THE ENTERPRISE ROBOTICS REPORT

MARKET FORECASTS, GROWTH DRIVERS, AND INDUSTRIES LEADING ADOPTION

JUNE 2016

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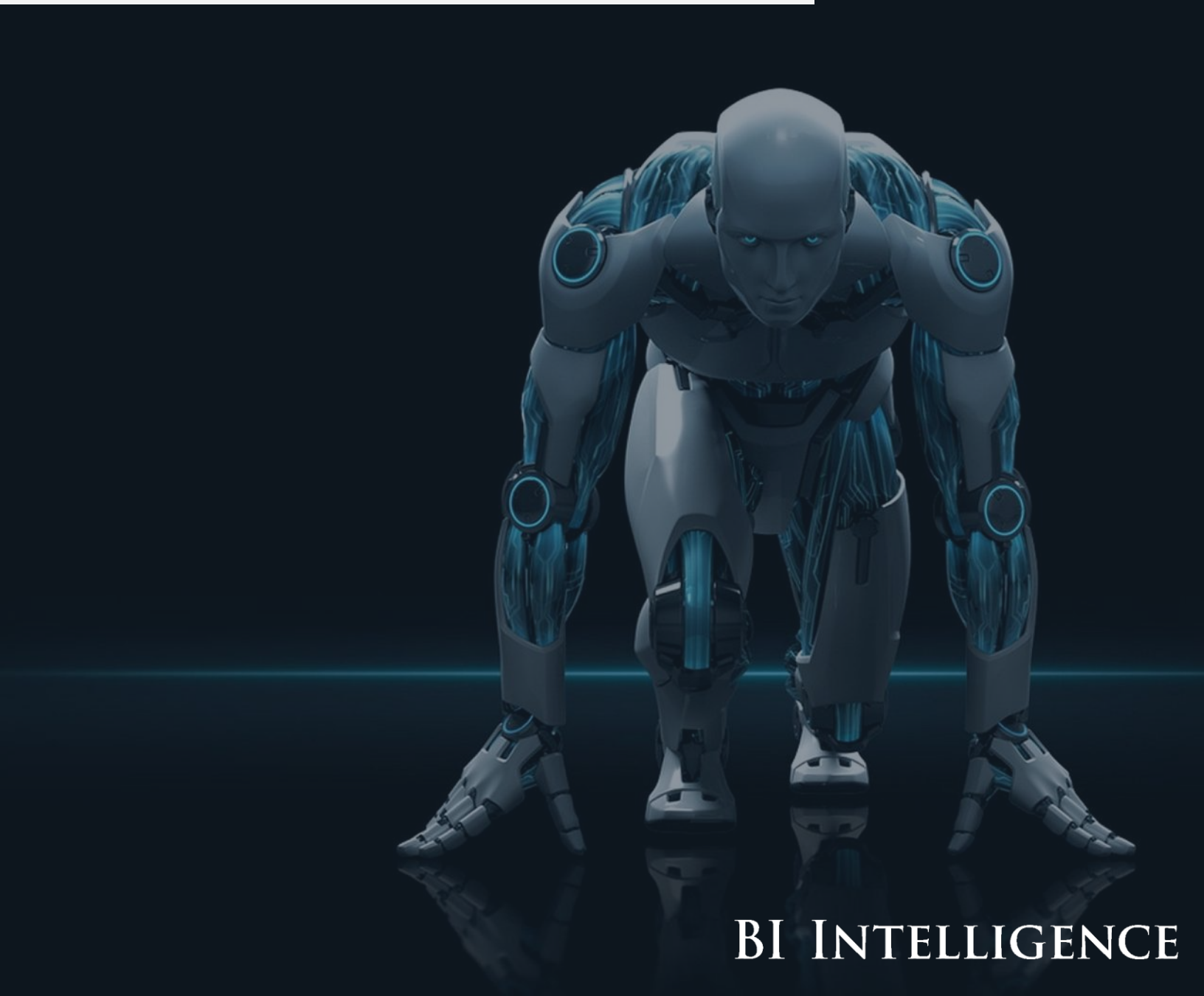


BI INTELLIGENCE

KEY POINTS

- **The enterprise robot market is heating up, and will continue to grow steadily.** We expect 2.8 million enterprise robots to ship between 2016 and 2021. This includes all robots used by businesses. Industrial robots, traditionally used in manufacturing, comprise the bulk of these shipments.
- **Some $390 billion will be spent on hardware, software, and installation costs for enterprise robots over the next five years.** This includes $91.2 billion for enterprise robot installations in 2021, up from $37.7 billion spent in 2015.
- **Key factors are driving up robotics adoption across industries.**
    - **IoT integration.** Robots are gaining internet connectivity, which boosts their automation and analytics capabilities while enabling predictive maintenance.
    - **Labor issues.** Business will look to robots as replacements for workers due to rising wages and aging population that will result in worker shortages.
    - **Competitive advantages.** Whether robots work in tandem with humans or replace them altogether, they can improve output and reduce operating costs.
- **Manufacturing is at the forefront in adopting enterprise robots.** That's because manufacturers can easily automate portions of the assembly line using robots. Boston Consulting Group (BCG) estimated in 2015 that robots will complete 10-25% of the share of tasks across all manufacturing industries by 2025.
- **We estimate that the shipping and logistics industry is just behind manufacturing as the No. 2 industry adopter of robots.** Shipping and logistics is well-suited to robot implementations because many of the tasks are repetitive and labor intensive, such as sorting items and moving heavy products.
- **In healthcare, robot use is still relatively nascent, but robots are increasingly being used in surgery and for other tasks.** Intuitive Surgical, one of the top surgical robot manufacturers, said its 3,597 da Vinci Surgical Systems robots in use performed 670,000 surgeries in 2015.
- **There are a few industries where robots might increasingly have a consumer-facing presence.** In the food service, retail, and hospitality industries robots are still largely a novelty, but if experiments pan out, we could see robots deployed more widely.

