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# Present and Future of Industrial Robotisation

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*Abstract. The following paper analyzing the installation of industrial robotisation in sectors and regions, in addition carry out forcastings on historical data. In recent years, automation and the use of industrial robotics have increased exponentially in the manufacturing sector. Given that companies prioritize enhanced production effi ciency, quality assurance, and safety, it is evident that substantial investment and implementation of automation continue to occur in manufacturing facilities worldwide. The number of industrial robots globally has been growing steadily since 2010. However, the rate of growth has slowed from 2020 onwards. The impact of the Covid-19 epidemic was still felt in 2020, but the deployment of industrial robots increased significantly in 2021. Global industrial robot deployment is projected to continue to grow in the coming years, although the rate of increase may vary between regions and countries. The analysis showed a number of differences between regions in the number and growth rate of industrial robot deployments. Asia and Australia are the largest markets for robots and the number of robots deployed is expected to continue to grow in the future. Europe is the second largest market and, although growing at a slower rate, industrial robot deployment is also increasing steadily. In the Americas, growth is slower than in other regions, but still increasing. Global growth trends suggest that there will be further growth in the coming years and that the deployment of industrial robots will become more widespread in different parts of the world.*

*Keywords: Industry 4.0, I4.0, Idustrial Robotisation, Linear Regression*

## Introduction

## 1. Industry 4.0 and industrial robotisation

The correlation between technical advancement and labor has been intensively debated for centuries. This argument has been a recurring concern throughout all four Industrial Revolutions. The First Industrial Revolution, originating in the United Kingdom throughout the 18th and 19th centuries, led to the emergence of labor opposition movements, including the Luddite movement [1]. In addition, the Second Industrial Revolution, which was triggered by the advancement of the steam engine in the early 20th century, significantly contributed to the issue of unemployment and the prevalence of low pay among factory workers [2]. The Third Industrial Revolution, which is centered around Information and Communication Technology (ICT), has increasde the wage gap between workers with advanced skills and those without, mostly because it favors individuals with specialized abilities [3]. Currently, the development of advanced technologies like AI is anticipated to have substantial effects on labor, irrespective of labor skills, in what is known as the Fourth Industrial Revolution [4].

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## 1.1. Concept of Industry 4.0

### *1.1.1. Automation*

The automation of industrial process had began in the third industrial revolution [5]. In traditional manufacturing, the production of different products was all manpower intensive, but thus the number of pieces produced was limited. In order to maximise the quantity that could be produced in a single shift, new methods had to be devised to meet the growing demand. Automation involved the creation of different production lines to replace the workforce, which made production processes much effective. However, it was not necessarily only the introduction of modern production equipment that was needed, the development of various tools to support the work process also became inevitable. Such as the constant modernisation of measuring instruments, material handling equipment and warehouse management. Automation is designed to replace manual workers from demanding, monotonous, unskilled jobs [6]. A machine makes it easier to ensure the same quality and to increase and control productivity. In the long run, such an investment will provide a better return on investment, predictability and, with regular maintenance, continuity of work, thus reducing the cost of human resources. In addition to replacing physical labour, automation is also responsible for the development of computer systems for processing data [7]. Various contemporary iterations of automated systems, such power plant monitoring devices, autonomous vehicles, drones, robots, and chatbots, heavily depend on computer technology. Humans utilize computer-automated systems and are anticipated to continue playing a crucial role in artificial and automated systems in the future [8].

### *1.1.2. Industry 4.0*

Industry 4.0 is the fourth industrial revolution, which has started today and will take place in the coming years/decades, which will transform and evolve industry and lead to the emergence of cyber-physical systems. This revolution will require a higher level of automation, the deployment of systems capable of performing more complex tasks and the extension of traceability to other areas. The fact that it is special is that previous industrial revolutions were named after their occurrences, while the current revolution is named in advance [9].

Industry 4.0 is no longer about the physical change in machines, but rather about the sophistication of the digital systems inside them and the amount of data that can be extracted from them. The data extracted in this way gives us a continuous picture of the performance of a given machine, but the proper processing, storage and interpretation of this data is of great importance. The fourth industrial revolution is therefore based on digitalisation and data. Due to advanced computing solutions and the Internet, the link between human and machine can be made permanent by the data extracted from the equipment. However, this link is no longer just between man and machine, but also between machine and machine, which can communicate by means of an appropriate data flow [10, 11]. An organisation of production processes which is described in Industry 4.0 as devices communicate autonomously with each other along the value chain. This gives to possibility to create a "smart" factory of the future, in which computer-controlled systems monitor physical processes, creating a virtual replica of physical reality. The mechanisms will make decentralised decisions based on self-organising mechanisms [9].

