INTERNATIONAL R&D TRENDS AND COMPARISONS

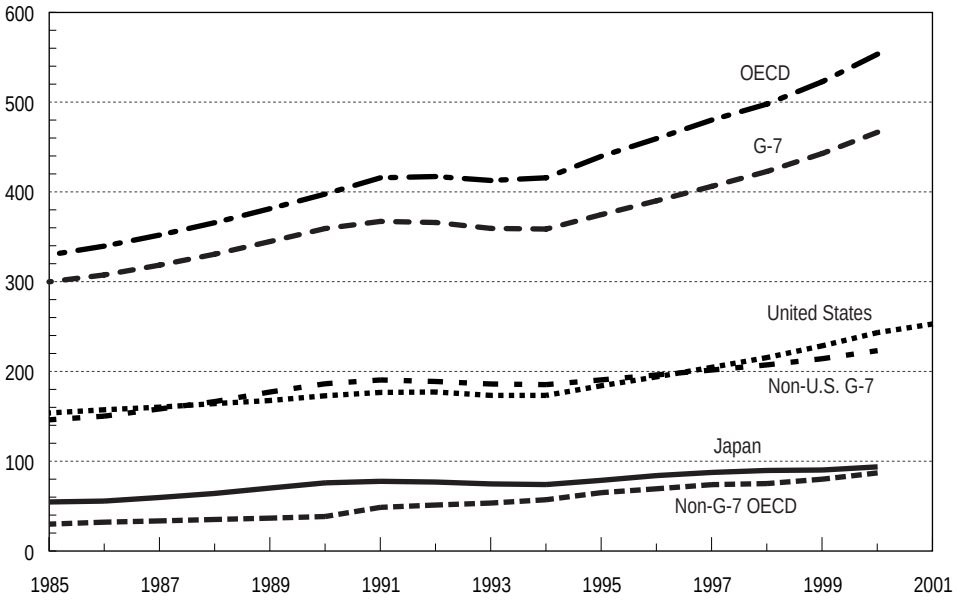
Worldwide R&D performance is concentrated in a few industrialized nations. Of the $603 billion in estimated 2000 R&D expenditures for the 30 member countries of the Organisation for Economic Co-operation and Development (OECD), fully 85 percent is expended in only 7 countries.[29] These estimates are based on reported R&D investments (for defense and civilian projects) converted to U.S. dollars with purchasing power parity (PPP) exchange rates.[30] (See sidebar, "Purchasing Power Parities: Preferred Exchange Rates for Converting International R&D Data.") R&D expenditures in the United States alone account for roughly 44 percent of all OECD member countries' combined R&D investments; R&D investments in the United States are 2.7 times greater than investments made in Japan, the second largest R&D-performing country. More money was spent on R&D activities in the United States in 2000 than in the rest of the "group of seven" (G-7) countries (Canada, France, Germany, Italy, Japan, and the United Kingdom) combined. (See figure 18 and appendix table B-18 for inflation-adjusted PPP R&D totals for OECD and G-7 countries.) South Korea is the only other country that accounted for a substantial share of the OECD total (3.1 percent in 2000, which was higher than expenditures in either Canada or Italy). In only four other countries (the Netherlands, Australia, Sweden, and Spain) did R&D expenditures exceed 1 percent of the OECD R&D total.[31]

[29]Current members of the Organisation for Economic Co-operation and Development (OECD) are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

[30]Although purchasing power parities technically are not equivalent to R&D exchange rates, they better reflect differences in countries' research costs than do market exchange rates.

[31]Data for 2000 were unavailable for Sweden, but in 1999 it accounted for 1.4 percent of the OECD total (OECD 2002a).

FIGURE 18. U.S., G-7, and Organisation for Economic Co-operation and Development countries research and development expenditures: 1985–2001



OECD Organisation for Economic Co-operation and Development
PPP purchasing power parity

NOTES: Non-U.S. G-7 countries are Canada, France, Germany, Italy, Japan, and the United Kingdom. 2001 data not available for OECD, G-7, non-U.S. G-7, Japan, and non-G-7 OECD.

SOURCE: OECD, *Main Science and Technology Indicators* (Paris, 2002).

Although non-OECD countries also fund and perform R&D, most of these national R&D efforts are comparatively small. The few reported exceptions in 2000 were China and Russia, whose R&D expenditures totaled $50.3 and $10.6 billion (PPP dollars), respectively; nondefense R&D expenditures in Israel totaled $5.6 billion (PPP dollars) (OECD 2002a).[32] Among non-OECD members of Red Iberomericana de Indicadores de Ciencia y Tecnologia (RICYT), the largest R&D expenditures are reported for Brazil ($4.6 billion in U.S. dollars at market exchange rates in 1999), Argentina ($1.3 billion in 2000), Chile ($0.4 billion in 2000), and Colombia ($0.2 billion in 2000) (RICYT 2002). The combined R&D expenditures of these seven countries (approximately $73 billion) are equivalent to about 12 percent of the OECD total, and about two-thirds of this is from China alone.

In terms of relative shares, U.S. R&D expenditures in 1984 reached historical highs of 55 percent of the G-7 total and 47 percent of the OECD total.[33] As a proportion of the G-7 total, U.S. R&D expenditures declined steadily to a low of 48 percent in 1991 and then increased to 52 percent in 2000. (See figure 18 for actual expenditure totals.) The U.S. share of total OECD expenditures for R&D has increased similarly. By 1994 the U.S. share had dropped to 42 percent of the OECD R&D total, partly the result of several countries joining OECD (thereby increasing the OECD R&D totals). The U.S. share climbed back to 44 percent of the OECD total by 2000 as a result of robust R&D growth in the United States.

Most of the increase in the U.S. percentage of total G-7 R&D expenditures after the early 1990s initially resulted from a worldwide slowing in R&D performance that was more pronounced in other countries. Although U.S. R&D spending stagnated or declined for several years in the early to mid-1990s, the reduction in real R&D spending in most of the other large R&D-performing countries was more striking. In Japan, Germany, and Italy, inflation-adjusted R&D spending fell for 3 consecutive years (1992, 1993, and 1994) at a rate exceeding the similarly falling rate in the United States.[34] In the late 1990s, R&D spending rebounded in several G-7 countries and in the United States. Because annual R&D growth was generally stronger in the United States than elsewhere, however, the U.S. percentage of total G-7 R&D spending continued to increase. Although the slowdown in the technology market in 2001 and 2002 has had a global reach, it remains to be seen whether the sharp slowdown in U.S. R&D expenditures in 2001 and 2002 will be as pronounced internationally.