- **Automation — which typically includes robots and AI-powered software — is likely to affect job growth considerably.** In the US, McKinsey estimates that increased automation could displace 10-15% middle-skill jobs over the next 10 years. The presumption is that robots will also create more white-collar jobs, however, robots are unlikely to create as many jobs as they displace.
- **Cost is the chief barrier to robot adoption.** Besides the cost of the hardware itself, robots also come with considerable associated costs, including the control system, software, and image-processing system. Other barriers include technological limitations, workforce pushback, and a growing skills gap.

Click here to download the charts and associated data in Excel »

INTRODUCTION

The enterprise robotics market has heated up over the past few years and will continue to grow steadily.

That's largely because of several key factors that are making investments in robots increasingly attractive to businesses. Robots are becoming internet-connected, which is making their maintenance less expensive and their capabilities more advanced.

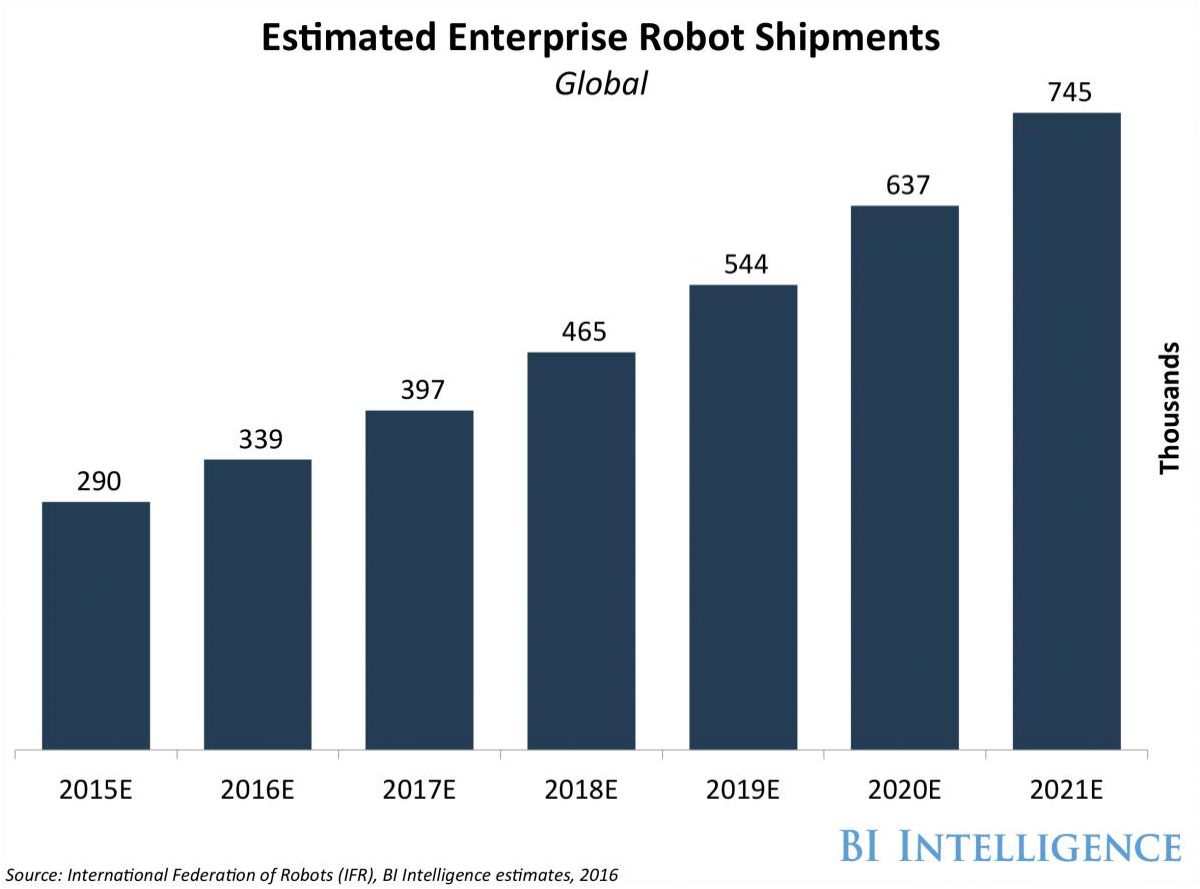
An enterprise robot is a machine that is programmed to complete a task in a business setting. Enterprise robots are currently most common in industrial settings, but they're increasingly being rolled out across other enterprises. As robots come down in price, they can increase productivity, lower costs, and reduce errors.

In this report, we size the global enterprise robotics market and examine the key growth drivers spurring more businesses to implement robots. We also examine the top use cases in manufacturing, warehouses and shipping, healthcare, and other enterprises just opening up to robots. And we discuss the broader projections for workplace automation, including how the use of robots and other tech will fundamentally change business staffing. Finally, we outline several barriers to growth in the enterprise robotics market.

