World 2002 ROBOTICS

Statistics, Market Analysis,
Forecasts, Case Studies and
Profitability of Robot Investment

Co-authored by:
THE INTERNATIONAL FEDERATION OF ROBOTICS

UNITED NATIONS
ECONOMIC COMMISSION FOR EUROPE

UNITED NATIONS
Economic Commission for Europe (UNECE)

IFR International Federation of Robotics

World ROBOTICS 2002

UNITED NATIONS
New York and Geneva, 2002

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UNITED NATIONS PUBLICATION
Sales No. GV.E.02.0.8
ISBN 92-1-101047-0
ISSN 1020-1076

FOREWORD

Since their introduction at the end of the 1960s, industrial robots have undergone an impressive technological evolution. With declining real prices and continuously improved performance, robots are now widespread in industry in many countries while in others the technology is on the verge of being introduced.

Robots have become a symbol and a test of industrial automation in its most advanced form. Together with computerized numerically controlled machine tools, automated guided vehicles and host computers of various kinds, robots form the centrepiece of computer-integrated manufacturing systems.

The introduction of industrial robots is not only motivated by a wish to improve productivity but also to obtain higher and more consistent product quality. Robotics is also an important technology for eliminating workplace hazards, e.g. those related to exposure to heat, gases and chemicals or those where heavy lifting or monotonous work movements are involved.

Total accumulated yearly sales of robots since the beginning of the 1970s amounted at the end of 2001 to some 1.25 million units, of which some 756,000 are estimated still to be in operational use. Driven by advances in semiconductor and computer technologies and the vast potential for new applications, not only in industry but also in construction and in services (hotels, health care, laboratories, surgery etc), there is every reason to believe that robotics will continue to expand rapidly and play an increasingly important role in production rationalization.

This yearly publication, in addition to summarizing the development of industrial robots to date, presents time-series data for the period up to 2001 and inclusive, forecasts for the period 2002-2005 and, for the fourth year in a row, an analysis of the diffusion of service robots. It is a joint effort of the United Nations Economic Commission for Europe (UNECE) and the International Federation of Robotics (IFR). The two organizations have enjoyed close and fruitful co-operation in the area of robotics for many years.

Monitoring economic and social trends, developing indicators with a focus on performance and outcomes, supporting business and policy decisions with an infrastructure of good quality information and analysis, are core preoccupations and strategic objectives of the ECE Statistical Division. This Report therefore provides an outstanding illustration of what can be achieved in monitoring industrial development.

For the fourth time World Robotics includes an editorial, where a well-known person with a worldwide reputation is invited to give his/her view of the future of robotics. The first editorial appeared in ***World Robotics 1999***. It was written by Mr. Marvin Runyon, Postmaster General and Chief Executive Officer of the United States Postal Service. In ***World Robotics 2000*** there were three editorials. The first was prepared by Mr. Björn Weichbrodt, International Federation of Robotics (IFR) and the second by Mr. Rolf Dieter Schraft and Mr. Matin Hägele, Fraunhofer Institute for Manufacturing Engineering and Automation (IPA). The third editorial was written by Mr. Hadi A. Akeel and Mr. Gary J. Rutledge, both from FANUC Robotics North America. In the 2001 issue, an editorial was presented by Mr. Lars-Erk Ringström, Business Manager of ABB Flexible Automation. In the present issue, Mr. Steffan Müller, Executive Vice President of KUKA Roboter GmbH, Germany is the author of the editorial.

The present publication and all previous yearbooks on robotics were written by Mr. Jan Karlsson, teamleader ECE Statistical Division. Mr. Yves Clopt, ECE, designed the cover page and made the photo set-ups. Ms. Linette Blanchandin, ECE Statistical Division, assisted in the text processing and the proof reading of the publication.

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EDITORIAL

Statistics sometimes make good reading!

