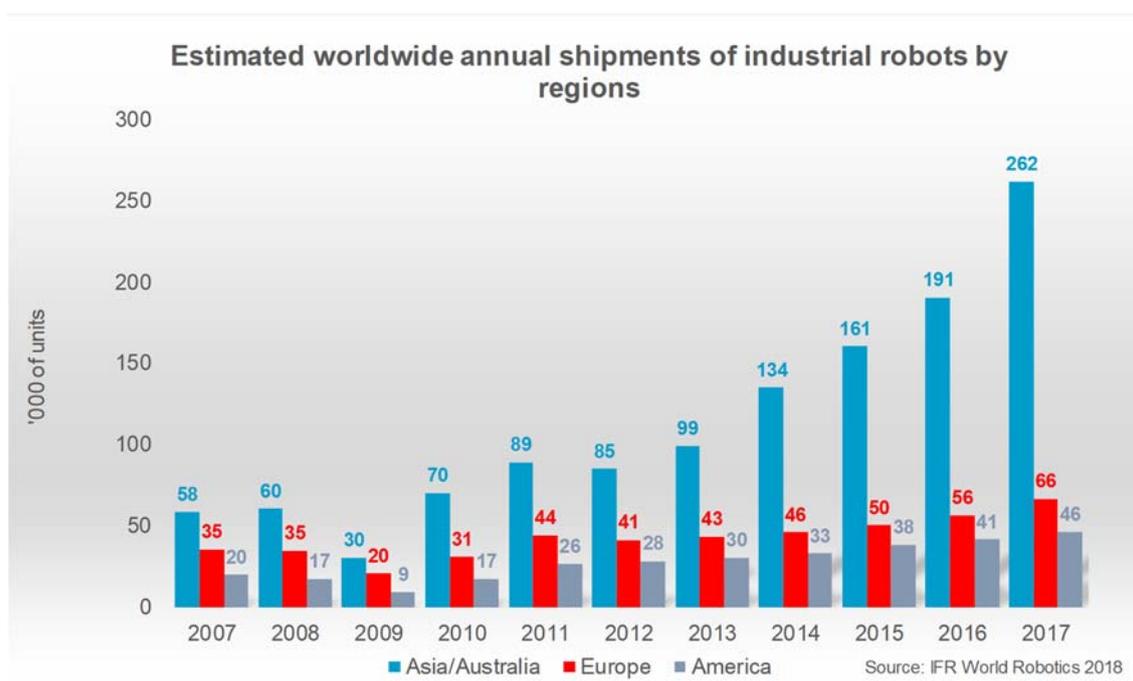


Executive Summary World Robotics 2018 Industrial Robots

Robot Sales 2017: Impressive growth

In 2017, robot sales increased by 30% to 381,335 units, a new peak for the fifth year in a row. The main drivers of this exceptional growth in 2017 were the metal industry (+55%) and electrical/electronics industry (+33%). Robot sales in the automotive industry increased by 22% and remained still the major customer of industrial robots with a share of 33% of the total supply in 2017. The electrical/electronics industry has been catching up, especially since 2015. In 2017, it reached almost the same share of total supply (32%). The electrical/electronics industry became the most important customer in almost all major Asian markets, e.g. China, Japan, Republic of Korea, already in 2016.

Since 2010, the demand for industrial robots has accelerated considerably due to the ongoing trend toward automation and continued innovative technical improvements in industrial robots. Between 2012 and 2017, the average robot sales increase was at 19% per year (CAGR). The number of robot installations had never increased so strongly before. Between 2005 and 2008, the average annual number of robots sold was about 115,000 units. 2009 however, was not an ordinary year because of the global economic and financial crisis which caused an exceptional plunge in robot sales that year. In 2010, investments which had been restrained in 2009 were the main driver of the significant increase in robot sales. Between 2011 and 2017, the average annual supply doubled to about 236,000 units compared to the average annual supply between 2005 and 2008. In the past three years (2015-2017) the average annual increase was about 310,000 units. This is a clear indication of the tremendous, accelerating rise in demand for industrial robots worldwide.



