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R&D SUBSIDIES AND EXPORT PERFORMANCE OF MANUFACTURING INDUSTRIES

by

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May 1987

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Introduction

In a sense, the current high-tech policies look like an anachronism: In almost all industrialized countries governments face the need to cut subsidies to private enterprises in order to reduce their budget deficits. In contrast to these efforts public fundings of company research and development (R&D) are growing to unprecedented levels. The most striking example is obviously given by the United States, where the SDI-programme conflicts with the Gramm-Rudman-Hollings act. But also in Western Europe a variety of new technology programmes was launched in past years. At the national level the 4-megabit chip programme of West Germany (Siemens) and the Netherlands (Philips/Valvo) could be mentioned. This project started in 1986 and involves public subsidies of about 250 million dollars. It centrally aims at reinventing a technology that is already available from Japanese and U.S. firms. The outstanding exception from this subsidy race is Japan, where direct government support to R&D has always been of minor importance. Instead, indirect measures like tax credits and low interest loans are preferred for stimulating innovative activities of enterprises.

At the international level the discussion focusses primarily on the EUREKA initiative, which started in 1985 and which now involves more than one hundred different research projects. The biggest EUREKA project is the Eurolaser with estimated public funds of about 200 million dollars. On average, public subsidies within the EUREKA initiative amount to 50 million dollars per project. In addition, the European Community runs some technology programmes of its own, e.g. ESPRIT (1984-88; 750 million ECU), BRITE (1985-88; 150 million ECU), the biotechnology-programme (1985-89; 55 million ECU), and RACE (1986-96). Most of these programmes are predominantly devoted to applied commercial R&D. Up to now, the EC funds are rather small as compared to national funds. In 1986 total EC expenditures on science and technology amounted to less than 1 billion ECU, whereas national governments within the European Community spent about 30 billion ECU on this subject. According to a proposal of the European Commission EC funds will be raised to 7.7 billion ECU for the period from 1987 to 1991.

The general purpose of all of these R&D programmes is giving European enterprises a competitive edge in high technologies, especially on U.S. and Japanese firms. The decisive point in this context is, therefore, whether R&D subsidies appear to be adequate means of improving the competitiveness of private firms. Before entering the details it seems appropriate to give a brief survey of R&D expenditures and technology policies in major industrialized countries.

Current Trends in Innovation Policies

Figure 1 presents the development of aggregate R&D intensities in five countries. These countries are spending about 90 per cent of total R&D expenditures within the whole OECD area. With the exception of the United Kingdom the share of R&D expenditures in gross domestic product is substantially increasing since the early eighties. Due to heavy cuts in the NASA-budget in the late sixties and early seventies and as a result of a rapid catching-up of Japan and West Germany the international differences in R&D intensities diminished over time. In relative terms the United States has lost its dominant position, whereas in absolute terms the United States still spends as much on R&D as Japan and Western Europe together.

Despite the similarities in R&D intensities the five countries vary considerably in the priority given to different objectives of R&D[1]. Table 1 shows the shares of the five