By

Mr. Stefan Mueller
Executive Vice President KUKA Roboter,
President VDMA Robotics + Automation,
Member of the Executive Committee of the International Federation of Robotics (IFR)

Dear Readers,

You have before you the current issue of World Robotics. This work, published annually, is the most important international source of industry statistics for suppliers, robot manufacturers, systems integrators and robot users. Instead of the reports about technological trends, market developments and current research topics you usually find here, I would like to take you for a glance "behind the scenes" at the creation of this book, to outline its uses and formulate a few suggestions as to how it might develop in the future.

The making of ...

The first stage in drafting World Robotics is the collection of data. This is not as easy as one might suppose: before you can start counting robots, you have to know what a robot is. We thus need a definition – this must be normative on the one hand, but capable of achieving general consensus on the other. This issue remains topical. Historically, Japan has always had a more liberal definition of what constitutes a robot, and thus correspondingly higher figures than those that would be generated using the more restrictive definitions that exist in North America and Europe. Then there is the question of the registration scheme and nomenclature. Here there is general consensus.

Robot manufacturers can register the number of robots they have produced. It is the national robotics associations, in the countries where such associations exist, that have the greatest chances of motivating the manufacturers to register their figures. Manufacturers are accustomed to registering data with their own associations and can rely on the fact that the information they provide will be treated in the strictest confidence. My company, KUKA Roboter, for example, registers the numbers of robots sold with VDMA Robotics + Automation, as do other German-based manufacturers.

Already at this stage, during the recording and preparation of the statistical data at trade association level, numerous questions arise which must be clarified in full with the companies registering the information. This results in a national aggregate, in this case for Germany. This is then closely scrutinized once again at a meeting of market experts from the different companies registering the data. What explanations are there for the

rates of change compared with the previous year? Are dramatic changes for individual robot types plausible? What market factors have influenced the results? Is it going to be necessary to increase the number of companies providing information in a specific category? Once these and other questions have been satisfactorily answered by the robotics experts, the "official" German figures are released.

These figures, and the statistics for the other countries involved, are then passed on to the International Federation of Robotics (IFR) where they are collected and forwarded to the UN/ECE. This multi-stage procedure, which is the only way of ensuring the reliability and security of the data, does of course have a downside: there is a significant delay between the end of the business year and the publication of World Robotics. For this reason, continuous efforts are made by UN/ECE, IFR and the national associations to accelerate the process.

Identifying markets and seizing opportunities

What is the advantage to our industry of a statistical handbook such as World Robotics? From a company's point of view, I can offer the following answers:

- Comparatively young branches of industry, such as the robotics sector, receive little or no coverage in official manufacturing and foreign trade statistics. It is thus necessary to collect one's own data if one wishes to describe the market, albeit on an ex-post basis.

- Public interest in young branches of industry – and particularly in sectors growing as dynamically as the robotics industry – is increasing steadily. In order to be able to carry out appropriately professional press and public relations work, we are reliant on people who are in a position to disseminate information in the business press and in technical journals, radio and television. The key to reaching such disseminators often lies in market data which are otherwise not available.

- In the case of research and development projects, the economic benefits must be investigated as well as the technical challenges. For example, an Expression of Interest registered with the European Robotics Forum (ERF) for an integrated project in the Sixth EU Framework Programme was based on a white paper, which referred again and again to World Robotics.

The nature of statistics is such that World Robotics, at least in part, describes the past – though what interests us of course is also the future. There are also a number of chapters, however, that deal with prognosis. Prognoses are a tricky business, and fortunately it is rare that anyone subsequently takes the trouble to go back and compare them with the actual situation. World Robotics 2001 offered prognoses for growth rates in Germany of 18% for 2001, 12% for 2002, 12% for 2003 and 10% for 2004. The actual growth rate in 2001 was 10% with probable growth of ±0% for the following year. As far as 2003 and 2004 are concerned, one instinctively thinks of crystal balls and tea-leaves – or at any rate of growth falling below the prognoses. It is fairly safe to assume that this also applies for all other countries.

It is thus down to you, the reader, to draw your own conclusions from the data provided here – unique in their completeness – on which to base your expectations for your own products and markets. World Robotics is an invaluable aid in this process.

