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INTERNATIONAL PATENTING TRENDS IN MANUFACTURING TECHNOLOGIES: ROBOTS

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Over the five-year period 1990-94, Japan ranks number one in robot technology patent activity.

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This report is the first in a three-part series that examines America's technological position vis-à-vis that of five other countries—Japan, Germany, France, the United Kingdom, and South Korea—in high-tech areas likely to be important to future economic competitiveness. The areas examined are advanced manufacturing, biotechnology, and advanced materials; the indicator used to determine a country's relative strength and interest in these areas is international patent activity. To facilitate patent search and analysis, the three broad areas are each represented by a narrower subfield. This report examines robot technologies as a proxy for advanced manufacturing technologies.[1]

*As used here, **robot technology** covers program-controlled manipulators—e.g., the manipulator, program control, gripping heads, joints, arm sensors, safety devices, and accessories—and excludes non-program-controlled manipulators, prosthetic devices, and toy robots.*

*The analysis is built around the concept of a **patent family** which consists of all the patent documents published in different countries associated with a single invention. The first application filed anywhere in the world is the **priority application**: it is assumed that the country in which the priority application was filed is the country in which the invention was developed. Similarly, the **priority year** is the year the priority application was filed. The **basic patent** is the first patent or patent application published in any of the roughly 40 countries covered in the database used (the Derwent World Patents Index Latest).*

***International patent families** are used to mitigate bias introduced by national systems, such as Japan's, that encourage large numbers of domestic patent applications. An international patent family is created when patent protection is sought in at least one other country besides that in which the earliest priority application was filed.*

*The **three indicators** used in this assessment are overall trends in international inventive (patenting) activity, highly cited inventions, and the size of international patent families.*

International Patenting Activity

Tabulated by priority year, this indicator provides a first measure of the extent and growth of each nation's inventive activity. These patent family counts represent inventions important enough to be patented outside of the country of origin. During the first half of the 1990s, 1,719 international patent families were formed in robotics with priority applications in the six countries examined (figure 1). Patenting activity in this six-country group accounts for about three-quarters of all families in this technology area.

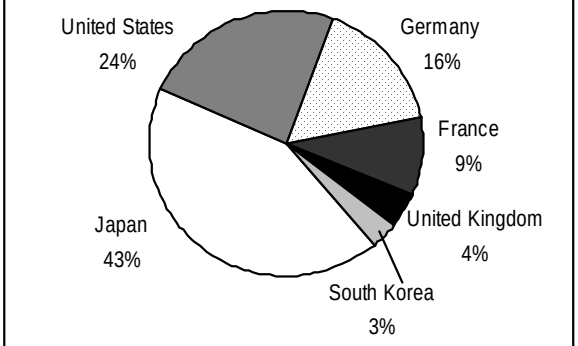
The conventional perception of Japan as an innovator in the area of advanced manufacturing techniques is reinforced by the large number of robotic inventions originating there. Japan led all other countries studied in the total number of international patent families

[1]These data were developed under contract for the National Science Foundation by Mogee Research & Analysis Associates and cover the period 1990-94; they were extracted from the Derwent World Patents Index Database published by Derwent Publications, Ltd. The technology areas selected for this study met several criteria:

- Each technology appeared on the lists of "critical" technologies deemed important to future U.S. economic competitiveness or national security (see Mogee 1991; OSTP 1995; and Popper, Wagner, and Larson 1998).
- Each technology could be characterized by the output of patentable products or processes.
- Each technology could be defined sufficiently to permit construction of accurate patent search strategies.
- Each technology yielded a sufficient population for statistical analysis.

The United States had the most highly cited robot inventions of the six nations examined.

Figure 1. Robot technology: Number of international patent families by priority year and country: 1990-94



Priority country	1990	1991	1992	1993	1994	Total
Japan	197	174	177	119	70	737
United States	112	59	66	87	87	411
Germany	68	56	64	50	40	278
France	39	56	22	25	20	162
United Kingdom	18	19	12	12	11	72
South Korea	15	10	14	9	11	59
Total	449	374	355	302	239	1,719

SOURCE: Derwent World Patents Index Database (London, Derwent Publications, Ltd.), special tabulations by Mogee Research & Associates under contract to the National Science Foundation.

in robot technology created during the 1990-94 period. Japanese inventors held 43 percent of the total number of international patent families formed by the six countries included in the study, followed by the United States (24 percent), Germany (16 percent), France (9 percent), the United Kingdom (4 percent) and South Korea (3 percent).

Over the five-year period 1990-94, Japan ranks number one in robot technology patent activity; however, this activity dropped dramatically after 1992. At about the same time, U.S. activity picked up: in 1994, the United States led Japan in the number of international robot technology patent families formed.

Although South Korea's share of international patent families was the lowest overall, its share approached that of the larger and more advanced economy of the United Kingdom. Given its newly industrialized economy status, South Korea's over-all international inventive activity in this technology area is noteworthy—especially when the data show that South Korea's robot technology patenting activity equaled that of the United Kingdom in 1994.

Highly Cited Robot Inventions

Interpatent citations are an accepted method of gauging the technological value or significance of different patents. These citations, provided by the patent examiner, indicate the "prior art"—the technology in related fields of invention taken into account in judging the novelty of the present invention. The number of citations a patent receives from later patents can serve as an indicator of its technical importance or value. In fact, Carpenter, Narin, and Woolf (1981) have shown that, on average, technologically important U.S. patents receive twice as many examiner citations as does the average U.S. patent, reinforcing the validity of interpatent citation as an indicator of patent quality.

