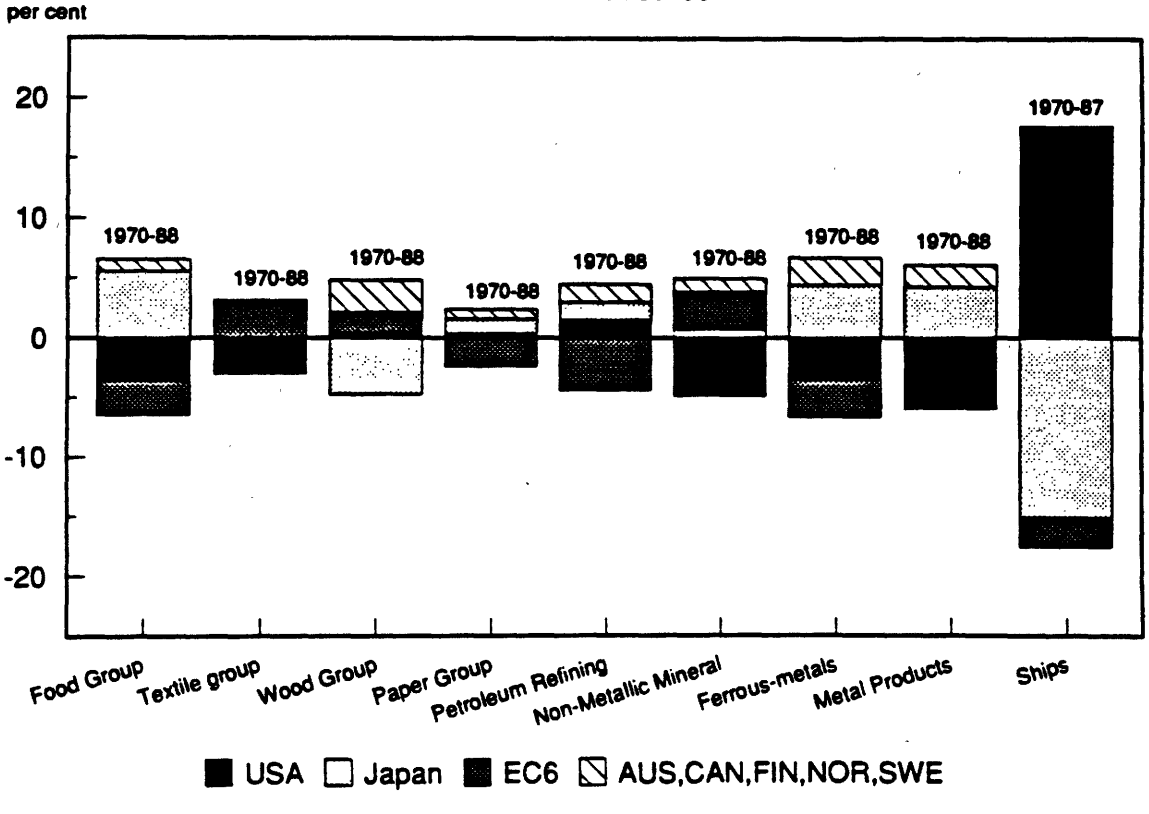


Figure PSO 3

Low-Tech Industries



The Share of GDP Contributed by Manufacturing

124. Over the last two decades the share of Gross Domestic Product (GDP) originating in the manufacturing sector declined in every country in our group of 13 OECD countries when measured in current prices. In constant prices a different picture emerged. For those nine countries where constant price data was available, five witnessed a decline, while three (Denmark, Italy and the United States) kept a constant share and one country, Japan, actually experienced an increase in the share.

125. As described in the box, the choice of whether to use current or constant prices to calculate the share a sector contributes to GDP, can dramatically affect the indicator. The two are best seen side-by-side. For example, the combination of a declining share (or level) in current prices and a level (or rising) share in constant prices reflects the fact that the price of manufactured goods has fallen over time relative to the price of other sectors (i.e. services). Usually this price decrease is due to relatively higher productivity: as many units are being produced as in the past, but at a lower relative price. When both the current and constant priced manufacturing shares are both declining, it is indicative of a general decline in the sector where less is being produced, not because of a relative decline in price, but because of a lower quantity of production.

A Description of the Indicator

The calculation of manufacturing's share of GDP is performed by summing the value added contributed by all manufacturing sectors and dividing it by the value added of the economy (GDP). The measure reveals the relative importance the manufacturing sector plays and how this role has changed over time. Although the calculation of the indicator is simple, the choice of whether to use current or constant priced value added in calculating the indicator is less straight forward and sectoral shares based in current and constant prices can lead to widely differing trends and conclusions.

Current price measures incorporate the relative inflation of one industry's product versus another (eg. technological advances leading to price declines in computers), the low productivity of one industry relative to another that forces its prices to rise relatively (eg. relative to services, manufacturing's productivity gains have led to relative price decreases), and monopoly power that allows price increases (eg. OPEC's influence on oil prices). Current priced shares have a strong intuitive appeal since they are the prices in which the transactions took place and changes in relative prices are an important determinant of structural change.

Constant prices eliminate prices as a variable and measure only volume or the quantity change. An important element of this procedure involves not only making adjustments for changes in prices due to inflation, but also changes in the quality of a product, facilitating common comparisons over time.

The constant prices used to measure manufacturing's share of GDP have been converted to a common, 1985, base year. This conversion allows a more accurate comparison of the levels between countries but forces the prices to deviate from the weights used to construct them, injecting some distortion into the calculation.

Country Profiles

126. The most precipitous decline in the manufacturing sector's share of GDP, regardless of valuation, occurred in France and the United Kingdom, where the share fell about eight percentage points in each country, over the last two decades (Figure MGDP 1). For the UK, most of this decline occurred during the late 1970s while in France the decline has been more evenly distributed over time. In Germany, the current priced shares have fallen by seven share points but the constant priced share has only dropped five points. Most of this decline occurred in the 1970s. Canada, as well, experienced a drop in both valuations of manufacturing's share of GDP, and as in the case of Germany and the UK, most of the decline happened in the 1970s; but unlike Germany and the UK, the drop was a comparatively small, two to three percentage points. Finland was the only other country where data was available that witnessed a drop in both valuations of the indicator. Unlike the other countries losing share, most of Finland's loss of manufacturing share occurred in the 1980s (Figure MGDP 2). In all of these countries -- Canada, Finland, France, Germany and the United Kingdom -- the loss in the share of GDP contributed by the manufacturing sector was roughly equal regardless of the valuation, current or constant prices, used. This reflects the fact that the loss of share was not because of a decline in price of manufactured goods versus other non-manufactured products (agriculture, mining and services), but rather, it was due to a reduction in the volume of production. In this sense, the economies of these countries are de-industrializing: the share of manufacturing is falling over time both in terms of total value of output and in terms of overall quantity of products being produced.

127. Both Italy and the United States had a decline in manufacturing's share of GDP in current prices, but had a relatively steady share when measured in constant prices. This reflects the fact that in terms of quantity of production, the same share was held by the manufacturing sector; but in terms of prices, manufactured goods become relatively less expensive. Frequently, this relative drop in price in associated with relatively larger productivity gains. In the US, this drop in the

current price share was rather uniform over the two decades while in Italy the bulk of the drop occurred in the 1980s.

128. Only in Japan, did manufacturing's share of GDP stay level in current prices and rise in constant prices. The interaction of these two trends suggests that manufacturing's share of the quantity of products being produced increased, but because of the relative price decline of manufactured goods, the current priced share was rather level (or as in the case of Japan in the mid-1970s, declining). The increase in Japan's constant price share was rather steady since 1975 with the exclusion of the 1985-1986 period which may be due to adjustments associated with the rapid appreciation of the Yen.

129. As shown in Table MGDP 1, the 1989 share of GDP originating in the manufacturing sector varied by over a factor of two across countries. As of 1989, Germany had the largest portion of its GDP coming from manufacturing, followed closely by Japan. Norway, Australia and Denmark had the lowest shares while all the other countries had a share that ranged between the high-teens or the low-twenties. Nevertheless, a pattern of convergence towards a similar share of GDP being contributed by the manufacturing sector is evident when viewed over the past two decades. Countries which had the largest initial share in 1970 were frequently the same countries that experienced the largest decline in share. This is supported by the fact that the variance in manufacturing's share of GDP existing between the countries dropped by a third between 1970 and 1989.

130. Three exceptions to this trend are found: in the UK, Australia and Norway each of whom had larger than normal losses in share from rather low initial bases. When these three countries are excluded, the size of the initial share of GDP held by manufacturing, explains 62 per cent of the variance in the change in share (Figure MGDP 3). Because of the few number of observations, this trend is not statistically significant, but it does suggest a convergence in economic structure over time between these countries. These findings raise some interesting questions concerning why this convergence has occurred and whether there is an absolute minimum manufacturing share level required by a modern, developed economy.

Table MGDP 1: Manufacturing's Share of GDP
(Current Prices)

	1970	1980	1989
Australia	24.3	19.3	16.1
Canada	19.8	17.9	17.5
Denmark	18.5	17.2	16.3
Finland	23.8	25.2	20.6
France	29.9	24.2	21.2
Germany	38.4	32.8	31.2
Italy	27.1	27.8	23.4
Japan	36.0	29.2	28.9
Netherlands	25.8	17.9	20.1
Norway	21.6	16.0	14.5
Sweden	25.0	21.1	21.1
United Kingdom*	28.7	23.2	19.7
United States	25.2	21.8	18.9
variance	33.2	26.3	23.4

* 1988

Manufacturing's Share of GDP: Current or Constant Prices?

The distinction between using current or constant prices to calculate value added shares is important, because, as illustrated below using three examples from the US, competitiveness of markets (oil), technological advances (computers), and relative productivity rates (manufacturing) can make the two indicators diverge.

Oil refining. When calculated using current prices, the share of the US refining industry's output to total output has had a "boom-bust" experience, increasing its share by over a factor of three from 1972 to 1981 and then falling by a factor of two from 1981 to 1986 -- a reflection of dramatic price changes associated largely with the strength and weakness of OPEC. Based in constant prices, a different picture of relative stability, with a slight downward trend.

Computers. By either measure, the computer industry has gained in its share of total manufacturing output, but when viewed using constant prices, the increase has been an extraordinary factor of 16 from 1976 to 1986. In current prices, the increase is a more subdued factor of two. The difference is largely due to adjustments in the price index for computers to account for improvements in quality.

Manufacturing. Measured in current prices, manufacturing's share of total US output has steadily fallen since 1977, prompting some analysts to suggest that the US has been de-industrialising. In constant prices, a picture of relative stability emerges. The difference between the two trends is largely attributable to the faster rate of productivity in the manufacturing sector versus the rest of the economy. This higher rate of productivity means that prices of manufactured goods have fallen relative to non-manufactured products (services). The relative drop in prices forces manufacturing's share in current prices to fall while in constant prices of a particular year, the trend is relatively stable.