The best is the enemy of the good ...

World Robotics is without doubt a masterpiece! If anyone is deserving of an award for outstanding services to the robotics industry, it is the author Jan Karlsson from UN/ECE.

Many robot system manufacturers consider World Robotics to be the most important and useful service provided by the IFR. It is thus necessary to address the following issues: how to increase the quality of the data still further, how to speed up the collection and verification of the data, and how to ensure the international comparability of the results. This, then, is the challenge that I have set myself in the Executive Committee of the IFR, and for which I intend to make corresponding suggestions.

These recommendations are to be implemented first at the European Robotics Forum (ERF) level of the IFR and then tested to see whether or not they are applicable to data collection worldwide. The following measures have already been implemented or are at the planning stage:

- The organizations responsible for gathering data at national level describe their sources, aggregation methods and control mechanisms using a standard form so that the procedures can be compared and assessed.

- UN/ECE carries out sample audits in order to check the quality and repeatability of the procedures. This has already long been standard practice for our products and services and should apply also to our "statistical products".

- Each robot manufacturer supplies consolidated data from head office covering all subsidiaries. In this way, subsidiaries throughout the world are prompted to pass on their data more quickly and the information gathered is subjected to an additional quality check at head office.

- In countries with no national robotics associations or where these associations do not gather data themselves, manufacturers should report directly to the relevant department of the IFR, e.g. the European Robotics Forum (ERF) for European manufacturers. Experience has shown that data collection by institutes, private individuals or journalists tends to be unreliable due to the lack of binding regulations governing the handling of the data.

These and other measures are intended to ensure that World Robotics maintains and consolidates its unique position. Look forward to a process of continuous improvement providing you ever more quickly with reliable data from the international robotics market. This work is based on the experience of suppliers, manufacturers and users, and the combined expertise of national associations, the corresponding international umbrella organization and the UN/ECE – the best possible guarantee that it will increasingly meet your every need.

I wish you every success using and interpreting World Robotics!

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EXECUTIVE SUMMARY

WORLDWIDE DIFFUSION OF INDUSTRIAL ROBOTS

2001 World Robot Market

World total, multipurpose robots, excluding Japan and Rep. of Korea: 45,700 units, -3% over 2000

World total, including all types of industrial robots in Japan and Rep. of Korea: 78,100 units, -21% over 2000

Total market value for robot units: $3.8 billion, -32% over 2000

Estimated market for robot systems: $12 billion

The total stock of operational industrial robots:
multipurpose industrial robots, excluding Japan and Rep. of Korea:
354,000 units, +9% over 2000
including all types of industrial robots in Japan and Rep. of Korea:
756,500 units, +1% over 2000

World market fell by 21% in 2001...

Worldwide sales of **multipurpose industrial robots**, admitting the fact that the figures for Japan and the Republic of Korea include all types of industrial robots, peaked in 1990 when they reached over 80,000 units (see table 1 and figure 1). Following the recession in 1991-1993, worldwide sales of industrial robots fell to about 53,000 units in 1993. The world robot market then started a period of strong recovery, which peaked in 1997 when it reached a level of 82,000 units. In 1998, however, sales plunged by 15% to just under 69,000 units. The market recovered sharply in 1999 with sales of nearly 80,000 units, an increase of almost 15% over 1998. In 2000, growth accelerated to 24%, attaining a record of almost 99,000 units. In **2001, however, the world market fell by 21%, reaching 78,100 units**.

... mainly as a result of plummeting sales in Japan and a depressed market in the United States

After two years of falling or stagnant sales, there was a sharp recovery in **Japan** in 2000. Sales of all types of industrial robots surged by 32% over 1999, reaching almost 47,000 units. This recovery was, however, only temporary because **in 2001 the market fell by nearly 40% to 28,400 units**, the lowest level since the middle of the 1980s.

