

Executive Summary

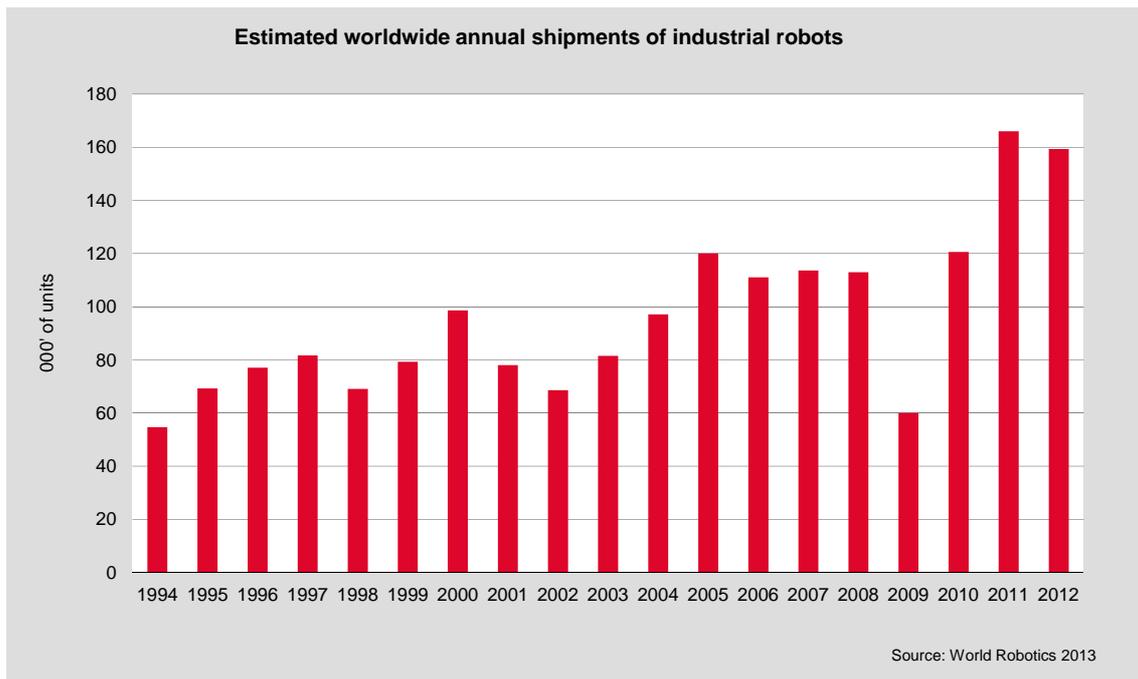
1. World Robotics 2013 Industrial Robots

2. World Robotics 2013 Service Robots

1. World Robotics 2013 Industrial Robots

2012: Second highest number of robots sold in 2012

Robot sales slightly decreased in 2012 by 4% to 159,346 units, the second highest level ever recorded for one year. The decline of robot sales to the electrical electronics industry was the main cause for the slight sales reduction. Sales of industrial robots to the automotive industry continued to increase. The chemical, and the rubber and plastics industries, as well as the food industry, increased their robot orders while the metal and machinery industry slightly reduced them. About 70% of the total robot sales in 2012 went to Japan, China, the United States, Korea and Germany.



In 2012, about 28,100 industrial robots were shipped to the **Americas**, 7% more than in 2011, reaching a new peak level. Since 2010, the modernization of the North American factories and the increase of production capacities in North America and in Brazil, especially by the automotive industry, accelerated the pace of robot installations substantially. **Between 2007 and 2012, the compound annual growth rate (CAGR) of robot supplies to the Americas was about 8% on average.**

In the **United States** robot shipments increased again by 9% to a new peak level of 22,414 units in 2012 compared to 2011. Robots sales already increased substantially in 2010 and 2011. In **Canada**, shipments somewhat decreased by 5% to 1,749 units in 2012. The peak level was about 3,000 units in 2007. Robot shipments to **Mexico** have

been considerably increasing since 2010. In 2012, with 2,106 units a new peak level was reached again. Also Robot sales to **Brazil** continued to increase to a new peak level of more than 1,600 units.