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### *1.1.3. Principles of Industry 4.0*

The high level of interconnection between the technological tools and the actors involved, based on the principles of Industry 4.0, will allow the development of a system capable of managing processes in a coordinated way. These principles are the folowing:

- Connectivity and communication: :

  Until the third industrial revolution, there were mostly only human-to-human relationships, which have since evolved into human-to-machine and machine-to-machine relationships.

- Information transparency:

  It is one of the most important pillars, since without proper processing of data, information is worthless. The advantage is that everything can be accessed quickly and digitally, and the user can get an immediate picture of the results of certain processes and monitor them.

- Technical assistance:

  The use of machinery and equipment in the production process simplifies processes and eliminates most human error. Therefore, production volumes are become more predictable and reliable.

- Decentralised decisions:

  Machines can be fed into different situations, and it can be determineded we can determine what to do in advance, thus only in very special cases human intervention is needed [12].

### *1.1.4. Impact of industrial robots*

Nowadays, mass production in large factories would be impossible without robots, but robotisation is also becoming more and more part of our everyday lives [13]. Moreover, robots have appeared in the hospitality and medical sectors, and even in many households, where robots are helping to clean the home. It has been more than 60 years since the emergence of industrial robots, but in recent years the use of robots in various manufacturing sectors has started to grow rapidly. Since robots do not need any kind of secured working environment, as they are just a machine designed to perform a specific task [14].

The rapid technological progress of the last decades is an unstoppable process, and the environment must adapt accordingly [15]. Industrial robots have a major impact on production in particular, which is undergoing constant change, but also on economic events and the social sphere. The use of robots in industry is even more accepted in an ageing society, where there is a greater shortage of labour and these robots are being used to fill the gap [16]. Although, the biggest risk is that a situation could arise where technological unemployment and environmental impacts unfold in roughly parallel. However, if full use can be made of evolving technology as a solution - while recognising and adapting to its impacts on employment and income distribution - the outcome is likely to be much more optimal. The greatest challenge of our time is to shape a future that offers broad-based security and prosperity [17].

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# 2. Materials and methods

## 2.1. Dataset

The research was based on data from the IFR database. This research offers comprehensive global statistics on industrial robots presented in standardized tables, facilitating direct comparisons across different countries. The data provided includes statistics for around 40 nations, categorized by application areas, customer industries, types of robots, and other technological and economic factors. The statistics for production, export, and import is provided for specific countries. Additionally, it provides the metric of robot density, which quantifies the number of robots per 10,000 employees, as a means of assessing the level of automation [18].

## 2.2. Method – liner regression

Regression is a common tool for analysing the relationship between variables. It basically looks at how a particular variable under study, called the outcome (or dependent) variable, depends on one or more so-called explanatory (or independent) variables.

In regression calculations, we look for the function that describes the relationship between the explanatory variable and the outcome variable, interpret the parameters and other characteristics of the function, analyse the effect of each of the influencing factors, the closeness of the relationship and the possibilities for prediction.

# 3. Results

## 3.1. Descriptive statistics

In 2021, more than 500,000 industrial robots will have been installed worldwide, setting a new record after the downturn caused by the Covid-19 pandemic, which had never seen so many new robots installed in any previous year (Figure 1). This is another sign that industrial robots are becoming more and more essential in the corporate culture. The level of robotisation in Africa is negligible and is therefore not addressed in this study.

Data shows that the installation of industrial robots worldwide has been steadily increasing over the last decade. The average annual growth rate is around 16.5%, which means that more and more industrial robots are being installed globally every year.

Another observation is that the pace of robot installations has been variable over the years and has not always shown an upward trend. There was a major jump in 2015, when the number of robots installed increased by 21.3%, and then the pace started to slow down in the following years, reaching a peak in 2019.

Overall, the data shows that the process of industrial robotisation is steadily evolving at a global level and is becoming increasingly important in industrial production and economies.

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The global increase in the number of robot installations shows that industrial automation is gaining ground in the world. This has a significant impact on the efficiency of industrial production and the quality of production processes.

The increase in the number of robotic installations creates significant business opportunities for companies that offer robotic technologies. This industry has significant growth potential for the future.

The data also show that the spread of industrial robotisation could bring further innovations in the field of robots, including human-robot collaborative robots and service robots.