From 1995 to 2000 the robot market in the **United States** was booming every second year and, in the years between, it was flat or falling. In 1995, 1997 and 1999 it increased by 32%, 28% and 37%, respectively. By contrast, in 1996 and 1998, the market dropped by 5% and 13%, respectively, while in 2000 it was almost flat (+1%). However, the highest sale of multipurpose industrial robots, in their strict definition, ever recorded was in 2000 when it reached nearly 13,000 units. **In 2001, the market fell by nearly 17% to 10,800 units**.

Table 1

Installations and operational stock of multipurpose industrial robots in 2000 and 2001 and forecasts for 2002-2005.
Number of units

Country	Yearly installations				Operational stock at year-end			
	2000	2001	2002	2005	2000	2001	2002	2005
Japan (all types of industrial robots)	**46,986**	**28,369**	**28,400**	**36,100**	**389,442**	**361,232**	**352,800**	**351,600**
United States	**12,986**	**10,824**	**11,100**	**14,200**	**89,880**	**97,268**	**104,700**	**130,600**
European Union	**29,796**	**30,553**	**32,600**	**41,800**	**198,897**	**219,333**	**239,700**	**321,400**
Germany	12,781	12,524	12,800	15,300	91,184	99,013	106,000	133,600
Italy	5,897	6,373	7,000	9,400	39,238	43,911	48,400	67,000
France	3,793	3,484	3,800	5,100	20,674	22,753	25,100	35,700
United Kingdom	1,538	1,941	2,100	2,800	12,344	13,411	15,000	20,700
Austria a/	320	330			3,046	3,153		
Benelux a/	630	620			8,211	8,590		
Denmark	307	330			1,414	1,683		
Finland	492	408			2,647	2,927		
Portugal	124	100			700	800		
Spain	2,941	3,584			13,163	16,378		
Sweden	973	859			6,276	6,714		
Other Europe	**858**	**801**	**900**	**1,200**	**10,783**	**10,869**	**9,300**	**10,300**
Czech Rep. a/	100	70			915	985		
Hungary	20	30			123	123		
Norway	97	98			540	618		
Poland	100	20			462	384		
Russian Fed. a/	250	250			5,000	5,000		
Slovakia b/								
Slovenia b/								
Switzerland a/	291	333			3,743	3,759		
Asia/Australia	**6,221**	**5,310**	**5,800**	**7,700**	**53,132**	**56,997**	**61,100**	**74,000**
Australia	440	270			2,833	2,953		
Rep. of Korea (all types of industrial robots)	4,731	4,080			37,987	41,267		
Singapore a/	300	300			5,370	5,458		
Taiwan, Province of China	750	660			6,942	7,319		
Other countries a/	**2,060**	**2,250**	**2,500**	**3,400**	**8,900**	**10,840**	**13,000**	**21,000**
Subtotal, excl. Japan and Rep. of Korea	**47,190**	**45,658**	**48,400**	**62,200**	**323,605**	**354,040**	**383,000**	**557,300**
Total, incl. all types of industrial robots in Japan and Rep. of Korea	**98,907**	**78,107**	**81,300**	**104,400**	**751,034**	**756,539**	**780,600**	**964,500**

Sources: UNECE, IFR and national robot associations.

a/ Estimated by the UNECE and IFR for some or for all the years. b/ As from 1999 included in the aggregate "Other countries".

The market in the European Union continued to grow...

In the **European Union**, sales of multipurpose industrial robots rose by 19% in 2000 to 29,800 units. **In 2001, sales continued to grow but by a modest 2.5%, reaching 30,500 units**. However, the market varied significantly between countries: -2% and -8% in Germany and France, respectively, to 26% in the United Kingdom and 22% in Spain.

Europe and the United States are rapidly catching up with Japan...

In the early 1990s, **installations of multipurpose industrial robots** in the European Union and the United States only amounted to about 20% and 7%, respectively, of Japan's installations of (all types of) industrial robots. **In 2001, for the first time ever, more multipurpose industrial robots were installed in the European Union than all types of industrial robots installed in Japan**. In fact, it could very well be that the 2001 installations of multipurpose industrial robots in the European Union were in the order of twice as high as the installations of the same robot types in Japan.