Figure MGDP-1

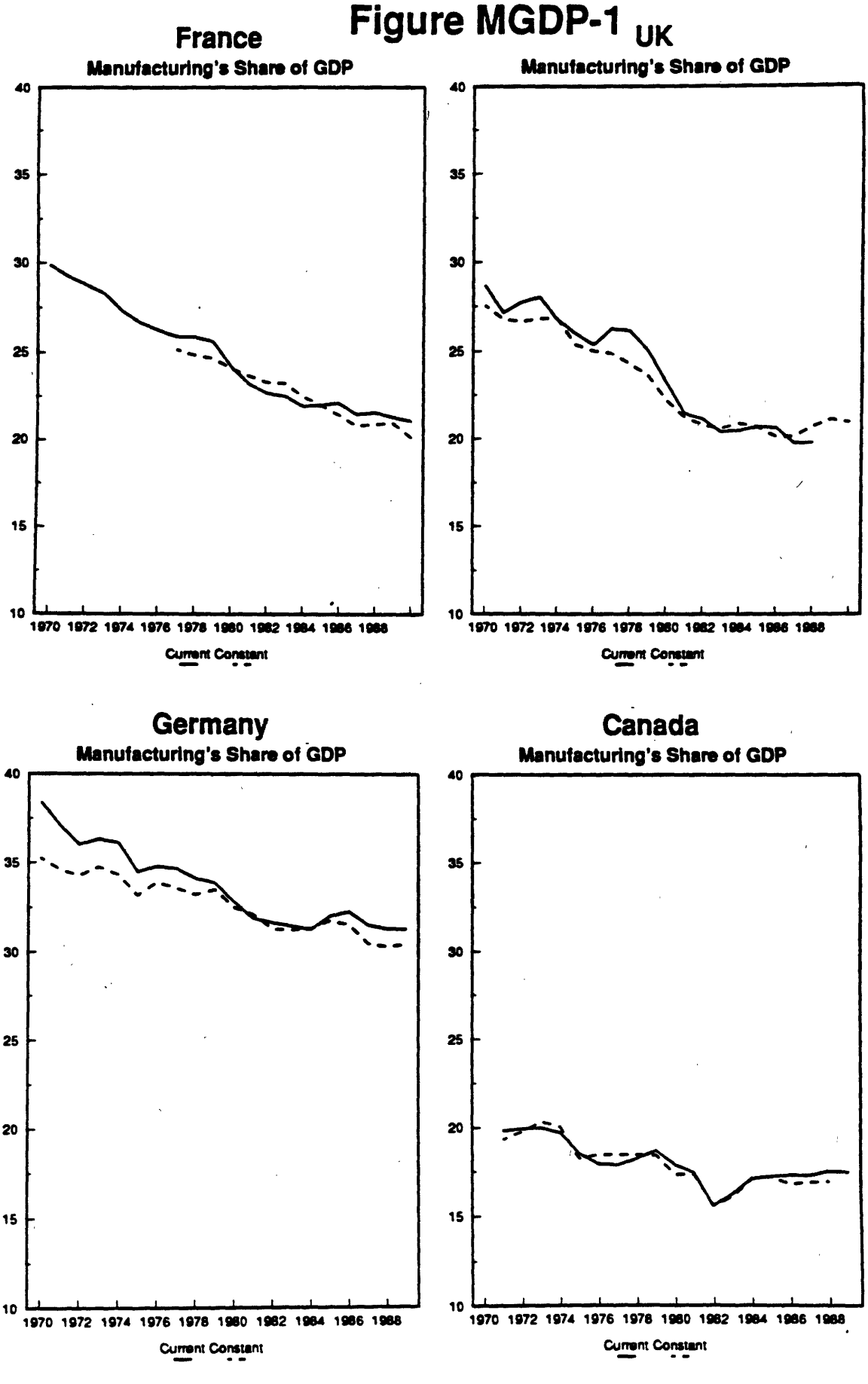
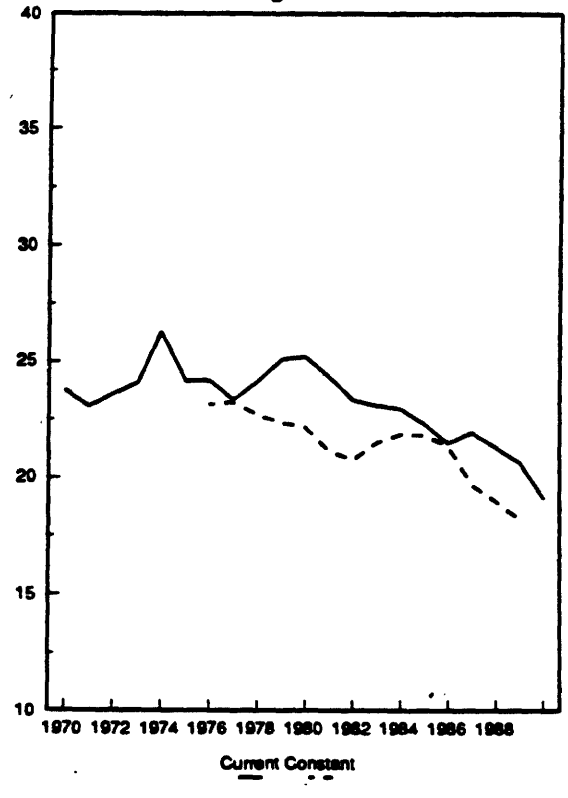


Figure MGDP 2

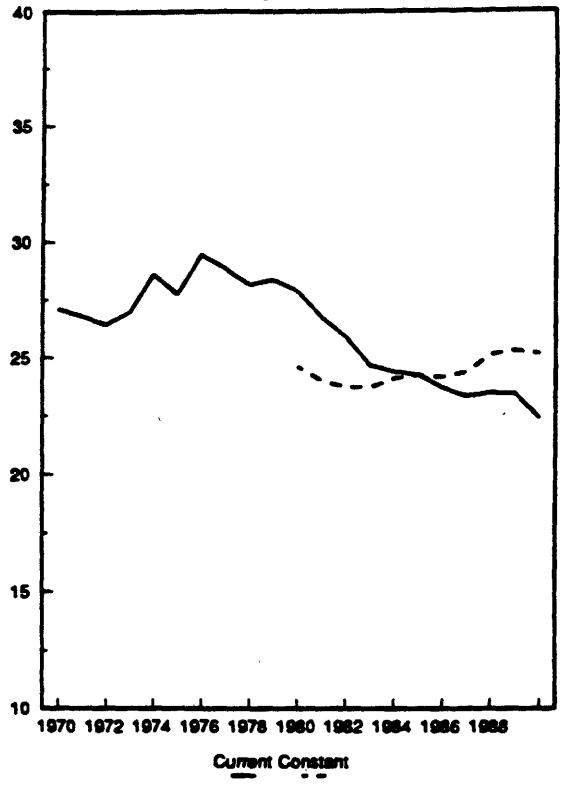
Finland

Manufacturing's Share of GDP



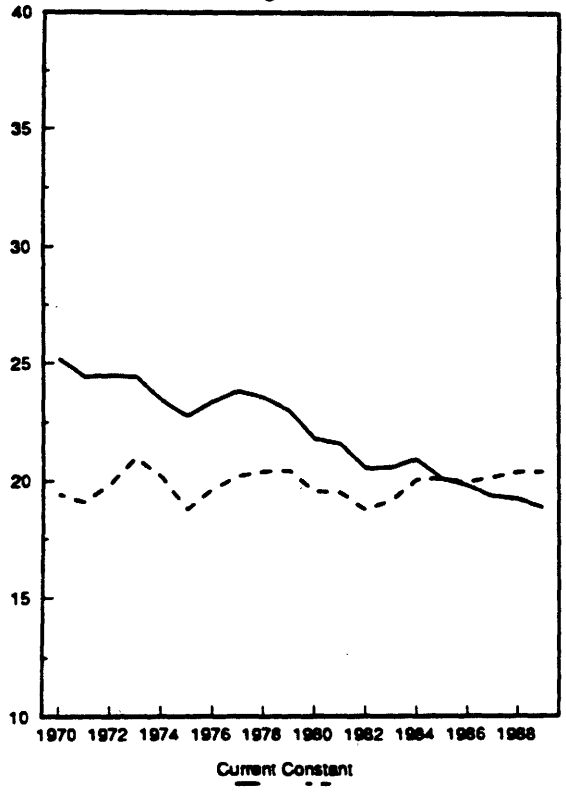
Italy

Manufacturing's Share of GDP



USA

Manufacturing's Share of GDP



Japan

Manufacturing's Share of GDP

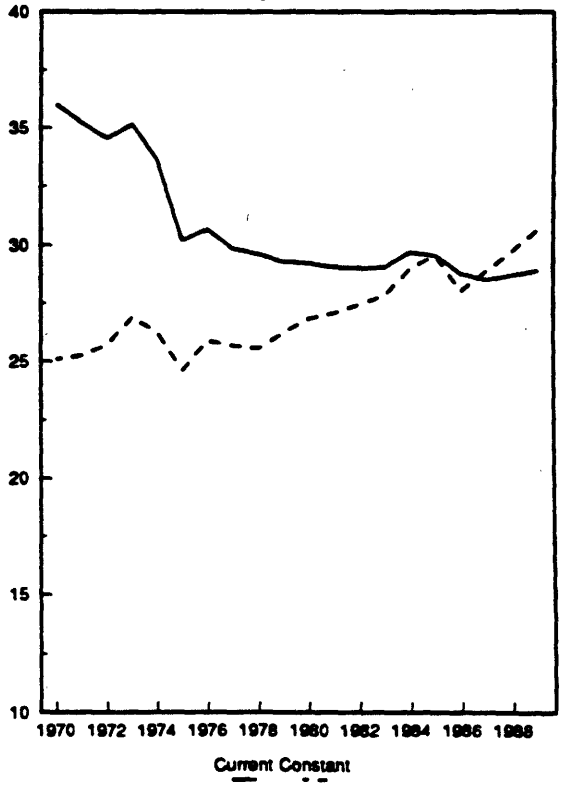
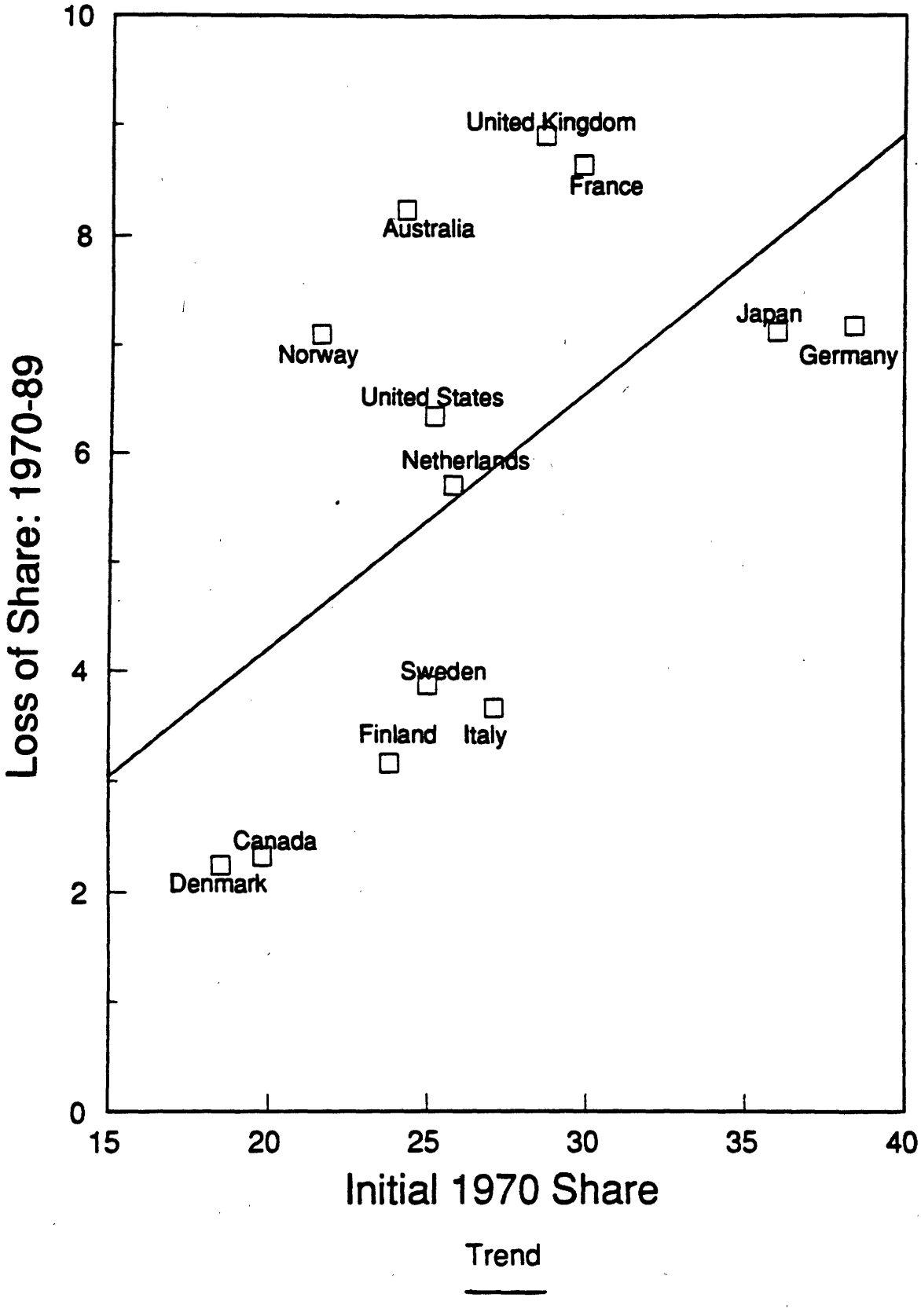


Figure MGDP 3
Manufacturing's Share of GDP
(current prices)



The Sectoral Distribution of Manufacturing's Value Added

131. Within the manufacturing sector, the distribution of value added between industries has changed significantly from the early 1970s to the late 1980s, moving from low-technology, labour and natural resource intensive industries to high and medium-technology and scale intensive and science based industries. These general trends vary significantly depending on the country and the valuation, constant or current prices, used (see box).