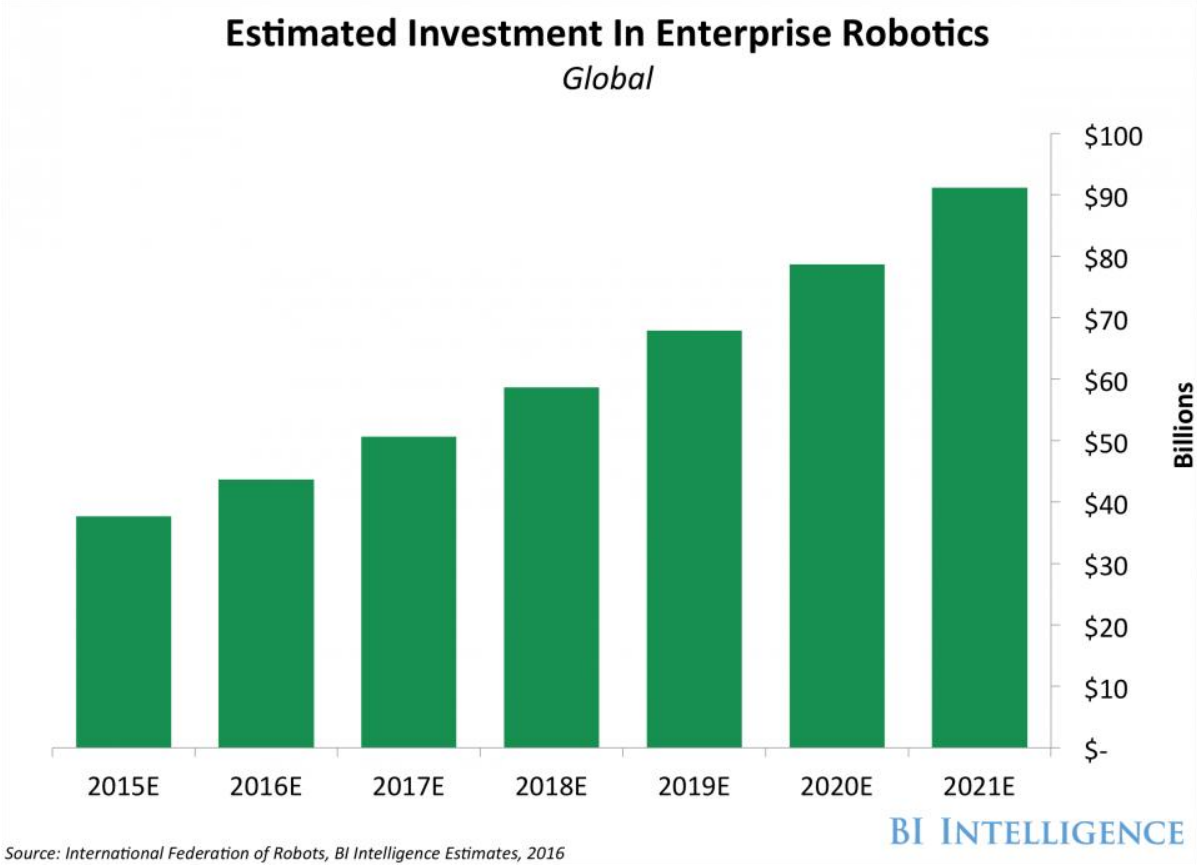
SIZING THE ENTERPRISE ROBOTICS MARKET

We expect 2.8 million enterprise robots to ship between 2016 and 2021. This includes all robots used by businesses. Industrial robots, traditionally used in manufacturing, comprise the bulk of these shipments. Other types include Amazon Robotics machines, which sort packages in warehouses, and da Vinci Surgical Systems robots, which assist surgeons.

- **Enterprise robot shipments will reach 745,000 by 2021, up from 290,000 in 2015.** Our estimates are based on data from multiple sources, including the International Federation of Robots (IFR), company filings, company press releases, and news sources.
- This translates to a **21% five-year compound annual growth rate** (CAGR).



Source: International Federation of Robots (IFR), BI Intelligence estimates, 2016

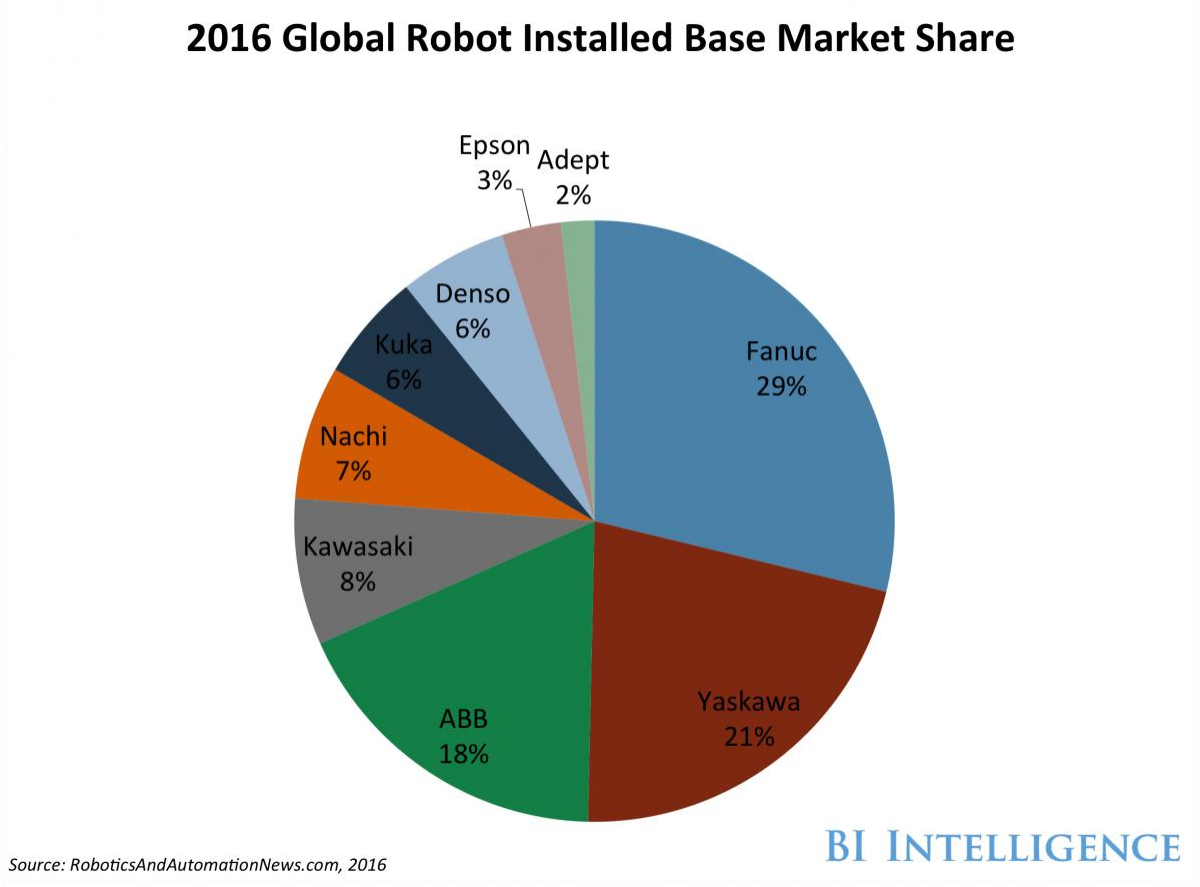


While those shipments numbers may sound low — robotics overall will be a major industry.