Asia (including Australia and New Zealand) was by far the biggest market with 84,645 industrial robots sold, 5% lower than in 2011. After the strong increase of 132% in 2010, sales of industrial robots again rose, by 27%, to a new peak of about 88,700 units in 2011. **Between 2007 and 2012, the compound annual growth rate (CAGR) of robot supplies to Asia/Australia was about 8% on average. With Japan excluded, the CAGR was about 20%.**

In 2012, **Japan** was again the biggest robot market in the world. robot sales continued to increase slightly to 28,700 units. The electronics industry reduced robot investments considerably, while the automotive industry continued to increase robot orders by 31%. Although robot sales to the **People's Republic of China** only slightly increased in 2012 to about 23,000 units, it is the most rapidly growing market in the world. Between 2005 and 2012, sales of industrial robots have increased by about 25% on average per year. China was the second largest destination for industrial robots in 2012. The reported robot supply of 23,000 units includes all the imported robots but does not include sales of the Chinese manufactured robots as well as Foxbot robots manufactured by Foxconn Electronics (Taiwanese enterprise Hon Hai Precision Industry). In 2012, robot supplies to the **Republic of Korea** decreased by almost 24% to 19,400 units following the strong investments of the electronics industry and the automotive industry in 2010 and 2011. **Thailand** is one of the rapidly growing robot markets in Asia. In 2012, the supply of industrial robots again peaked to about 4,000 units. Robot sales to **India** stagnated. The substantial increase of robot sales to **Australia** to about 1,200 units was the result of investments of the automotive industry.

About 41,200 industrial robots were sold in **Europe** in 2012, 6% less than in 2011, the second highest level ever recorded. Sales hit a new peak in 2011 with about 43,800 units. After substantial investments of the automotive industry in 2011 robot installations in this sector was somewhat reduced, while almost all the other industries continued purchasing robots. **Between 2007 and 2012 the compound annual growth rate (CAGR) of robot supplies to Europe was about 3% on average.**

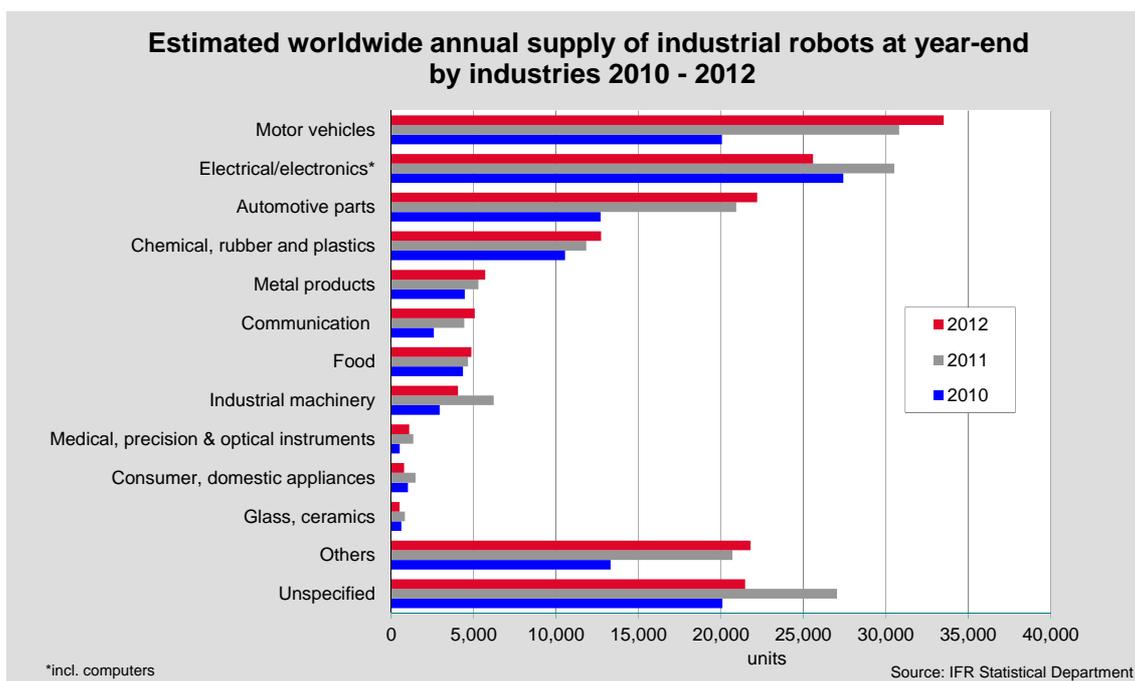
In 2012, robot sales to **Germany** – by far the largest robot market in Europe - were 10% lower than the all-time-high level of 2011. About 17,500 units were sold in 2012, which is the second highest number ever recorded for one year. Since 2010, the automotive industry was the driver of an almost unlimited growth of robot installations in Germany. In 2012, the automotive industry reduced its investments in industrial robots while the General Industry ordered more. However, sales to the General Industry did not reach the peak level of 2008. In 2012, total sales of industrial robots to **Italy** were down by 14%, to 4,402 units after a substantial recovery in 2010 and a further increase in 2011. The automotive industry considerably reduced robot investments while the rubber and plastics industry, the industrial machinery industry, the basic metals industry, the electrical/electronics industry and the pharmaceutical industry increased robot installations in 2012. The robot supply to Italy decreased between 2008 and 2012 by about 2% on average per year (CAGR). In 2012, robot sales to **France** slightly decreased by 3% to 2,956 industrial robots from 3,058 units in 2011. The robot supply to the automotive industry stagnated while almost all other industries increased robot investments. In 2012, sales of industrial robots to the **United Kingdom** almost doubled to 2,943 units, by far the highest level ever recorded. The United Kingdom became the fourth largest robot market almost as high as France. Since 2010, robot sales have been surging due to the restart of investments of the automotive industry. In 2012, sales of industrial robots to **Spain** slumped by 35% to about 2,000 units compared to 2011. Robot sales to the **Czech Republic** decreased to