132. Table VAS 1 contains an index of structural change (see box) which provides and overview of the magnitude of the sectoral change that has occurred over the last two decades. Japan has consistently registered the largest amount of structural change in every period as measured by this indicator, with a 1970 to 1989 index nearly twice as large as the next closest country, Denmark. Nevertheless, Denmark has had a relatively high rate of structural change over the last two decades, although the rate of change declined somewhat in the 1980s from the 1970s. The United States anked third in the overall rate of structural change from 1970 to 1989, but unlike Denmark and Finland, the bulk of this change occurred in the 1980s where the rate of change was nearly double what occurred in the 1970s. Norway exhibited a similar turn around. The large European countries -- Germany, France, Italy and the UK -- tended to fall into the middle or lower ranks with an unweighted average which is only two-thirds of the overall average. In particular, the United Kingdom and France had the two lowest indices in the 1980s.

133. By and large, these indices of structural change tend to track the real manufacturing growth rates where Japan experienced a 1980 to 1989 rate of growth which was 50 per cent higher than the United States' or Denmark's, the countries with the second and third fastest growing manufacturing sector's. This adds support to the general roposition that it is easier to achieve structural change while experiencing growth.

134. Table VAS 2 reveals that the sectors driving these real changes in the share of manufacturing's value added differed widely between countries. While most of the countries saw shifts out of the food, textiles and wood products industry groups and into fabricated metal products and to a lessor extent, chemicals, there are numerous exceptions. It was the magnitude of this general shift which determined the differences in the 1980 to 1989 index of structural change with Japan, Denmark and the United States at the forefront of this transition. Japan and the United States also made large shifts out of the basic metal industry during this period, but all the other countries either saw an increase in the share of manufacturing's value added held by this sector (Norway and Canada) or a slight decline.

135. As mentioned in the box, one problem with constant price measures of industry shares of manufacturing value added is the lack of industrial detail. Although current price measures can be affected by changes in relative prices between sectors over time, they allow a much more detailed analysis, especially within the fabricated metal products and machinery sector which is the source of much of the real gain in share and contains many of the sectors which are of particular policy interest: computers, motor vehicles and aircraft. In addition, given the significant problems with applying a price of one year to products that might have undergone significant *quality* changes over time (i.e. computers), an analysis

A Description of the Indicator

The value added shares indicator is calculated by dividing each sector's value added by the total value added of the manufacturing sector and converting this ratio to a percentage. This measure presents the industrial composition of an economy's manufacturing sector, revealing the relative importance of different industries and the industrial specialisation of an economy's manufacturing sector. Although this more narrow focus illuminates some detail that would be otherwise lost, it can be deceiving since in most countries the manufacturing sector only contributes a relatively small part of all economic activity. (See previous indicator on manufacturing's share of GDP.) Nevertheless, because manufacturing has traditionally been the sector which has played a key role in international trade and the development of technology, and is thus frequently the focus of economic policies, this more limited focus is warranted because it provides insight into sectors of particular interest.

As mentioned in the previous indicator on manufacturing's share of GDP, this figure can be calculated in either current or constant prices, with both calculations providing different, but consistent trends. Shares based in constant prices eliminate the effect of changing relative prices between sectors and are generally preferred. But because of mechanical and conceptual difficulties, it is nearly impossible to obtain value added in constant prices at a detailed sector level. Thus shares based in current prices are used to provide finer sectoral detail and allow the calculation of broad groups.

Caution should be exercised in interpreting current price shares because trends in an industry's share of value added can be affected by relative price changes, not true structural changes. Balancing this caveat is the fact that shares based in current prices reflect the price that the transaction actually took place in, not a price from some other period. This consideration is especially important for industries such as computers or electronics where due to technological advances, the output of that industry is quite different from the product produced 20, 10 or even five years ago, making the application of another year's prices to the output of a different period problematic.

based on current price shares has strengths as well as weaknesses.

Table VAS-1: Index of Structural Change
(Constant Price, 1985=1.00)

	1970-80	1980-89	1970-89
Canada	5.2	5.8	9.9
Denmark	6.4	5.9	11.7
Finland	6.9	4.8	10.9
France	na	2.7	na
Germany	4.5	5.1	9.6
Italy	na	5.4	na
Japan	10.4	12.9	22.3
Norway	4.5	8.4	9.9
United Kingdom	5.1	3.4	5.9
United States	4.0	7.9	11.1
Average*	5.9	6.2	11.4

na = constant price data not available
* Based on available data.

An Index of Structural Change

A standard summary measure of structural change, sums the absolute value of the sectoral change in the share of value added over a particular time across all sectors and divides the total sum in half. When there is large movement in the shares of many industries, the index is large; when changes in shares are few or small the index is small. An index of 100 would represent a complete reversal of structure while zero would indicate no change what so ever. This measure is often called the rate or coefficient of (compositional) structural change, and there are numerous variations on it.

Calculation of the index of compositional structural change, and other similar summary measures, is sensitive to both the industrial classification chosen (the more detailed the classification, the more structural change observed) and the time period selected (care must be taken to avoid cyclical effects). In addition, while the indicator may have relevance in terms of analysing response to discrete shocks, it is much less useful in cases of gradual but nevertheless extensive structural change, such as the liberalisation of global trade or the development and diffusion of microelectronics.

Structural Change within the Three Broad Groups

136. Table VAS 3 presents the current price share changes by the three summary groups: wages, technology and orientation. The table shows that the volatility of share change differs between groups and among countries with the United States, Canada and Finland exhibiting much more change on the basis of wages than the other countries, while in terms of technology Germany and Japan are the most active.

137. In terms of wages, the United States and Canada and to a lessor extent Sweden, Germany and Japan saw a shift in the structure of their manufacturing sectors into high wage industries. For the US this high-wage gain was achieved by shifting into the industrial chemical, pharmaceuticals and motor vehicle industries and out of the medium-wage industries of ferrous and non-ferrous metals and non-electrical machinery. Aside from Italy and Norway, the US was the only other country to have an increase in the share of low-wage manufacturing due to a gain by the electrical machinery industry. In Italy, the low-wage gain was associated with increases by the food and textile groups while in Norway is was all due to the food group. For Canada, the gain in the high wage sector was predominantly due to an increase in the share held by motor vehicles and a smaller gain by the chemical and pharmaceuticals sectors. The medium wage loss was largely due to a decrease in share held by the metal products sector while the low wage decline was due to a loss by the textiles group.

138. When categorized by high-, medium- and low-technology, Japan, the United States, Italy and the UK saw large shifts into the high-tech sector while Australia, Canada, Finland, Germany and Sweden exhibited a shift of manufacturing value added into medium-technology industries. The gain associated with the high-tech sector in Japan was largely due to the computer and radio, TV and communication equipment industries while in the UK it was the computer and pharmaceutical sectors and in the US and Italy the pharmaceuticals and aircraft industries. For Italy, the UK and the US the main industry causing a loss of medium-technology share was non-electrical machinery while for Japan it was non-ferrous metals. In the low-technology sector, the losses for the US and Japan were in ferrous metals while in UK the decline was led by the refined petroleum sector.

139. By and large, for those countries that saw a realignment of their manufacturing sector into the medium-technology group, it was due to gains by the motor vehicle industry (Canada, Germany and Sweden) or gains by the industrial chemicals industry (Australia, Canada and Germany). Only in Finland, was the medium-technology gain associated with non-ferrous metals and non-electrical machinery. The losing, low-technology sectors were similarly clustered with ferrous metals the source of decline in Australia, Sweden and the textile group being the source of decline in Canada, Finland, Germany.

A Late 1980s "Snap-Shot"

140. Table VAS 4 concludes the analysis of industrial shares of manufacturing value added by showing the industrial composition of manufacturing for as many countries as possible in 1988. Although a one-time, static "snap-shot" is limiting in terms of understanding the direction of change, it does reveal how the structure differs between countries, indicating the magnitude of the relative industrial specialisation. At first glance, the countries exhibit a rather similar structure: the food group consistently holds a share in the teens, regardless of country; the chemical group has a relatively strong presence in every country, ranging from 10 per cent to 25; non-metallic materials are in the mid- to low-single digits; and fabricated metal products and machinery consistently commands a large portion of manufacturing's value added, varying from 29 to 47 per cent.

141. But the outliers by sector, reveal differences in the economic structure which reflect a specialisation of economic activity, some of which has been dictated by natural resources and some of which is the result of policies. For example, the country dedicating the largest share of manufacturing value added to the textiles group is Italy while Finland leads in the share originating from the wood and paper groups. Norway and Australia have disproportionately large shares emanating from the food and basic metals groups, but have two of the lowest shares for fabricated metal products and machinery. The importance of the chemicals group is especially pronounced in the Netherlands, France and Germany. Within the large fabricated metal products and machinery group, it is apparent that US manufacturing relies the most of any of the countries on the computer sector, while Japan derives a relatively larger share from its electrical machinery sector than other countries. Although, the performance and importance of the US and Japanese motor vehicle sectors are widely discussed, the manufacturing sectors of Canada, Germany and Sweden are more dependant on this industry. Lastly, as expected, the share held by the aircraft industry varies by over a factor of ten across countries with the US, UK and France having the largest shares.

Country Specialisation

142. When an unweighted average share is calculated for each sector across the 12 countries, and this average is compared to the actual value of that sector calculated for each sector, a summary measure which indicates the relative dispersion of a sector across all countries from the average can be derived.[7] Those sectors exhibiting a high dispersion are those sectors that enjoy the greatest heterogeneity between countries, a reflection of national specialization. Table VAS 5 lists the sectors in descending order of specialization. Not surprisingly, sectors which rely on natural endowments such as non-ferrous metals and petroleum refining tend to have a high degree of specialisation: in those countries where the sector exists, it tends to be relatively large, in those countries where it does not, it is small. The other characteristic which defined those sectors which have a high degree of variation across countries was the technological sophistication of the sector. Three of the top six industries with a high level of heterogeneity were high-technology industries: aircraft, radio, TV & communication equipment and computers & office machinery. Specialisation in these industries tends to reflect a competitive advantage (human capital, innovation), national characteristics (large defense sector) or a deliberate public policy (Airbus).

[7] The dispersion measure for each sector equal the absolute value of the difference between the share of manufacturing's value added contributed by a sector in a particular country minus the average share for that sector calculated across all 12 countries. To adjust for the size of a sector, this difference is then divided by the average: (ABS (value-average)) / average.

143. Those sectors whose shares are relatively homogenous across countries tend to be sectors whose output is required for human existence (the food group) and the maintenance and construction of a basic infrastructure (ferrous metals and non-metallic mineral products).