Looking at the **operational stock** of industrial robots, again relating Japan's stock of all types of robots to those of multipurpose robots in the European Union and the United States, the same pattern prevails. **The EU stock rose from 23% of that of Japan in 1990 to 61% in 2001. The corresponding figures for the United States were 12% and 27%, respectively**. Again, if separate data had been available for multipurpose industrial robots in Japan, they might very well have shown a stock of a magnitude between that of the United States and that of the European Union.

Figure 1. Yearly installations of industrial robots, 1998-2001 and forecast for 2002-2005

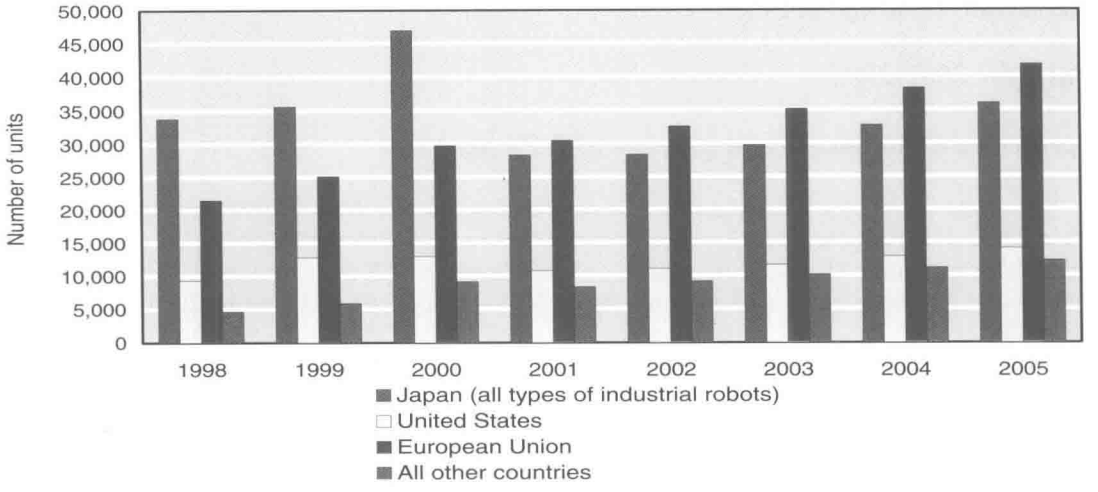
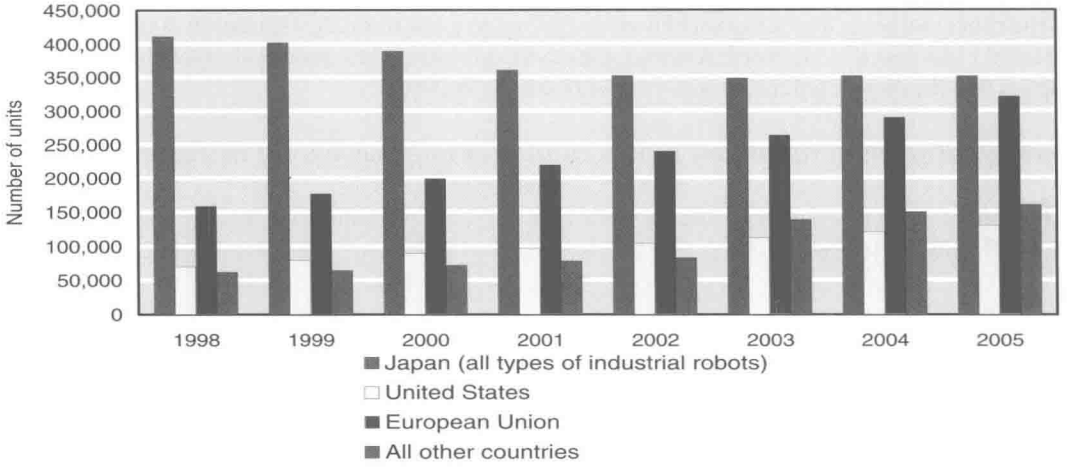