Continued considerable increase in all regions

Asia¹ is still the world's strongest growth market. With a total of about 261,800 units sold in 2017, a rise of 37% more than the global sales volume of 2015 (253,300) was reached in this region. This was the highest sales level ever recorded for the fifth year in a row. Between 2012 and 2017, robot installations rose by an average annual rate of 25%. Industrial robot sales in the second largest market, **Europe**, increased by 18% to almost 66,300 units (a new peak, for the fifth year in a row) and an annual average increase rate of 10% between 2012 and 2017, like in the **Americas**. About 46,100 industrial robots were shipped to the Americas, 12% more than in 2016, establishing a new peak for the sixth year in a row.

73% of the global robot sales in five countries

There are five major markets representing 73% of the total global sales volume in 2017: **China, Japan, the Republic of Korea, the United States and Germany**. Since 2013 China has been the biggest robot market in the world with a continued dynamic growth.

China has significantly expanded its leading position as the biggest market with a share of 36% of the total supply in 2017 (30% in 2016). About 137,900 industrial robots were sold to China in 2017, 59% more than in 2016. This was considerably more than the total sales volume of Europe and the Americas together (112,400 units). About 34,700 units of robots were sold by Chinese robot manufacturers in China according to the information from the China Robot Industry Alliance (CRIA). Their sales volume was about 29% higher than in 2016 (27,000 units). Foreign robot suppliers increased their sales by 72% to 103,200 units, including robots produced locally by the international robot suppliers in China. This is the first time that the foreign robot suppliers have a higher growth rate than the local ones. The market share of the Chinese robot suppliers decreased from 31% in 2016 to 25% in 2017. (For more details see chapter 3.3.1.)

In 2017, robot sales in **Japan** increased by 18% to 45,566 units, representing the second highest value ever observed for this country. Only in the year 2000 a higher value (46,986 units) was recorded. Main driver of the growth in 2017 was the electrical/electronics industry, while the automotive industry remained at previous year's level. Between 2012 and 2017, robot sales increased by 10% on average per year (CAGR). (For more details see chapter 3.3.4.)

Robot supplies in the **Republic of Korea** decreased by 4% to 39,732 units in 2017. The year before, industrial robot installations peaked at 41,373 units. The main driver of this development is the electrical/electronics industry that reduced robot installations by 18% in 2017. Between 2012 and 2017, robot sales increased by 15% on average per year (CAGR) in the Republic of Korea. (For more details see chapter 3.3.5.)

Robot installations in the **United States** continued to increase to a new peak in 2017 – for the seventh year in row - (33,192 units), 6% higher than in 2016. Since 2010, the driver of the growth in all manufacturing industries in the U.S. has been the ongoing trend

¹Australia and New Zealand included in the category

to automate production in order to strengthen the US-industries in both domestic and global markets. (For more details see chapter 3.2.2.)

Germany is the fifth largest robot market in the world. In 2017, the number of robots sold increased by 7% to 21,404 units - a new peak - compared to 2016 (20,074 units). Between 2014 and 2016, annual sales of industrial robots stagnated at around 20,000 units. (For more details see chapter 3.4.11.)

Other important Asian markets

Since 2013, **Taiwan** has ranked sixth among the most important robot markets in the world regarding the annual supply. Robot installations increased considerably between 2012 and 2017, by 26% on average per year (CAGR). In 2017, robot sales surged by even 44% to about 10,900 units, a new peak. In 2017, **Vietnam** became the seventh largest robot market in the world. Robot sales jumped from about 1,600 units in 2016 to almost 8,300 units in 2017. The driver of the growth was the electrical/electronic industry. The electronics industry is also responsible for the significant increase of robot sales in **Singapore** in 2017, +72% to about 4,500 units. After decreasing in recent years, robot sales in **Thailand** were up by 28% to 3,400 units in 2017. Robot installations increased by 30% to a new peak of about 3,400 units in **India**, the same level as in Thailand. (For more details see chapter 3.3.)