Table VAS-5: Descending Rank Order of Sector Share of Manufacturing Value Added Heterogeneity Across Countries

1. non-ferrous metals
2. aircraft
3. refined petroleum products
4. shipbuilding
5. radio, TV & communication equip.
6. computers & office equipment
7. other transportation equipment
8. professional goods
9. motor vehicles
10. textiles, apparel & leather
11. non-electrical machinery
12. electrical machinery
13. other manufacturing
14. paper products & printing
15. wood products & printing
16. pharmaceutical
17. industrial chemicals
18. rubber & plastic products
19. non-metallic materials
20. ferrous metals
21. food, beverages & tobacco

Table VAS 2
1980 to 1989 Change in Industry's Share of Manufacturing Value Added
(Constant Prices, 1985=1.0)

ISIC	Industry	Canada*	Denmark	Finland	France	Germany	Japan	Norway	United Kingdom	United States
3100	Food, beverages & tobacco	-2.7	-0.9	2.6	0.2	-2.1	-5.0	-4.6	-1.8	-2.0
3200	Textiles, apparel & leather	-0.1	-3.8	-1.4	-1.8	-1.0	-1.8	-1.8	-1.2	-1.3
3300	Wood products & furniture	0.5	-1.1	0.3	-0.3	-1.0	-1.4	-1.3	0.1	-0.6
3400	Paper products & printing	-1.9	0.4	-2.0	0.5	0.0	-0.4	1.9	0.6	-0.4
3500	Chemical products	0.6	-0.1	0.3	0.9	0.6	-0.3	4.2	1.9	0.8
3600	Non-metallic mineral products	-0.4	-0.0	-1.4	-0.4	-0.6	-0.3	-0.8	-0.2	-0.7
3700	Basic metal industries	0.6	0.1	-0.1	0.1	-0.5	-3.8	2.3	0.1	-2.8
3800	Fabricated metal products	4.5	5.3	0.9	1.0	4.4	12.9	-0.1	0.7	6.9
3900	Other Manufacturing	-0.4	0.0	0.7	-0.2	0.0	-0.0	0.0	-0.3	0.3

+ may not add due to rounding
* Canadian data is for the 1980 to 1988 period.

Table VAS 3
1980 to 1989 Changes in the Share of Manufacturing's Value Added by Major Group
(current prices)

	Australia*	Canada*	Finland	Germany	Italy+	Japan	Norway	Sweden	United Kingdom*	United States
High wage	1.55	5.69	0.29	3.43	0.92	2.86	0.59	3.72	2.04	6.25
Medium wage	0.37	-2.94	5.90	0.74	-1.12	-1.67	-3.19	-1.31	-0.66	-6.42
Low wage	-1.92	-2.76	-6.19	-4.16	0.20	-1.18	2.60	-2.41	-1.38	0.18
High technology	0.03	0.88	2.92	2.71	1.54	4.64	0.84	0.02	2.80	3.06
Medium technology	2.35	3.87	3.32	4.92	0.09	1.66	0.65	1.43	-1.51	1.13
Low technology	-2.38	-4.75	-6.25	-7.63	-1.63	-6.31	-1.49	-1.45	-1.28	-4.19
Resource intensive	-1.19	-0.36	-1.65	-4.76	0.16	-3.14	4.36	0.52	-1.84	-1.86
Labour intensive	-1.07	-3.17	-2.71	-1.26	-1.17	-0.82	-3.35	-0.88	-1.30	-2.93
Scale intensive	3.34	4.28	0.44	3.94	0.34	-0.44	-1.80	0.49	2.97	5.49
Specialised supplier	-0.67	-1.71	2.51	1.40	-1.14	2.73	-0.56	-1.97	-2.33	-3.06
Science based	-0.40	0.96	1.41	0.67	1.81	1.66	1.35	1.84	2.49	2.36

* 1980 to 1988 changes
\+ 1980 to 1987 Changes

Table VAS 4
Shares of Manufacturing's Value Added by Industry in 1988
(current prices)

ISIC		Australia	Canada	Finland	France	Germany	Italy*	Japan	Netherlands	Norway	Sweden	United Kingdom	United States	Unweighted Average
3100	Food, drink & tobacco	17.8	13.4	11.9	12.4	10.3	10.8	11.5	14.8	18.0	10.3	12.8	10.4	12.9
3200	Textiles, footwear & leather	7.2	5.5	4.8	6.7	4.1	16.6	5.1	3.5	2.2	2.8	5.8	5.1	5.8
3300	Wood, cork & furniture	5.6	6.3	7.2	3.0	3.0	5.4	2.7	2.5	6.5	7.0	3.3	4.7	4.8
3400	Paper, print & publishing	11.2	16.1	23.2	7.4	4.4	5.9	7.9	10.6	14.9	16.1	10.7	10.7	11.6
3500	Chemicals	13.0	12.9	10.1	19.6	19.0	na	15.7	25.7	11.7	11.5	17.7	17.5	14.5
351+352-3522	Industrial chemicals	6.5	6.6	6.5	7.6	10.1	6.4	6.9	14.8	7.0	4.2	9.0	9.0	7.9
3522	Pharmaceuticals	1.5	1.7	0.9	1.8	1.9	2.7	2.9	2.1	1.1	2.8	2.9	2.6	2.1
353+354	Petroleum refining	0.6	1.5	0.7	6.4	3.2	na	1.1	5.9	1.4	1.9	1.6	2.1	2.2
355+356	Rubber & plastic products	4.4	3.0	1.9	3.8	3.8	4.1	4.7	2.9	2.3	2.6	4.1	3.9	3.5
3600	Stone, clay & glass	5.0	3.5	4.8	4.3	3.7	7.2	3.9	4.0	3.5	3.2	5.4	3.1	4.3
3700	Basic metal industries	9.8	8.3	5.0	5.6	7.2	4.0	8.3	5.0	12.6	4.3	5.0	4.9	6.7
3710	Ferrous Metals	4.7	4.0	3.9	3.5	5.2	3.2	6.7	3.0	3.8	3.2	3.7	3.1	4.0
3720	Non-ferrous metals	5.1	4.3	1.1	2.1	2.0	0.8	1.6	na	8.9	1.1	1.3	1.7	2.5
3800	Fabricated metal products & machin	29.4	31.4	32.2	39.5	47.5	35.9	43.4	31.9	30.0	43.9	38.2	42.0	37.1
3810	Fabricated metal products	8.4	6.8	6.9	7.2	8.9	9.1	6.4	8.1	6.4	9.2	5.4	7.5	7.5
3820-3825	Non-electrical machinery	4.1	4.9	11.4	na	8.6	8.7	9.1	6.0	10.3	11.3	9.2	5.8	7.5
3825	Computers & office machinery	1.7	1.1	1.5	na	2.2	0.8	3.0	0.5	1.0	1.5	2.3	3.7	1.6
3830-3832	Electrical machinery	3.1	2.6	3.7	na	4.5	5.3	6.0	1.6	3.2	2.7	4.7	3.2	3.4
3832	Communicat. equip. & semiconduc	2.2	3.4	2.5	na	8.3	1.6	8.2	10.1	2.5	4.7	4.9	6.7	4.6
3841	Shipbuilding	1.2	0.4	2.0	0.4	0.3	0.5	0.5	1.3	3.5	0.4	0.9	0.6	1.0
3843	Motor vehicles	5.6	9.6	2.0	7.8	10.6	5.2	8.4	3.2	0.9	10.0	5.5	6.5	6.3
3845	Aerospace	1.0	1.8	0.4	2.7	0.9	1.0	0.3	na	1.0	1.7	3.5	4.7	1.6
3842+3844+3849	Other transport equipment	0.9	0.9	0.8	0.3	0.2	0.9	0.3	0.4	0.6	0.6	0.3	0.1	0.5
3850	Instruments	1.1	0.0	1.2	1.5	3.0	2.7	1.4	0.7	0.5	1.8	1.5	3.1	1.5
3900	Other manufacturing	0.9	2.4	0.8	1.5	0.7	1.1	1.5	2.0	0.6	1.0	1.2	1.7	1.3

na = data not available

II. Relationships Between Investment, Output and Competitiveness

Introduction

144. As the previous section has documented, the countries which compose the triad have witnessed a convergence in structure, overall R&D intensity and relative positions in international trade. Although significant strengths and weaknesses at a sectoral level set them apart, increasingly these three regions are focusing on the same set of technologically intensive, high wage industries: chemicals & pharmaceuticals, motor vehicles, electronics, computers and aircraft. These industries are characterized by unusually high investment or R&D intensities.

145. Although the previous section has analysed these sectors, as well as less glamorous ones, from a number of different perspectives, the more general role of these indicators and their relationship to other one another has not been examined and is the focus of this section. In particular, three broad questions are examined:

1) Are the industries that perform the bulk of R&D also the ones that conduct a large share of tangible investment?;

2) Which type of investment, R&D or tangible investment, plays a more significant role in terms of generating output?;

3) Which type of investment, R&D or tangible investment, has a greater association with performance in the international markets?

Strengths and Weaknesses of Cross Variable Analysis

This section relies on monovariate regression analysis (ordinary least squares) to estimate the relationship that exits between various indicators presented in the pervious section.

The strength of this approach is that it reveals the direction (positive or negative) and strength of various combinations of indicators, revealing characteristics of the indicator which are not apparent when seen in isolation. It also begins to shed light on a number of questions of more direct relevance to policy makers such as what the impact is of R&D on the economy.

Nevertheless, as with any statistical analysis which uses actual data, a number of limitations should be acknowledged and kept in mind when interpreting the findings. Foremost among these is the fact that what is being plotted represents the relationships observed in one point in time. This simplistic "snap shot" ignores the existence of dynamic or lagged effects. In addition, because of the availability of data, not all the data for each country are for the same year and in the case of the EC-6 area, some important industries could not be plotted because the data was missing for one of the six countries. (The second box specifies the years used and the industries which are missing for the EC-6 area.)

Lastly, another caveat involves the limitations associated with the use of monovariate regressions where because only one variable is regressed against the other what appears to be a relationship between the two variables could be an illusion caused by left out variable bias. Thus, instead of R&D being strongly correlation with export market shares, it could be simply that those industries that do R&D are also better managed and thus do better in international markets. In this case, R&D is a proxy for management and it is not R&D that is key to "competitiveness," but good management. Similarly, the direction of causality can not be determined: is a high share of value added due to a high share of investment or vias versa?

Until further work can be done to more fully analyse these relationships and specify a more complete model, these relationships should be interpreted with caution.

Intangible versus Tangible Investment

146. R&D is one of the primary forms of intangible investment, but a significant portion of R&D spending (10 to 20 per cent) is on tangible investment such as equipment and structures.[8] Besides this direct link between the two types of investment is the more general notion that industries which are likely to engage in one type of investment would be predisposed to engage in the other as well. As Figure III-1 shows, the connection between the two types of investment varies across countries. In the EC-6, although the correlation is positive, the strength of the relationship is very weak (R^2=2.5 per cent). By and large, those industries that make up a large share of total tangible investment, account for a small share of total manufacturing R&D. Although the US has a greater dispersion of industries, their is almost no relationship between those industries that conduct a large share of manufacturing R&D and those that conduct the bulk of tangible investment (R^2=0.2 per cent). In other words, those industries that conduct the largest share of manufacturing R&D are almost purely R&D performers and do not engage in the type of manufacturing which involves heavy investments in capital equipment and structures. The situation in Japan is much different. Here a strong correlation between the two investment indicators exists (R^2=52.5 percent). Industries tend to engage in the two types of investment in parallel. This is probably because of the more even distribution of R&D across the manufacturing

[8] This figure is based on examining the current to total R&D expenditures for France, Germany, Japan and the United Kingdom for the period from 1985 to 1989. The main portion of current expenditures are for labour costs. OECD, EAS Databank, April 1993.

sector in Japan, particularly in the medium-technology group which tends to be a large investor in tangible forms of investment. This is in contrast to the clumping of R&D shares in a few select industries which is what occurs in the US and the EC.