Some $390 billion will be spent on hardware, software, and installation costs for enterprise robots between 2016 and 2021. This includes $91.2 billion for enterprise robot installations in 2021, up from $37.7 billion spent in 2015. While we expect the cost of robots to drop, more will be shipped, thus increasing spending.

To calculate our estimate, we looked at average selling/installation prices across various types of robots and accounted for the expected drop in price over time.

In terms of market share, industrial robot maker FANUC dominates. The company accounts for 29% of installed robots globally, according to RoboticsAndAutomationNews.com. FANUC said in December that it has sold over 400,000 robots. The company recently embraced the Internet of Things (IoT) and announced a partnership with Cisco and Rockwell Automation to develop the FANUC Intelligent Edge Link and Drive (FIELD) platform, which connects its robot with other IoT devices in the factory.



GROWTH DRIVERS

Robots are becoming increasingly important to enterprises in select industries as a result of key tech advancements and factors within the broader economic environment.

IoT integration. Robots are gaining internet connectivity, which boosts their automation and analytics capabilities while enabling predictive maintenance.

- Automation refers to the ability to manipulate the robot remotely, while analytics allow the system to adjust how a robot performs without human intervention. Enterprise employees can additionally review the data captured on a robot's performance and make broader scope adjustments to processes.
- Predictive maintenance refers to a data analytics or machine-learning systems that monitor how a robot is performing. Based on historical data, a predictive maintenance system can predict when a robot will need repair, enabling the entity that owns the robot to fix it during downtime instead of during peak hours. For instance, without connectivity, an automaker can get only diagnostic data from its robots during downtime on the assembly line — and one hour of downtime at a car factory can cost up to $1 million, according to a 2016 FANUC report. Predictive maintenance also likely lessens the amount of repair needed, much like how regular maintenance of a car helps car owners keep the vehicle running better over time.

These capabilities are very much in keeping with how adding internet connection to inert objects in the enterprise — like factory light bulbs — can benefit companies. In the case of robots though, the IoT can marry a machine with physical capabilities with powerful data and analytics through internet monitoring.

Labor issues. Business will look to robots as replacements for workers for two chief reasons:

- **Rising wages.** Labor costs are rising dramatically in the manufacturing industry, the top adopter of enterprise robots. Manufacturing wages in China have increased nine times since 2000, according to Merrill Lynch. In the US, manufacturing wages have increased by 25% since 2006 versus a national average of 20%, according to the Bureau of Labor Statistics. While robots are likely to be more expensive than workers in the near term, long-term cost savings will encourage some businesses to replace workers with robots. A Citi analysis in China found that the cost and maintenance of a spot welding robot in the auto industry will drop 11-12% between 2015 and 2017, while annual worker wages will rise by 18%. Since this type of robot can replace three workers, Citi estimates it will pay for itself in 1.3 years by 2017, down from 2.1 years in 2015.
- **Aging populations will result in worker shortages.** The global birth rate has dropped by more than half since the 1960s, according to The World Bank, which means the world's population is aging. As more people age out of the workforce and fewer young workers join it, we'll see more worker shortages. In Japan, as much as 26% of the population is over 65, and 30% will be by 2030, according to UN population estimates and Citi Research. In the US, 21% will be over 65 by 2030, up from 15% in 2015. For industries in many of these countries, robots will be a necessity as the labor market tightens.

Competitive advantages. Whether robots work in tandem with humans or replace them altogether, they can improve output and reduce operating costs.

- **Fewer errors.** Much as autonomous cars are proving to be better drivers than humans, robots reduce human error.
- **More productive.** A robot can run continuously — a robot operating 24 hours a day potentially replaces three factory employees each working an eight-hour shift. As many as 95% of Citi institutional clients agree that automation and technology will help drive productivity growth over time, according to a recent Citi Research survey, and 60% believe it will happen "to a significant degree."

INDUSTRIES LEADING THE WAY IN ROBOT ADOPTION

From manufacturing to healthcare, almost every industry is finding a use case for robots. Although some of these may sound gimmicky — like the customer service OSHbots in Lowe's stores that speaks multiple languages and helps shoppers find items — they show potential concepts that could evolve in the market.

Manufacturing

Manufacturing is at the forefront in adopting enterprise robots. That's because manufacturers can easily automate portions of the assembly line using robots. Robot use in manufacturing has historically been high — as of 2014, 59% of manufacturing executives used robots, according to a PwC and Zpyrme survey. Boston Consulting Group (BCG) estimated in 2015 that robots will complete 10-25% of the share of tasks across all manufacturing industries by 2025.