Other important European markets

Robot investments increased by 19% to a new record of 7,700 units in **Italy**. The **French** robot market was up by 16% to a new peak level of about 4,900 units. In **Spain**, sales of industrial robots further increased to a new peak of 4,200 units. Sales of Robot installations in **all other Western European** countries rose, except in Austria and Portugal. **Nordic countries** saw a decrease. Sales in most **Central and Eastern European** markets increased considerably, except in the Romania and Slovakia. Sales in Turkey continued to increase in 2017. (For more details see chapter 3.4.)

Other important markets in the Americas

Mexico has become an important emerging market for industrial robots. Robot sales again reached a new peak, with 6,334 units in 2017, 7% more than in 2016. In **Canada**, robot sales surged by 72% to 4,003 units in 2017, the highest level ever reached. Robot sales in **Brazil** decreased in 2017. (For more details see chapter 3.2.)

Main driver of the growth: electrical/electronics industry

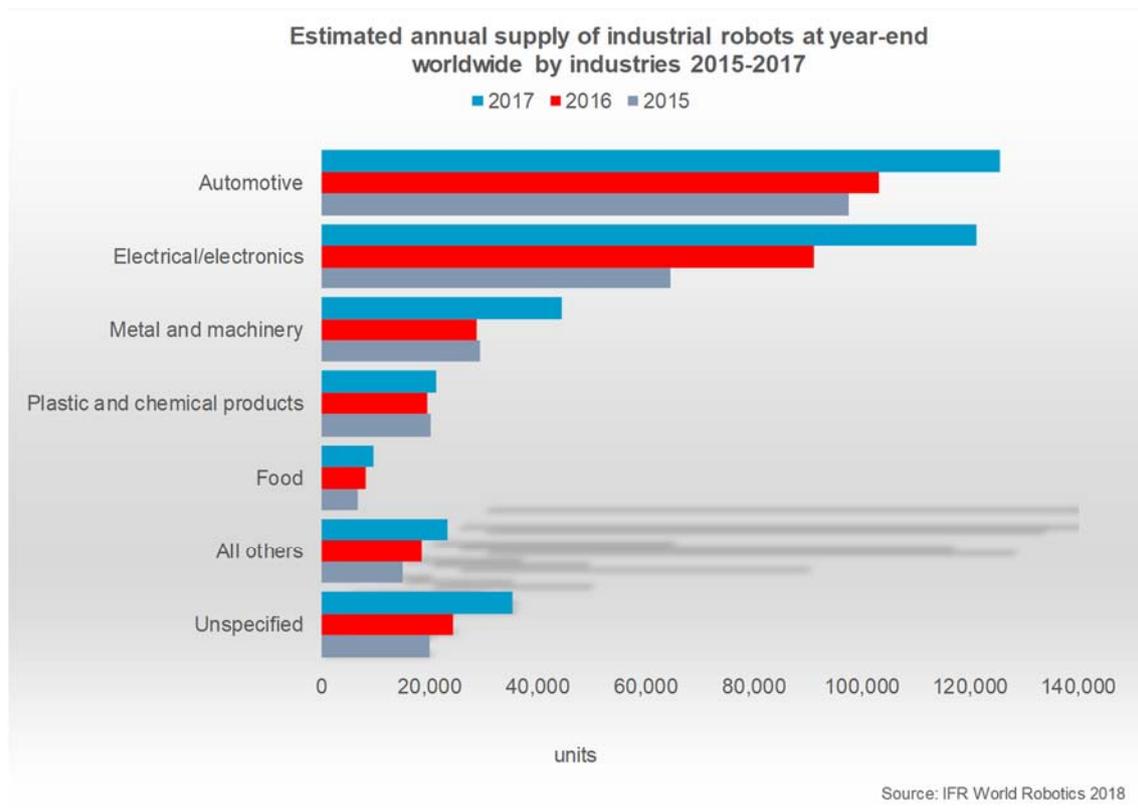
Since 2010, the **automotive industry** –the most important customer of industrial robots– considerably increased investments in industrial robots worldwide. After two years of single-digit growth rates, robot sales increased in 2017 by 22% to a new peak of almost 125,700 units. This is 33% of the total supply. Between 2012 and 2017, robot sales to the automotive industry increased by 14% on average per year (CAGR). After the economic crisis in 2008/2009, car manufacturers started to restructure their businesses. Since 2010, investments in new production capacities in the emerging markets as well as investments in production modernization in major car producing countries have led to a rising number of robot installations. Using new materials, developing energy efficient drive systems, as well as high competition in all major car markets pushed for investments despite the existing overcapacities. The automotive parts suppliers were heavily affected by the restructuring of the car industry after the economic crisis in 2009. The restructuring of the automotive parts suppliers began after the motor vehicle suppliers started to carry out their investment plans. Therefore, the supply of robots to the automotive parts suppliers gained momentum only in 2011.