about 1,000 units after considerable investments in 2011. Robot sales to all other **Central/Eastern European** countries slightly decreased. Those to **Turkey** continued to increase in 2012 to almost 1,000 units, a new peak level.

Continued increase of robot sales to the automotive industry

Since 2010, the **automotive industry** – the most important customer of industrial robots – has considerably increased investments in industrial robots worldwide. Between 2006 and 2009, installations were continuously reduced. About 63,200 new robots, 6% more than in 2011, were installed in 2012 establishing again a new peak. The share of the total supply was about 40%. Between 2009 – when robot installations hit rock bottom – and 2011, robot sales to the automotive industry surged from 19,300 units to 59,700 units. With regard to Australia, China, India, Thailand, Taiwan and other Asian countries, the data concerning the distribution of robots according to various industries is not complete. But, considering that most of these countries are emerging markets with regard to the automotive industry, the real share of robot supplies to the automotive industry is probably even higher.

The **electrical/electronics industry** (including computers and equipment, radio, TV and communication devices and equipment and medical, precision and optical instruments) reduced robot orders by 13% to 32,700 units in 2012. This was the second highest level following 2011 (37,750 units). The share of the total supply in 2012 was about 21%. In 2010, the worldwide shipments of industrial robots almost tripled to about 31,500 units, up from 10,900 units in 2009.



The **rubber and plastics industry** has continuously increased the number of robot installations since 2009 from about 5,800 units to 11,400 units in 2012. However, this is still far below the peak of almost 15,000 units which was reached in 2006 and 2007. The **food and beverage industry** increased robot orders by 4% to almost 4,900 units, accounting for a share of 3% of the total supply. Sales have been continuously increasing, except in 2009.

In 2012, sales to the **metal and machinery industry** declined by 3% to about 13,700 units, accounting for a share of almost 9% of the total supply. In 2009, sales dropped to

about 5,250 units. In 2010, sales started to recover considerably, and gained further momentum in 2011.

Sales to **all industries, except for automotive and electrical/electronics**, slightly increased by 1% in 2012. The robot suppliers have been reporting a considerable increase in the number of customers in the past years. However, the number of units ordered by these customers is often very small.