International R&D/GDP Comparisons

One of the first and now one of the more widely used indicators of a country's R&D intensity is the ratio of R&D spending to GDP. Economists often use the ratio of R&D expenditures to GDP to examine R&D in the context of a nation's overall economy. This ratio reflects the intensity of R&D activity in relation to other economic activity, and it is often interpreted as a relative measure of a nation's commitment to R&D.

Since 1953, the first year for which national R&D data are available, U.S. R&D expenditures as a percentage of GDP have ranged from a minimum of 1.36 percent (in 1953) to a maximum of 2.87 percent (in 1964) (figure 20). From 1994 to 2001, R&D outpaced growth of the general economy and the R&D/GDP ratio rose to 2.72. R&D expenditures subsequently slowed in relation to GDP. It is estimated that the amount of R&D performed in the United States equaled 2.65 percent of GDP in 2002, and 2.61 percent of GDP in 2003.[35]

Most of the growth over time in the R&D/GDP ratio can be attributed to increases in non-Federal R&D spending.[36] Nonfederally financed R&D, the majority of

[32] Data for defense-related R&D expenditures are not available for Israel.

[33] OECD maintains R&D expenditure data that can be categorized into three periods: (1) 1981 to the present (data are properly annotated and of good quality); (2) 1973 to 1980 (data are probably of reasonable quality, and some metadata are available); and (3) 1963 to 1972 [data are questionable for most OECD countries (with notable exceptions of the United States and Japan), many of which launched their first serious R&D surveys in the mid-1960s]. The analyses in this report are limited to data for 1981 and subsequent years.

[34] The United Kingdom similarly experienced 3 years of declining real R&D expenditures, but its slump took place in 1995, 1996, and 1997. The falling R&D totals in Germany were partly a result of specific and intentional policies to eliminate redundant and inefficient R&D activities and to integrate the R&D efforts of the former East Germany and West Germany into a united German system.

[35] Growth in the R&D/GDP ratio does not necessarily imply increased R&D expenditures. For example, the rise in R&D/GDP from 1978 to 1985 was due as much to a slowdown in GDP growth as it was to increased spending on R&D activities.

[36] Non-Federal sources of R&D tracked by NSF include industrial firms, universities and colleges, nonprofit institutions, and state and local governments.

Purchasing Power Parities: Preferred Exchange Rates for Converting International R&D Data

Comparisons of international R&D statistics are hampered because R&D expenditures are denominated in the performing country's currency. Two approaches are commonly used to normalize the data and facilitate aggregate R&D comparisons: (1) dividing R&D by GDP, which results in indicators of relative effort according to total economic activity and circumvents the problem of currency conversion, and (2) converting all foreign-denominated expenditures to a single currency, which results in indicators of absolute effort. The first method is a straightforward calculation that permits only gross national comparisons. The second method permits abolute-level comparisons and analyses of countries' sector- and field-specific R&D investments, but it entails choosing an appropriate currency conversion series.

Market Exchange Rates and Purchasing Power Parity Rates

Because (for all practical purposes) no widely accepted R&D-specific exchange rates exist, the choice is between market exchange rates (MERs) and purchasing power parities (PPPs). These rates are the only series consistently compiled and available for a large number of countries over an extended period of time.

Market Exchange Rates. At their best, MERs represent the relative value of currencies for goods and services that are traded across borders; that is, MERs measure a currency's relative international buying power. Sizable portions of most countries' economies do not engage in international activity, however, and major fluctuations in MERs greatly reduce their statistical utility. MERs also are vulnerable to a number of distortions, including currency speculation, political events such as wars or boycotts, and official currency intervention, which have little or nothing to do with changes in the relative prices of internationally traded goods.

PPP Rates. Because of the MER shortcomings described above, the alternative currency conversion series of PPPs was developed (Ward 1985). PPPs take into account the cost differences across countries of buying a similar basket of goods and services in numerous expenditure categories, including nontradables. The PPP basket is, therefore, representative of total GDP across countries. When the PPP formula is applied to current R&D expenditures of other major performers, such as Japan and Germany, the result is a substantially different estimate of total R&D spending than that given by MERs (figure 19). For example, Japan's R&D in 1998 totaled $91 billion based on PPPs and $116 billion based on MERs, and the German R&D expenditure was $45 billion on PPPs and $50 billion on MERs. (In comparison, the U.S. R&D expenditure was $226 billion in 1998.)

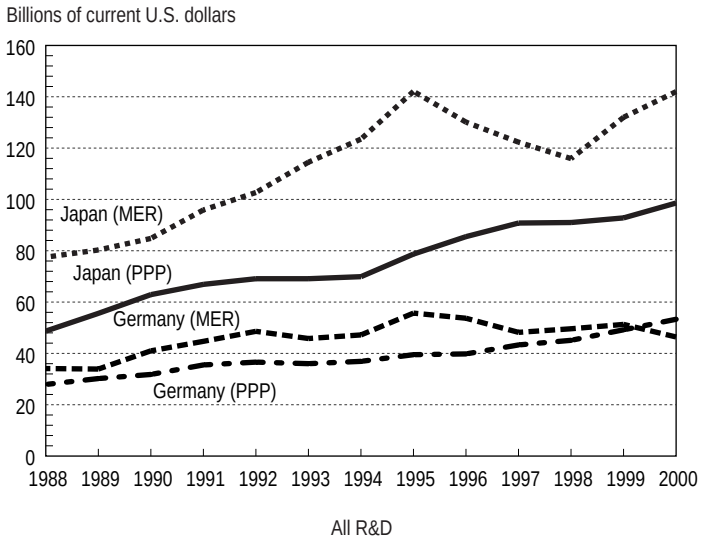
PPPs are the preferred international standard for calculating cross-country R&D comparisons wherever possible and are used in all official R&D tabulations of OECD. Unfortunately, they are not available for all countries and currencies. They are available for all OECD countries, however, and are therefore used in this report.