Figure 2. Estimated operational stock of industrial robots 1998-2001 and forecast for 2002-2005



Estimate of the worldwide operational stock of industrial robots

Total accumulated yearly sales, measured since industrial robots started to be introduced in industry at the end of the 1960s, amounted at the **end of 2001** to some **1,250,000 units, including, the dedicated industrial robots installed in Japan**. Many of the early robots, however, have by now been taken out of service. The stock of industrial robots in actual operation is therefore lower. UNECE and IFR estimate the

total worldwide stock of operational industrial robots at the end of 2000 between a minimum of 757,000 units and a possible maximum of 1,020,000 units

The minimum figure above is derived on the assumption that the average length of **service life is 12 years**. A UNECE/IFR pilot study has indicated that the average service life might in fact be as long as **15 years**, which would result in a **worldwide stock of 1,020,000 units**.

The **net increase** in the Japanese robot stock fell sharply in the period 1992-1994. The net increase in 1994 was less than a fifth of that in the record year of 1990, underscoring the depth of the Japanese recession. As from **1998, the robot stock in Japan started to decline at an accelerated rate; 0.3% in 1998, 2.3% in 1999, 3.2% in 2000 and by as much as 7.2% in 2001**. The 2001 robot stock was only 87% of that of 1997.

Excluding Japan and the Republic of Korea, the world stock of multipurpose industrial robots amounted at the end of 2001 to 354,000 units, or 9% more than in 2000. In the **European Union** and the **United States**, the stock of industrial robots rose by an impressive 8% and 10%, reaching 219,000 units and 97,000 units, respectively. In Spain the increase was as high as 24%.

Forecasts for 2002-2005

Sales projected to increase by an average of 7.5% per year

The world market for industrial robots is projected to increase from 78,000 units in 2001 to just over 104,000 in 2005 when including all types of industrial robots in Japan and the Republic of Korea, or by a yearly average of 7.5% (see table 1). Excluding Japan and the Republic of Korea, worldwide sales of multipurpose industrial robots are forecasted to increase from almost 46,000 units to 62,000 units by 2005, an average yearly increase of 8%.

Sales in Japan expected to show slow recovery ...

Growth in robot investment in Japan will be spurred by an increasing demand for replacement investment. Between 2001 and 2005, sales are projected to increase from 28,000 units to about 36,000 units, which, bearing in mind the slump of 2001, is a rather modest recovery.

Steady growth in Europe and in North America

The robot market in the European Union is expected to grow from 30,500 units in 2001 to 42,000 units in 2005 (see table 1 and figure 1). In North America, the market is estimated to grow by an average annual rate of 7%, which implies that the market will reach just over 14,000 units in 2005.

The operational stock of industrial robots continues to grow, except in Japan

In terms of units, it is estimated that the worldwide stock of operational industrial robots will increase from almost 757,000 units at the end of 2001 to 965,000 at the end of 2005 (see table 1 and figure 2).

The year 1997 was the peak one for the Japanese robot stock, when it reached 413,000 units, including all types of industrial robots. By end 2001, it had fallen to 361,000 units and is projected to fall to 349,000 units in 2003, after which it will start to increase, reaching 352,000 in 2005.

When excluding Japan and the Republic of Korea, the remaining world operational stock of multipurpose industrial robots is forecasted to increase from 354,000 units to 557,000 units in the period 2001-2005, an average yearly increase of 12%.

In the United States, the operational stock of multipurpose industrial robots is forecast to reach 131,000 units in 2005. The projection for the European Union is 321,000 units, of which 134,000 in Germany; 67,000 in Italy; 36,000 in France; and 21,000 in the United Kingdom (see table 1 and figure 2).

Results in the first half of 2002

Looking at the first half of 2002, the UNECE/IFR quarterly survey on order intake of industrial robots, which includes most of the world's largest companies, showed that worldwide order intake decreased by 7%, compared with the same period in 2001. This figure, however, hides some major differences between regions:

Order intake of industrial robots, first half of 2002 compared with the same period in 2001: **North America +2%, Europe -15%, Asia +8% and World total -7%**.