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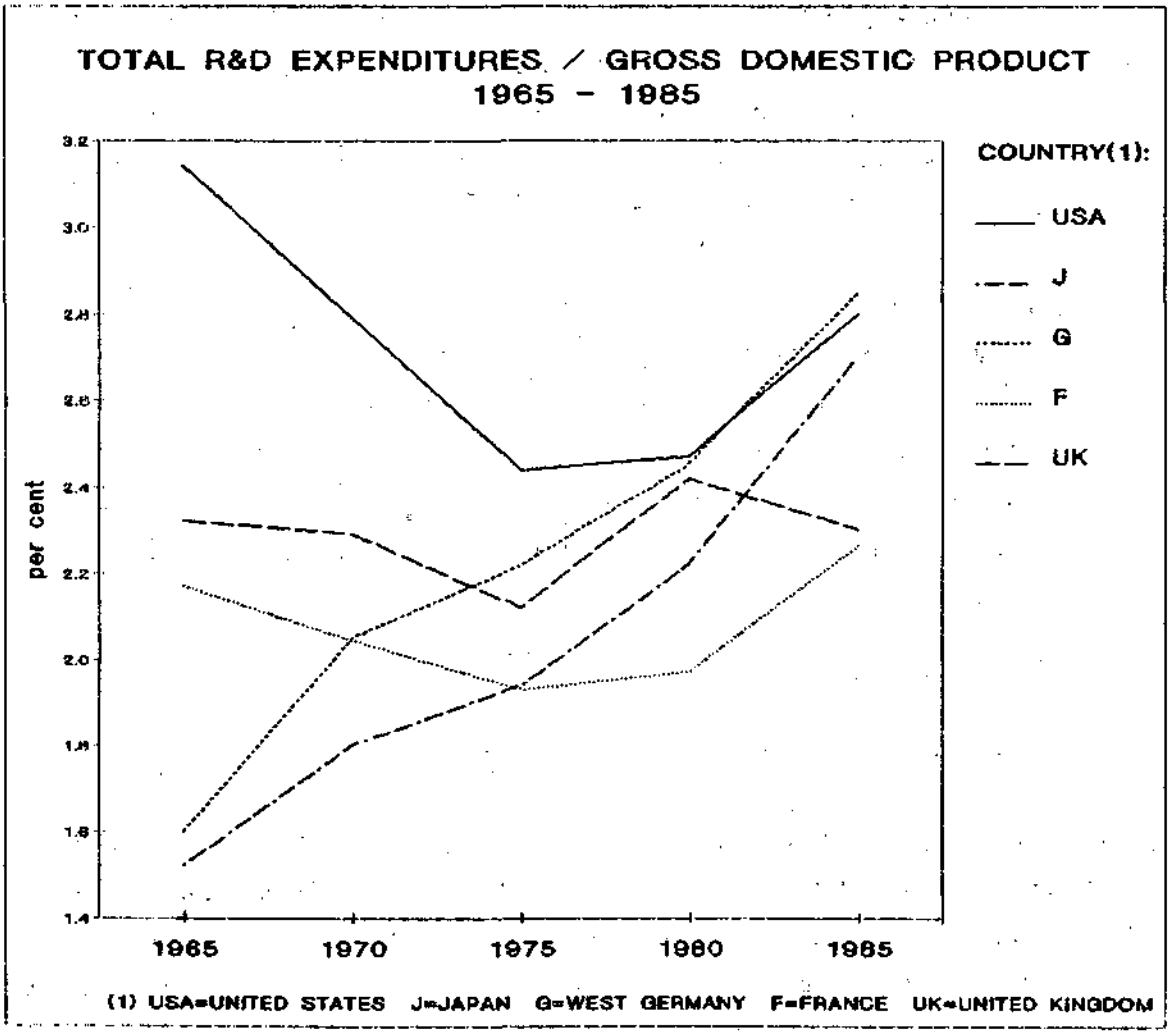
[1] Cf., e.g., OECD (1984).

Figure 1



Source: OECD; own calculations.

most important government institutions in total public R&D expenditures for each country. It reveals the predominance of military R&D in the United States, in France and in the United Kingdom. Japan and West Germany, on the other hand, concentrate their funds on civilian R&D. This table does not show, however, the extent of coordination among the different public institutions. In the United States, France, and the United Kingdom, the level of coordination among different institutions is quite low. By and large, in these countries each department is left to decide how much it needs to spend on R&D. In West Germany, in contrast, the

Table 1 - Share of the Five Largest Ministries, Departments or Agencies in Direct Government R&D Funding

		Percentage
UNITED STATES	Department of Defence	53
	National Aeronautics and Space Administration	15
	Department of Energy	12
	Department of Health and Welfare	10
	National Science Foundation	3
JAPAN	Prime Minister's Office	57
	Ministry for International Trade and Industry	17
	Ministry of Agriculture, Forestry and Fischeries	9
	Ministry of Education	8
	Ministry of Health and Welfare	4
WEST GERMANY	Federal Ministry of Research and Technology	55
	Federal Ministry of Defence	19
	Federal Ministry of Economic Affairs	10
	Federal Ministry of Education and Science	8
	Federal Ministry of Agriculture and Forestry	2
FRANCE	Ministry of Defence	38
	Ministry of Industry	26
	National Centre for Scientific Research	15
	National Centre for Telecommunication Studies	4
	Ministry of Agriculture	3
UNITED KINGDOM	Ministry of Defence	58
	Department of Education and Science	14
	Department of Trade and Industry	10
	Department of Energy	8
	Ministry of Agriculture, Fisheries and Food	4

Source: OECD; own calculations.