Exchange Rate Movement Effects

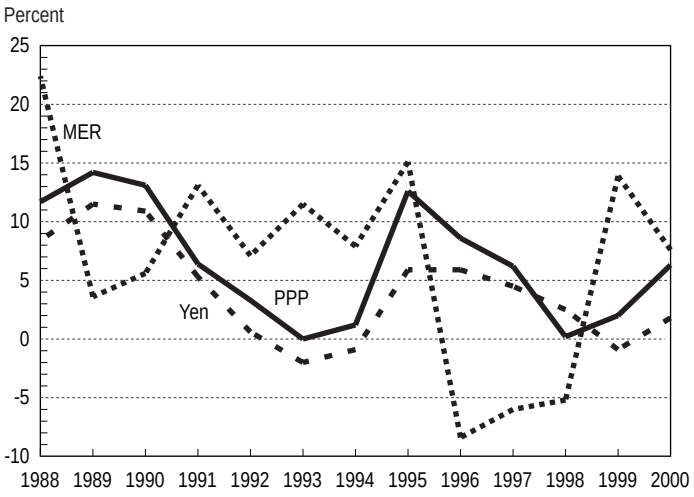
Although the goods and services included in the market basket used to calculate PPP rates differ from the major components of R&D costs—fixed assets as well as wages of scientists, engineers, and support personnel—they still result in a more suitable domestic price converter than one based on foreign trade flows. Exchange rate movements bear little relationship to changes in the cost of domestically performed R&D (figure 19). When annual changes in Japan's and Germany's R&D expenditures are converted to U.S. dollars with PPPs, they move in tandem with such funding denominated in their home currencies. Changes in dollar-denominated R&D expenditures converted with MERs exhibit wild fluctuations that are unrelated to the R&D purchasing power of those investments. MER calculations indicate that, between 1988 and 2000, German and Japanese R&D expenditures each increased twice by 15 percent or more. In reality, nominal R&D growth was only a fourth to a third of those rates in either country during this period. PPP conversions generally mirror the R&D changes denominated in these countries' home currencies.

Purchasing Power Parities: Preferred Exchange Rates for Converting International R&D Data (Continued)

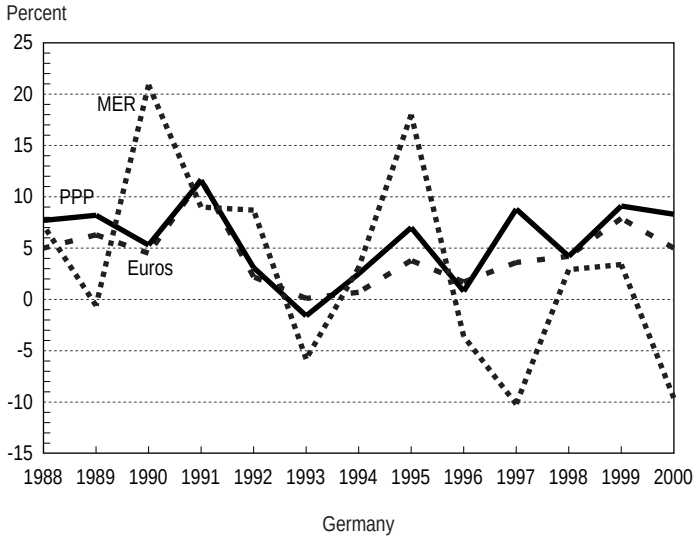
FIGURE 19. Research and development expenditures and annual changes in research and development estimates for Japan and Germany: 1988–2000



All R&D



Japan

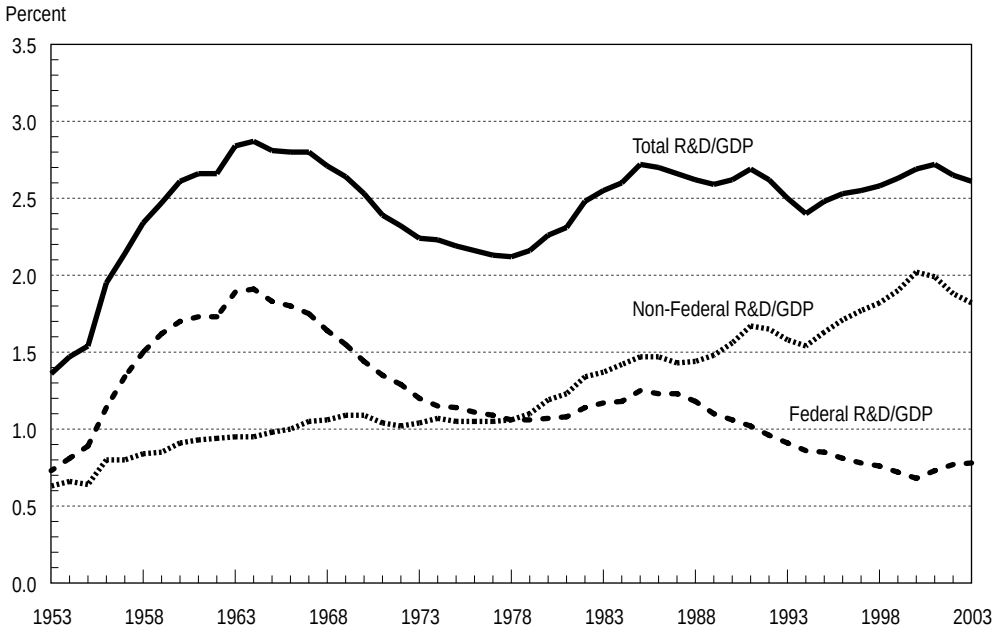


Germany

MER market exchange rate
PPP purchasing power parity
R&D research and development

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (Paris, 2002).

FIGURE 20. Research and development share of U.S. gross domestic product: 1953 2003



GDP gross domestic product
R&D research and development

SOURCE: National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources*, annual series. See appendix table B-9.

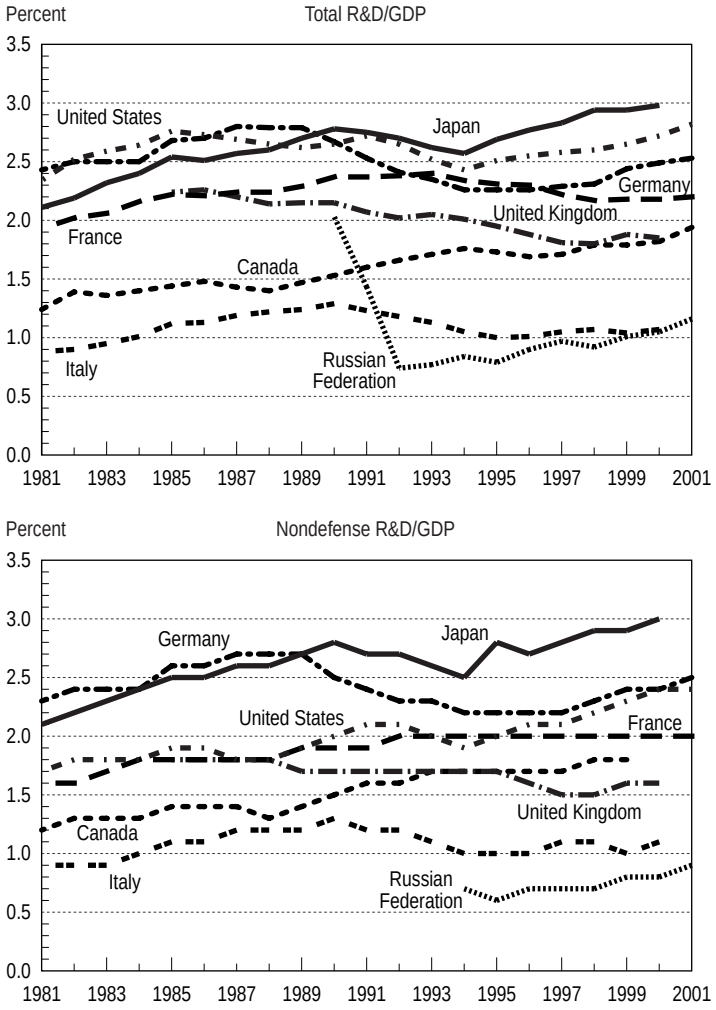
which is company financed, increased from 0.63 percent of GDP in 1953 to a projected 1.82 percent of GDP in 2003 (down from a high of 2.02 percent of GDP in 2000). The increase in nonfederally financed R&D as a percentage of GDP illustrated in figure 20 corresponds to an upward trend in R&D and technology intensive activities in the U.S. economy.