Robot sales to the **electrical/electronics industry** (including computers and equipment, radio, TV and communication devices, medical equipment, precision and optical instruments) have been significantly up since 2013 and are almost at the same level as the automotive industry. In 2017, sales increased by 33% to a new peak of 121,300 units, accounting for a share of 32% of the total supply in 2017. Between 2012 and 2017, the average annual growth rate was 30%. The rising demand for electronic products and new products, the need to automate production and the increasing need for batteries, chips and displays, were driving factors behind the boost in sales. The production facilities belonging to this industry are mainly located in Asian countries.

The **rubber and plastics industry** has continuously increased the number of robot installations since 2009 from about 5,800 units to the peak value of 17,300 units in 2015. After a setback in 2016 (16,000 units), sales crossed the 17,000-unit mark again in 2017. The industry's share of the total supply in 2017 was below 5%. Between 2012 and 2017, sales were up by 8% on average per year. Robot sales to the **pharmaceutical and cosmetics industry** substantially increased to a new peak of 4,184 units, 24% more than in 2016. This was mainly the result of considerable sales increase in China. Despite the high degree of automation in this industry, the number of industrial robot installations has remained relatively low for many years. The **food and beverage industry** increased robot orders in 2017 by 19% to over 9,700 units, but this is still less than 3% of the total supply. Sales continuously increased between 2010 and 2014 but decreased in 2015. The annual average growth rate between 2012 and 2017 was 15%.

In 2017, sales to the **metal and machinery industry** increased by 55% to a new peak value of 44,536 units. Sales strongly increased in all subcategories (basic metals, metal products, industrial machinery). Between 2012 and 2017, the average annual growth rate was 26%.

Sales to all industries, except for automotive and electrical/electronics, increased by 32% in 2017. Between 2012 and 2017, the average growth rate per year was 18%. This suggests that robot suppliers offer more and more robotics solutions that are not only attractive for the automotive and electrical/electronics industries, but also for other customers in the manufacturing industry.



Continued considerable increase of worldwide operational stock

In 2017 the total worldwide stock of operational industrial robots significantly increased by 15% to 2,097,500 units. Since 2012, the stock has been increasing considerably by 11% on average per year.

Value of the global market was up to US\$ 16.2 billion

In 2017, sales value increased by 21% to a new peak at US\$16.2 billion. It should be noted that the figures cited above generally do not include the cost of software, peripherals and systems engineering. Including these 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 2017 is therefore estimated to be at US\$48 billion.

Robot Density unveils high potential in many countries

The comparison of values for different countries² is a frequent application of the World Robotics Industrial Robots data. Depending on the point in question, the absolute number of units might be a misleading measure when countries have different economic sizes. The economic size varies between countries (cross-sectional) and over time (longitudinal). The absolute number of operating robots by country (operational stock) does not reflect the size of the economy.

It is therefore preferable to use robot density as a standard for comparison. To improve readability, World Robotics Industrial Robots defines robot density as the number of multipurpose industrial robots in operation per 10,000 persons employed. It distinguishes the manufacturing industry, the automotive industry as defined by ISIC revision 4:10-33 and the general industry (manufacturing industry without automotive).

In 2017, the average robot density in the manufacturing industry was 85 robots per 10,000 employees. Europe is the region with the highest robot density with an average value of 106 units. In the Americas, the value is 91 units and in Asia/Australia it is 75 units.

