GLOBAL
Insight

RBC Wealth Management

Special report

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Robotics comes of age

Emerging technological advancements are driving innovations all around us, transforming how we live, work, and interact with one another, today and in the future. RBC Wealth Management's "Innovations" series examines these agents of change and how they can bring up compelling investment opportunities.

Frédérique Carrier

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Special report

Robotics comes of age

The word ‘robot’ originated in a 1920 play by Karel Čapek. It is derived from the Czech ‘robota’, meaning drudgery or forced labour. Over a century later, it still evokes futuristic fascination. Is the era of R2-D2 and C-3PO, the two Star Wars robots, upon us? This article explores the innovations transforming robotics and the industry’s state of play. We focus on the intriguing and much-hyped world of humanoid robots, considering how the workplace and the home might change with these machines before exploring investment opportunities.



Frédérique Carrier
London, United Kingdom
frederique.carrier@rbc.com

Key points

- **Powerful hardware and software advances, moving in lockstep, are transforming robotics.**
- **Industrial and service robots remain the backbone of today’s robotics industry.**
- **Humanoid robots’ athletic prowess is impressive, but they remain confined to structured industrial pilots—for now.**
- **Actionable investment opportunities lie across the whole robotics value chain.**

Innovations gather pace

Extraordinary scientific advances are transforming the robotics industry.

Daniela Rus, director of the Massachusetts Institute of Technology (MIT) Computer Science and Artificial Intelligence Laboratory, told McKinsey in a June 2026 interview that a robot should be thought of as having two components: the body (hardware) and the brain (software). She maintains that while both have progressed significantly, meaningful advancement requires them to move forward in tandem, as they have in recent years.

The body

Robotic bodies have evolved from metal and heavy plastic to a wide range of materials, at times even engineered for specific tasks. Chinese company XPENG’s robot, unveiled in November 2025, is a machine disconcertingly humanlike, with synthetic skin stretched across lattice muscles that feel soft to the touch. These new materials are now paired with markedly smaller, lighter motors than a decade ago.

This matters because dexterity requires fitting motors into tight places: a hand has many small joints. Previous-generation motors were too large or too weak.

Today’s motors are also more precise, reporting and controlling positions and force with minimal mechanical slop, or slack, between the motor and the part it is moving. This precision enables robots to perform delicate tasks such as tying shoelaces.

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The brain

AI has transformed how robots perceive and respond to their environment. Legacy robots required step-by-step programming and precise physical conditions. In a manufacturing setting, for instance, a part had to arrive at the exact spot and orientation required, or the robot would not recognize it.

Today's robots learn to recognize objects the way image-recognition software on a phone does: by studying a vast number of examples until they can identify an object regardless of its position, lighting, or orientation. They then use that recognition to adjust their movements accordingly. This eliminates the need to reprogram robots when the production line changes.

Moreover, a newer generation of AI systems, known as vision-language-action (VLA) models, enable robots to turn plain language instructions, such as 'pick up the glass on the right', directly into movement. In older systems, seeing, understanding language, and generating motor commands were performed by separate systems, which engineers then manually integrated.

Today, VLA models can merge all three into one trained system that reads the scene, interprets the instruction, and generates the movement in a single step. That lets robots attempt tasks they were never specifically trained for, and be directed in plain language, without a specialist writing code for every new task.

The body and the brain as a team

Rus believes that the clearest gains arise when body and brain improve together, and she points to the example of robot navigation. Researchers once designed navigation software for sonar technology which judges distance by measuring how sound waves bounce back, like a submarine detecting nearby objects. The software was theoretically well-designed but unreliable, due to imprecise readings. When laser sensors arrived, measuring distance with light far more precisely than sound could, the same software's performance improved. That is, more accurate sensors (the body) gave the algorithm (the brain) the data it needed to work more effectively.

A similar coupling shows results on a commercial scale. Amazon's robotic arm system Vulcan, unveiled in May 2025, pairs force-feedback sensors and a gripper fitted with a camera and suction cup (the body) with perception-and-action software (the brain) that lets it adapt to items it has never specifically encountered before. Vulcan reliably handles roughly 75 percent of the more than one million items in Amazon's catalogue, widely varying in shapes, sizes, and textures, including deformable items such as a soft toy in flexible packaging, at speeds comparable to human workers. Boston Consulting Group (BCG), in an April 2026 report, calls this achievement 'previously unimaginable'.

The industry has taken to calling these breakthroughs 'Physical AI'—systems that perceive and act in the physical world, rather than simply processing text or data.