Worldwide operational stock of industrial robots increased again considerably in 2012

Total accumulated sales, measured since the introduction of industrial robots at the end of the 1960s, amounted to about **2,470,000 units** by the **end of 2012**. These units include the dedicated industrial robots installed in Japan up to and including 2000 (see the tables in annex A). Most of the early robots, however, have by now been taken out of service. Based on the assumptions made in chapter 1, the IFR estimates:

**the total worldwide stock of operational industrial robots
at the end of 2012 was in the range of 1,235,000
and 1,500,000 units.**

The minimum figure above is based, as was discussed in chapter 1, 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 of an industrial robot might in fact be as long as **15 years**, which would then result in a **worldwide stock of 1,500,000 units**.

In 2012, the minimum stock considerably increased by 7%. Due to the tremendous decrease of robot installations in 2009, for the first time the minimum stock of 1,021,000 units in 2009 was about 1% lower than the stock of the year before. In 2010, the stock increased by 1% to the level of 2008. Since then, the stock has been increasing considerably.

Value of the market was up to US\$8.5 billion

In 2012, the sales value increased by 2% to US\$8.7 billion to a new peak, while unit sales decreased by 4%. It should be noted that the figures cited above generally do not include the cost of software, peripherals and systems engineering. Including the mentioned costs might result in the actual robotic systems market value to be about three times as high. The worldwide market value for robot systems in 2012 is therefore estimated to be \$26 billion.

High potential for robot installations in many countries

When comparing the distribution of multipurpose industrial robots in various countries, the robot stock, expressed in the total number of units, can sometimes be a misleading measure. In order to take into account the differences in the size of the manufacturing industry in various countries, it is preferable to use a measure of robot density. One such measure of robot density is the number of multipurpose industrial robots per 10,000 persons employed in manufacturing industry or in the automotive industry or in the “general industry” (which is all industries excluding the automotive industry).

In 2012, the **Republic of Korea again reached the highest robot density in the world**. Per 10,000 employees, 396 industrial robots were in operation. The reason is the continued large volume of robot installations in the recent years. The robot density in Japan stagnated at 332 units and in Germany it continued to increase to 273 units. 11 countries of the 45 surveyed countries have a robot density between 103 (Canada) and 164 (Sweden), 6 countries from 60 (Czech Republic) to 84 (Netherlands). The

robot density of all other countries, particularly the emerging markets, have robot densities below the world average. The average robot density in the world was about 58 robots per 10,000 employees in 2012. Thereof, 80 units are in Europe, 68 in the Americas and 47 units are in Asia.

The considerable high rate of automation of the automotive industry compared to all other sectors is demonstrated in the evaluation of the number of industrial robots in operation per 10,000 employees in automotive industry and in all other industries. **Japan** has by far the highest robot density in the automotive industry. 1,562 industrial robots are installed per 10,000 persons employed in the automotive industry, and 219 are installed in all other industries. The robot density of the automotive industry declined to 1,137 units in 2012 in **France**¹. In **Germany** 1,133 robots per 10,000 employees were installed in the automotive industry in 2012. In all other German industries the robot density continued to increase to 147 units, which is significant compared to the other countries. Only Japan and the Republic of Korea had a higher robot density rate, 219 and 302 units respectively. In both countries, these higher rates are mainly due to robot installations in the electronics industry. The comparatively high rate in Germany is due to a more diversified distribution of industrial robots in all industries, especially the metal, the chemical, and the food industries, as well as in the electronics industry.

Regarding the robot density in the automotive industry, **the United States** ranked fourth with a robot density of 1,091 units, but only 76 units were installed in all the other sectors per 10,000 employees. The robot density has been decreasing in **Italy** since 2010 and reached 1,090 units in 2012. In other sectors the robot density stagnated at 115 robots operating per 10,000 employees in 2012.

In **China**, the huge amount of robot investments in the recent years resulted in a substantial increase in the robot density of the automotive industry. Between 2006 and 2012, it was up from 51 to 213 robots per 10,000 employees. All other sectors also increased the number of robot installations, but the robot density rate was only about 11 robots per 10,000 employees. The potential for robot installations in this market is still tremendous.

The overall conclusion indicates that in almost all the surveyed countries, the potential for robot installations in the non-automotive industries is still tremendous, but it is also considerably high in the automotive industry among the emerging markets and in some traditional markets as well. This is mostly due to the necessary modernization and retooling that is needed in these markets.