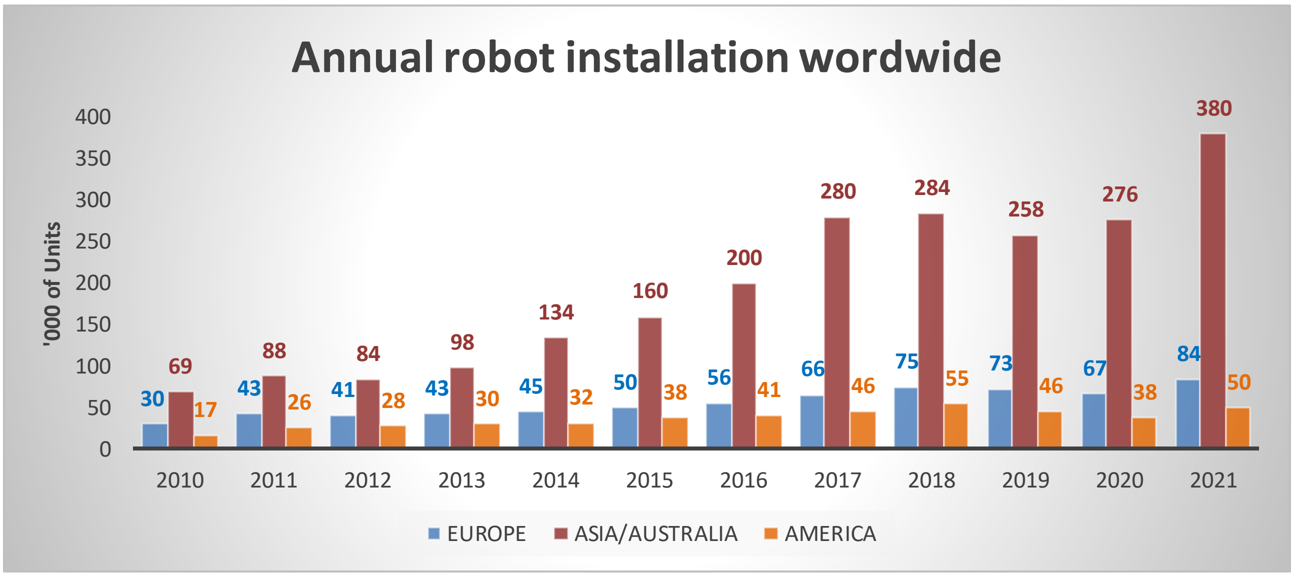


*Figure 1. Annual robot installation globally – own editing based on [18]*

This rapid growth is mainly triggered by three sectors. These three sectors are Electrical/electronics, Automative and Metal and machinery. In 2020, the Electrical/electronics sector became the largest purchaser of industrial robots, ahead of the automative sector, and maintained this position in 2021 (Figure 2,3,4).