Historically, most of the peaks and valleys in the R&D/GDP ratio can be attributed to changing priorities in Federal R&D spending. The initial drop in the R&D/GDP ratio from its peak in 1964 largely reflects Federal cutbacks in defense and space R&D programs. Gains in energy R&D activities between 1975 and 1979 resulted in a relative stabilization of the ratio. Beginning in the late 1980s, cuts in defense-related R&D kept Federal R&D spending from keeping pace with GDP growth, whereas growth in non-Federal sources of R&D spending generally kept pace with or exceeded GDP growth.

For many of the G-8 countries (that is, the G-7 countries plus Russia), the latest R&D/GDP ratio is no higher now than it was at the start of the 1990s, which ushered in a period of slow growth or decline in their overall R&D efforts (figure 21).[37] The United States and Japan reached 2.7 and 2.8 percent, respectively, in 1990–91. As a result of reduced or level spending by industry and government in both countries, the R&D/GDP ratios declined several tenths of a percentage point, to 2.4 and 2.6, respectively, in 1994 before rising again to 2.7 and 3.0 percent in 2000. Growth in industrial R&D accounted for much of the recovery in each of these countries. However, the steady increase in Japan's R&D/GDP ratio in 1994–2000 is also partially a result of anemic economic conditions overall: GDP fell in both 1998 and 1999 with only a marginal increase in 2000, so that even level R&D spending would have resulted in a slight increase in its R&D ratio.

[37]A country's R&D spending and therefore its R&D/GDP ratio is a function of several factors in addition to its commitment to supporting the R&D enterprise. Especially because the majority of R&D is performed by industry in each of these countries, the structure of industrial activity can be a major determinant of a country's R&D/GDP ratio. For example, economies with high concentrations in manufacturing (which traditionally have been more R&D intensive than nonmanufacturing or agricultural economies) have different patterns of R&D spending. See "Industrial Sector" for further discussion of such considerations.

FIGURE 21. Research and development share of gross domestic product for G-8 countries: 1981–2001



G-8 group of 8 countries
GDP gross domestic product
R&D research and development

NOTES: Total R&D/GDP data not available for Japan (2001), United Kingdom (2001), and Italy (2001). Nondefense R&D/GDP data not available for Japan (2001), United Kingdom (1982, 1984, and 2001), Italy (2001), and Canada (2000 and 2001).

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators,* 2002. See appendix tables B-18 and B-19.

Among the remaining six G-8 countries, three (Germany, Canada, and Russia) display recent increases in their economy's R&D/GDP ratio, and three (the United Kingdom, France, and Italy) report an R&D/GDP ratio that has remained stable or has declined. In Germany the R&D/GDP ratio fell from 2.8 percent at the end of the 1980s, before reunification, to 2.3 percent in 1994 before rising to 2.5 percent in 2001. Canada's R&D/GDP ratio also rose in the late 1990s from 1.7 percent in 1996 to 1.9 percent in 2001. The end of the cold war and collapse of the Soviet Union had a drastic effect on Russia's R&D intensity. R&D spending in Russia was estimated at 2.0 percent of GDP in 1990; that figure plummeted to 1.4 percent in 1991 and then tumbled further to 0.7 percent in 1992. Moreover, the severity of this R&D decline is masked somewhat: although the R&D share was falling, it also was a declining share of a declining GDP. By 1999 the R&D/GDP ratio in Russia had inched back to about 1.0 percent; it accelerated to 1.2 percent in 2001 as R&D performance in the country grew by more than 30 percent in real terms over those 2 years. In comparison, the R&D/GDP ratio slipped slightly in the United Kingdom in the late 1990s to 1.9 percent in 2000. Between 1997 and 2001, the R&D/GDP ratio fluctuated narrowly around 2.2 and 1.1 percent in France and Italy, respectively.

Overall, the United States ranked fifth among OECD countries in terms of reported R&D/GDP ratios (table 14). Israel (not an OECD member country), devoting 4.4 percent of its GDP to R&D, led all countries, followed by Sweden (3.8 percent), Finland (3.4 percent), Japan (3.0 percent), and Iceland (2.9 percent). Nations in Southern and Eastern Europe tend to have R&D/GDP ratios below 1.5 percent, whereas Nordic nations and those in Western Europe generally report R&D spending shares greater than 1.5 percent.

In practically all OECD countries, the business sector finances most of the R&D. However, OECD countries with relatively low R&D/GDP ratios tend to be relatively low-income countries, where government funding generally provides a larger proportion of the R&D support than it provides in countries with high R&D/

TABLE 14. Research and development share of gross domestic product, by country/economy

Country/economy	Percent	Country/economy	Percent
Total OECD (2000)	2.24	Italy (2000)	1.07
European Union (2000)	1.88	New Zealand (1999)	1.03
Israel (2001)	4.43	China (2000)	1.00
Sweden (1999)	3.78	Spain (2001)	0.97
Finland (2000)	3.37	Brazil (1999)	0.87
Japan (2000)	2.98	Cuba (2000)	0.82
Iceland (2001)	2.90	Hungary (2000)	0.80
United States (2001)	2.71	Portugal (1999)	0.76
Korea (2000)	2.65	Greece (1999)	0.67
Switzerland (2000)	2.64	Poland (2001)	0.67
Germany (2001)	2.53	Slovak Republic (2001)	0.65
France (2001)	2.20	Turkey (2000)	0.64
Singapore (2001)	2.11	Chile (2000)	0.54
Denmark (1999)	2.09	Mexico (1999)	0.43
Chinese Taipei (2000)	2.05	Argentina (2001)	0.42
Netherlands (2000)	1.97	Romania (2001)	0.40
Belgium (1999)	1.96	Panama (1999)	0.35
Canada (2001)	1.94	Bolivia (2000)	0.28
Austria (2001)	1.91	Costa Rica (1998)	0.27
United Kingdom (2000)	1.85	Uruguay (1999)	0.26
Australia (2000)	1.53	Colombia (2000)	0.24
Slovenia (2000)	1.52	Trinidad and Tobago (1997)	0.14
Norway (2001)	1.46	Nicaragua (1997)	0.13
Czech Republic (2001)	1.31	Ecuador (1998)	0.08
Ireland (1999)	1.21	El Salvador (1998)	0.08
Russian Federation (2001)	1.16	Peru (1999)	0.08

OECD Organisation for Economic Co-operation and Development

NOTES: Civilian research and development only for Israel and Taiwan. Year of data is shown in parentheses.