Continued increase between 2013 and 2016

In 2013, global robot sales will increase by about 2% to 162,000 units. The demand will vary among the regions and the industries. The demand of the automotive industry will start to slow down in certain markets after three years of continued increasing robot installations in the traditional as well as the emerging markets. The electrical/electronics industry will increase robot investments in production automation as well as in retooling for new production processes. A further increase of robot orders from other industries is also expected, particularly from the pharmaceutical industry, the food and beverage industry, and the metal and machinery industry. Continued growth of robot sales is expected in North America, Brazil, the Republic of Korea, China, in most of all other South East Asian markets as well as in most of the Central and Eastern European markets, and in Turkey. Robot sales to

¹ Employment data of the automotive industry has been revised back to 2005 according to the OECD Stan data excluding employment in other transport equipment sectors such as aircraft, ships and locomotives.

Japan will decrease due to the continuing weak economic position of its electrical/electronics industry. Also in Germany a decrease in robot sales is likely. After the significant robot investments of the automotive industry over the past three years, it is likely that the industry will reduce the volume of robot orders in Germany. The United Kingdom is in a similar situation and will also have a reduction in robot installations in 2013. Due to the continuing tight economic situation, robot sales will either decrease or stagnate in Italy, France and Spain. Robot supplies to the Americas will increase by 9% and to Asia/Australia by 2%, while robot sales to Europe will decrease by 6%. However due to the more complex robot systems entering the market, the increase in turnover might be higher, just as in 2011 and 2012.

From 2014 to 2016, robot installations are estimated to increase by 6% on average per year (CAGR): about 4% in the Americas and in Europe, and about 8% in Asia/Australia. The trend towards automation continues to increase the volume of robot installations. But, the rate of increase in robot sales will be more moderate. The robotics industry is looking into a bright future:

- Global competition requires modernisation of production facilities.
- Energy-efficiency and new materials, e.g. carbon-composites, require retooling of production.
- Growing consumer markets require expansion of production capacities.
- Decreasing life-cycles of products and increasing variety of products require flexible automation.
- Technical improvements of industrial robots will increase the use of robots in the general industry and in small and medium sized companies, e.g. easier to use robots, uncomplicated, low priced robots for simple applications, collaboration of robots with human workers.
- Improved quality requires sophisticated high tech robot systems.
- Robots improve the quality of work by taking over dangerous, tedious and dirty jobs that are not possible or safe for humans to perform.

Impulses will mainly come from the emerging markets and from the United States. The automotive industry will continue to be the innovator for new technology. However, a cyclical decrease of investments of the automotive industry is likely to take place between 2014 and 2015. But in 2016 at the latest, investments in retooling of production sites for new car models will also push robot installations in the traditional markets. The growing global demand for electronic products, new products, and new production technologies are boosting investments in retooling of existing production processes and expanding production capacities of the electrical/electronics industry particularly in Asia. More details are provided in Table 1 and 2; figure 1 and 2.

Certain risks are involved with regard to this rather optimistic forecast: Continuing financial problems of the major markets, new environmental regulations and governmental measures to reduce growth in China may result in restrained investments. However, investments in automation are necessary and are deemed to continue, perhaps at a later point.

Table 1

Estimated yearly shipments of multipurpose industrial robots in selected countries. Number of units

Country	2011	2012	2013*	2016*
America	26,227	28,137	30,800	34,900
Brazil	1,440	1,645	2,000	3,500
North America (Canada, Mexico, USA)	24,341	26,269	28,500	31,000
Other America	446	223	300	400
Asia/Australia	88,698	84,645	86,000	107,200
China	22,577	22,987	25,000	38,000
India	1,547	1,508	1,500	3,000
Japan	27,894	28,680	27,200	32,000
Republic of Korea	25,536	19,424	20,500	19,500
Taiwan	3,688	3,368	4,000	4,500
Thailand	3,453	4,028	3,500	5,000
other Asia/Australia	4,003	4,650	4,300	5,200
Europe	43,826	41,218	39,800	45,000
Czech Rep.	1,618	1,040	1,000	1,500
France	3,058	2,956	2,900	3,200
Germany	19,533	17,528	16,500	18,000
Italy	5,091	4,402	4,200	4,500
Spain	3,091	2,005	2,000	2,500
United Kingdom	1,514	2,943	2,000	2,600
other Europe	9,921	10,344	11,200	12,700
Africa	323	393	500	700
not specified by countries**	6,954	4,953	4,900	4,000
Total	166,028	159,346	162,000	191,800

Sources: IFR, national robot associations.