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These advancements transform robotics economics. According to BCG estimates, roughly three-quarters of the total cost of robot ownership goes to setup and re-engineering. Their analysis finds that the new generation of software-defined, perception-driven systems can cut setup costs by up to half.

The excitement generated by advancements in this industry is palpable. Crunchbase, a data provider, estimates that global robotics startups raised $18.8 billion in the first half of 2026 alone, surpassing the $15 billion raised in all of 2025, as venture capital firms broaden their holdings, and major technology players such as NVIDIA and Meta Platforms increase their exposure to robotics.

State of play

Industrial and service robots remain the backbone of today's robotics industry. The International Federation of Robotics (IFR), a trade association, counts more than five million industrial robots in operation worldwide alongside a fast-growing and far more varied fleet of service robots, doing everything from warehouse picking to surgery.

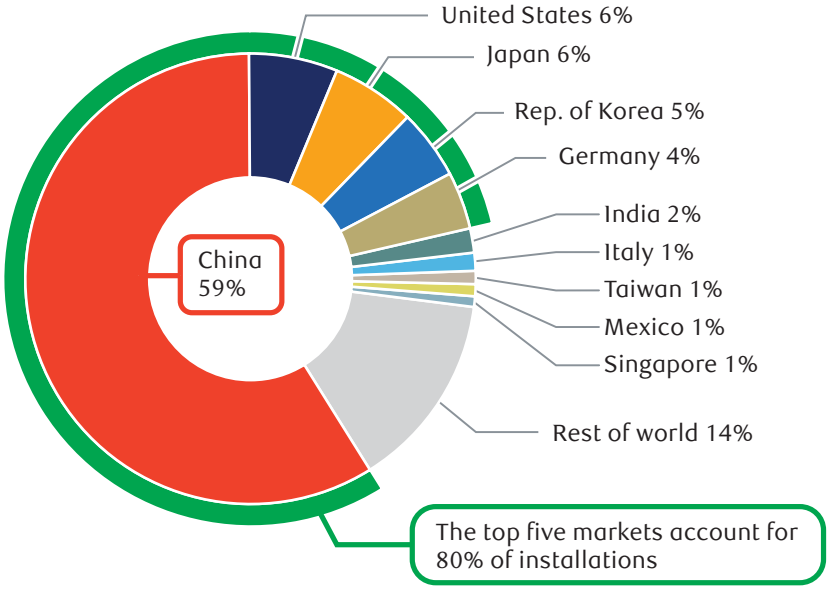
Industrial robots: Broadening beyond automotive

Industrial robots are automated, multipurpose machines used in manufacturing, or 'arms on a factory line', as defined by the International Organization for Standardization (ISO), an independent body that develops technical standards across industries.

According to the International Federation of Robotics (IFR) trade association, 603,000 new robots were installed worldwide in 2025. This brings the global operational stock to more than five million industrial robots, growing at an average annual rate of 11 percent from 2020 to 2025.

China dominates in industrial robots

Annual installations of industrial robots (2025)



Source - RBC Wealth Management, International Federation of Robotics

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The IFR attributes recent growth to nearshoring trends, the need to improve productivity amid labour shortages, and concerns regarding supply chain vulnerabilities. General manufacturing (spanning metals and machinery, plastics and chemicals, food, and other sectors) has become the dominant customer, with its share of installations climbing to 53 percent in 2025 from 26 percent in 2015. Meanwhile, automotive manufacturing's traditional dominance has declined in relative terms.

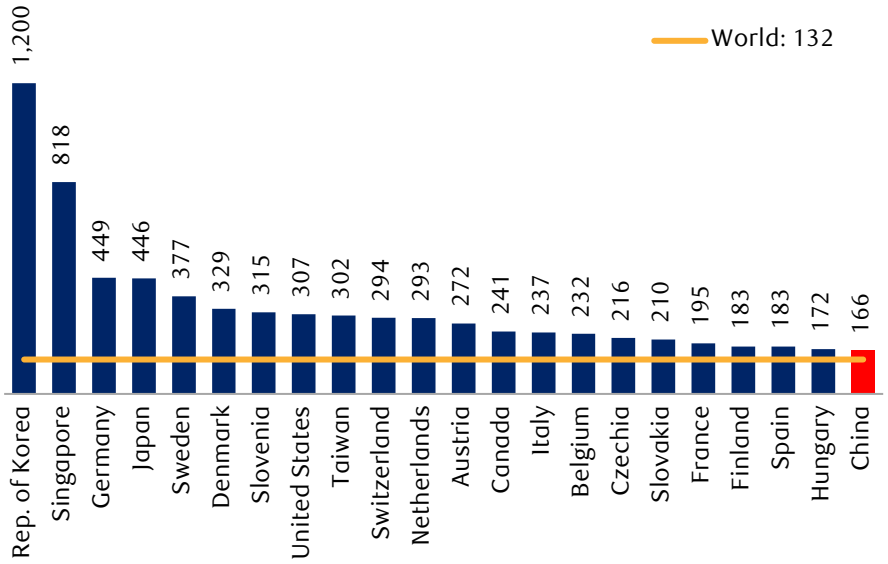
The top five markets by geography accounted for 80 percent of global industrial robot installations in 2025.