SOURCES: OECD, Main Science and Technology Indicators database, 2002; and Iberomerican Network of Science and Technology Indicators, *Principales Indicadores de Ciencia y Tecnologia Argentina 2001 (Buenos Aires, 2002).*

GDP ratios. Furthermore, the private sector in low-income countries often has a low concentration of high-technology industries, resulting in low overall R&D spending and therefore low R&D/GDP ratios. Indeed, a strong link exists between countries with high incomes that emphasize the production of high-technology goods and services and those that invest heavily in R&D activities. This highlights that R&D/GDP ratios are most useful when comparing countries with national S&T systems of comparable maturity and development.

Outside the European region, R&D spending has intensified considerably since the early 1990s. Several Asian countries, most notably South Korea and China, have been particularly aggressive in expanding their support for R&D and S&T-based development. In Latin America and the Pacific region, other non-OECD countries also have attempted to increase R&D investments substantially during the past several years. Even with recent gains, however, most non-European (non-OECD) countries invest a smaller share of their economic output in R&D than do OECD members (with the exception of Israel). All Latin American countries for which such data are available report R&D/GDP ratios below 1 percent (table 14). This distribution is consistent with broader indicators of economic growth and wealth. However, many of these countries also report additional S&T-related expenditures on human resources training and S&T infrastructure development that are not captured in R&D or R&D/GDP data (RICYT 2002).

Nondefense R&D Expenditures and R&D/GDP Ratios

Although the R&D intensities of many countries have changed little over the past decade, there have been significant changes in the composition of their R&D. One indicator of these changes is the relative increase in nondefense R&D. Although defense-related R&D does result in spillovers that produce social benefits, nondefense R&D is more directly oriented toward national scientific progress, standard-of-living improvements, economic competitiveness, and commercialization of research results. Indeed, conclusions about a country's relative standing may differ dramatically, depending on whether total R&D expenditures include or exclude defense-related expenditures; for some countries, the relative emphasis has shifted over time. Among G-8 countries, the inclusion of defense-related R&D has had little impact on R&D totals for Japan, Germany, Italy, and Canada, where defense-related R&D represents 5 percent or less of the national total. In other countries, defense has accounted for a more significant proportion of the national R&D effort, although this proportion has generally declined since the end of the cold war. Between 1988 and 2000, the defense share of the R&D total fell from 31 to 14 percent in the United States and fell from 19 to 8 percent in France. In the United Kingdom the defense share of R&D decreased marginally from 16 to 15 percent. Data over this entire period are not available for Russia, but in 2000 defense-related R&D accounted for an estimated 24 percent of total Russian R&D.

If current trends persist, the distinction between defense and nondefense R&D expenditures in international comparisons may become less important. In absolute dollar terms, nondefense R&D spending is still considerably larger in the United States than in other countries. In 2000 (the latest year for which comparable international R&D data are available for most OECD countries), U.S. nondefense R&D was more than twice that of Japan's and was close to the non-U.S. G-7 countries' combined nondefense R&D total (appendix table B-19).

In terms of R&D/GDP ratios, the relative position of the United States is somewhat less favorable when only nondefense R&D is included in the metric. Japan's nondefense R&D/GDP ratio (3.0 percent) exceeded the U.S. ratio (2.4 percent) in 2000, as it has for years (figure 21 and appendix table B-19). In 2001, Germany's nondefense R&D/GDP ratio (2.5 percent) slightly exceeded the U.S. ratio (2.4 percent). The 2001 nondefense ratio for France (2.0 percent) was below the U.S. ratio. In 1999–2000, ratios for the United Kingdom (1.6 percent in 2000), Canada (1.8 percent in 1999), and Italy (1.1 percent in 2000) were considerably lower than U.S. ratios. In 2001, the nondefense R&D/GDP ratio for Russia (0.9 percent) was less than half the U.S. ratio.

International R&D by Performer and Source of Funds

R&D performance patterns by sector are broadly similar across countries, but national sources of support differ considerably. In nearly all OECD countries, government has provided a declining share of all R&D funding during the past 2 decades, and the industrial share of R&D funding has increased considerably. The emphases of industrial R&D efforts, however, differ

across countries, as do governmental R&D priorities and academic S&E field research emphases, as described subsequently in this report.

Government and industry together account for roughly 80 percent or more of the R&D funding in each of the G-8 countries, although the respective contributions vary substantially across countries.[38] In recent years, the industrial sector provided 72 percent of R&D funds in Japan, 68 percent in the United States, 66 percent in Germany, 53 percent in France, 49 percent in the United Kingdom, and 42 percent in Canada[39] (figure 22). In Russia, industry provided approximately 34 percent of the nation's R&D funding. Government provided the largest share of Russia's R&D (57 percent), as it did in Italy in past years (more than 50 percent in 1999). In the remaining six countries, government was the second largest source of R&D funding, ranging from 20 percent (in Japan) to 39 percent (in France) of the total. In each of these eight countries, government provided the largest share of the funds used for academic R&D performance (appendix table B-20).

The industrial sector dominates R&D performance in each of the G-8 countries as well as in South Korea (figure 22). Industry's share of R&D performance for the 2000–2001 period ranged from 50 percent in Italy to more than 70 percent in the United States, Japan, Germany, Russia, and South Korea. During the same period, industry's share was between 57 and 66 percent in Canada, France, and the United Kingdom. Most of the industrial R&D in these countries was funded by industry. Government's share of funding for industrial R&D ranged from as little as 2 percent in Japan and Canada to 49 percent in Russia (appendix table B-20). In the other G-8 countries, government funded between 7 and 11 percent of industrial R&D.

