

Status and trends in the development of the industrial robots market

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Abstract: Industrial robots are one of the main driving forces of the fourth industrial revolution and one of the most promising technologies for increasing the degree of automation in modern production. Since their entry into mass industrial production in the 1960s, they have evolved significantly, and today they are being implemented in the construction of high-tech smart manufacturing enterprises. With the development of technique and technology, industrial robots are becoming more productive, flexible, versatile, safe and easy to use, revealing new possibilities for modern industrial ecosystems. As a key tool for improving efficiency and productivity, they enter a number of sectors such as automotive, mechanical engineering, energy, electronic production, food industry, space sector, defense, etc.

The purpose of this report is to present the status and trends in the development of robotics and its spread among the industrial sectors of the economy. **The results of the research** show the state of the global robotics market and Bulgaria's place in it.

Keywords: ROBOTICS, INDUSTRIAL ROBOTS, ROBOTS MARKET, INDUSTRIAL ENTERPRISES

1. Introduction

In recent years, there has been a rapid development and implementation of robotic and automated systems in manufacturing enterprises. [1] Wide spread is due to their ability to achieve cheaper, more accurate and more reliable performance of work processes, compared to human labor. [2] Industrial robots are getting smarter and in sync with the intelligent digital transformation of industry. [3] They are widely used in manufacturing, assembly, packaging and packaging, transportation of goods, earth and space exploration, surgery, weapons industry, laboratory research and mass production of consumer and industrial goods of various sectors. They replace jobs to perform production operations that are dangerous, harmful or repetitive. [4] They are increasingly entering warehouse activity, logistics and office management. [5]

In modern enterprises, autonomous manufacturing processes powered by robots are focused on safety, flexibility, multi-functionality and cooperation between robots and humans. Among their main advantages are their wide functional range and an increasingly affordable price. [6]

The global robotics market has grown significantly in recent years (Fig. 1). For the past year 2023, it is estimated at 68.9 billion dollars. Expectations for 2024 are for \$68.9 billion.

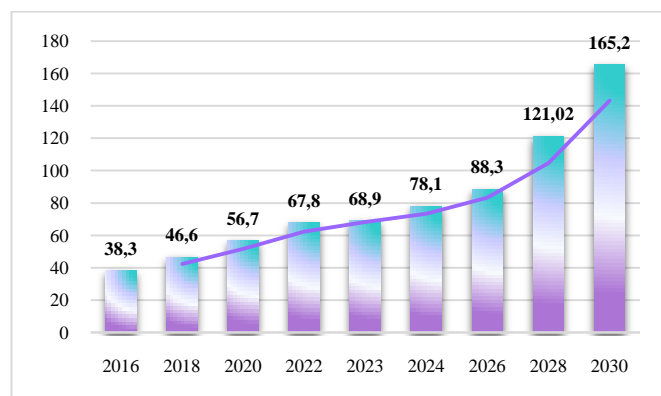


Fig.1. Global market for robotics, in USD bn

Source: <https://scoop.market.us/robot-statistics/>

Forecasts show that by 2030, industry revenue will reach \$165.2 billion at a compound annual growth rate (CAGR) of 16.1% during the period 2024 to 2030. Among the leading trends driving the growth of the robotics market and automation in industrial enterprises stands out - the shortage of skilled labor, the development of digital technologies, artificial intelligence, machine learning, government policies, the search for innovation for new and improved robots with better functionality.

The distribution of the robotics market by geographic region is presented in Fig. 2.