The countries with the highest robot densities by far are the Republic of Korea (710 robots per 10,000 employees) and Singapore (658 robots). The **Republic of Korea** has had by far the highest robot density in the manufacturing industry since 2010. The rate has been increasing from 311 units in 2010 due to continued installation of a large volume of robots since 2010, particularly in the electrical/electronics industry and in the automotive industry. **Singapore** follows due to a very low number of employees in the manufacturing industry - some 240,000 employees according to ILO. About 84% of the robots in Singapore are installed in the electronics industry.

Compared to **Germany** (322 units per 10,000 employees) and **Japan** (308), the gap is remarkable. 2009, Japan had the highest robot density worldwide. But since 2010 the Republic of Korea, since 2015 Singapore, and since 2017 Germany have passed Japan in this respect. Japan's robot density was 331 in 2009 and declined to 301 in 2016.

In 2009, China had 11 units installed per 10,000 employees in the manufacturing sector, so its density increased almost by factor 10 to 97 units per 10,000 employees.

Europe is the region with the highest robot density with an average value of 106 units. In the Americas, the value is 91 units and in Asia/Australia it is 75 units.

The level of automation is generally much higher in the **automotive industry** than in all other sectors. In the **Republic of Korea**, 2,435 industrial robots per 10,000 employees were in operation in 2017. That is twice the value of 2010 (1,239) and by far the highest level ever reached. Since 2014, a significant number of industrial robots have been sold to the automotive industry in the Republic of Korea. Huge projects aimed at

² To improve readability, the word „country“ refers to geographical units in general.

manufacturing batteries for hybrid and electro cars might be the reason for this high increase in robot density.

Canada's robot density increased to 1,354 units per 10,000 employees in the automotive industry in 2017. Note that more precise employment data became available and robot densities were revised for this issue of World Robotics Industrial Robots. The **United States** (1,200), **Germany** (1,162), **Japan** (1,158) and **France** (1,156) also have high robot densities in the automotive industry. **Austria** (1,083) and **Slovenia** (1,075) now join the list of countries that exceed the mark of 1,000 robots per 10,000 employees in 2017. Robot densities in **Spain** (990), **Thailand** (974) and **Taiwan** (940) are also at a high level.

The **robot density in the general industry** (all industries excluding automotive) is still comparatively low. However, countries with an important electronics industry have a higher rate. The **Republic of Korea** is on top with 533 robots installed per 10,000 employees. It is followed by **Japan** with 225 robots, **Germany** with 191 and **Sweden** with 180 units. Germany and Sweden do not have any important production sites regarding the electronics industry. The comparatively high rate in both countries is due to a more diversified distribution of industrial robots in all industries. The increasing automation in the production of electronic devices will push robot installations within the related production hubs, particularly in Asian countries. **Taiwan** ranks fifth with 164 units, **Italy** follows with 160 units. The **United States** and **Austria** share seventh place with 117 units. A number of other European countries, China and Canada have densities between 30 and 90. Most of the emerging robot markets have a robot density below 30.

Overall, in all surveyed countries, the potential for robot installations in the general industry is tremendous. Even in the Republic of Korea, the robot density in the general industry is just about a fifth of the density in the automotive industry. The potential for robot installations is also high in the automotive industry in the emerging markets and in some traditional markets. Moreover, continued necessary modernization and retooling also guarantee further robot investments in already highly automated countries. Some shifts between countries may occur if production is relocated abroad, but this will hardly affect overall robot investments.