Despite this installation effort, China's robot density (the number of robots relative to the size of the national workforce) remains relatively low, suggesting to us that its buildout is still at a relatively early stage. According to an April 2026 IFR report based on 2024 data, China had 166 robots per 10,000 employees, ranking only 22nd globally, reflecting how thinly robots are spread across the country's vast manufacturing workforce. Figures for 2025 aren't available yet and may show some improvement given the pace of installations, but China's robot density is likely to have remained comparatively low, in our opinion.

By contrast, countries such as South Korea, Singapore, Germany, Japan, and Sweden have the highest densities, according to the IFR report.

China's robot density suggests room for upside

Robot density in the manufacturing industry (2024)



Robot density measures the number of robots in use per 10,000 employees in the manufacturing industry, enabling a cross-country comparison that is more insightful than a simple tally of robots in use. The IFR calculated that China's robot density reached 470 in 2023, ranking it third worldwide. But the following year, the IFR changed its methodology to include private companies and self-employed manufacturing workers, a much larger base than before. Density based on the new methodology was still up 17 percent year over year. UK robot density was 112 in 2023.

Source - RBC Wealth Management, International Federation of Robotics

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Key trends

Working alongside robots



The share of collaborative industrial robots, or cobots, reached 11 percent in 2025, nearly double what it was five years ago.



Cobots are industrial robots designed specifically to work directly alongside people without the safety cages traditional industrial robots require, thanks to force-limiting sensors and speed controls that make them slow down or stop automatically when a person gets close. Cobots are simpler to set up and cheaper to redeploy than fixed, fenced-off robots.

China on the up

The Chinese robotic ecosystem is asserting itself. Chinese suppliers installed 55 percent of robots in China in 2025, up from just 30 percent in 2020. At 195,000 robots installed, Chinese suppliers alone installed more robots domestically than the next nine largest national markets combined. This points to a domestic supply chain, including robot makers, component suppliers, and integrators, that is scaling quickly enough to challenge the foreign manufacturers that historically dominated the industry.

These countries all have a manufacturing base heavily weighted towards automotive and electronics—both unusually robot-intensive sectors.

Overall, the IFR expects global installations to grow nine percent to 655,000 units in 2026, and to surpass 800,000 units by 2029, with high-single-digit growth in China and mid-to-low single digits elsewhere.

Service robots: Everywhere but the factory floor

The IFR defines service robots as anything that isn't bolted to the factory floor. They perform a broad range of activities.

Transport & logistics robots, used mainly to automate materials flow and delivery, lead the professional service robots category. Hospitality ranks second, followed by professional cleaning, led by commercial floor scrubbing machines used in large facilities. Medical robotics is growing fastest through surgical robots, reflecting growing clinical acceptance. Consumer services robots, or those sold directly to households, were another fast-growing category, led by vacuum cleaners and lawnmowers.

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The IFR expects demographic change and the persistent shortage of skilled labour to sustain long-term demand for service robots, even as near-term investment may be affected by economic and geopolitical uncertainty.

Nearly half of all professional service robots are used in transportation & logistics

Service robot installations (2025)

Category (1)	Number of units	% of category	Year-over-year growth
Professional service (incl. AMRs) (2)	**250,000**		24%
Transportation & logistics (3)	117,488	47%	21%
Hospitality (4)	55,941	22%	19%
Professional cleaning	44,644	18%	40%
Agriculture	17,141	7%	19%
Inspection and maintenance	6,467	3%	83%
Medical	**15,300**		19%
Surgical	8,400	55%	57%
Consumer services	**34.2 million**		37%

(1) Based on a sample of 238 out of more than 1,000 known manufacturers; sample composition may vary from year to year.

(2) Autonomous Mobile Robots (AMRs) are self-navigating robots that move through a facility without fixed tracks.