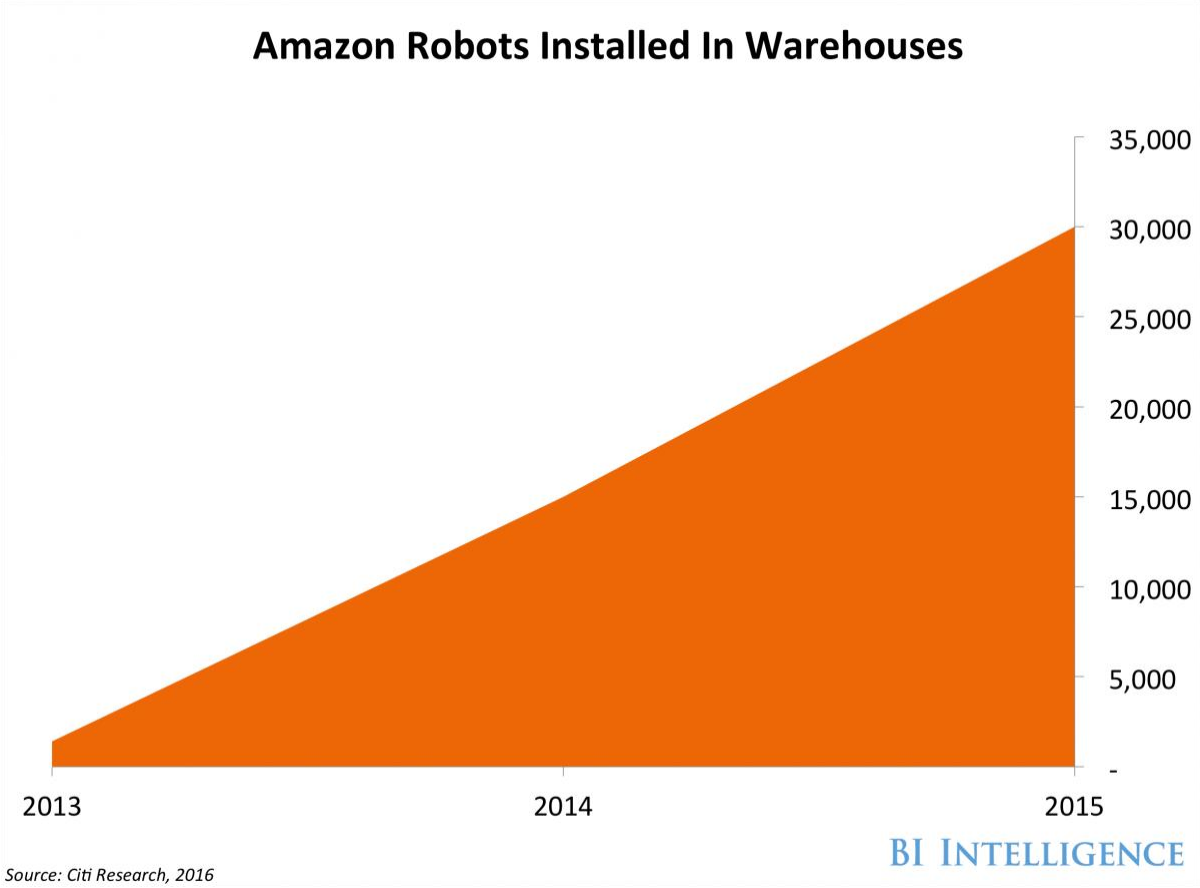
- **Through 2025, 75% of industrial robot installations will be used in four subsets of the manufacturing industry: machinery, transportation equipment, electrical equipment, and computers and electronic products**, according to BCG. BCG determined that 85% of "production tasks" in each manufacturing subset could already be automated and that companies are not yet taking full advantage of opportunities to save on wage costs.
- **China, Japan, and the US will account for more than 60% of industrial robot shipments by 2020,** according to BCG. To date, Indonesia, South Korea, Taiwan, and Thailand have recorded the most rapid YoY growth for industrial robot purchases. Meanwhile, Chinese corporations have been the primary purchasers of industrial robots used in manufacturing, due largely to rising wages in the country, according to the IFR.
    - For example, Chinese manufacturing giant Foxconn has reportedly replaced 60,000 out of 110,000 workers at one of its factories with robots, according to the BBC citing South China Morning Post. These robots will take the place of workers who perform repetitive tasks on its assembly lines. Foxconn said that it plans to reallocate some of its workers to other departments in the company, like quality control and research and development.

Shipping And Logistics

Based on individual company adoption of robots and discussions within the industry, we believe the shipping and logistics industry is just behind manufacturing as the No. 2 industry adopter of robots. Shipping and logistics is well-suited to robot implementations because many of the tasks are repetitive and labor intensive, such as sorting items and moving heavy products.

More than half (51%) of professionals in the supply chain and logistics industry believe robotics and automation will provide a competitive advantage in their industry, according to a recently released survey from industry association MHI and Deloitte. That's up from 39% in a similar survey fielded last year, as reported in The Wall Street Journal.

In warehouses, internet-connected robots are programmed to move goods. Citi estimates that **Amazon now has 30,000 robots deployed across 13 warehouses.** Retailers including Zara and Bonobos use Locus robots in their warehouses to help fulfill online orders.



Source: Citi Research, 2016

Automated guided vehicles (AGVs) — robots specifically designed for moving items from one location to another — like the Amazon Robotics machines, can significantly cut costs.

- Amazon has estimated that AGVs will lower their operating costs by up to 20%.
- In shipping, industry analysts say automation can cut time in port by up to 30%.

Some two dozen giant robots currently move cargo containers around TraPac LLC's terminal at the Port of Los Angeles. Another set of robots then carries the containers to spots around the terminal for picking up or unloading.

For now, robots typically work behind the scenes within the shipping and logistics industry, but new initiatives suggest that robots will soon be used to deliver products to the customer's door:

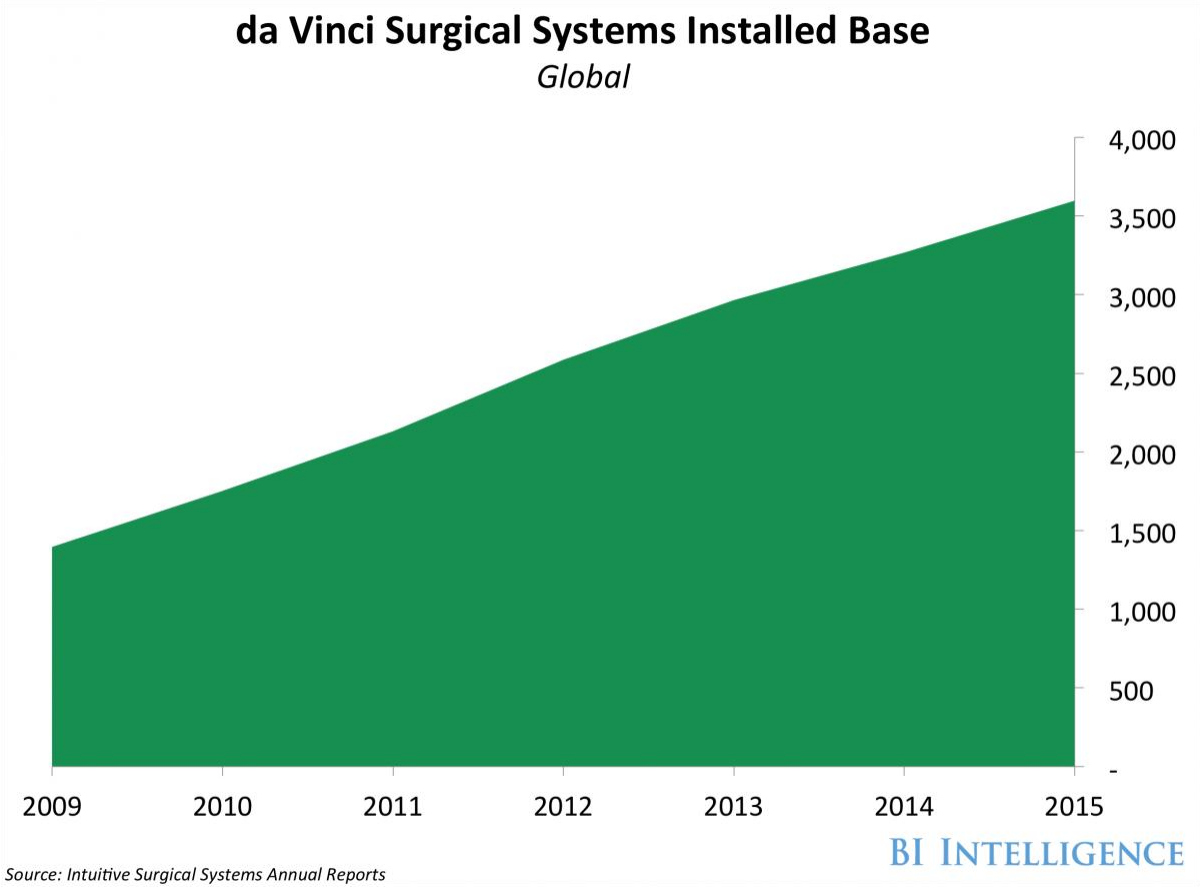
- Skype's co-founders have created Starship, a small robot that autonomously navigates sidewalks at around 4 miles per hour to deliver up to 20 pounds of goods, according to Business Insider. The company has tested Starship in 20 cities in the US and Europe, according to Bloomberg.
- Domino's is piloting a similar robot, dubbed DRU (Domino's Robotic Unit), that can keep pizza hot and drinks cool while making deliveries.

Healthcare

In healthcare, robots are still relatively nascent but are increasingly being used in surgery, to deliver medication to patients, and for tasks like drawing blood.

Surgical robots, one of the most talked-about robot uses in healthcare, enable greater precision during medical procedures. Intuitive Surgical, one of the top surgical robot manufacturers, said its 3,597 da Vinci Surgical Systems robots in use performed 670,000 surgeries in 2015.

The cost of surgical robots is holding back growth, however. One da Vinci Surgical System costs $1.5 million to $2 million on average. And many hospitals don't use them enough to justify the cost. For example, a Wisconsin hospital that bought a da Vinci Surgical System in 2014 expected to perform around 100 surgeries a year with it, according to Modern Healthcare. Experts say that's far below the average volume needed to produce a return on investment within six years. This helps explain why Intuitive Surgical, the market leader, installs only about 367 robots per year.



More affordable alternatives may be on the horizon. Johnson & Johnson and Alphabet's Verily Life Sciences partnered in December 2015 to create a surgical robot that is both less expensive and 20% smaller than the da Vinci device, according to Reuters. Johnson & Johnson's global chairman of medical devices explained at the time: "Our goal is to have a lower-cost product with the smallest footprint, with greater capability, that helps to raise the standard of care. That would be market disruption."

In the short term, surgical robots will likely be restricted to large hospitals that perform a high volume of surgeries that benefit from robotic assistance. In the longer term, the market will open up to small- to medium-sized hospitals as the price drops.

There's a variety of other applications for robots within the healthcare industry. For example, startup TeleHealthRobotics is making a robot that can perform ultrasounds. Robots can also transport patients and healthcare products through hospitals, much as Amazon uses robots to move goods through its warehouses.

The University of California, San Francisco Medical Center (UCSFMC) has been using 25 Tug robots to deliver medication, linens, meals, trash, and medical waster throughout the hospital, according to WIRED. Each TUG robot is equipped with sensors that enable it to travel down the hallways. It uses biometric fingerprint scanners as a security measure to verify that the correct staff member is accessing the medication the TUG is transporting.

UCSFMC purchased the robots in 2014 from Aethon for $3.5 million and spent another $2.5 million adapting the robots and hospital so they could work in harmony, according to CNBC.

Despite the high cost, UCSFMC expects a return on its investment by 2017 because robots will still be less expensive than paying employees to perform the same function. The robots need to be charged for only a few hours per day, meaning they replace multiple workers who have to work in shifts or who might get sick frequently as a result of the hospital environment. Comparatively, robots never take a sick day, and they are capable of lifting hundreds of pounds, preventing common injuries. Aethon claims that a TUG robot lowers the cost per drug delivery by 50-80%.

INDUSTRIES THAT COULD BE DISRUPTED NEXT

There are a few industries where robots might increasingly have a consumer-facing presence. In the food service, retail, and hospitality industries robots are still largely a novelty, but if experiments pan out, we could see robots deployed more widely.

Food service: Some restaurants are using robot waiters to deliver food to customers, and there are also robots that do menial tasks in the kitchen, like lifting the cover off a pan. Companies working to improve food services' robotic technology include Momentum Machines, a San Francisco startup developing a robot that can fully assemble a burger in 10 seconds.

As food service wages continue to rise, restaurant owners may become more interested in automating more of their operations. As much as 81% of a food prep worker's job and 64% of a server's job could be automated, according to McKinsey.

The top goal of 2016 tech projects in the food services industry will be to improve operational/process efficiency, according to a Hospitality Technologies survey of restaurant executives. As in most other industries, the top challenge is justifying the technology's ROI.