Academic Sector

In many OECD countries, the academic sector is a distant second to industry in terms of national R&D performance. Among G-8 countries, universities accounted for as little as 5 percent of Russia's R&D total to more than 31 percent of Italy's.[40] For most of these countries, the government is now, and historically has been, the largest source of academic research funding. However, in each of the G-8 countries for which historical data exist (except Russia), the government's share has declined during the past 20 years, and industry's share has increased. Specifically, the government's share, including both direct government support for academic R&D and the R&D component of block grants to universities, has fallen by 8 percentage points or more in five of the G-7 countries since 1981 (except in France and Italy, where the government's share of academic R&D dipped by 6 and 2 percentage points, respectively).[41] In comparison, and as an indication of an overall pattern of increased university-firm interactions (often intended to promote the commercialization of university research), the proportion of academic R&D funded by industry for these seven countries combined climbed from 2.6 percent of the academic R&D total in 1981 to 5.2 percent in 1990 and to 6.0 percent in 1999. In Germany, more than 11 percent of university research was funded by industry in 2000 (table 15).

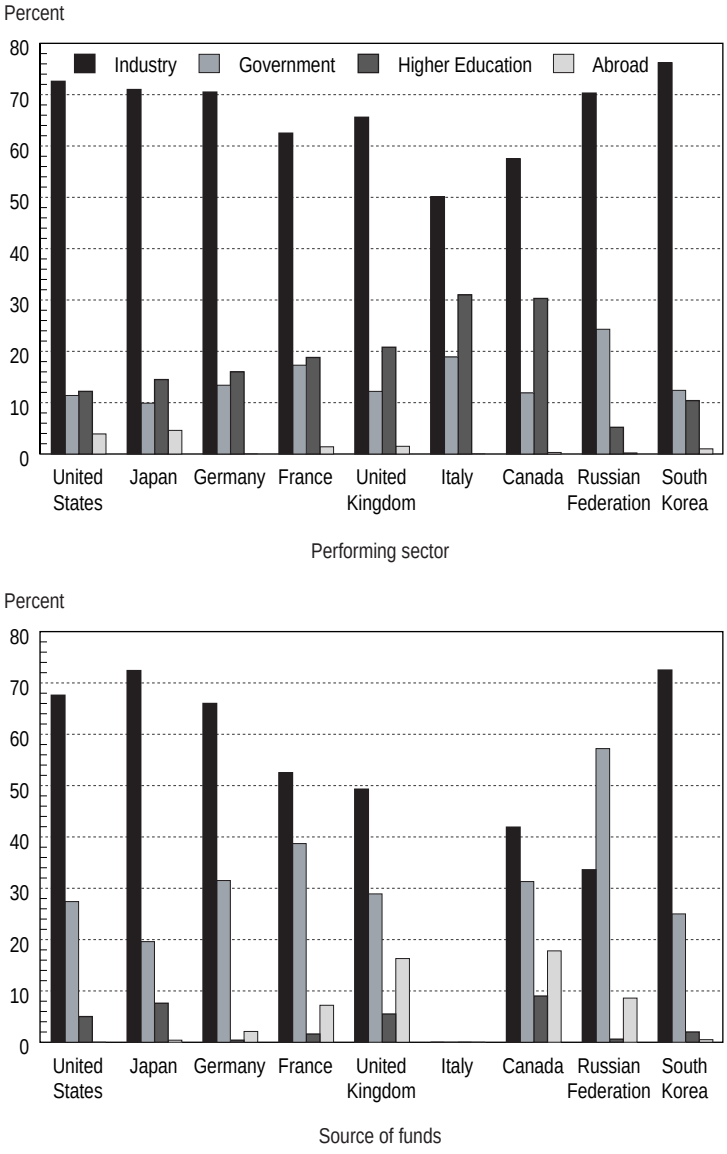
[38]In accordance with international standards, the following sectors are recognized sources of funding: all levels of government combined, business enterprises, higher education, private nonprofit organizations, and funds from abroad. Because data on foreign sources of R&D funding are unavailable for the United States, the figures reported for the share of industrial R&D funding in the United States includes funding from both foreign and domestic sources.

[39]Canada and the United Kingdom both report relatively large amounts of R&D funding from abroad, much of which originates from business enterprises. Therefore, industry's shares of R&D funding for these countries are particularly understated compared with that for the United States. Distribution of R&D by source of funds was not available for Italy for 2000. In earlier years, government sources accounted for more than half of Italy's R&D, industry accounted for more than 40 percent, and foreign sources funded the remainder.

[40]Country data are for 2000 or 2001 (appendix table B-20).

[41]Whereas general university funds (GUF) block grants are reported separately for Japan, Canada, and European countries, the United States does not have an equivalent GUF category. In the United States, funds to the university sector are distributed to address the objectives of the Federal agencies that provide the R&D funds. Nor is GUF equivalent to basic research. The treatment of GUF is one of the major areas of difficulty in making international R&D comparisons. In many countries, governments support academic research primarily through large block grants that are used at the discretion of each individual higher education institution to cover administrative, teaching, and research costs. Only the R&D component of GUF is included in national R&D statistics, but problems arise in identifying the amount of the R&D component and the objective of the research. Government GUF support is in addition to support provided in the form of earmarked, directed, or project-specific grants and contracts (funds for which specific socioeconomic categories can be assigned). In the United States, the Federal Government (although not necessarily state governments) is much more directly involved in choosing which academic research projects are supported than are national governments in Europe and elsewhere. In each of the European "group of seven" (G-7) countries, GUF accounts for 50 percent or more of total government R&D to universities and for roughly 45 percent of the Canadian government academic R&D support. Thus, these data indicate not only relative international funding priorities but also funding mechanisms and philosophies regarding the best methods for financing research.

FIGURE 22. Research and development expenditures for selected countries, by performing sector and source of funds: 2000 or 2001



NOTES: Separate data on foreign sources of research and development (R&D) funding are unavailable for the United States but are included in sector totals. In most other countries, "foreign sources of funding" is a distinct and separate funding category. For some countries (such as Canada), foreign firms are the source of a large amount of foreign R&D funding, which is reported as funding from abroad. In the United States, industrial R&D funding from foreign firms is reported as industry. Data for Japan, France, United Kingdom, and Italy are for 2000. Data for the United States, Germany, Canada, Russian Federation, and South Korea are for 2001. Recent data by source of funds were unavailable for Italy.

SOURCES: Organisation for Economic Co-operation and Development, unpublished tabulations, 2003; and National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources,* annual series. See appendix table B-20.