(3) Transportation & logistics robots are self-navigating machines that move goods within warehouses and factories.

(4) Hospitality robots provide telepresence in public spaces.

Source - RBC Wealth Management, International Federation of Robotics

Key trends

Robots as a service

Companies are increasingly renting or subscribing to automation rather than purchasing it outright. The IFR reports that 'robots as a service' is now the dominant business model in the United States. This subscription-based model lowers the barrier to adoption for smaller companies. Suppliers are also moving away from single-purpose machines towards robots capable of handling multiple tasks.

Humanoids: From backflips to usefulness

Recent technological breakthroughs are perhaps most visible in humanoid robots, machines designed to resemble humans and operate in human-centric environments.

Videos of humanoids jumping or dancing on stage have stunned viewers. But these are staged, one-off events, the robots having been trained on thousands of simulated hours in virtual reality. Such training builds athletic skills, but not an understanding of how the world works. Getting a

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robot to do a task reliably—with all the complications such as the forces and torques that arise when interacting with the physical world—is far harder, Rus argues.

In his RBC Imagine™ report 'The Rise of Robotic Intelligence', RBC Capital Markets, LLC Global Automobiles and Auto Parts Analyst Tom Narayan argues that robots as domestic assistants are likely more than 20 years away, given the complexity of home tasks that require dexterity and the ability to multitask.

In the near term, Narayan expects industrial and commercial applications to take precedence over household robots due to their narrower capability requirements and faster return on investments for businesses.

Many pilot programmes are underway to integrate humanoids into industrial settings, but progress has been limited since early attempts, McKinsey notes. Humanoid robots remain confined to repetitive, moderately complex tasks in structured, predictable settings such as mapped factory aisles, controlled warehouse lanes, or routine inspection routes. The more dynamic, close-contact roles many roboticists envision for humanoids remains elusive for now.

The table below illustrates some current use cases, as well as the capability of some of the humanoids.

Humanoids on the factory floor: Early industrial pilots

Narrow tasks, heavy safety constraints, still far from autonomy

End user / Robotics company	Use case	Robot / description	Capabilities
BMW / Figure AI	Pilot for a humanoid to move components between stations in mapped, controlled settings, emphasizing mobility over fine manipulation.	**The Figure 02** • Height: 1.68 m (5′5″) • Weight 70 kg (154 lbs)	• Run time: 5 hours • Fourth-generation hands with 16 degrees of freedom (1)
Amazon / Agility Robotics	Pilot for a humanoid to handle repetitive tote movement in warehouses. Despite being able to navigate dynamic environments, it currently operates in semi-segregated zones due to gaps in safety systems and the lack of humanoid-specific regulation.	**The Digit** • Height: 1.75 m (5′9″) • Weight: 65 kg (143 lbs)	• Run time: 4 hours • Can lift 16 kg (35 lbs) • Charges itself via a charging station, docking on its own • Legs have 5 degrees of freedom, arms have 3 • The next-gen Digit announced for end of 2026 aims to have a 50 lb (23 kg) payload and fence-free 'cooperative safety'
Airbus / UBTech robotics	Pilot for a humanoid to do strenuous tasks on aircraft assembly lines so humans can focus on quality control and specialised operations. Currently in testing phase.	**The Walker S2** • Height: 1.76 m (5′9″) • Weight: 73 kg+ (160 lbs) (2)	• Hands have 11 degrees of freedom & tactile sensors • Can hold 7.5 kg (16.5 lbs) in each hand and 1 kg (2.2 lbs) with each finger • Walks at about 2 meters per second • First humanoid robot that can hot-swap its battery while in operation, enabling continuous operation in factories

(1) Degrees of freedom are the number of independent ways a joint can move.

(2) Weight of the Walker S2 ranges from 73 kg to 95 kg.

Source - Bloomberg, Forbes, IEEE Spectrum 'Robots Guide', company reports

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Still, given the promise of robotics, China's government is backing the industry. The Ministry of Industry and Information Technology's 2024 roadmap called for an end-to-end humanoid robotics ecosystem by 2025. It has been backed by a 1 trillion yuan (roughly $140 billion) state venture capital fund launched to support AI, robotics, and other advanced technology sectors. Many local governments are setting up development centres, making it easier for companies to test out new technology. China's humanoid industry also benefits from the robust manufacturing base described above, and an ability to scale hardware production rapidly. Inexpensive components, such as motors and batteries, are readily available, while collaboration between universities and industry enables Chinese firms to iterate and deploy at scale faster than anyone else.