Federal Ministry of Research and Technology is specifically responsible for coordinating every federal R&D expenditure. The science policy of Japan, finally, is mainly characterized by the large measure of common accord achieved by numerous councils and committees at various levels. In addition, the share of subsidies and research contracts in government funds to company R&D is quite low (Table 2)[1].

Table 2 - Direct and Indirect Government Support to Company R&D in Japan (percentage)

Year	Government funds				Share of government funds in company R&D
	Total	Subsidies and research contracts	Preferential tax/ treatment	Low interest rate loans	
1965	100	18.9	81.1	-	6.5
1970	100	35.5	61.1	2.9	3.8
1975	100	46.1	51.0	2.9	3.8
1980	100	60.2	37.6	2.2	3.2
1983	100	49.9	48.4	1.7	2.6

Source: Goto, Wakasugi (1987); own calculations.

All in all, the different strategies of R&D policies in these five countries could be summarized as follows[2]: The U.S. government commits its money to R&D primarily through research contracts with private firms. There is no strict separation, therefore, of government purchases from R&D subsidies. Western Europe's governments, in contrast, are more obliged to promoting specific technologies. In many cases catching-up with U.S. and Japanese technologies is the major incentive of spending public funds. In Japan, finally, private enterprises are involved in government decisions to a large extent and direct R&D subsidies are very limited.

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[1] In the United Stataes, in contrast, the R&D tax credit is estimated to cost close to $ 1 billion a year, whereas direct government support to company R&D amounts to more than $ 20 billion (Brown, 1984).

[2] For an international comparison of high-tech policies see Klodt (1987); Nelson (1984); Pavitt, Walker (1976).

Export Performance of Research-Intensive Industries

Government inputs in technology programmes are fairly well documented. The measurement of output of these programmes is much more difficult and raises severe conceptual problems. The appropriate assessment of the technological performance of countries and firms is far from clear. The numbers of patents granted, the levels of productivity and the shares of new products in sales are some of the proposed indicators[1]. Another often used indicator is the export-import ratio in high-technology products. Such products are identified by the R&D intensity of production processes in technologically advanced countries. The first of such lists, the so-called "Kelly list", was generated by the OECD in the late sixties (OECD, 1970). For an assessment of the technological position of the five countries in consideration an updated version of Kelly's list was applied in order to calculate export-import ratios in technology-intensive goods for the year 1984[2].

The results are presented in Figure 2. Japan's exports of high-tech products are more than four times as high as its imports in this product category. The remaining four countries also show an export-import ratio above unity, but their surplus is substantially lower than the Japanese one. In addition, Figure 2 gives information on the share of direct government funds in total company R&D expenditures. Notably, the most successful netexporter of high-tech products has the lowest level of government subsidies. And West Germany ranks fourth in government funding, whereas it ranks second in export-import ratios. If any, the relationship between direct government R&D support and export-import ratios in high-technology products seems to be inverse (other things equal).