TABLE 15. Academic research and development expenditures, by country and source of funds: 1981, 1990, and 2000
(Percent)

Country and source of funds	1981	1990	2000
Canada			
Government	78.8	75.0	59.9
Industry	4.1	5.0	8.9
Other	17.1	20.0	31.2
France			
Government	97.7	92.9	91.5
Industry	1.3	4.9	2.7
Other	1.0	2.2	5.8
Germany			
Government	98.2	92.1	85.9
Industry	1.8	7.9	11.6
Other	0.0	0.0	2.5
Italy[a]			
Government	96.2	96.7	94.4
Industry	2.7	2.4	4.8
Other	1.1	0.9	0.8
Japan			
Government	57.8	51.2	50.2
Industry	1.0	2.3	2.5
Other	41.2	46.5	47.3
United Kingdom			
Government	81.3	73.5	64.7
Industry	2.8	7.6	7.1
Other	15.9	18.9	28.2
United States			
Government	74.1	66.9	65.0
Industry	4.4	6.9	7.1
Other	21.5	26.2	27.9

[a] Italian data are for 1999.

SOURCES: Organisation for Economic Co-operation and Development, Science and Technology Statistics database, 2003; and National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources* (Arlington, VA, annual series).

INDUSTRIAL SECTOR

Industrial firms account for the largest share of total R&D performance in each of the G-8 countries. However, the purposes to which the R&D is applied differ somewhat, depending on the overall industrial composition of each country's economy. Funding patterns for industrial R&D also differ from country to country, with respect to both domestic sources of funds as well as the relative proportion of foreign funding.

The structure of a country's industrial activity can be a major determinant of the level and change in industrial R&D spending. National variations in such spending can result from differences in absolute output, industrial structure, and R&D intensity. Countries with the same size economy could have vastly different R&D expenditure levels (and R&D/GDP ratios). Some nations have much higher concentrations of R&D-intensive industries such as pharmaceutical manufacture as opposed to food processing. And even individual firms in the same industries can devote substantial resources to specific R&D activities in one country and to other activities in another country. Table 16 shows recent distributions of industrial R&D performance in the G-7 countries, South Korea, and the European Union.

The sector distribution of U.S. industrial R&D performance is among the most widespread and diverse among OECD members. The accumulated knowledge stock, well-developed S&T infrastructure, and large domestic market in the United States have enabled it to invest and become globally competitive in numerous industries rather than just a few industries or niche technologies. In 2000 no one industrial sector accounted for more than 13 percent of total U.S. industrial R&D as detailed by the OECD in its ANBERD database (table 16). In comparison, most of the other countries displayed somewhat higher sector concentrations. For example, over one-fourth of total industrial R&D was concentrated in electronic equipment manufacturing in South Korea (37 percent) and Canada (29 percent). Indeed, the electronic equipment sector was the largest performer of industrial R&D in five of the eight countries shown and was the second largest performer of industrial R&D for the entire European Union. Among other manufacturing sectors, motor vehicles in Germany and pharmaceuticals in the United Kingdom accounted for 20 percent or more of total R&D performance.

One of the more significant trends in both U.S. and international industrial R&D activity has been the growth of R&D in the service sector. According to the internationally harmonized data in table 16, this sector accounted for 34 percent of total industrial R&D performance in the United States in 2000.[42] A number of other countries also reported substantial increases in their service sector R&D expenditures during the past 25 years. Among G-7 countries, nonmanufacturing shares of total industrial R&D increased about 5 percentage points in France and Italy and 13 percentage points in the United States, United Kingdom, and Canada from the early 1980s to the late 1990s (Jankowski 2001). In each of these countries, computer and related services account for a substantial share of the service R&D totals.

[42] As previously discussed, the recent growth in R&D in the U.S. trade industry reflects statistical procedures more than actual R&D activity in wholesale and retail trade companies. (See sidebar, "Redistributing Trade R&D.") The relatively high trade industry R&D for Canada (which, like the U.S., uses the North American Industry Classification System) is also likely the result of statistical procedures.

TABLE 16. Shares of industrial research and development, by industry sector for selected countries: 1999 or 2000

Industry	United States (2000)	Canada (2000)	Germany (2000)	France (1999)	Italy (2000)	Japan (2000)	United Kingdom (2000)	South Korea (2000)	European Union (1999)
	Billions of PPP dollars								
Total	199.5	9.0	37.4	19.2	7.4	69.7	17.8	14.1	101.7
	Percent distribution								
All business enterprise	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Manufacturing	64.9	67.3	91.3	85.7	79.9	95.0	80.2	83.7	84.3
Food, beverages, and tobacco	0.8	1.0	0.6	1.8	1.3	2.4	2.3	1.4	1.7
Textiles, fur, and leather	0.1	0.7	0.6	0.5	0.3	0.7	0.3	0.9	0.5
Wood, paper, printing, and publishing	1.6	1.3	0.4	0.4	0.3	1.1	0.3	0.4	0.7
Coke, refined petroleum products, and nuclear fuel	0.6	0.5	0.1	1.4	0.9	0.3	1.6	2.0	0.8
Chemicals (less pharmaceuticals)	4.2	1.4	10.9	6.1	5.1	8.1	5.9	4.7	NA
Pharmaceuticals	6.5	6.1	6.1	13.2	8.6	6.9	24.7	1.4	NA
Rubber and plastic products	0.8	0.4	1.7	2.8	1.8	2.4	0.5	1.4	1.7
Nonmetallic mineral products	0.4	0.1	1.2	1.3	0.3	1.6	0.4	0.5	0.9
Basic metals	0.3	1.4	0.7	1.4	0.4	2.8	0.5	1.3	1.0
Fabricated metal products	1.0	1.1	1.4	1.0	0.6	1.1	0.6	0.6	1.1
Machinery NEC	3.4	2.2	9.5	4.5	7.5	9.3	6.1	2.8	7.6
Office, accounting, and computing machinery	5.2	4.8	1.9	1.9	1.1	10.8	1.0	7.1	1.8
Electrical machinery	1.9	1.4	3.0	3.7	2.3	9.8	3.7	1.7	3.1
Electronic equipment (radio, television, and communications)	12.9	28.8	10.7	12.5	19.3	18.8	8.9	36.7	13.5
Instruments, watches, and clocks	9.6	1.3	4.9	6.7	2.9	4.5	4.2	1.0	4.6
Motor vehicles	9.3	1.9	29.6	13.4	15.4	12.4	7.5	14.3	16.1
Other transport equipment (less aerospace)	0.6	0.1	1.0	0.6	1.2	0.3	2.0	1.9	1.0
Aerospace	5.2	12.3	6.6	11.8	10.5	0.8	9.5	2.9	7.6
Furniture, other manufacturing NEC	0.4	0.6	0.5	0.8	0.2	0.9	0.2	0.8	0.5
Recycling	NA	NA	0.0	0.0	0.0	NA	0.0	0.0	NA
Electricity, gas, and water	0.1	1.6	0.3	2.5	0.2	0.9	1.4	1.8	NA
Construction	0.1	0.2	0.2	0.9	0.2	1.7	0.3	3.7	NA
Agriculture and mining	NA	NA	NA	NA	NA	NA	NA	NA	NA
Services	34.4	29.0	7.8	9.1	19.7	2.1	16.6	10.5	13.0
Wholesale, retail trade, motor vehicle repair, etc.	12.6	7.3	NA	0.0	0.4	NA	NA	0.3	NA
Hotels and restaurants	NA	NA	NA	0.0	0.0	NA	NA	0.0	NA
Transport and storage	0.1	0.2	NA	3.6	0.1	0.2	NA	0.5	NA
Communications	0.7	0.9	NA	NA	0.1	NA	5.9	3.6	NA
Financial intermediation (including insurance)	2.0	1.9	NA	NA	1.2	NA	NA	0.0	NA
Computer and related activities	7.4	6.2	NA	2.5	2.5	1.9	5.3	3.9	3.7
Research and development	7.0	10.5	2.5	NA	12.9	NA	3.7	0.3	NA
Other business activities NEC	NA	1.9	NA	3.0	2.2	NA	1.1	1.8	2.2
Community, social, and personal service activities, etc.	NA	NA	NA	NA	0.2	NA	0.1	0.2	NA