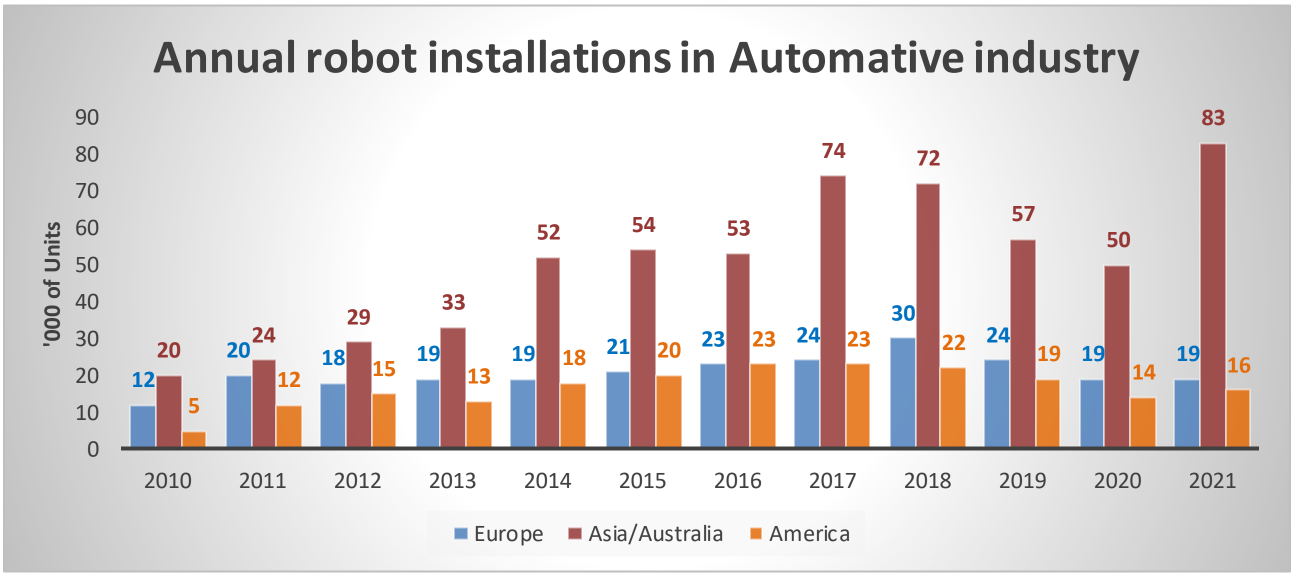


*Figure 2. Annual robot installations in automative industry– own editing based on [18]*

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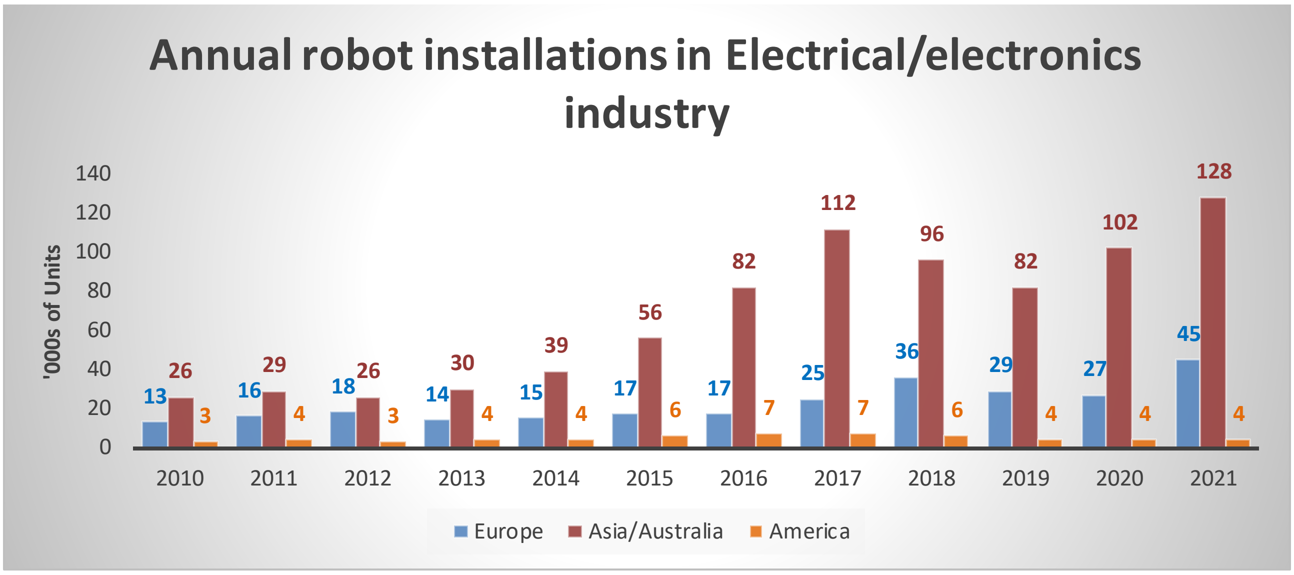


*Figure 3. Annual robot installations in electrical/electronics industry– own editing based on [18]*