Retail stores: While the retail experience has been shifting online, brick-and-mortar stores still account for approximately 93% of US retail sales, according to the US Department of Commerce. With wages rising, retailers are trying to boost margins by replacing workers with robots. In addition, the novelty factor, along with improved customer service (if robots do improve customer service), could potentially drive more foot traffic. Here are a few examples of retailers using robots in-store:

- As mentioned earlier, Lowe's has been working on OSHbot, a customer service robot that speaks multiple languages and helps shoppers find items. The company has been testing them in its Orchard Supply Hardware subsidiary.
- Best Buy has integrated Chloe, a robot that fetches goods that customers request from a kiosk.
- Target recently ran a trial of Tally, a robot that moves through the aisles taking inventory.

Hospitality: While hotels are only just starting to experiment with robots, **21% of hotel executives globally believe hotels could have a robotic concierge or butler in the future,** according to a 2016 report from Hospitality and Technology. These are some of the ways hotels have integrated robots so far:

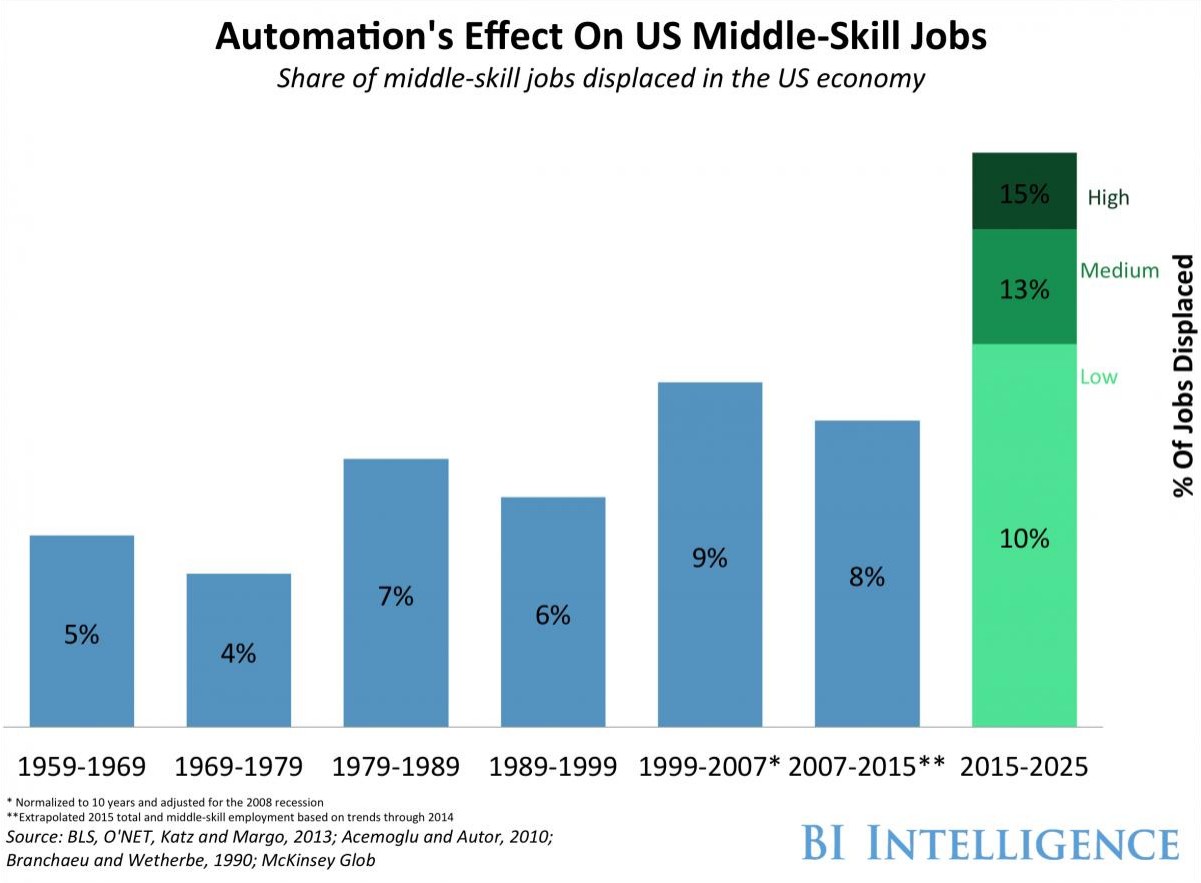
- **Yotel uses robotic arms to carry luggage and help clean rooms** at its London, New York City, and Amsterdam locations.
- **Hilton is testing an $8,000 concierge robot powered by IBM's Watson artificial intelligence.** The humanoid machine is designed to answer questions that guests might normally ask a concierge.
- Aloft Hotels introduced Botlr, **a robot that drops off toiletries or room service meals for guests,** in 2014. The Crowne Plaza is using a similar robot, dubbed Dash, which can move autonomously and call up the elevator using its Wi-Fi connection, according to hospitalitynet.

As food service, retail and hospitality executives test out robots in their workforce, they will be working to clarify answers to several fundamental questions:

- Is the robot more productive than a human worker?
- Is the robot able to address consumer needs as effectively or more effectively than a customer service rep?
- How are customers reacting to interactions with robots?
- And ultimately, is the robot worth the cost?

WILL ROBOTS TAKE YOUR JOB?