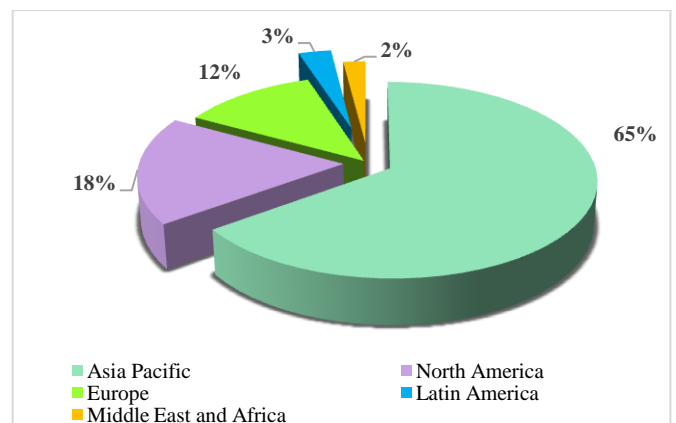


Fig. 2. Robots Market Distribution by Geographical Regions, 2023

Source: <https://www.precedenceresearch.com/industrial-robotics-market>

According to data for 2023, the Asia-Pacific region generated 65% of the revenue share in the sector. In second place is North America with a share of 18%, followed by Europe with 12% of revenues and Latin America with a share of 3%.

2. Literature review

Robotics is an applied engineering science that combines machine technology and tooling with computer science. It deals with the creation of devices that can move and react to sensory data. [7], [8] It is focused on the design, device, operation and application of robots, as well as the computer systems for their control, information perception and feedback.[9],[10] Some robots are controlled by artificial intelligence. Modern robots are widely used to perform tasks with a high degree of accuracy.

The word robot comes from the Slavic word "robota" (work, labor). [11], [12] It was first mentioned by the Czech writer Karel Čapek in 1920 in his play R.U.R. (Rossum's Universal Robots). [13], [14] According to the Oxford English Dictionary, the word robotics was first used by Isaac Asimov in his science fiction story "Liar!" published in May 1941 in Astounding Science Fiction. The history of robotics is presented in Fig. 3

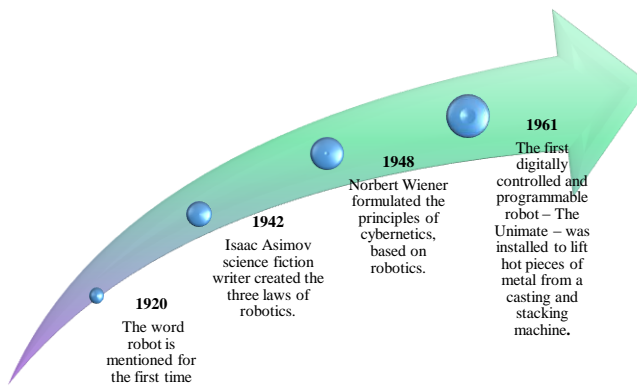


Fig. 3. History of robotics

Modern industrial robots are considered as a complex system consisting of a mechanical structure, motion transmission elements, power supplies and drives, working organs, computer electronics, program control, means of monitoring and communication. [15], [16] In this sense, robots are typical mechatronic systems with a complete set of their constituent elements.

There are different types of robots that are used in a variety of environments with different purposes and tasks, but despite the differences in their application and construction, they share common characteristics in terms of their construction. [17], [14]

- All robots have a mechanical structure, frame, or shape designed to accomplish a specific task. The decision of the constructor is the way in which the robot will perform the assigned task and cope with the peculiarities of its surrounding environment. Form follows purpose.
- Robots have electrical components that power and control the mechanical part. This energy comes in the form of electricity through a wire. The electrical aspect of robots is used to move, monitor and perform operations.
- All robots contain some level of programming code that determines how and when a robot should do something.

The following *types of robots* are found in practice:

- *Pre-programmed robots*. They perform simple, repetitive activities in a controlled environment.
- *Autonomous robots* – they do not require human operators to operate. They are designed to work in open spaces without the need for human supervision. They use sensors to learn about the environment, then use decision-making mechanisms (usually a computer) to choose the best next action based on their data and goal.
- *Humanoid robots* – designed to look and behave like humans. These robots often perform human tasks (such as running, dancing, communicating, carrying goods, etc.)
- *Tele-controlled robots* - semi-autonomous robots that can be controlled remotely over a wireless network. They are used in areas with a harsh climate, harmful and dangerous environment (repair of broken underwater pipes, drones for locating land mines on battlefields, etc.)
- *Augmenting robots* - can enhance current human skills or replace those that have been lost (robotic prosthetic limbs, exoskeletons used for heavy lifting).