NA not available separately
NEC not elsewhere classified
PPP purchasing power parity

NOTES: Data for communications industry in United States include only telecommunications research and development. Data are for years listed under country names.

SOURCES: Organisation for Economic Co-operation and Development (OECD), ANBERD database, 2002; and OECD, *R&D Efforts in China, Israel, and Russia: Some Comparisons With OECD Countries* (Paris, 2000).

Furthermore, the service sector appears to be an important locus of industrial R&D activity in several countries, reflecting in part the growth in outsourcing and greater reliance on contract R&D in lieu of in-house performance, as well as intramural R&D in these industries.

According to national statistics for recent years, the service sector accounted for less than 10 percent of total industrial R&D performance in only three of the G-7 countries (Germany, France, and Japan). Among the countries listed in table 16, the service sector share ranged from as little as 2 percent in Japan to 34 percent in the United States. The latter figure, however, is partly the result of some manufacturing companies being classified into wholesale trade as discussed earlier in this report.

Most of the funding for industrial R&D in each of the G-7 countries is provided by industry itself. As is the situation for OECD countries overall, government financing accounts for a small and declining share of total industrial R&D performance within G-7 countries. (See "Government Sector.") Government financing shares ranged from as little as 2 percent of industrial R&D performance in Japan to 11 percent in Italy (appendix table B-20). In the United States in 2001, the Federal Government provided about 9 percent of the R&D funds used by industry, and the majority of that funding was obtained through DOD contracts. The role of foreign funding in R&D varied from country to country, accounting for as little as 0.6 percent of industrial R&D in Japan to as much as 31 percent in Canada in recent years. This foreign funding predominantly came from foreign corporations but also included funding from foreign governments and other foreign organizations.

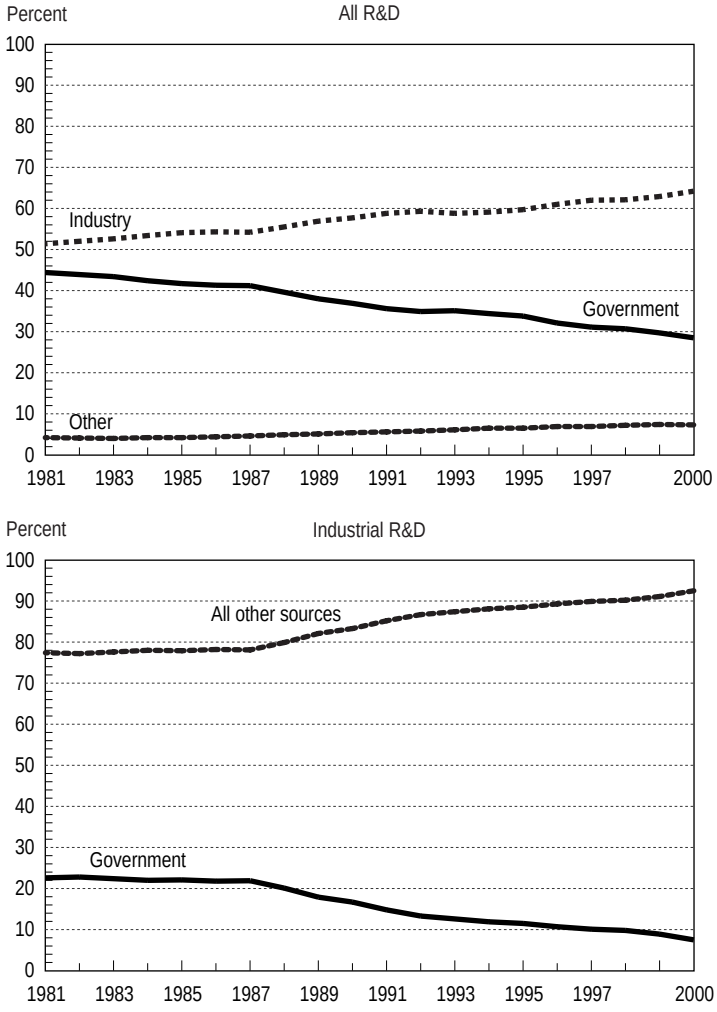
Government Sector

As in the United States, the role of the government as a performer of R&D has been shrinking internationally. The government sector accounted for 13 percent of the OECD R&D performance total as recently as 1995. This share fell to 10 percent of OECD members' combined R&D performance in 2000.

In most countries, including the United States, the government sector funds much more R&D than it performs, however a significant trend in the G-7 and other OECD countries has been a decline in government R&D funding relative to R&D funding from the private sector. In 2000, less than 30 percent of all R&D funds were derived from government sources, down considerably from the 44 percent share reported in 1981[43] (figure 23). Part of the relative decline reflects the effects of budgetary constraints, economic pressures, and changing priorities in government funding (such as the relative reduction in defense R&D in France and the United States). This trend also reflects the absolute growth in industrial R&D funding as a response to increasing international competitive pressures in the marketplace, irrespective of government R&D spending patterns. Both of these considerations are reflected in funding patterns for industrial R&D performance. In 1982, government provided 23 percent of the funds used by industry in conducting R&D within OECD countries, whereas by 2000 government's share of the industrial R&D total had fallen by almost two-thirds, to 8 percent of the total.

[43]Among all OECD countries, the government sector accounts for the highest funding share in Portugal (63 percent of its 2000 R&D total) and the lowest share in Japan (20 percent in 2000).

FIGURE 23. Sources of research and development expenditures in Organisation for Economic Co-operation and Development countries: 1981–2000



R&D research and development

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (Paris, 2002).