Output and Investment

147. One of the main driving forces behind conducting investment, whether it be tangible or intangible, it to generate more output (sales) with fewer inputs; thereby raising productivity and creating profits. Given this, it is expected that those industries which have a large share of investment will also contribute a large share of value added. Figure III-2 shows that for tangible investment such a relationship with value added does exist: regardless of location, the larger the share of total manufacturing investment held by an industry, the larger the share of manufacturing's value added it contributes. In the EC-6 group the relationship is almost a one-for-one exchange (slope=0.92).[9]

148. A different relationship is apparent when the focus shifts to the share of manufacturing R&D held by an industry (Figure III-3). Here the correlation is weak and not statistically significant. Only in Japan is there a strong positive trend, but even here there are many industries that hold a relatively large share of manufacturing value added but have a relatively low share of R&D. Nevertheless, the placement of the industries reveal different patterns between the three areas. The EC-6 group reflects a bifurcated distribution where there is a large gap between industries in terms of their R&D share with those that do have a large share of manufacturing R&D (greater than ten per cent) contributing anywhere from two to nine percent of manufacturing value added. In Japan, a much more evenly dispersed pattern is evident and those sectors which contribute a large share of R&D tend to contribute between six and eight percent of manufacturing value added. The United States is characterized by a high variance in the distribution of R&D shares where a few sectors hold a large share of total manufacturing R&D.

Data Availability of the Cross Variable Analyses

Cross Tabulation	EC-6	Japan	USA
IS x RDS	1986; missing 8 industries*	1987	1989; missing one industry+
VAS x IS	1986; missing 8 Industries*	1987	1989
VAS x RDS	1986; missing 8 industries*	1989	1989; missing one industry+
RCA x IS	1986; missing 8 industries*	1987	1989
RCA x RDS	1990	1990	1990; missing one industry+
XMSO x RDI	1986	1989	1989; missing one industry+

* the missing industries include industrial chemicals, petroleum refining, pharmaceuticals, rubber & plastic, non-electrical machinery, computers, electrical machinery and communication equipment.
+ the missing sector is shipbuilding.

149. Although these figures plot a static relationship between output and investment that neglects the role of lag factors, spillovers and dynamic interactions, they do suggest that investment in plant and equipment is much more directly correlated with output than investments in R&D.

Investment and Competitiveness

150. Another key reason to invest is to improve the competitiveness of an industry in international markets. A series of correlations between indicators of tangible investment (shares of total manufacturing investment and investment per employee) and "competitiveness" (export market shares across the 13 OECD countries and revealed comparative advantage) were calculated. By and large the relationship between competitiveness as measured by the two export indicators and tangible investment was weak. Figure III-4 shows the strongest relationship which existed between shares of total manufacturing investment and revealed comparative advantage. Although the slopes are positive for all three areas, indicating a positive correlation between RCA and IS, only in the EC-6 did IS explain more than ten per cent of the variance in RCA (R^2=23.9 per cent).

[9] The R^2 for the EC-6 group is 89.1 per cent, for Japan 76.9 per cent and for the United States, 83.3.

151. A much stronger relationship exists between competitiveness and R&D. As shown in Figure III-5, the share of manufacturing R&D contributed by an industry is positively correlated with its RCA in Japan and the US, while a negative correlation occurred in the EC-6. Although the correlations in both Japan and the US have nearly identical slopes, indicating a similar link between R&D share and RCA, the US correlation has a higher level of statistical significance (US R^2=71.0 per cent, Japan R^2=20.8 per cent). As Figure III-6 shows this general trend occurs even when different permutations of R&D (R&D intensity) and "competitiveness" (export market shares across the OECD-13) are used.

152. Again, although causation can not be established and the limits of a static analysis must be recognized, it is evident from the correlations which have been calculated that in terms of improving performance in international markets, intangible investment as represented by R&D has a much stronger impact, at least for the US and Japan, than tangible investment.

Figure III-1

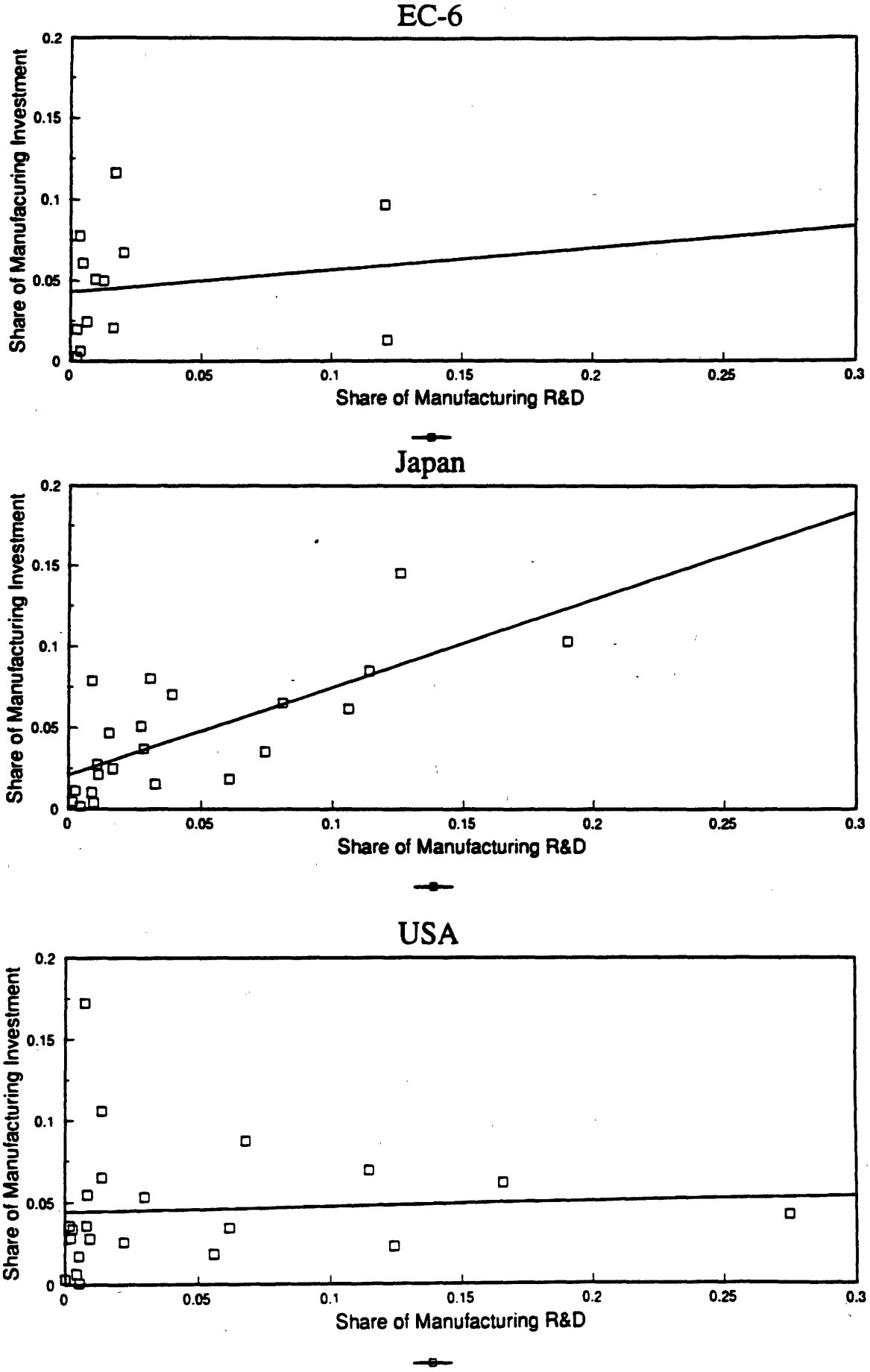
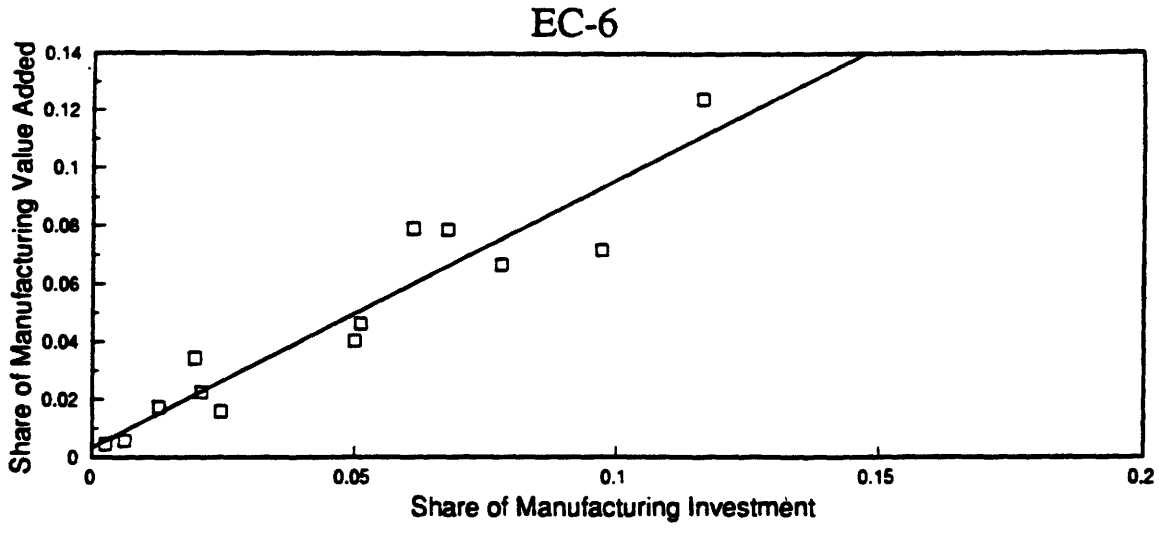
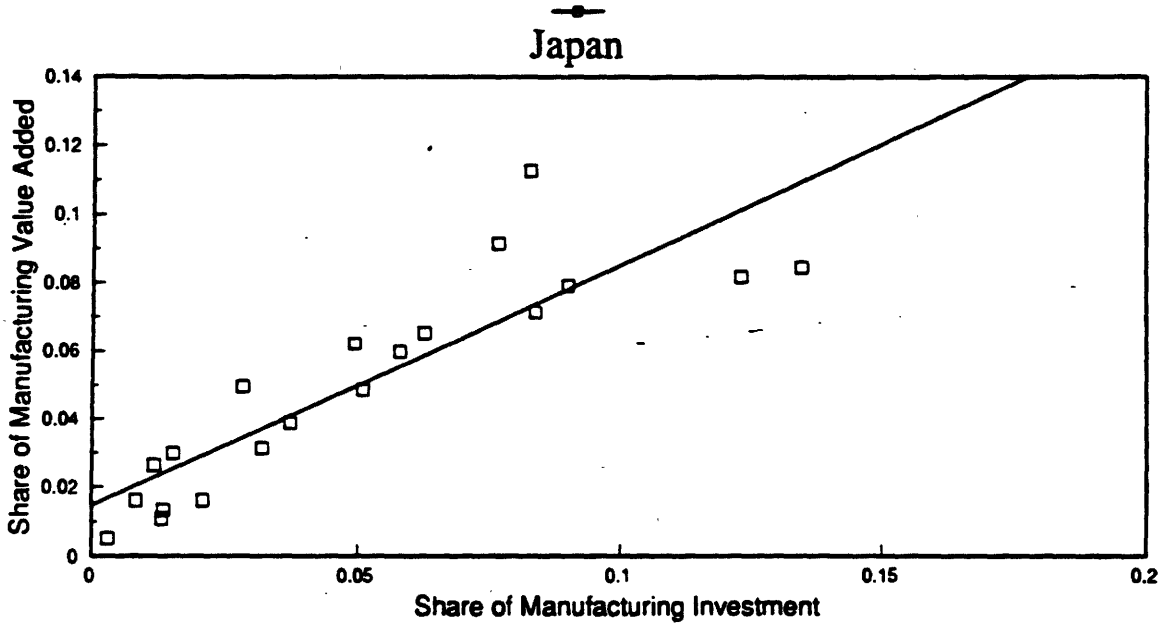