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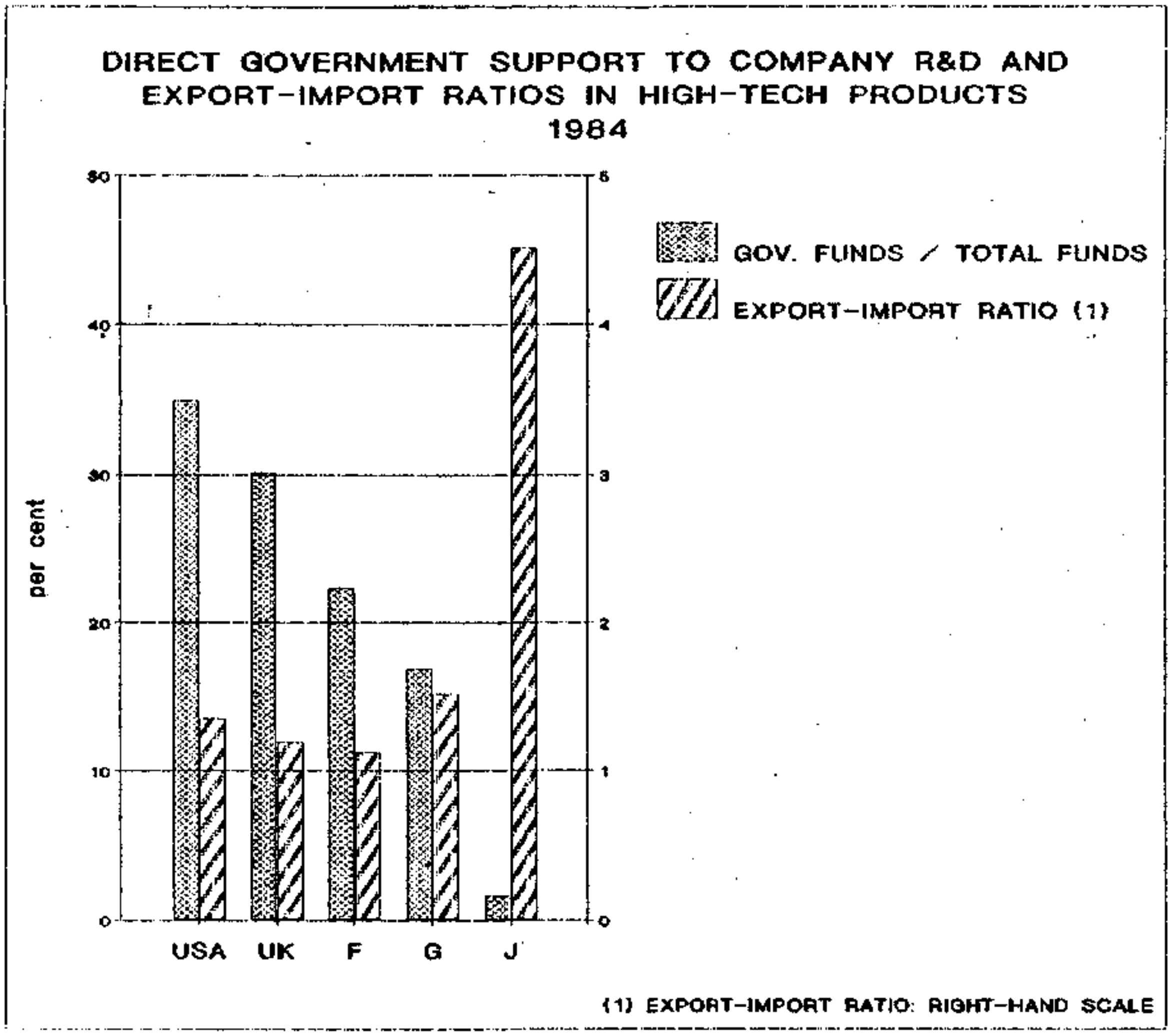
[1] Cf., e.g., Glismann, Horn (1986).

[2] This updated list is presented in Klodt (1987).

Figure 2



Source: OECD; own calculations.

One reason of the relative ineffectiveness of public support may be found in the fact that all governments are concentrating their subsidies on only a few industries. Within the usual industrial classifications there are six industries that could be called highly research-intensive: namely aerospace, electrical equipment, machinery, chemicals, instruments, and motor vehicles. On average, R&D expenditures of these branches account for 80 to 90 per cent of aggregate R&D expenditures, whereas their share in total output of manufacturing is about 50 per cent. The distribution of public funds as compared to privately financed funds is presented in Table 3. Obviously, two out of six research-intensive industries are receiving the lion's share of government funds. In the United Kingdom, e.g., the subsidies to aerospace and electrical equipment account for more than 90 per cent of total R&D subsidies, whereas the share of these industries in private funds is less than 40 per cent.

Table 3 - Distribution of R&D Funds by Industry 1983 (per cent)

Industry	United States	Japan	West Germany	France	United Kingdom	Average
			Public Funds			
Aerospace	53.7	.1	25.8	56.1	45.7	36.3
Electrical equipment	26.5	21.7	38.6	31.5	47.8	33.2
Machinery	6.0	7.9	10.0	3.9	3.5	6.3
Chemicals	2.3	11.5	8.4	5.0	.7	5.6
Instruments	3.3	.6	1.7	.8	.2	1.3
Motor verhicles	3.0	.1	1.9	1.4	.6	1.4
			Private Funds			
Aerospace	8.3	.1	1.9	10.4	10.2	6.2
Electrical equipment	20.6	29.0	18.9	24.1	26.5	23.8
Machinery	17.4	11.8	16.4	8.5	14.6	13.7
Chemicals	21.3	19.4	26.8	28.2	25.2	24.2
Instruments	9.0	3.8	1.8	1.3	2.4	3.7
Motor vehicles	11.6	14.4	18.3	14.3	7.2	13.2

Source: OECD, own calculations.