Growth in robot investment is spurred by plummeting robot prices but price decreases are starting to level off...

In the 1990s, prices of industrial robots have been plummeting while at the same time their performance, measured both for mechanical and electronic characteristics, have continuously improved. A UNECE/IFR survey,

which covered the period 1990-2000, showed the following results

- List price of one robot unit -43%
- Number of units delivered +782%
- Number of product variants that can be supplied to customers +400%
- Total handling capacity (including gripper module) +26%
- Repetition accuracy +61%
- Speed of the 6 axes +39%
- Maximum reach +36%
- Mean-time between failures +137%
- RAM in Mbytes over 400 times
- Bit-size of the processor +117%
- Maximum number of axes that can be controlled +45%

Prices of industrial robots, expressed in constant 1990 US dollars, have fallen from an index 100 to 56 in the period 1990-2001, without taking into account that robots installed in 2001 had a much higher performance than those installed in 1990 (see figure 3 and table 2). When taking into account quality changes it was estimated that the index would have fallen to 25. In other words, an average robot sold in 2001 would have cost only a fourth of what a robot, with the same performance, would have cost in 1990, if it ever had been possible to produce such a robot in that year.

In the same time, the index of labour compensation in the American business sector increased from 100 to 152 (see figure 3 and table 2). This implies that the relative prices of robots have fallen sharply in the period 1990-2001.

Measurements of robot density based on the total number of persons employed

In figure 4, five groups of countries can be distinguished with respect to robot densities, expressed as the number of robot per 10,000 persons employed in the manufacturing industry (ISIC rev.3: D). The **first group** includes **Japan** and the **Republic of Korea**, which collects data on all types of industrial robots and are therefore not comparable with other countries. In 2001, these two countries had robot densities of about 270 and 125, respectively. While the density in the Republic of Korea is increasing rapidly, it has fallen in Japan since the peak in 1998.

The **second group** is topped by **Germany**, which in 2001 had a density of 127, followed by **Italy** with 102 and **Sweden** with 89 robots per 10,000 employed in the manufacturing industry. The **third group** of countries includes **Finland** with 67, **France** with 63, and **Spain** with 62 robots per 10,000 employed in the manufacturing industry. In the **fourth group**, the densities ranged between 52 and 34 in the **United States, Benelux, Denmark, Austria** and the **United Kingdom**. In **Norway** and **Australia** the density amounted 31 and 21, respectively, while at the bottom was **Portugal** with 8. Countries in central and eastern Europe, with the exception of the Czech Republic, have even lower densities.

Despite this large range in the robot densities of European countries, it is interesting to note that **the robot density in the European Union is 55% higher than that of the United States**.

Robot densities - 1 robot per 10 workers in the motor vehicle industry

Figure 5 shows data on the number of multipurpose industrial robots per 10,000 production workers in the motor vehicle industry. Japan is in the lead with 1,600 robots per 10,000 workers but bearing in mind that Japan includes all types of robots it is not comparable to the densities of other countries. Thereafter followed Italy with a density of 980, Germany 890, United States 700, Spain 670, Sweden 550, France 540 and the United Kingdom 520. The technological level with respect to robotics is thus rather homogenous in the motor vehicle industry in the above-mentioned countries.

Installations of advanced multipurpose industrial robots with 5 axes or more

When countries collect data they, do not always include the same types of robots - some countries concentrate on the more sophisticated robots while others, e.g. Japan, collect data on all types of robots that satisfy the IFR definition. For this reason, country data are not always comparable.

Figure 3
Price index of industrial robots for international comparison (based on 1990 $ conversion rate), with and without quality adjustment.