Robotic technologies are constantly improving and, in combination with artificial intelligence and machine learning, are finding more and more useful applications. The integration of robots into human workplaces is becoming increasingly economical, cost-effective and creating new opportunities and applications in a number of mass production industries. Industrial robots provide a number of advantages in a work environment related to:

- reducing production costs and increasing efficiency, by speeding up production, reducing labor costs, increasing quality and minimizing waste;
- shortening of the production cycle, which is due to the possibility of working at a constant speed, without breaks;
- higher quality and reliability, adhering to the high accuracy when performing the set operations;
- better utilization of the available production space;
- optimization of the amount of raw materials used and reduction of waste, which is due to the precision in performing the set operations;
- safe working conditions, minimizing the risk of occupational accidents at the workplace;
- increased qualification of employees as a result of interaction with the robotic equipment.

3. Research and discussions

The market for industrial robots is one of the fastest growing in recent years. Its dynamics are influenced by trends in the development of Industry 4.0 technologies, such as the industrial Internet of Things, mobile autonomous robots, open source software, 5G technologies, etc.

The global market size for industrial robots in 2023 is estimated to be USD 54.0 billion. Forecasts show that by 2032, its volume will grow to 143 billion USD with a compound annual growth rate (CAGR) of 11.4% for the period 2024-2032 (Fig.4)

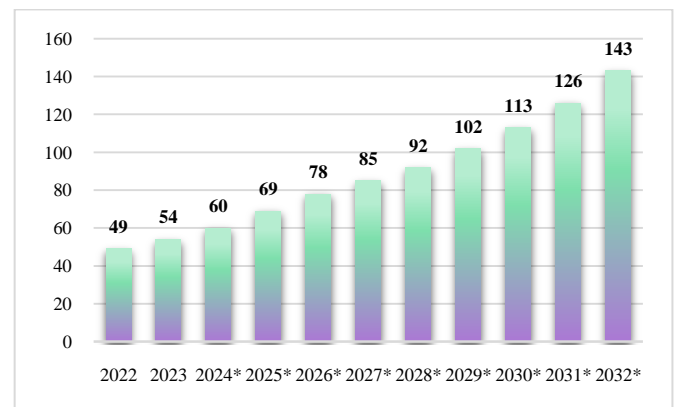


Fig. 4. Global market for industrial robots, billion dollars

Source: <https://scoop.market.us/robot-statistics/>

According to the latest World Robotics report, in 2022, 553,052 industrial robots will be installed in industrial enterprises worldwide. (fig. 5) The growth rate in 2022 compared to the previous year is 5%.

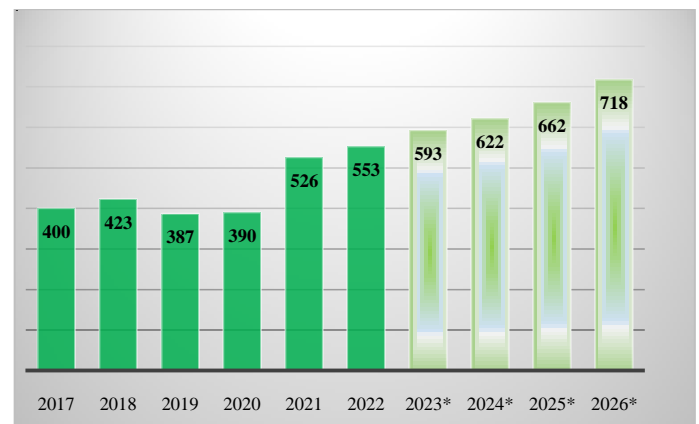


Fig. 5. Annual installations of industrial robots ('000 of units)

<https://ifr.org/ifr-press-releases/news/world-robotics-2023-report-asia-ahead-of-europe-and-the-americas>

By 2023, the global number of industrial robots installed and operating will reach approximately 4 million units. (Fig. 6) Since 2017, their number has grown by 13% per year.