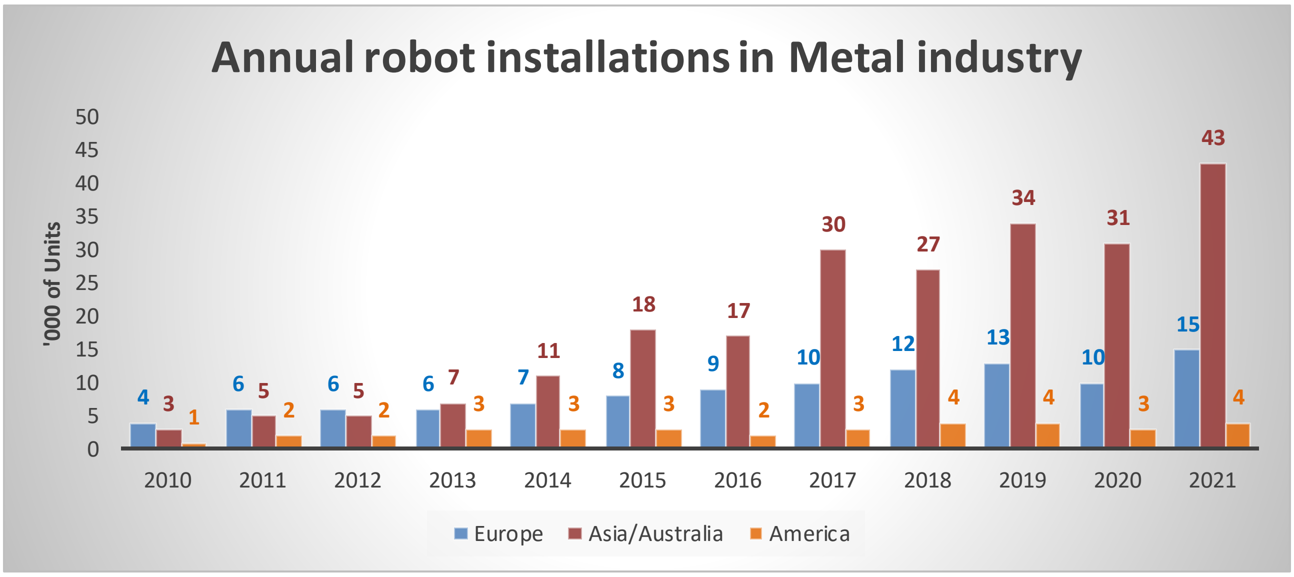


*Figure 4. Annual robot installations in metal industry– own editing based on [18]*

## 3.2. Industrial robotisation in Europe

Industrial robotisation in Europe has increased significantly over the past decade. Figure 1 is shown the quantity of newly installed robots between 2010 and 2021. The decline in 2020 was probably due to the Covid-19 pandemic, but by 2021 the number of investments was at its highest level in the last 10 years. Figure 5 is shown the percentage change between 2011 and 2021. The following sectors are leading the way in robotisation: electrical/electronics industry, automative industry and metal industry (Figure 2-4).

Although the rate of growth has slowed down a little in recent years, the number of robot installations is still expected to increase further in the near future. Growing demands in industry, the shift to automation and increasing business efficiency will continue to drive the installation of industrial robots. Digital technologies, such as artificial intelligence and robotics, are becoming increasingly important in

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optimising and improving industrial processes and are expected to further boost industrial robot deployment in the future.