As a result, China now leads the humanoid race. According to Smart Analytics Global, a California-based research firm, Chinese manufacturers accounted for more than 97 percent of the roughly 19,100 humanoid robots shipped globally in the first half of 2026. China is following the same playbook it used for electric vehicles—state backing, a wide domestic supplier base, and fast model turnover—which could position it to set the global standard.

While China has some software innovation gaps, Narayan thinks these could be narrowed through open-source efforts that are encouraging collaboration and progress. Several Chinese robotics firms, including leader AgiBot, have published their hardware designs and robot training data publicly, letting rivals build on each other's work rather than starting from scratch. This is important given that training a humanoid to move and manipulate objects requires huge amounts of real-world interaction data, which is expensive and slow to collect.

Narayan found that while Chinese firms generally excel in hardware, U.S. and European companies lead in software innovation—arguably the most important factor for how far this technology can progress. Companies such as Tesla and Boston Dynamics (now owned by Hyundai) are pushing toward genuine general-purpose intelligence and dexterity rather than volume. This may delay commercialization, but it could enable the U.S. to define what humanoids can actually do, not just how many are built. Though Europe faces a slower path to commercialization, he believes the region's strength lies in research depth. Narayan also thinks European and UK universities have a genuine edge in software sophistication, particularly for longer planning horizons and more advanced autonomy.

Forecasts of how large this industry could become vary enormously. McKinsey expects general-purpose robotics (including humanoids) to reach hundreds of billions of dollars by 2040; other projections are even more aggressive.

Further breakthroughs are needed. On safety, AI models controlling robots make educated guesses, so mistakes remain possible. Layered software and hardware safeguards, from sensors to force limits, can help contain that risk, but clear regulation and certification standards are needed. Humanoids also need more staying power: most can operate for between two and four hours before recharging, much less than the 8- to

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12-hour shifts needed for real deployment. Swappable batteries and faster charging are helping. Dexterity also lags; the joints in human hands can move in more than 20 ways, letting fingers grasp and twist with a level of nuance most robot hands lack. Tactile sensors that mimic human touch and cameras fast enough to guide split-second adjustments mid-grasp could help. Finally, today's humanoid prototypes cost between $150,000 and $500,000 to build, according to McKinsey, well above the $20,000 to $50,000 needed to compete with human labour. As MIT's Rus notes, her lab's robots can already fold laundry, but 'at a price point that is not affordable to regular consumers'.

Tools or teammates?

Rus expects a future with a wide range of machines: some humanoids, others built and optimized for specific tasks.

For Mikell Taylor, director of robotics strategy at General Motors, the future of robotics lies in thoughtful system design that lets humans do their best work alongside increasingly capable collaborative machines. It has little to do with humanoid-filled factories, or 'lights out manufacturing'.

Though many factories have been automated for decades, this automation has largely been designed around existing human workflows. Taylor believes assembly lines need to be redesigned so people can work more closely alongside increasingly advanced automation.

Amazon's logistics transformation illustrates her point. Employees once walked up and down aisles. Today, robots bring the aisles to them while they stand still. Automation has completely transformed the process.

Many industries will likely undergo a similar rethink, in our view. In the automotive sector, manufacturers are already opening experimental facilities to explore what this enhanced automation could mean for their industry.

Further out, robots may become genuinely task-agnostic, able to learn a new activity within hours by merely watching a human perform it, and to work safely alongside people without the cages or segregation that separate them today. Robotics could also undergo a democratization similar to that of spreadsheets. It could move from a specialized domain requiring expertise in physical AI, that is the perception-and-action systems discussed earlier, to a general tool anyone can use. That shift, however, is likely beyond a practical investment horizon.

For now, actionable investment opportunities exist across the robotics value chain, though investors should be aware of how competitive parts of it already are. On the hardware side, these include:

- upstream parts suppliers, such as manufacturers of sensors, actuators, cameras;
- robot makers themselves, particularly those with genuine cost or platform advantages; and
- design companies competing on aesthetics and functionality for consumer appeal.

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On the software side, potential opportunities include developers building the operating systems and apps that run robots, as well as the communication frameworks that let them talk to each other.

Importantly, shares in humanoid robotics companies could be subject to the same pattern seen in other early technology cycles, where genuine technological promise is accompanied by valuations that run ahead of commercial reality.

A century after ‘robot’ took its name from a word for forced labour, the question the industry faces is not how to make machines work for us, but how to make them work alongside us.

Research resources

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