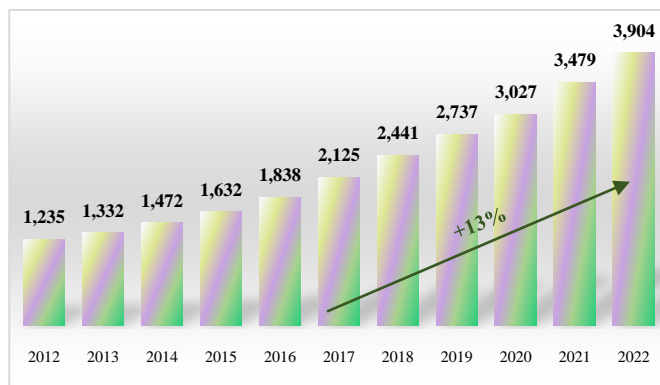


Fig. 6. Number of installed units of industrial robots worldwide ('000 units)

Source: World robotics, 2023

The most automated countries by 2023, according to the World Robotics 2023 report presented by IFR (International Federation of Robotics), by density of robots among 10,000 employees (Fig. 7) are the Republic of Korea (1'012 robots per 10'000 employees), Singapore (730 units) and Germany (415 units).

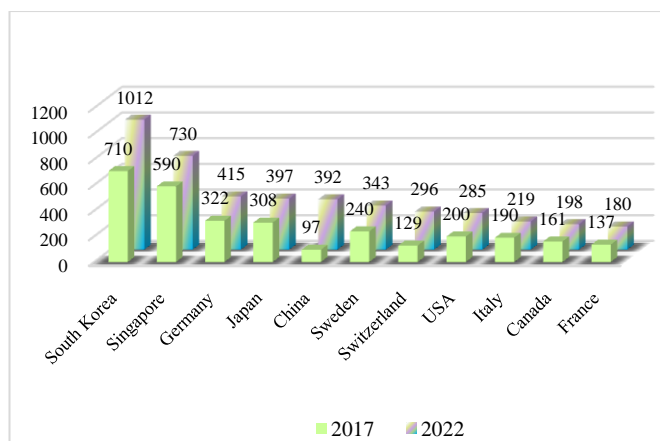


Fig. 7. Change in the density of the number of robots in operation, by country for the period 2017-2022.

Distribution of the density of robotic and automated systems by geographic regions is presented in fig. 8.

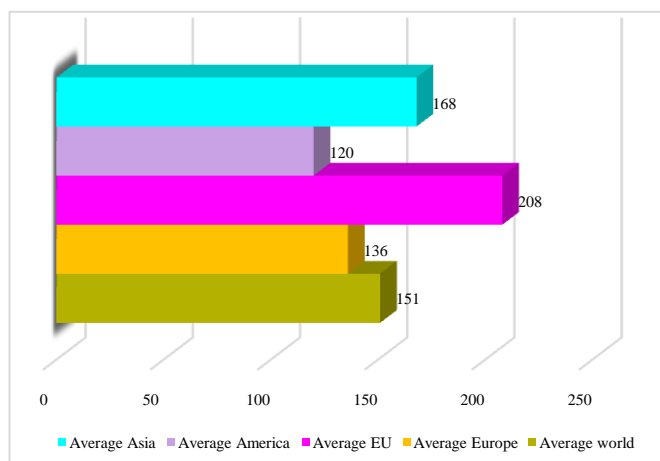


Fig.8. Density of industrial robots by geographic region, by 2023.

Source: <https://www.statista.com/chart/13645/the-countries-with-the-highest-density-of-robot-workers/>

The data shows that the average level of installed industrial robots among 10,000 employees globally for 2023 is 151. In the Asian region, the number is 168, in Europe it is 136 (with only 208 in the EU), America remains in third place with 120 units.

Industrial robots are used in various sectors. (Fig. 9) The largest share of 27.25% is in the medicine sector and the "home services" sector with a share of 19.63%.