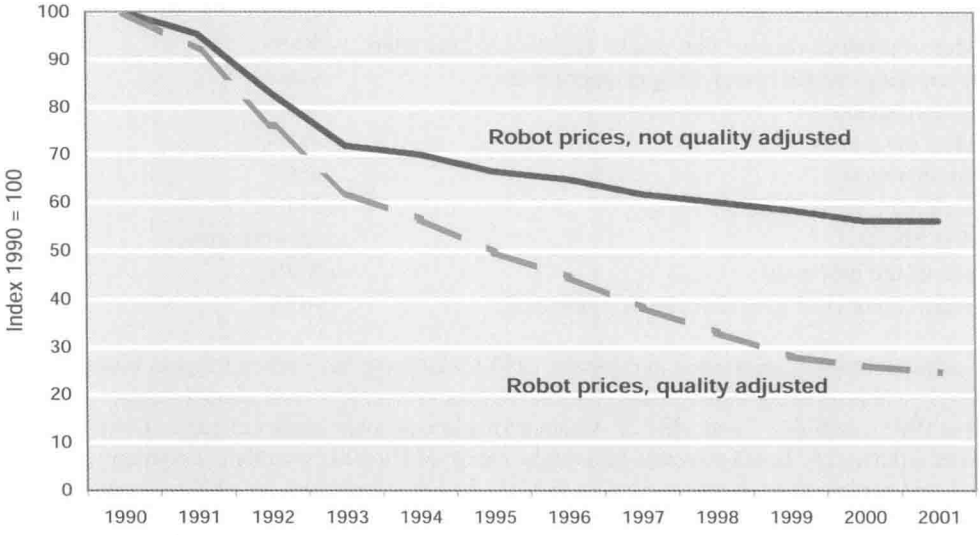


Table 2

Price index (1990=100) for industrial robots based on fixed 1990 US$ conversion and current US$ conversion. Indices without and with quality adjustment. Index of labour compensation in the business sector in the United States and hourly wages in dollars, excluding social costs, in the manfucaturing industry (ISIC rev.3: D) and in the motor vehicle industry (ISIC rev.3: 34)

Year	1990 $ conversion		Current $ conversion		Labour	Hourly wages, excl. social costs	
	No quality adjustment	Quality adjustment	No quality adjustment	Quality adjustment	compen-sation a/	Manufact.	Motor veh.
1990	100.0	100.0	100.0	100.0	100.0	10.8	14.6
1991	95.5	92.2	95.5	93.2	103.9	11.2	15.2
1992	82.9	76.1	69.0	64.5	109.8	11.5	15.5
1993	72.0	61.9	52.1	45.4	112.9	11.7	16.1
1994	70.0	56.5	55.9	47.0	115.5	12.1	17.0
1995	66.5	49.6	58.7	47.6	117.7	12.4	17.3
1996	64.9	44.6	55.1	41.8	120.6	12.8	17.7
1997	61.8	38.2	45.6	30.1	124.5	13.2	18.0
1998	60.1	33.1	45.3	27.5	130.7	13.5	17.8
1999	58.4	28.1	40.0	20.0	136.3	13.9	18.1
2000	56.3	26.0	36.6	17.6	144.0	14.4	18.8
2001	56.3	24.8	30.9	11.2	151.9	14.8	19.4

Sources: United Nations Economic Commission for Europe (UNECE) and the International Federation of Robotics (IFR).

Note: The indices calculated with fixed 1990 US$ conversion can be seen as a general index without any reference to a particular country while the index calculated from current annual $ conversion is only relevant for the United States.

a/ Index of labour compensation in the business sector. Source: OECD.

By looking only at the subset of **robots with 5 axes or more**, the comparability between countries is significantly improved (see table 3). While, for instance, Taiwan, Province of China (1997) installed an estimated 750 new robots, only 14% or 108 were robots with 5 axes or more. In the **United States, Spain** and **Sweden**, on the other hand, **more than 90% of all the new robots installed in 2001 had 5 axes or more**.

Diffusion of service robots

Table 4 gives details about the results of the UNECE/IFR survey of sales of service robots, broken down by application areas. As many companies did not provide market data, the figures reported here probably underestimate significantly the true sales amounts as well as the installed base of robots.