*forecast

** reported and estimated sales which could not be specified by countries

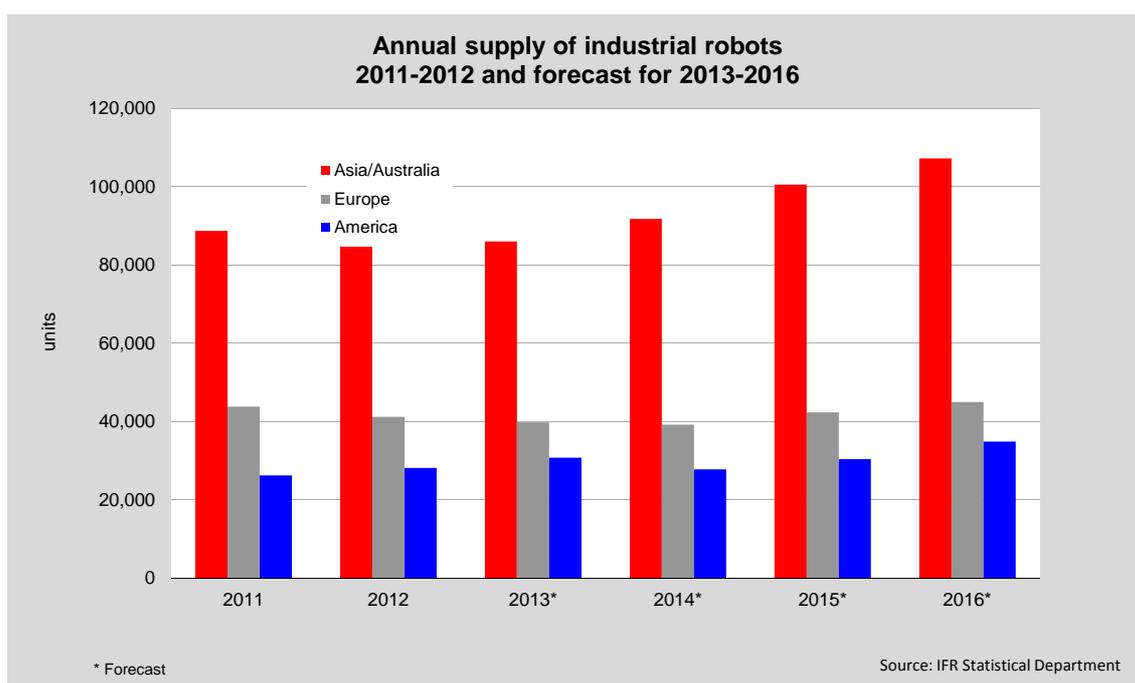


Table 2

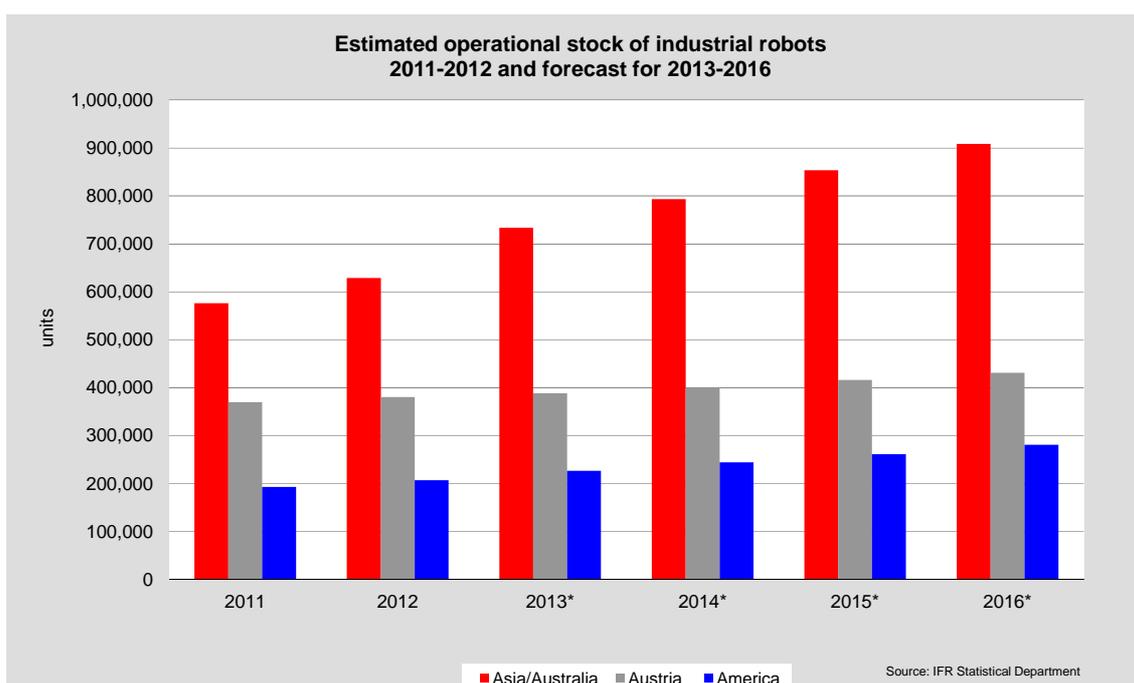
Estimated operational stock of multipurpose industrial robots at year-end in selected countries. Number of units

Country	2011	2012	2013*	2016*
America	192,966	207,017	226,550	281,000
Brazil	6,971	7,576	9,170	17,400
North America (Canada, Mexico, USA)	184,679	197,962	215,650	260,800
Other America	1,316	1,479	1,730	2,800
Asia/Australia	576,545	628,889	733,500	908,500
China	74,317	96,924	121,200	215,800
India	6,352	7,840	9,300	16,300
Japan	307,201	310,508	309,400	312,900
Republic of Korea	124,190	138,883	155,300	201,700
Taiwan	29,837	32,455	35,800	43,000
Thailand	13,088	17,116	20,600	32,600
other Asia/Australia	21,560	25,163	81,900	86,200
Europe	369,965	380,546	388,800	431,700
Czech Rep.	5,890	6,830	7,800	11,000
France	34,461	33,624	33,000	33,200
Germany	157,241	161,988	165,800	177,900
Italy	62,245	60,750	58,600	55,400
Spain	29,847	28,911	27,300	27,100
United Kingdom	13,641	15,046	15,500	20,000
other Europe	66,640	73,397	80,800	107,100
Africa	2,495	2,858	3,300	4,900
not specified by countries**	11,126	16,079	20,850	33,400
Total	1,153,097	1,235,389	1,373,000	1,659,500

Sources: IFR, national robot associations.

*forecast

** reported and estimated sales which could not be specified by countries



2. World Robotics 2013 Service Robots

The total number of professional service robots sold in 2012 rose by a relatively low 2% compared to 2011 to 16,067 units up from 15,776 in 2011. The sales value slightly decreased by 1% to US\$ 3.42 billion. Since 1998, a total of more than 126,000 service robots for professional use have been counted in these statistics. It is not possible to estimate how many of these robots are still in operation due to the diversity of these products resulting in varying utilization times. Some robots (e.g. underwater robots) might be more than 10 years in operation (compared to an average of 8 years in industrial robotics). Others like defence robots may only serve for a short time.

With about 6,200 units, service robots in defence applications accounted for almost 40% of the total number of service robots for professional use sold in 2012. Thereof, unmanned aerial vehicles seem to be the most important application as their sales increased by 8% to 5,453 units. However, the true number of these robots as well as the value might be much higher. The total number of field robots sold in 2012 was about 5,300 units, accounting for a share of 33% of the total unit supply of professional service robots. The sales value of field robots decreased by 4% to US \$847 million, accounting for about 25% of the total value of professional service robot sales.