Bright and challenging prospects for industrial robot installations:

- Energy-efficiency and using new materials require continuous retooling of production.
- Rapid production and delivery of customised products at competitive prices are main incentives to automate production.
- Automation enables manufacturers to keep or to relocate production in developed economies without sacrificing cost efficiency.
- Localization and regionalization of production will increase to respond swiftly to customer demands in local markets, shorten production lead time and reduce logistical and political risks.
- The digitalization of production (Industry 4.0), linking the real-life factory with virtual reality, will continue to play an increasingly important role in global manufacturing.
- The range of industrial robots continues to expand – from traditional caged robots capable of handling all payloads, fast and precise, to newer collaborative robots that can work safely alongside humans, and robots that can be fully integrated into workbenches.
- Robots work around the clock with a consistent standard of quality and perform an increasing range of so-called 3D (dull, dirty and dangerous) tasks, improving workers' health, safety and job satisfaction. Robot adoption can enable workers to move on to higher-skilled tasks such as production planning and supervision.
- Ease of programming - ready to use applications are getting more popular with the customers.
- Ease of integration /plug and play - it is becoming easier to link robots into manufacturing production systems, with wide-ranging benefits for process optimization.
- Self-optimization: robots can increasingly adjust their parameters to adapt to real-time conditions, reducing the risk of defects and enabling manufacturers to improve process quality.
- Cloud Robotics – Storing data from multiple robots performing the same process in the cloud provides a storage of data on which to apply machine learning to optimise robots' performance.
- Global competition requires continuous modernization of production facilities.
- Growing consumer markets require expansion of production capacities.
- Continued, strong demand from the automotive industry – investments in eco-friendly driving systems.
- Increasing demand from the electrical/electronics industry.
- Increasing demand from the metal and machinery industry, the rubber and plastics industry, and the food and beverage industry.
- China will remain the main driver of the growth but with lower growth rates than in 2017 (+59%).
- Continued, considerable increase of robot installations in all other growing Asian robot markets, e.g. India, Taiwan and other Southeast Asian markets.
- Continued increase in Japan and in the Republic of Korea.
- Continued increase in North America after a slight decrease in 2018. General industry is catching up with the automotive industry.

- Continued, significant growth of robot sales in Central and Eastern Europe.
- Continued growth of robot sales in Western Europe.

Robot sales are estimated to increase by 10% in 2018 to about 415,700 units. Sales to Europe will increase by 7% in 2018, by 14% in Asia and will decrease slightly, by 4% in the Americas. Growth rates will accelerate between 2019 and 2021 to 14% on average per year, in Europe by 10%, in the Americas by 13% and in Asia by 16%.

Between 2018 and 2021, it is estimated that almost 2.1 million new industrial robots will be installed in factories around the world.

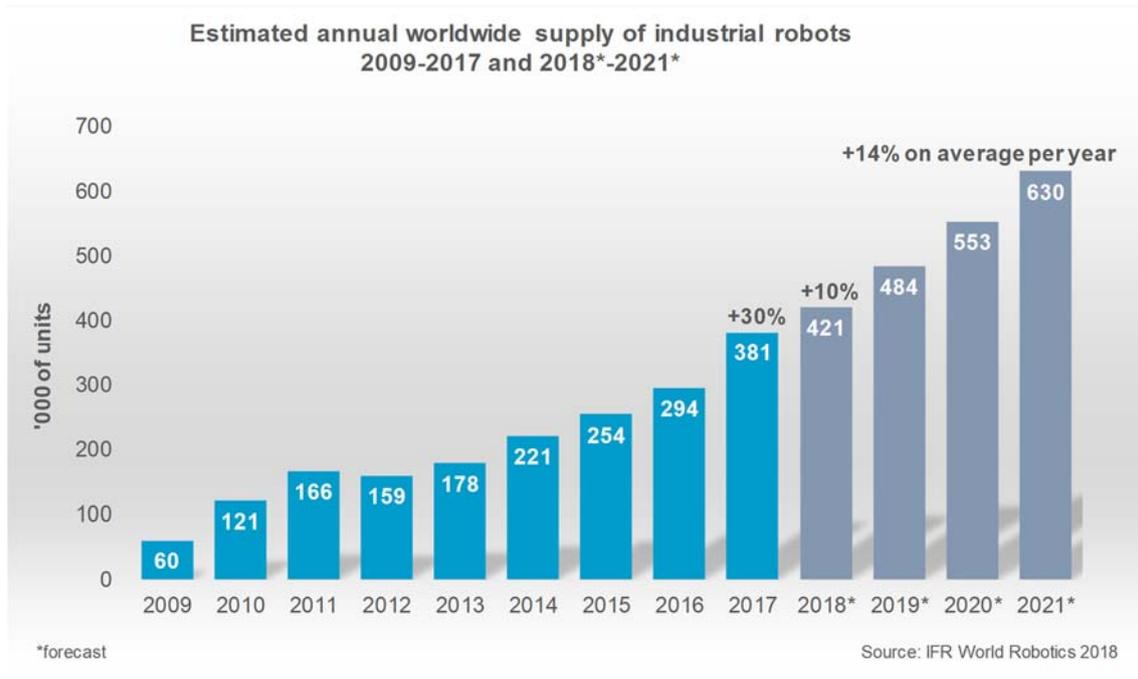
Estimated annual shipments of multipurpose industrial robots in selected countries.
Number of units