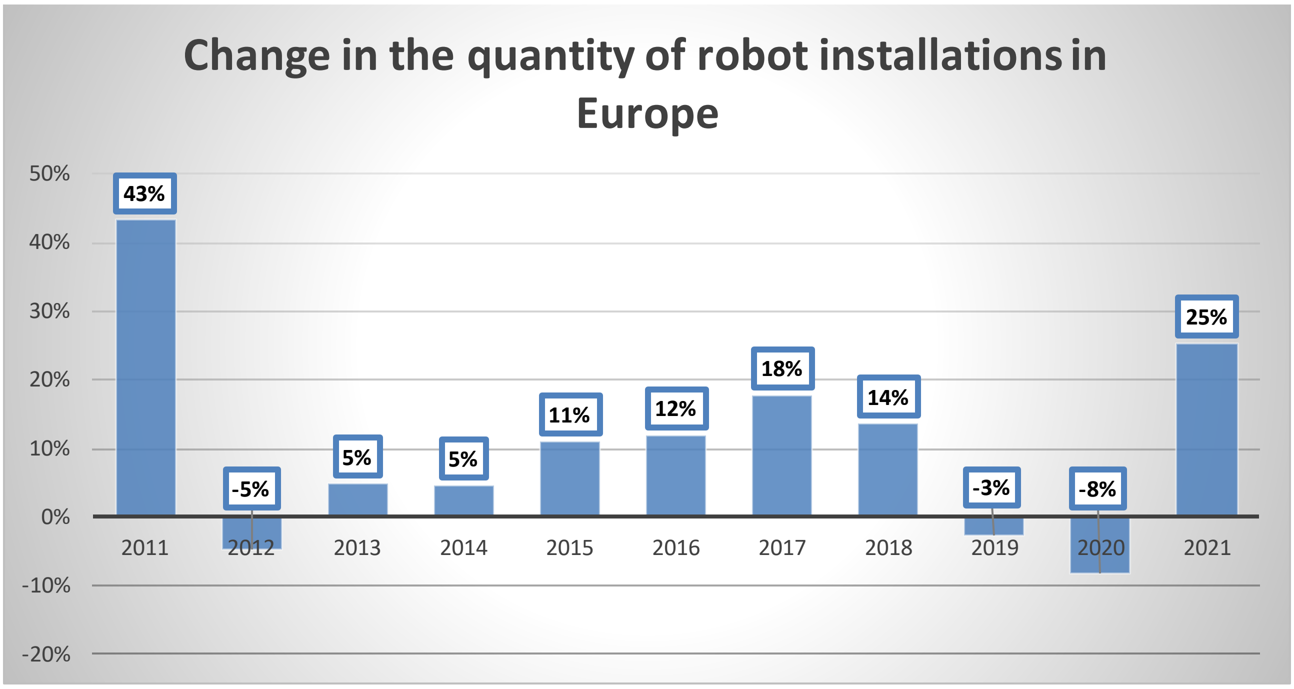


*Figure 5. Change in the quantity of robot installations in Europe – own editing based on [18]*

## 3.3. Industrial robotisation in Asia/Australia

Growth in industrial robots has been highest in Asia and Australia over the past 10 years. Here, too, the same sectors dominate as in Europe, as a consequence of the fact that these sectors have the highest substitutability of low-skilled labour with robots [10,11]. The Covid-19 pandemic caused a decline here, but by 2021 this region has also recovered from the economic difficulties and has seen greater investments in industrial robots than at any time in the last decade.

Data shows that the installation of industrial robots in Asia and Australia has increased significantly in recent years. Growth rates in individual years have varied, but the trend is clearly positive. The largest increases occurred in 2014 and 2017, when the number of robots installed grew by 37% and 40% respectively. However, 2012 and 2019 also saw decreases, -5% and -9% respectively. The last year, 2021, was particularly positive with an increase of 38%. The data suggests that the growth in the use of industrial robots in this region could continue in the future.

China deserves special mention as it is the largest market for industrial robots and has shown significant growth in this area in recent years. The country's leading position has been strengthened by a combination of cheap labour and technological advances. However, China is increasingly seeking to become more independent from foreign technology companies and to promote its own domestic developments in industrial robotics. The Chinese government is also investing heavily in R&D in robotisation and artificial intelligence, and is encouraging the use of industrial robots in various sectors of the economy. As a result, China is both the largest producer and exporter of industrial robots [9].

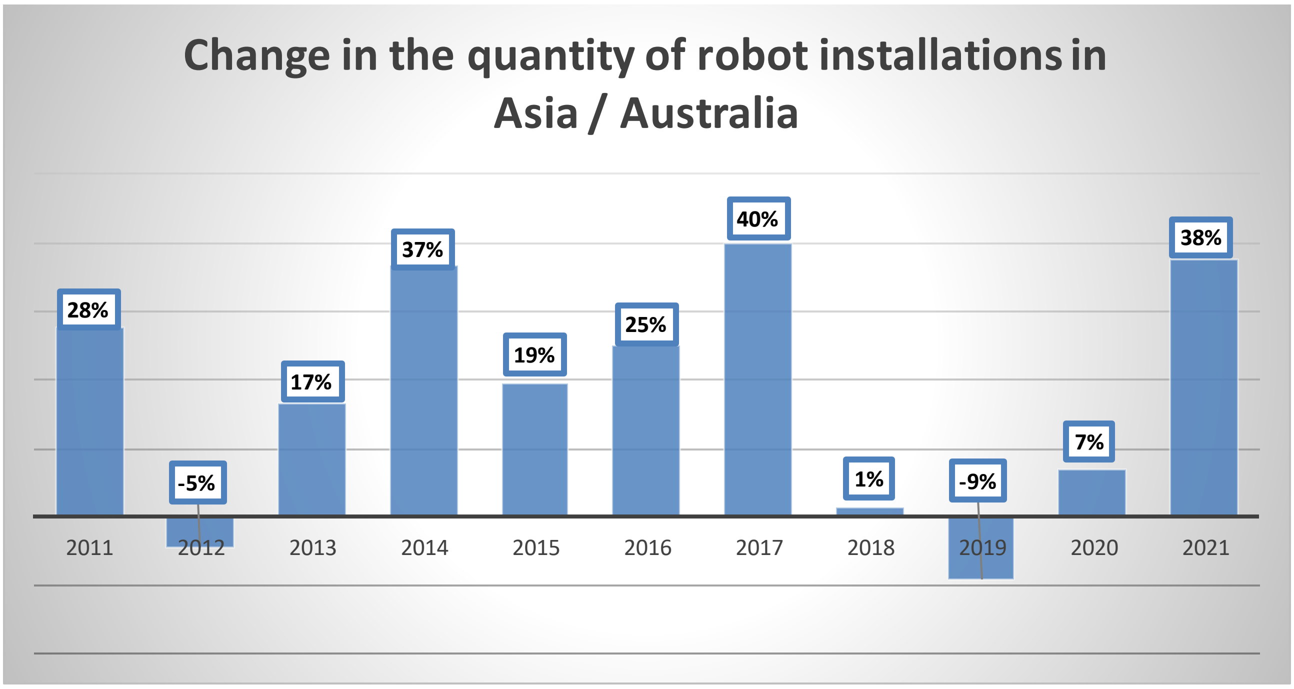


*Figure 6. Change in the quantity of robot installations in Asia/Australia – own editing based on [18]*