EC-6
Share of Manufacuring Investment
0.2
0.15
0.1
0.05
0
0
0.05
0.1
0.15
0.2
0.25
0.3
Share of Manufacturing R&D
Japan
Share of Manufacturing Investment
0.2
0.15
0.1
0.05
0
0
0.05
0.1
0.15
0.2
0.25
0.3
Share of Manufacturing R&D
USA
Share of Manufacturing Investment
0.2
0.15
0.1
0.05
0
0
0.05
0.1
0.15
0.2
0.25
0.3
Share of Manufacturing R&D

Figure III-2


EC-6
Share of Manufacturing Value Added
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.05
0.1
0.15
0.2
Share of Manufacturing Investment


Japan
Share of Manufacturing Value Added
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.05
0.1
0.15
0.2
Share of Manufacturing Investment

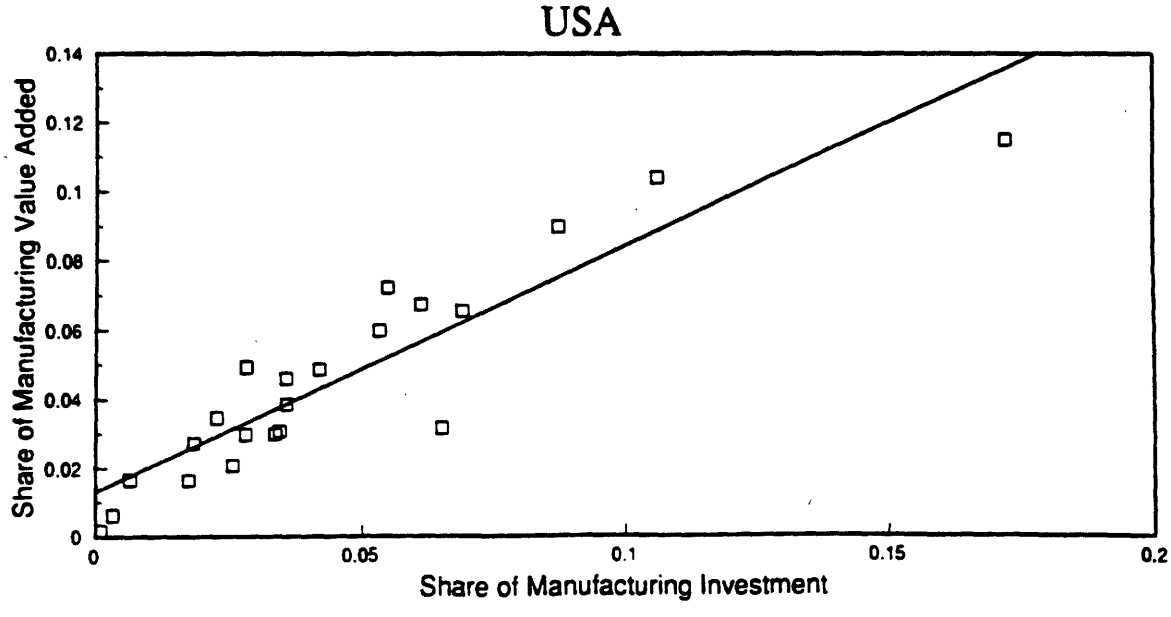
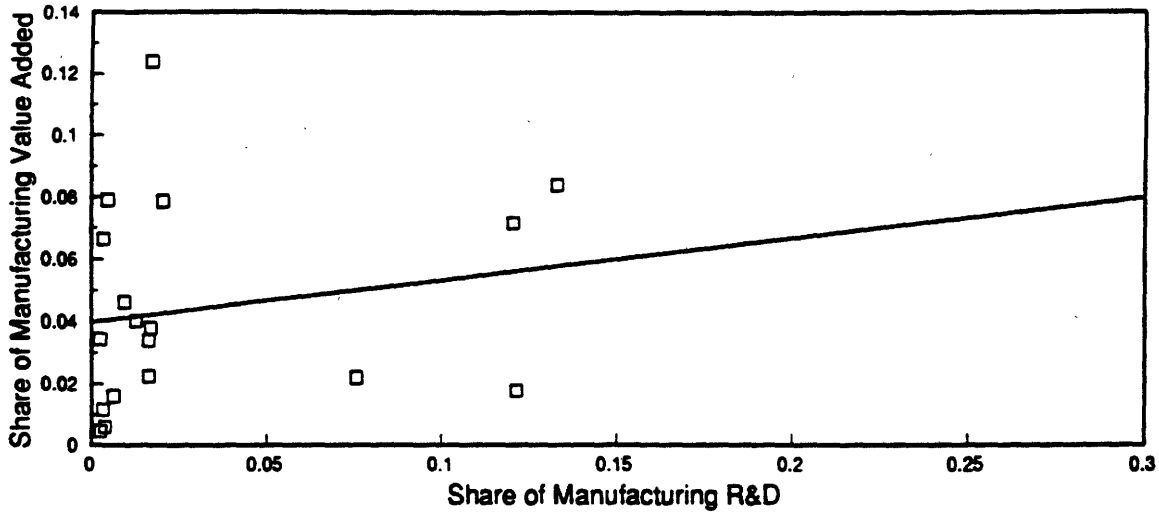
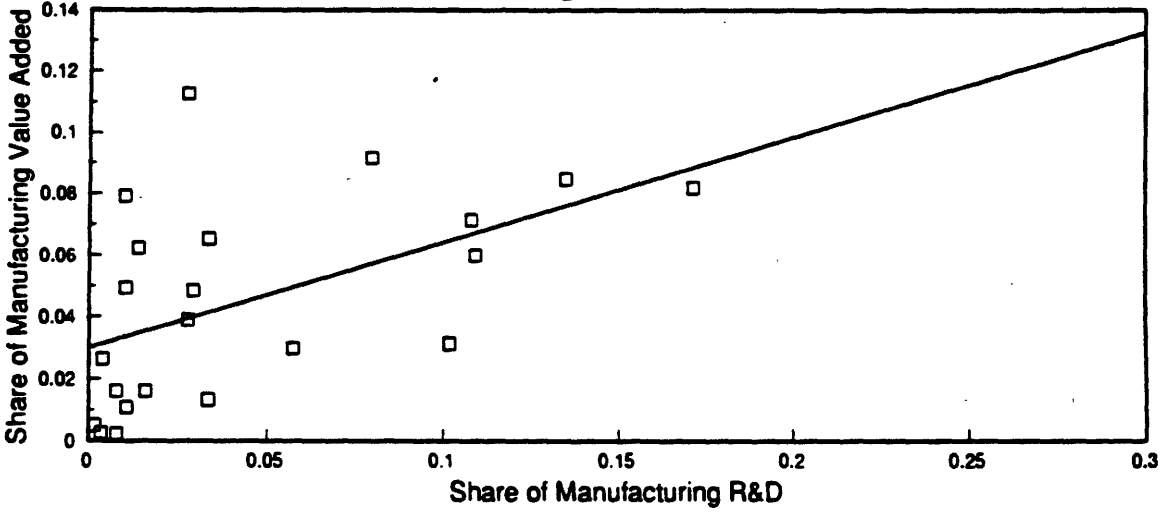

USA
Share of Manufacturing Value Added
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.05
0.1
0.15
0.2
Share of Manufacturing Investment

Figure III-3

EC-6



Japan



USA

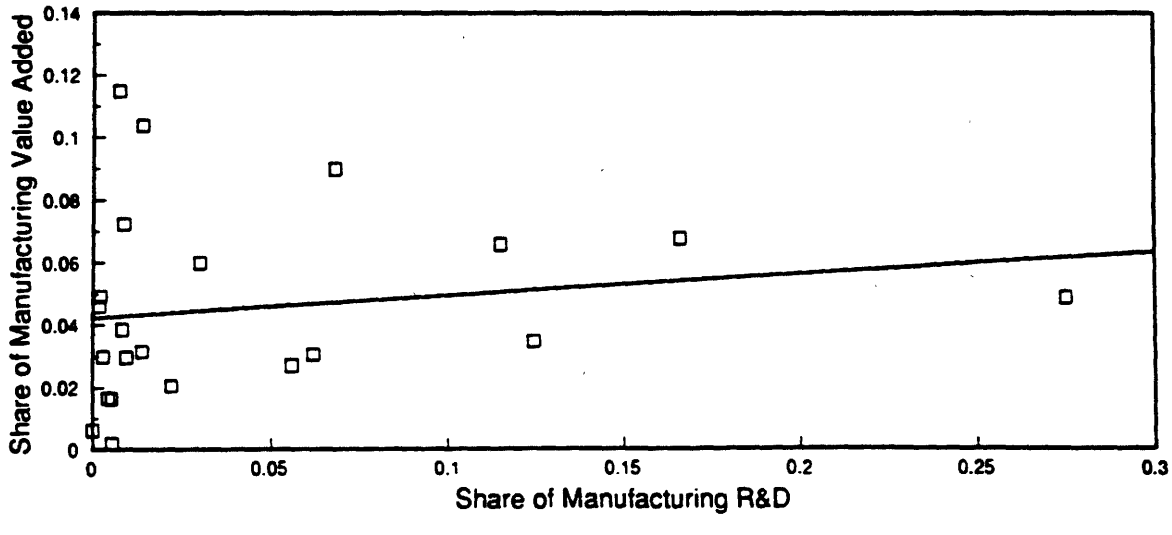
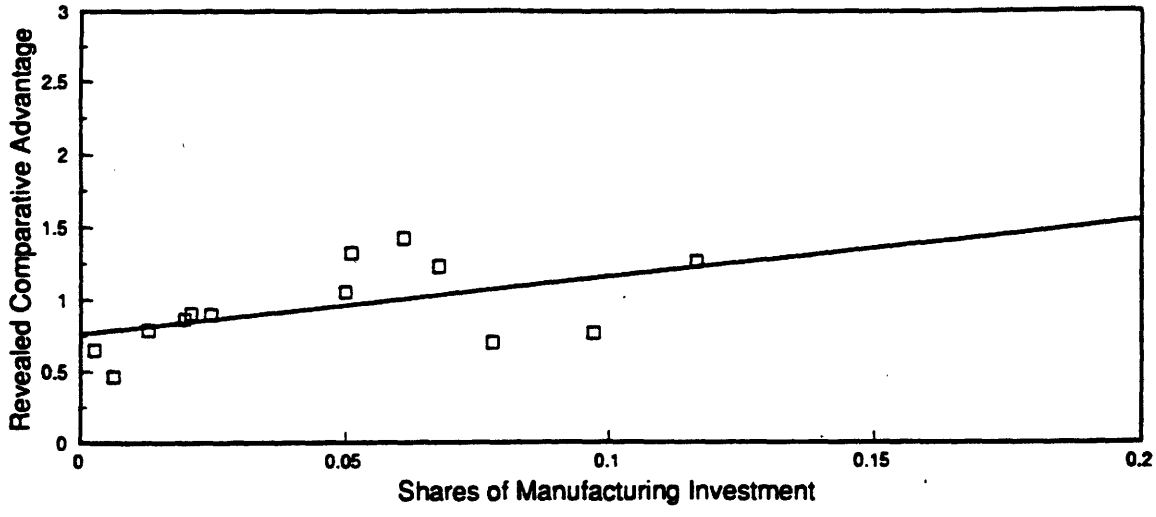
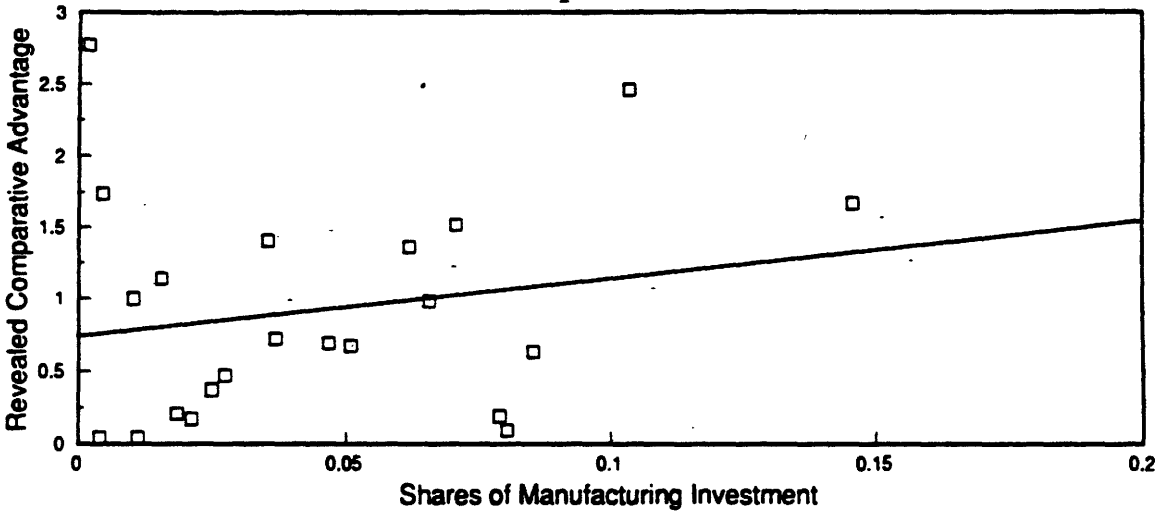