The United States led the group with 55.6 percent of all highly cited robot technology international families generated during the 1990-94 period (10 of 18).[2] Japan, with 33.3 percent of the highly cited patents, and Germany, with 11.1 percent, trailed distantly (table 1). The United Kingdom, France, and South Korea did not have any international robot families in the highly cited group.

Only the United States had more highly cited international patent families than might be expected—2.3 times—based on its level of activity (that is, the total number of U.S. international robot technology families). Specifically, Japan produced only 80 percent of what might be expected based on the number of inventions it produced during this period, and Germany produced only 70 percent of what might be expected. Again, France, the United Kingdom, and South Korea—with nearly 300 international robot patent families among them—had no highly cited robot inventions during this period.

[2]The data used here include all international patent families with priority application dates from 1990-94 with eight or more citations. The citation counts are those placed on European Patent Office (EPO) patents by EPO examiners, as the EPO citations are believed to be a less biased and broader source of citation than those of the U.S. Patent and Trademark Office. See Claus and Higham (1982). To adjust for the advantage countries with large numbers of international families would have on this indicator, a country's share of highly cited patents is divided by its share of total patent families.

Table 1. Robot technology: International patent families, highly cited international patent families, and citation ratios, by priority country: 1990-94

Priority country	Number of international families	Number of highly cited international families a/	Country share of total (Percent)	Country share of highly cited (Percent)	Citation ratio b/
Total	1,719	18	100.0	100.0	1.0
United States	411	10	23.9	55.6	2.3
Japan	737	6	42.9	33.3	0.8
Germany	278	2	16.2	11.1	0.7
France	162	0	9.4	0.0	0.0
United Kingdom	72	0	4.2	0.0	0.0
South Korea	59	0	3.4	0.0	0.0

a/ An international patent family was considered highly cited if the number of citations it received ranked it within the top 1 percent compared with all other robot technology international patent families. The top 1 percent threshold was used so that those counted as highly cited would more certainly represent important inventions. For this technology area, the top 1 percent received 8 or more citations.

b/ A citation ratio of greater than 1.0 indicates that a country has a higher share of highly cited international patent families than might be expected based on its share of total families.

SOURCE: Derwent World Patents Index Database (London: Derwent Publications, Ltd), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

The United States thus appears to have contributed a disproportionate number of important robot inventions relative to its level of inventive activity.

Average International Patent Family Size

Given the significant costs associated with obtaining patent protection in multiple countries, this indicator attempts to measure the perceived economic potential of a robot invention by calculating the number of countries in which patent protection is being sought, adjusted for market size.[3] When average international patent family size is calculated for each country's robot technologies, there is not as much separation in the scores as might be expected (table 2). U.S. inventions received the highest score and therefore have the highest level of perceived commercial value based on this measure. South Korean inventions received the lowest score. Since most inventions are first patented in the country in which the inventor resides, U.S. inventions have an advantage in this indicator due to the large size of the U.S. economy.[4] But European inventions also have the advantage of many commercial, locational, and historical ties that facilitate multiple-country patenting. Furthermore, the move toward European unification has encouraged wider patenting within Europe. U.S. inventions nonetheless scored slightly higher on average than did European robot inventions. Japan's robot inventions also scored well on this indicator, bolstered by the tendency of Japanese inventors to seek patent protection in large economies such as the United States and Germany (79 and 60 percent, respectively). South Korea scored high, but it too sought patent protection for most of its robot inventions in large markets like the United States (64 percent) and Japan (41 percent).

Summary of U.S. Position

Based on this examination of international patenting in robot technologies during 1990-94, the U.S. science and technology enterprise

[3]Operationally, this means counting the number of countries in a family in which a patent publication (a published patent application or an issued patent) exists. Patents in each family are weighted by an index based on the gross domestic product (GDP) in purchasing power parities at current U.S. dollars of the patent country. The index runs from 0 to 1.00, and U.S. GDP is set at 1.00.

[4]Using international patent families as the unit of comparison—as is done here—reduces this bias. Because of its market size, the United States attracts most commercially important inventions and is likely to be a member of many of the international patent families included in this indicator.

Table 2. Robot technology: Number of international patent families and average international family size: 1990-94

Priority country	Number of families	Average international family size	Adjusted average international family size a/
United States	411	7.9	1.6
France	162	8.8	1.4
Japan	737	4.6	1.3
United Kingdom	72	10.1	1.3
Germany	278	8.3	1.2
South Korea	59	2.1	1.0

a/ Patent family data weighted by an index based on gross domestic product measured in purchasing power parities at current U.S. dollars of the patent country. This weighting adjusts family size for the size of the national markets in which protection is being sought in an effort to better reflect the commercial potential of the invention.

NOTE: Patent family size is determined by the number of countries for which patent protection is sought for a single invention.

SOURCE: Derwent World Patents Index Database (London: Derwent Publications, Ltd), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

emerges as an important producer of inventions in this key technology area, whose inventions are patent protected throughout the world. Over the five-year period examined, the number of U.S. robotic inventions patented in more than one country was second only to Japan's. By 1994, the United States surpassed Japan in the number of international patent families formed. U.S. robot inventions appear to be important: they were cited by later patents far more often than those originating in any of the other five countries studied. Finally, U.S. robot inventions have the highest perceived economic value as measured by average international patent family size among those of the five countries; however, the large size of the U.S. economy provides a considerable advantage in this calculation.

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