## 3.4. Industrial robotisation in America

The data show that the percentage growth of robot installations in America has been volatile in recent years (Figure 7) . However, the reasons for the declines are not clear from the data. The Covid-19 epidemic led to a decline in industrial production and investment in 2020, which may have affected the number of robot installations. However, the growth in 2021 shows that industry continues to rely on robotisation and automation to improve efficiency and competitiveness.

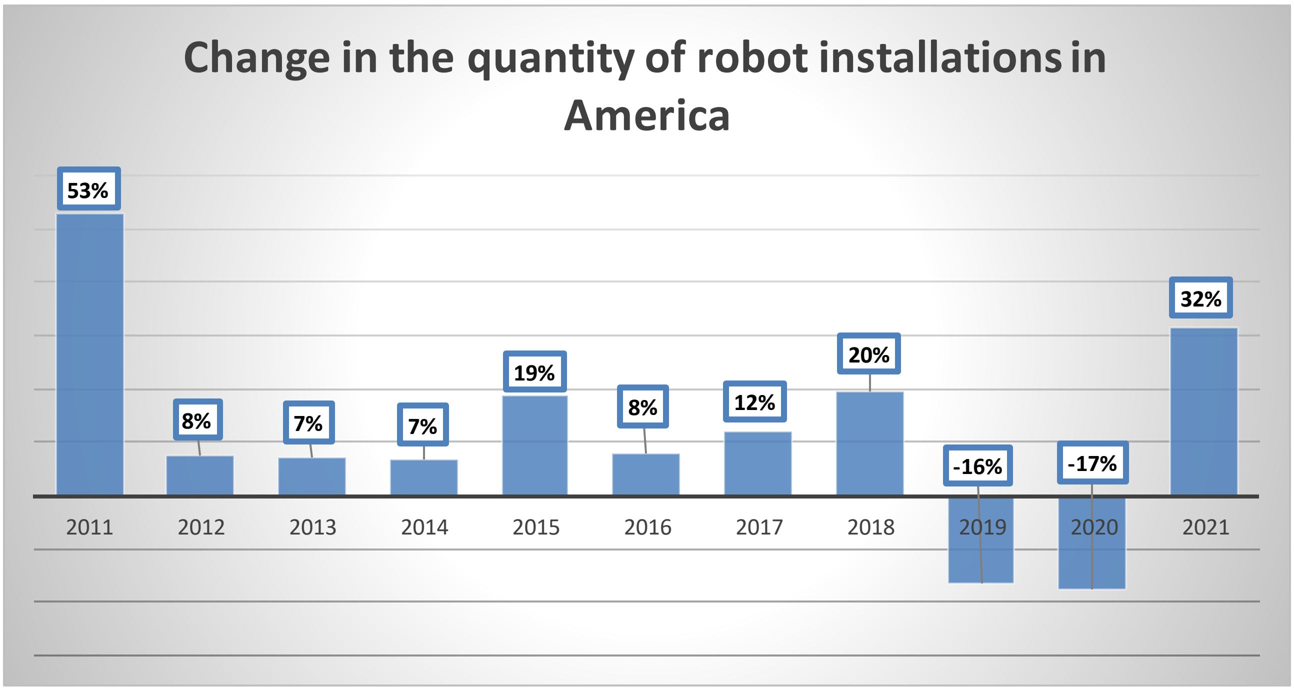


*Figure 7. Change in the quantity of robot installations in America– own editing based on [18]*

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The Americas also show an increasing trend, based on data from the last 10 years (Figure 7). The distribution of new robots installed here is also similar to that in Europe and Asia/Australia. The Covid-19 outbreak in 2020 has also reduced the number of new robots here. This reduce in 2020 was the biggest between the continent, the value of this reduction was 17%. The 2021 figure shows an increase compared to the previous two years, below the peak in 2018.