Figure III-4

EC-6



Japan



USA

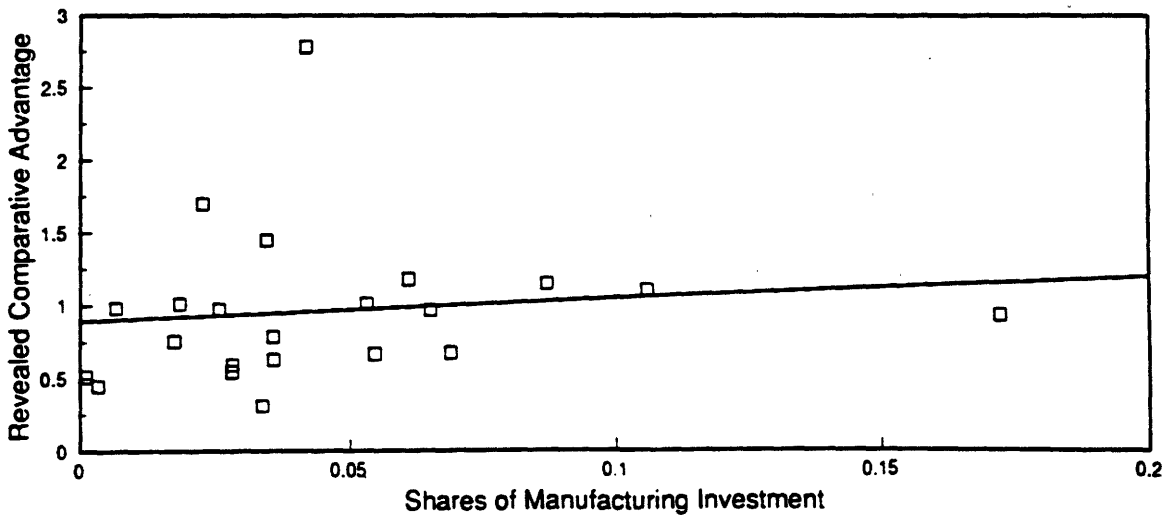


Figure III-5

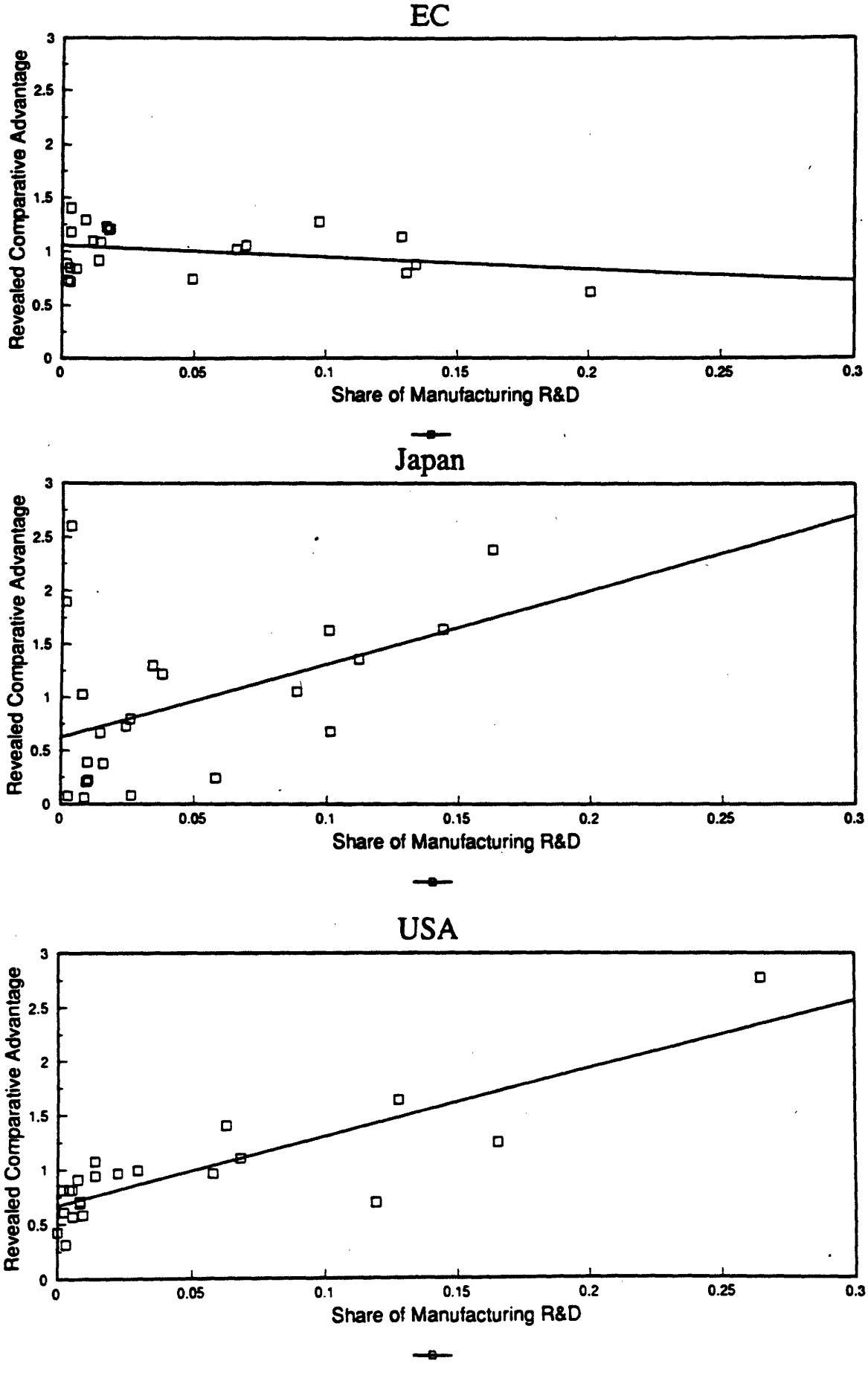
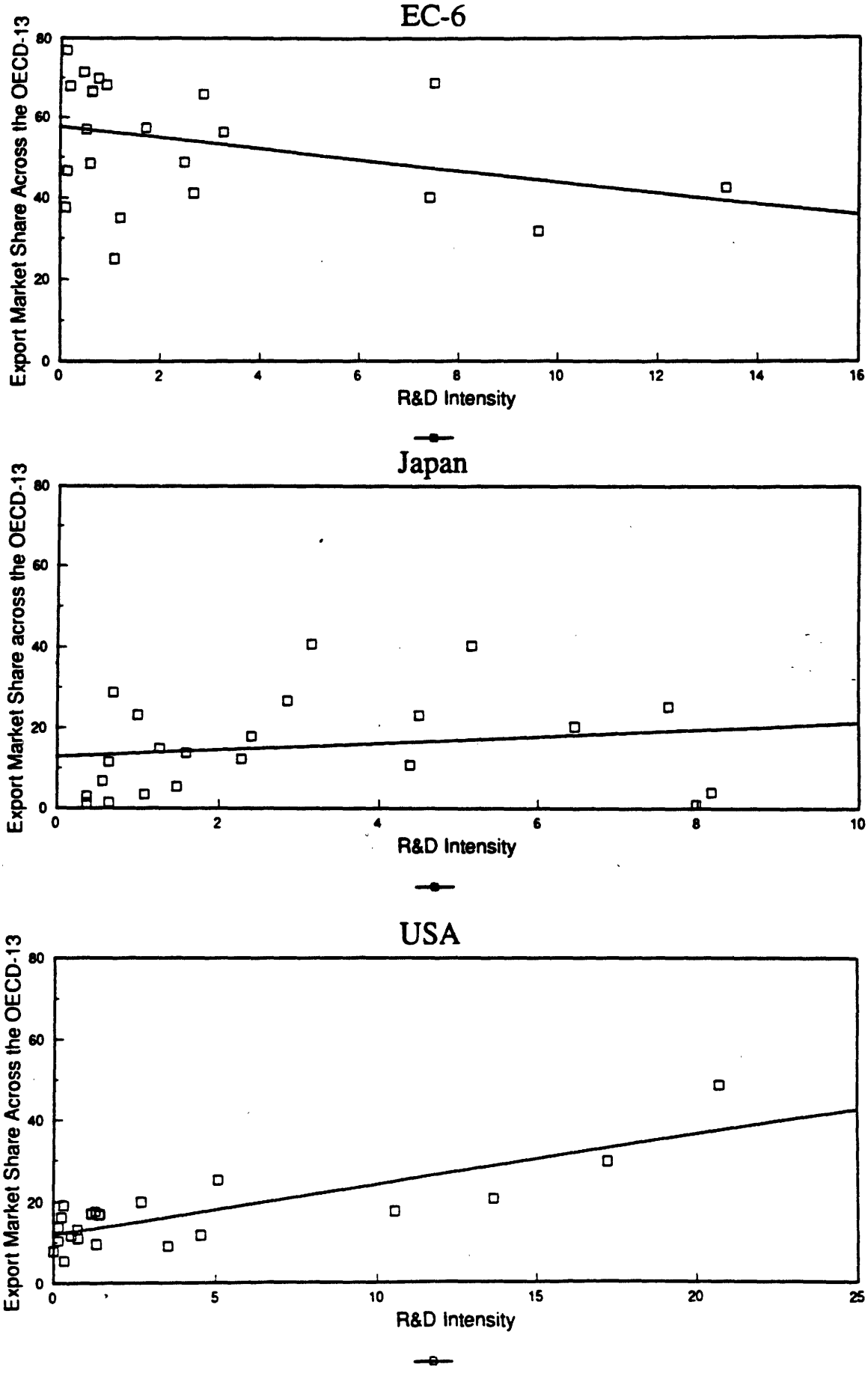

EC
Revealed Comparative Advantage
Share of Manufacturing R&D
Japan
Revealed Comparative Advantage
Share of Manufacturing R&D
USA
Revealed Comparative Advantage
Share of Manufacturing R&D

Figure III-6


EC-6
Export Market Share Across the OECD-13
R&D Intensity
Japan
Export Market Share across the OECD-13
R&D Intensity
USA
Export Market Share Across the OECD-13
R&D Intensity