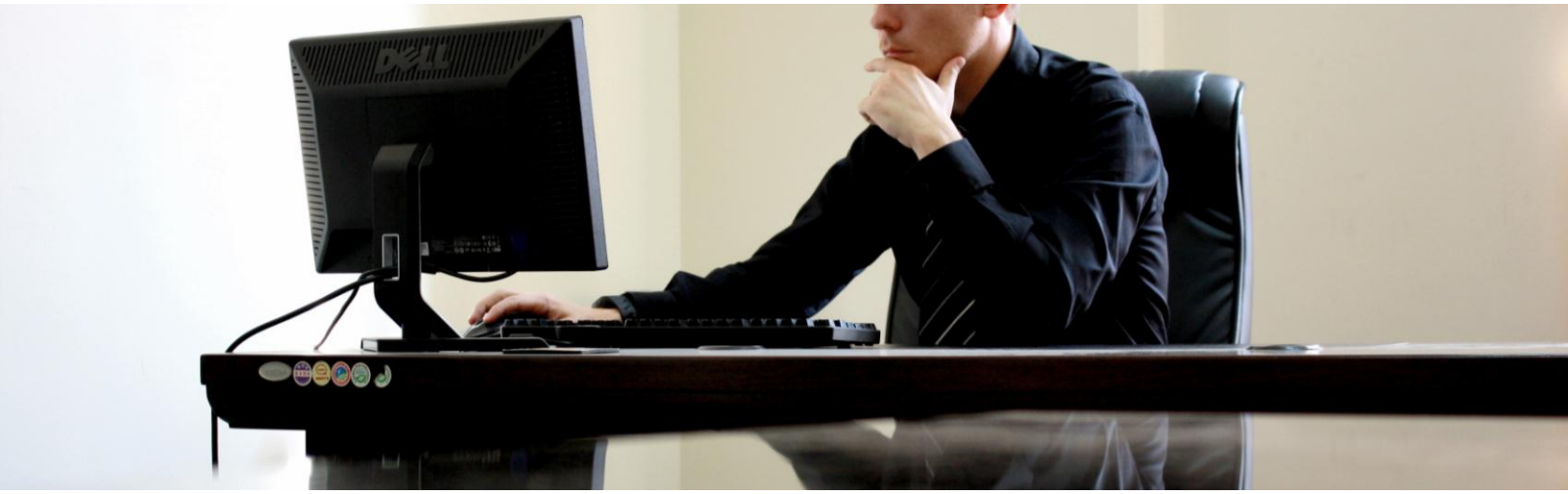
The prevailing market sentiment is that robots will negatively affect blue-collar jobs while creating more white-collar jobs. This if referred to as "job displacement." For example, a new robot on the factory floor might eliminate a worker's job but would also mean adding an employee to manage and repair that robot. However, robots are unlikely to create as many jobs as they displace, and some argue even the jobs they create may be challenging to fill, as not enough people will have the skills to manage the robot workforce.



The issue more broadly is automation, which generally groups robots together with artificial intelligence (AI)-powered software, a rapidly developing area (for instance, chatbots are software programs that can talk with consumers).

Automation is likely to affect job growth considerably. Below are several estimates:

- **Global: By 2020, 5 million net jobs will be lost to increased automation in 15 of the world's developed economies, including the US, the UK, and Japan,** according to a World Economic Forum report. New jobs will be concentrated in technology, math, and engineering; the report predicts that automation would help create 2.1 million jobs in these areas.
- **US: McKinsey estimates that increased automation could displace 10-15% of middle-skill jobs (e.g. operational, clerical, production, sales) over the next 10 years.** McKinsey's high estimate of 15%, or 12 million jobs, is equivalent to the number of jobs displaced since 1999, the beginning of the tech boom.
- **UK: 15 million jobs could be automated over the next 20 years,** according to a study by the Bank of England, as Business Insider has reported. Administrative, clerical, and production jobs are at the highest risk for automation. The Bank of England's chief economist warned that technology could lead to many workers losing their jobs but said it will also open up new opportunities, especially for skilled workers.



BARRIERS TO ROBOT ADOPTION IN THE ENTERPRISE

- **Cost is still the biggest barrier to robot adoption.** Besides the cost of the hardware itself, robots also come with considerable associated costs, including the control system, software, and image-processing system. But **robot prices are dropping.** For example, the cost of a robotic welder decreased from $182,000 to $133,000 between 2005 and 2014, according to BCG.
- **Robot mechanical technology still has much room for improvement.** While the software capabilities of robots are advancing rapidly, operational capabilities are still limited. At Fortune's Global Forum last year, **one robotics industry executive compared the abilities of today's robot with that of a two-year-old.** Manufacturing robots in particular are designed to perform just one specific task within the production cycle. For example, Kawasaki recently showcased a robotic arm for spray-painting cars coming off the assembly line. Manufacturers must therefore buy multiple robots to complete a series of assembly line tasks. Further, many robots must operate within a cage for safety purposes. But some robot makers are now removing the need for cages by integrating sensors that detect when a human is nearby.
- **Workforce and PR push back.** Businesses generally integrate robots into a workforce slowly; full automation isn't possible overnight. If unions sense that jobs are soon to be replaced en masse, they could strike and halt production. And, if it becomes apparent that robots are replacing jobs, worker morale will likely sink. Moreover, cutting jobs will likely put companies under scrutiny and could negatively impact a company's reputation.
- **Economic challenges.** Some argue that replacing workers with robots is self-defeating because it will up unemployment and thus reduce demand for products and services. But businesses that don't adopt this technology will likely be unable to compete on price with competitors that have lowered operating costs thanks to robot workers.
- **A growing skills gap.** As many as 2 million of the 3.4 million job openings in the US manufacturing industry over the next decade won't be filled because workers lack the required skills, according to Deloitte estimates. Finding and attracting talent to complement robot workers will be difficult.

THE BOTTOM LINE

- The enterprise robot market is heating up, and will continue to grow steadily. We expect 2.8 million enterprise robots to ship between 2016 and 2021.
- Some $390 billion will be spent on hardware, software, and installation costs for enterprise robots over the next five years.
- The key factors driving up robotics adoption across industries include IoT integration, labor issues, and competitive advantages.
- Manufacturing is at the forefront in adopting enterprise robots. That's because manufacturers can easily automate portions of the assembly line using robots.
- Shipping and logistics is well-suited to robot implementations because many of the tasks are repetitive and labor intensive, such as sorting items and moving heavy products.
- In healthcare, robot use is still relatively nascent, but robots are increasingly being used in surgery and for other tasks.
- In the food service, retail, and hospitality industries robots are still largely a novelty, but if experiments pan out, we could see robots deployed more widely.
- Automation — which typically includes robots and AI-powered software — is likely to affect job growth considerably. In the US, McKinsey estimates that increased automation could displace 10-15% middle-skill jobs over the next 10 years.
- Cost is the chief barrier to robot adoption. Besides the cost of the hardware itself, robots also come with considerable associated costs, including the control system, software, and image-processing system.

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