As a consequence, the governmental preference for aerospace and electrical equipment is discriminating all other research-intensive industries. This discrimination even applies to Japan, where the share of instrument and motor vehicles in public funds is less than one per cent, whereas their share in private funds amounts to 18 per cent. Moreover, the actual discrimination is partly hidden by the data given in Table 3 due to a comparatively high level of aggregation. In fact, there are only three technologies which are heavily subsidized all over the world: Aerospace, microelectronics and nuclear power plants.

In the following an attempt is made to reveal the impact of R&D subsidies on the export performance of research intensive industries. For this purpose three indexes of national specialization in exports and R&D are calculated:

$$I_x = \ln \ (x_{ij}/\sum_j x_{ij}) \ : \ (\sum_i x_{ij}/\sum_{ij}\sum x_{ij})$$

$$I_p = \ln \ (p_{ij}/\sum_j p_{ij}) \ : \ (\sum_i p_{ij}/\sum_{ij}\sum p_{ij})$$

$$I_g = \ln \ (g_{ij}/\sum_j g_{ij}) \ : \ (\sum_i g_{ij}/\sum_{ij}\sum g_{ij})$$

where x denotes exports, p and g denote private and government R&D funds, i and j denote industries and countries. The data for the six industries and five countries in consideration are presented in Tables A1 and A2 in the appendix[1]. Hence, a pooled sample of 30 observations for each index is available. An OLS regression approach on these data yields the following equation[1]:

$$I_x = \underset{(-1.70)}{-.241} + \underset{(4.53)}{.961}\ I_p - \underset{(-2.17)}{.355}I_g \qquad \bar{R}^2 = .47 \quad F = 13.94$$

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[1] The appendix presents the original values instead of the logarithmic indexes. For a list of concordance between the classifications of OECD-data on trade and on R&D see Klodt (1987).

According to these results the impact of government funds on export performance is even negative, whereas the impact of private funds is positive.

Apparently there is a high overlapping in the sectoral structure of technology policies. Imitating the strategy of the technological leader still seems to be the major guideline for governments to shape public R&D expenditures. This strategy usually aims at "picking the winners"[2]. According to the empirical evidence, however it appears not to be a very successful one. Since governments do not know the winners of tomorrow, they usually pick the winners of yesterday. As a result, public R&D subsidies give support to excess capacities in some industries and discriminate against R&D activities in other industries[3]. Perhaps the excess capacities in producing microelectronic chips and the sharp competition in passenger aeroplanes can at least partially be attributed to competing high-tech policies in these areas all over the world.

Lessons from Case Studies

By and large, this critical assessment of public R&D subsidies is supported by case studies on big science projects. In the following, a brief comment on some of the outstanding examples in this respect are presented. As a first example, the British energy policy is devoted to promoting advanced gas-cooled reactors. The first of these power plants was intended to be completed in 1970. Actually, it was commissioned in 1983 (Table 4). Moreover, despite the large amount of public funds the United Kingdom did not export any

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[1] t-values in brackets.

[2] Cf. OECD (1982).

[3] Cf. Nelson (1983); Eliasson (1984).

nuclear power plant at all since the year 1957. And in West Germany the Federal Ministry of Research and Technology has spent more than DM 3 billion on a natrium-cooled fast breeder, which initially should have been finished in 1979 and still is in the course of construction[1]. In the United States, finally, the Clinch River fast breeder project was ceased in 1983 after a twenty-year development period.

Table 4 - AGR Stations: Targets and Outcomes

	Construction begun	Commissioning date	
		Initial prediction	Actual result
Dungeness B-1	1965	1970	1983
Hinkley Point B	1967	1972	1976
Hunterston B	1968	1973	1976
Hartlepool - 1	1970	1974	1983
Heysham I-1	1970	1975	1983

Source: Henderson (1977); Jahrbuch der Atomwirtschaft (1984).

In the case of microelectronics, the above mentioned 4-megabit chip provides a good illustration of European policy strategies. This programme of the Dutch and and the West German governments subsidizes the research of Siemens and Philips-Valvo. When the programme started, Toshiba had already been successful in producing such a chip. And on the 1987 CeBit-fair in Hanover IBM presented a 4-megabit chip of its own. In March 1987, Siemens and Valvo finally arrived at producing the European 4-megabit chip. It seems to be doubtful that this project will ever become a commercial success.