III. Appendix: Industry Classification and Data Sources

Industrial Coverage

ISIC*	Industry	Commonly used Abbreviations
3100	Food, Beverages & Tobacco	Food group
3200	Textiles, Apparel & Leather	Textile group
3300	Wood Products & Furniture	Wood group
3400	Paper, Paper Products & Printing	Paper group
3500	Chemical Products	Chemical group
351+352-3522	Industrial Chemicals	Chemicals
3522	Pharmaceuticals	Pharmaceuticals
353+354	Petroleum Refineries & Products	Petroleum Refining
355+356	Rubber & Plastic products	
3600	Non-Metallic Mineral Products	
00	Basic Metal Industries	Basic Metals
371	Iron & Steel	Ferrous metals
372	Non-Ferrous Metals	
3800	Fabricated Metal Products	
381	Metal Products	
382-3825	Machinery, neć. exc. Office & Computing Machinery	
3825	Office & Computing Machinery	Computers
383-3832	Electrical Machinery exc. Radio, TV & Comm. Equip.	Electrical Machinery
3832	Radio, TV & Communication Equipment	Communications Equipment
384	Transport Equipment	
3841	Shipbuilding & Repairing	Ships
3843	Motor Vehicles	
3845	Aircraft	
3842+3844+3849	Other Transport Equipment, nec.	
385	Professional Goods	Instruments
3900	Other Manufacturing nec.	
3000	Total Manufacturing	

* International Standard Industrial Classification, Revision 2 (ISIC Rev.2)

Industry Aggregations

Technology Based Industry Groups

153. The standard OECD definition of high, medium and low-technology industries has been used in this report.[10] This definition was established in 1986 using 1980 data, and is scheduled to be updated in the very near future. Nevertheless, analysis conducted last year using different databases (STAN and ANBERD) and a different selection of countries than the 1986 work, reconfirmed the 1970 and 1980 rankings of technological sophistication based on R&D intensities and did a preliminary update for 1989. This work indicated that the ranking of the industries is relatively stable over time and would not change significantly if more recent data was used.[11]

High-technology

3522	Drugs & Medicines
383-3832	Electrical machines excluding comm. equip.
3832	Radio, TV & communication equip.
3845	Aircraft
3850	Professional goods
3825	Office & computing equipment

Medium-technology

351+352-3522	Chemicals excluding drugs
355+356	Rubber & plastic products
372	Non-ferrous metals
382-3825	Non-electrical machinery
3842+3844+3849	Other transport equipment
3843	Motor vehicles
3900	Other manufacturing

Low-technology Industries

3100	Food, beverages & tobacco
3200	Textiles, apparel & leather
3300	Wood products & printing
3400	Paper products & printing
353+354	Petroleum refineries & products
3600	Non-metallic mineral products
3710	Iron & Steel
3810	Metal products
3841	Shipbuilding & repairing

Orientation Based Industry Groups

This classification is based on one developed for the 1987 OECD study entitled Structural Adjustment and Economic Performance. The scheme was originally developed for dividing manufactured trade into groups based on the primary factors that affect the competitive process.

Resource Intensive

3400	Wood products & furniture
353+354	Petroleum refineries & products
3600	Non-metallic mineral products
3720	Non-ferrous metals

Labour Intensive

Specialised Supplier Industries

382-3825	Non-electrical machinery
383-3832	Electrical machines excluding comm. equip.
3832	Radio, TV & communication equip.

Science Based Industries

3522	Drugs & medicines
3825	Office & computing equipment
3845	Aircraft
3850	Professional goods

[10] OECD (1986), OECD Science and Technology Indicators, No. 2, Paris.
[11] OECD (1992), Industrial Policy in OECD Countries - Annual Review, Paris.

3200	Textiles, apparel & leather
3810	Metal products
3900	Other manufacturing

Scale Intensive Industries

3300	Paper products & printing
351+352-3522	Chemicals excluding drugs
355+356	Rubber & plastic products
3710	Iron & steel
3841	Shipbuilding & repairing
3842+3844+3849	Other transport equipment
3843	Motor vehicles

Wage Based Industry Groups

154. The classification of industries into high, medium and low wage groups was based on the average labour compensation (labour compensation includes not only wages and salaries but also supplementary benefits paid by the employer) across nine countries: Australia, Canada, Finland, Germany, Japan, Norway, Sweden, the United Kingdom and the United States, for the year 1985. The average was calculated in US PPPs as labour compensation per number engaged. The high wage grouping was defined as industries in which the wage was more than 15 per cent above the median wage, the medium wage grouping as industries in which the wage was within 15 per cent of the median and the low wage grouping as industries in which the wage was at least 15 per cent below the median wage. These groupings were tested for two other time periods: 1975 and 1980 and for additional country groupings, where data was available. These groupings appear to be quite stable. The only industries which move between groups over time and alternate country groupings are iron & steel and other transport equipment.

High Wage Industries

351+352-3522	Chemicals excluding drugs
3522	Drugs & medicines
353+354	Petroleum refineries and products
3825	Office and computing equipment
343	Motor vehicles
3845	Aircraft

Medium Wage Industries

3400	Paper products and printing
355+356	Rubber and plastic products
3600	Non-metallic mineral products
3710	Iron and Steel
3720	Non-ferrous metals
3810	Metal products
382-3825	Non-electrical machinery
3832	Radio, TV and communications equipment
3841	Shipbuilding and repairing
3850	Professional goods

Low Wage Industries

3100	Food, beverages and tobacco
3200	Textiles, apparel and leather
3300	Wood products and furniture
383-3832	Electrical machines excluding comm. equip.
3842+3844+3849	Other transport equipment
3900	Other manufacturing

Country Coverage

OECD-13	EC-6	G-7	Nordic-4
Australia	Denmark	Canada	Denmark
Canada	France	France	Finland
Denmark	Germany	Germany	Norway
Finland	Italy	Italy	Sweden
France	Netherlands	Japan	
Germany[12]	United Kingdom	United Kingdom	
Italy		United States	
Japan			
Netherlands			
Norway			
Sweden			
United Kingdom			
United States			

[12] The statistics for Germany in this publication refer to western Germany (The Federal Republic of Germany) before the unification of Germany.

The STructural ANalysis (STAN) Industrial Database

Introduction

155. The STAN database was created to fill the gap that exists between detailed data collected through industrial surveys and censuses, which lack international comparability, and national accounts data that is internationally comparable but only available at fairly aggregate levels. Survey-level data is inappropriate for international comparisons because it does not always adhere to international standards and definitions. For example, Italian survey values for manufacturing value added are only about two-thirds of those reported in the national accounts. This is because the Italian survey covers only those businesses with 20 or more employees.[13] The United States survey value for manufacturing value added exceeds the national accounts figure by about one-third because the US survey-level data fails to exclude some purchased services.[14] These differences severely limit the reliability of international comparisons and analyses based on survey data.

156. Through the use of an estimation technique, the OECD Secretariat has created a national accounts compatible database for 13 countries, which cover 46 manufacturing industries for six variables over 20 years from 1970 to 1990. Unlike many OECD databases which are based on submissions from Member countries, the STAN database is an estimated database, it is not composed of Member countries' official data. This is because data of this type (national accounts data at a detailed sectoral level) do not usually exist or are not available because of confidentiality restrictions. The philosophy behind the development of STAN was to create a database that reflects general trends over time and captures the relative relationships that prevail between industries. This approach was adopted in order to create an industrial database which is a useful tool in economic research and analysis such as discerning general trends, creating industrial indicators (eg. productivity, R&D intensity, export market shares), and undertaking modelling exercises at a detailed industry level. For a more detailed description of the STAN database and the estimation processes employed, see OECD (1992), The OECD STAN Database for Industrial Analysis.

Variable Coverage and Definition in the STAN Database

Production is national accounts compatible production (gross output) in current prices. "National accounts compatible" means that the data are consistent with national accounts data where available; elsewhere OECD estimates have been made.

Value added is current price national accounts compatible value added and represents the contribution of each industry to national GDP.

Gross Fixed Capital Formation is current price national accounts compatible gross fixed capital formation (land, buildings, machinery & equipment).

Number Engaged includes number of employees as well as self-employed, owner proprietors and unpaid family workers.

Number of Employees is national accounts compatible employment of employees corresponding roughly to a head count of wage and salary workers.

Labour Compensation is current price national accounts compatible labour costs which include wages as well as the costs of supplements such as employer's compulsory pension, medical payments, etc.

Export and **Import** data are not estimated through the STAN estimation process. They are obtained from OECD's Compatible Trade and Production (COMTAP) database which contains flows by ISIC Revision 2. These data have been converted from the OECD's NEXT database, using the SITC classification, to ISIC Rev.2 using a convertor developed by the OECD. This trade data has not been subjected to the same review process as the one described in the STAN publication because

[13] OECD (1992), Industrial Structure Statistics 1989/90, Paris, p.250

[14] IBID, p.269

the data was not estimated. Taking into consideration that the SITC to ISIC, Rev.2 conversion process is not exact, a country's trade data by industry may not be strictly comparable to the trade flows published in other sources. Nonetheless, this trade data has the advantage of being consistently treated across countries, enhancing its comparability.
The series for Production, Value Added, Gross Fixed Capital Formation, Number Engaged, Number of Employees, and Labour Compensation may not be identical with the standardised SNA data published in the most recent issue of OECD Annual National Accounts due to differing publication dates and deadlines for incorporating revisions and for other technical reasons.

The ANBERD Database

157. The Analytic Business Enterprise R&D (ANBERD) database contains business enterprise expenditure on R&D (BERD) performed by industry. This database contains OECD estimates and differs significantly from official data for a number of countries. It was constructed with the objective of creating a consistent data set that overcomes the problems of international comparability and time discontinuity associated with the official BERD data provided to the OECD by the member countries. It is designed to provide analysts with a comprehensive and internationally comparable data set on R&D expenditures.

158. ANBERD is based on the official BERD but involves estimates wherever:

- there are significant problems associated with the enterprise basis of the survey or with borderline institution classifications. In general, ANBERD data tend to be closer to product field data than to enterprise data. In addition, where ever possible, ANBERD estimates include adjustments to ensure that the BERD of borderline institutions and public enterprises is allocated to the relevant industries;

- there are important deviations (e.g. aircraft is included in motor vehicles) from the standard ISY BERD industrial classification;

- there are significant adjustments required for incomplete survey coverage;

- there are discontinuities or breaks in series due to change in industrial classification or survey techniques.

- there are missing data for entire years in circumstances where surveys are not conducted every year.

9. The United States and Japan, which collectively represent about two-thirds of OECD's total BERD, present two cases where official data is significantly limiting and where ANBERD estimates are necessary for the type of analysis presented in this report. The official BERD data for the United States, in the 1980s, is only available for about one-half of the manufacturing industries because of confidentiality reasons associated with federal government funding. For Japan, the official data is provided for most industries, however, this is strictly enterprise based data. There is thus a bias in the allocation of BERD across industries because of the presence of very large diversified firms whose secondary R&D activities are often misclassified. The ANBERD database uses estimation techniques and supplementary product field R&D data to complete and adjust the official data sets for both these countries.

160. The ANBERD data set for each country is constructed in close collaboration with national statistical authorities. For additional detail on what estimation techniques were used for a particular industry or country, see OECD (1992), Business Enterprise Expenditure on R&D in OECD Countries: Data at the Detailed Industry Level from 1973 to 1990, Paris.

EIMS DOCUMENTS

INNOVATION POLICY	Publication N°
An integrated Approach to European Innovation and Technology Diffusion Policy: a Maastricht Memorandum, 1993	
Public Measures supporting new technology based firms: Workshop Proceedings, 1994	7
Policies to support Tacit knowledge Transfer: Workshop Proceedings , 1993	8
Public Measures to support the Clustering and Networks of Innovative SMEs: Workshop Proceedings, 1995	16
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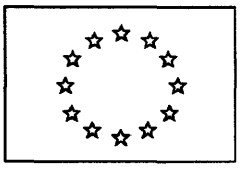

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