Sales of medical robots increased by 20% compared to 2011 to 1,308 units in 2012, accounting for a share of 8% of the total unit sales of professional service robots. The most important applications are robot assisted surgery and therapy with 1,053 units sold in 2012, 6% more than in 2011. The total value of sales of medical robots increased to US\$ 1,495 million, accounting for 44% of the total sales value of the professional service robots. Medical robots are the most valuable service robots with an average unit price of about US\$ 1.5 million, including accessories and services. Therefore, suppliers of medical robots also provide leasing contracts for their robots.

Due to more companies reporting their data and thus better information coverage, the data for logistics systems were revised. 1,376 logistic systems were installed in 2012, 11% more than in 2011 (revised data: 1,235 logistic systems), accounting for 9% of the total sales of professional service robots. 796 automated guided vehicles in manufacturing environments and 557 in non-manufacturing environments are building up an increase of 11% compared to automated guided vehicles sales numbers in 2011. Despite the improvement of the data base, it is assumed that the actual number of newly deployed systems is far higher. The value of sales of logistic systems is estimated at about US\$ 196 million. Medical robots as well as logistic systems are well established service robots with a considerable growth potential.

Other professional service robots with lower units sales are construction and demolition systems, robots for professional cleaning, inspection and maintenance systems, rescue and security robots, mobile robot platforms and underwater systems. Underwater systems are among the most valuable professional service robots with a unit price of about one million US\$.

In 2012, about 3 million service robots for personal and domestic use were sold, 20% more than in 2011. The value of sales increased to US\$1.2 billion.

Service robots for personal and domestic use are recorded separately, as their unit value is generally only a fraction of that of many types of service robots for professional use. They are also produced for a mass market with completely different pricing and marketing channels.

So far, service robots for personal and domestic use are mainly in the areas of domestic (household) robots, which include vacuum and floor cleaning, lawn-mowing

robots, and entertainment and leisure robots, including toy robots, hobby systems, education and research.

Handicap assistance robots have not taken off to the anticipated degree in the past few years. In 2012, 159 robots were sold, up from 156 in 2011. This is still quite a low number but the prospects are promising. A lot of national research projects in many countries concentrate on this huge future market for service robots. In contrast to the household and entertainment robots, these robots are high-tech products.

The market of robots for personal transportation could not be surveyed sufficiently because the available information was very poor. However, this market as well as home security and surveillance robots will gain importance in the future.

In 2012, it was estimated that 1.96 million domestic robots, including all types, were sold. The actual number might, however, be significantly higher, as the IFR survey is far from having full coverage in this domain. The value was about US\$ 697 million. Compared to 2011 this represents an increase of 53%.

As for entertainment robots, about 1.1 Mio units were counted in 2012, 29% more than in 2011. Numerous companies, especially Asian ones, offer low-priced "toy robots". But among those mass products there are increasingly more sophisticated products for the home entertainment market. Since many years, the LEGO® Mindstorms® programme has belonged to the more high quality products. The total value of the 2012 sales of entertainment robots amounted to US\$ 524 million.

Projections for the period 2013-2016:

About 94,800 new service robots for professional use to be installed

Turning to the projections for the period 2013-2016, sales forecast indicate an increase to about 94,800 units with a value of US\$ 17.1 billion.

Thereof, about 28,000 robots for defence applications will be sold in the period 2013-2016. They are followed by milking robots with about 24,500 units. This is probably a rather conservative estimate. These two service robot groups make up 55% of the total forecast of service robots at the current time.

Projections for the period 2013-2016:

About 22 million units of service robots for personal use to be sold

It is projected that sales of all types of robots for domestic tasks (vacuum cleaning, lawn-mowing, window cleaning and other types) could reach almost 15.5 million units in the period 2013-2016, with an estimated value of US\$ 5.6 billion.

The size of the market for toy robots and hobby systems is forecast at about 3.5 million units, most of which for obvious reasons are very low-priced.

About 3 million robots for education and research are expected to be sold in the period 2013-2016.

Sales of robots for elderly and handicap assistance will be about 6,400 units in the period of 2013-2016. This market will increase substantially within the next 20 years.