## 3.5. Expected change in the number of robot installations (2022-2025)

For the model, we assume that we have two variables, both measured at some high level of measurement (typically on an interval scale) and that there is a roughly linear relationship between them. In the regression model, the variable on the left (y), which is the focus of our analysis, is called the outcome variable, and the variable on the right (x) is called the explanatory variable. The relationship between the two variables is stochastic, i.e. the linear function can only describe the evolution of the outcome variable with error (residual). This residual is now assumed to have a mean of 0 and to be unrelated to either the explanatory or the outcome variable. This model is called a bivariate descriptive linear model:

$$y = \beta_0 + \beta_1 x + \varepsilon \qquad (1)$$

The linear regression model was created by using Excel, the results of which are as follows (Table 1). The linear regression models for the data are:

- America:

$$y = 2{,}6818x + 19{,}818 \qquad (2)$$

- Europe:

$$y = 27{,}059x + 27{,}379 \qquad (3)$$

- Asia / Australia:

$$y = 27{,}059x + 16{,}697 \qquad (4)$$

- Globally:

$$y = 34{,}402x + 69{,}803 \qquad (5)$$

| Expected annual robot installation (pcs) | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|
| Europe | 87 | 92 | 96 | 101 |
| Asia / Australia | 402 | 429 | 456 | 483 |
| America | 52 | 54 | 57 | 60 |
| Globally | 483 | 517 | 551 | 586 |

*Table 1. Expected annual robot installation ('000 of Units)*

The variable x is time and the variable y is the number of robots. The equation shows the relationship between time and the number of robots: the number of robots (y) depends on time (x) according to the constants are given in the equation. The constants imply that the deployment of industrial robots is expected to increase over time, and the rate of increase is determined by the values of the constants.

Global data include data from the Africa.

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According to the Table 1, industrial robot deployment is expected to grow in all regions and globally. In the European region, the number of industrial robots will start from 87,000 in 2022 and is expected to increase to 101,000 in 2025. In the Asia and Australia region, the number of industrial robots will start from 402,000 in 2022 and is expected to increase to 483,000 in 2025. In the Americas region, the number of industrial robots will start from 52 thousand in 2022 and is expected to grow to 60 thousand in 2025. Globally, the number of industrial robots will start from 483,000 in 2022 and is expected to increase to 586,000 in 2025. The data shows that the Asia and Australia region is expected to see the highest growth, while the Americas region will see the lowest.

In order to calculate the average annual growth rate, it is first necessary to determine the differences between the data in successive years. The average annual growth rate can be calculated using the following formula:

$$\frac{Final\ value}{Initial\ value}^{\frac{1}{Number\ of\ years\ calculated}-1} \tag{6}$$

Where,

$$Number\ of\ Years\ Calculated = Number\ of\ years\ Examined - 1 \tag{7}$$

The calculated growth rates are then compared to determine the growth rate of industrial robot deployment on different continents.

The results are as follows:

| Average annual growth rate (%) | |
|---|---|
| Europe | 5,42 % |
| Asia / Australia | 5,61 % |
| America | 5,37 % |
| Globally | 6,03 % |

*Table 2. Average annual growth rate in 2022-2025*

The comparison shows that the growth rate of global industrial robot deployment is decreasing year on year. The average annual growth rate can decrease in Europe and Asia in 2022-2025, while it cav increase slightly in the Americas. However, in 2022-2025, the growth rate seems to be slowing down in all three continents, indicating that industrial robot deployment is slowly approaching saturation levels in different parts of the world.

# Conclusions

Over the past decade, the number of industrial robots has been steadily increasing on all continents, although the annual growth rate has been volatile. Asia has been at the forefront of robotisation, with an average annual growth rate of between 25-30 % in recent years. The Americas and Europe have also shown growth, although at a slightly slower rate.

The rise in the number of industrial robots will continue in the future, across all continents.

The data show that the deployment of industrial robots has been steadily increasing in recent years and this trend is expected to continue in the coming years. The total value of global industrial robot deployments was 120,000 in 2010 and is expected to reach 586,000 in 2025. There are significant differences between regions in the number of industrial robots deployed and the annual growth rate. The Asian and Australian regions have the highest number of industrial robot deployments, while Europe and the Americas have lower figures. The Asia and Australia region has the highest annual growth rate, indicating that this region is the leader in robot deployment.

The main limitations of the research are that it only looks at industrial robots, service robots are not included in the data, and that the data are confounded by the covid epidemic. The same problem arises with the 2008 crisis, so this period is not included in the research as it would make the data too hectic. As complementary research, a longer time period could be added to the research, or, with appropriate modifications, industrial robots and service robots could be included in a joint study.

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