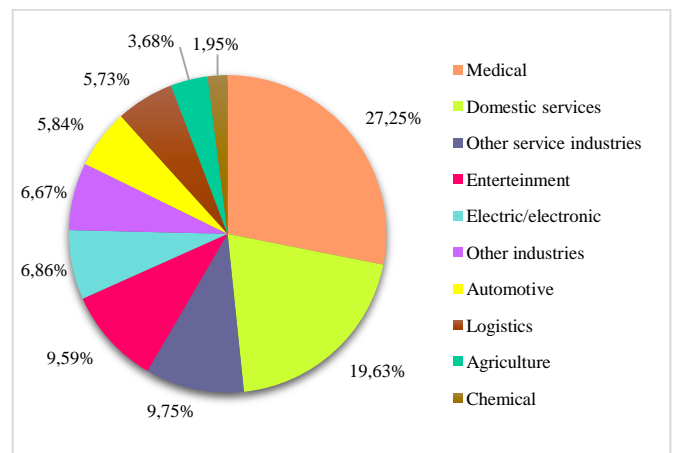


Fig. 9. Application of robots by industrial sectors, 2023

Source: Statista Market Insights, <https://www.statista.com/robotics/worldwide#revenue>

Bulgaria is not lagging behind the global trends in the production and trade of robotic systems. According to data from PARAI - Professional Association of Robotics, Automation and Innovations, for two consecutive years (2021 and 2022) the country is one of the 15 countries in the world that realizes a trade surplus from trade in industrial robots (more industrial robots are exported than are imported). (table 1)

Table 1. Ranking of countries benefiting from a trade surplus in industrial robots trade, 2022

Nº	Country	Value	Up /down since 2021
1	Japan	2.4 billion	up 26.5%
2	Germany	302.5 million	up 37.4%
3	Denmark	290.9 million	up 28.5%
4	France	132.3 million	down -29%
5	Finland	83.7 million	up 171.1%
6	Sweden	79.3 million	down -33.5%
7	Austria	63.6 million	down -50.8%
8	Italy	58.3 million	down -71.7%
9	United Kingdom	35.6 million	down -433.8%
10	Luxembourg	27.2 million	down -29.3%
11	Belgium	21.7 million	down -439.1%
12	Slovenia	15.2 million	down -190.9%
13	Bahrain	15 million	down -3,389%
14	Taiwan	13.2 million	down -30.1%
15	Bulgaria	11.1 million	up 280.6%

Source: <https://www.worldstopexports.com/top-industrial-robots-exporters>

According to the statistics, Japan tops the list for the countries that hold the largest share of exports, measured as the value of receipts in US dollars. It earned 2.4 billion, representing a share of 26.5% of exported industrial robots. It is followed by Germany with 37.4% (302.5 million), Denmark - 28.5% (290.9 million), Finland -

171.1% (83.7 million). The total share of the first five in world trade amounts to 62.3%, and in terms of realized volumes, all 25 exporting countries in the ranking form a share of 97% of global sales.

The Bulgarian high-tech sector realizes a trade surplus of 11.1 million dollars by 2023. With this result, the country falls among the technological giants of Japan, Germany, France and Taiwan. Exported industrial robotic production from Bulgaria by 2023 covers industrial robots, manipulators, CNC machines, automatic solutions for semiconductors, metal dosing and casting, production of optical cables, food and electronics, and other technique developed according to the customer's order. The main markets for the export of finished products are the markets of Germany, Romania, France, Italy and the Czech Republic. In our country, the most active in the search for robotic equipment are companies from the production sectors of metalworking, electronics, the food industry, machinery, etc.

4. Conclusion

The population of working robots worldwide has reached nearly 4 million units. This is due to the rapid development in technological innovation, growing labor shortage, rising labor costs, search for automated solutions, imposition of various government initiatives and funding, expanding areas of application.

Among the major driving forces of the market are rapid technological advances in artificial intelligence (AI) and machine learning (ML), new applications of cobots providing human-robot collaboration, mobile manipulators (automating operations related to material handling in industries such as automotive, logistics, aerospace), digital twins (a tool to optimize the performance of a physical system by creating a virtual replica), humanoid robots (human-designed robots designed to perform a wide range of tasks in different environments).

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