Country	2016	2017	2018*	2019*	2020*	2021*	2018/ 2017	CAGR 2019 - 2021
America	41,295	46,118	44,300	48,900	55,600	63,500	-4%	13%
North America	39,671	43,529	43,000	47,500	54,000	61,500	-1%	13%
- United States	31,404	33,192	35,000	37,500	41,000	46,000	5%	10%
- Canada	2,334	4,003	3,500	4,000	5,500	6,500	-13%	23%
- Mexico	5,933	6,334	4,500	6,000	7,500	9,000	-29%	26%
Brazil	1,207	961	900	900	1,000	1,200	-6%	10%
Rest of South America	394	300	400	500	600	800	33%	26%
America unspecified**	23	1,328						
Asia/Australia	190,542	261,826	298,150	351,250	405,400	462,600	14%	16%
China	87,000	137,920	165,000	210,000	250,000	290,000	20%	21%
India	2,627	3,412	4,500	5,000	6,000	7,500	32%	19%
Japan	38,586	45,566	54,000	56,000	59,000	64,000	19%	6%
Republic of Korea	41,373	39,732	41,000	42,000	44,500	46,000	3%	4%
Taiwan, Province of China	7,569	10,904	13,000	14,000	17,000	20,000	19%	15%
Thailand	2,646	3,386	4,000	5,000	6,000	7,000	18%	21%
Vietnam	1,618	8,252	2,500	3,000	4,500	7,000	-70%	41%
other Asia/Australia	9,123	12,654	14,150	16,250	18,400	21,100	12%	14%
Europe	56,078	66,259	70,950	75,250	82,500	93,600	7%	10%
Central/Eastern Europe	7,758	10,538	13,500	16,500	19,750	24,300	28%	22%
France	4,232	4,897	5,200	5,600	6,000	6,500	6%	8%
Germany	20,074	21,404	22,500	23,500	25,000	26,000	5%	5%
Italy	6,465	7,713	9,000	9,000	9,500	10,500	17%	5%
Spain	3,919	4,180	4,700	4,600	5,100	6,500	12%	11%
United Kingdom	1,787	2,334	2,400	2,200	2,300	2,600	3%	3%
Rest of Europe	11,706	12,133	12,850	13,300	14,350	16,600	6%	9%
Europe unspecified**	137	3,060	800	550	500	600	-74%	-9%
Africa	879	451	500	600	700	800	11%	17%
not specified by countries**	5,553	6,681	7,100	8,000	8,800	9,500	6%	10%
TOTAL	294,347	381,335	421,000	484,000	553,000	630,000	10%	14%

Sources: IFR, national associations

*forecast

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



In 2017, the global operational stock of industrial robots grew by 15%. Given the forecast on robot installations, this growth rate will prevail in 2018. In the following years, growth of operational stock will slightly accelerate and is expected to be around 16% on average per year until 2021. After crossing the mark of two million units in 2017, the operational stock will reach the level of three million units in 2020 and approach 3.8 million units in 2021. This overall trend is mainly attributed to Asia, where the operational stock is expected to grow by 19% in 2018 and at an annual average rate of 20% until 2021. In Europe, as in America, the operational stock is expected to grow by 8% in 2018. Until 2021, the annual average growth forecast for Europe is 9% and for America it is 10%.