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[1] Cf., e.g., Keck (1981).

In addition, the Super-Computer Project of the British government, a similar project of the French government and West Germany's Siemens computer project could be mentioned. None of them could menace the leading position of U.S. and Japanese firms in the computer market.

Aerospace is the third field of big-science failures. Perhaps the most prominent example is given by the supersonic jet Concorde. Initially, production of more than one hundred aircrafts of this type was intended to start in 1970. In fact, the first aircraft was finished in 1975. In 1978, when production was stopped, only fifteen Concordes were completed and all of them where exclusively sold to British and French airlines. To the British taxpayer the Concorde project meant a loss of about 2 billion pounds and the losses of the French government presumably are in a similar order of magnitude.

A final word on the Airbus: This project is the most cited example of a successful European technology policy. Evidently, the Airbus can be regarded as a technological success. It largely benefitted by the trends towards energy-saving engines and wide-bodied aeroplanes. The market shares of Boeing and McDonnell Douglas were reduced and Lockheed was completely driven out of the market for non-military passenger jets (Economist, 1985). Despite these impressive results, however, Airbus Industries is still unable to pay for the development and production costs of its own (Table 5). When the Airbus programme was started, government subsidies were intended to provide temporary assistance for an infant industry. Nowadays, the former infant has become a grown-up, but it still depends on public support.

This enumeration could easily be extended: The Supersonic Transport Program of the U.S. government brought about a

Table 5 - Subsidies of the West German Government to the Airbus-Programme up to 1990

Government support to ...	Billion DM
Development costs	
A 300, 310, 320	3.6
A 330/340 (estimate)	2.9
Sales promotion	
A 300, 310, 320	.8
Production costs	
A 300, 310, 320	4.2
Total	11.5

Source: Manager-Magazin (1987).

loss of one billion dollars[1], the French Caravelle could not be sold at cost, and the West German passenger jet VFW 614 was never finished. All in all, the lessons from subsidized big science projects are unequivocal - unequivocally negative.

Hence, our proposition would be that government funds should be less concentrated on big science projects. In addition, the empirical evidence suggests that indirect means should be preferred over direct support of company is R&D in order to avoid distortions of the allocation of R&D funds to the largest extent possible. Finally, it should be kept in mind that attention tends to be diverted away from commercial activities if a growing part of income comes directly from public sources.

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[1] The follower of this programme, the Aerospace Plane, is expected to be finished by the end of the next decade. According to an M.I.T. estimate the total costs of this project will amount to $ 17 billion (Korthals-Altes, 1987).

Table A1 - Specialization Index (1) of R&D Funds 1983

Industry	United States	Japan	West Germany	France	United Kingdom
			Public Funds		
Aerospace	1.479	.001	.711	1.545	1.259
Electrical equipment	.798	.654	1.163	.949	1.440
Machinery	.952	1.254	1.587	.619	.556
Chemicals	.411	2.054	1.500	.893	.125
Instruments	2.538	4.62	1.308	.615	.154
Motor vehicles	2.143	71	1.357	1.000	.429
			Private Funds		
Aerospace	2.339	.003	.306	1.677	1.645
Electrical equipment	.866	1.218	.794	1.013	1.113
Machinery	1.270	.861	1.197	.620	1.066
Chemicals	.880	.802	1.107	1.165	1.041
Instruments	2.432	1.027	.486	.351	.649
Motor vehicles	.879	1.098	1.386	1.083	.545

(1) National share in R&D funds in relation to average share in R&D funds (see page 9).

Source: Table 3.

Table A2 - Specialization Index (1) of Exports 1983

Industry	United States	Japan	West Germany	France	United Kingdom
Aerospace	2.067	.038	.576	.733	1.675
Electrical equipment	.920	1.988	.754	.670	.085
Machinery	1.161	.950	1.026	.655	1.092
Chemicals	1.024	.433	1.138	1.164	1.627
Instruments	1.398	1.480	.097	.748	1.406
Motor vehicles	.795	1.614	1.204	.832	.063

(1) National share in exports in relation to average share in exports (see page 9).

Source: OECD; own calculations.

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