Deutsche Bank
Chief Investment Office

PERSPECTIVES

Special

AI Series

Humanoids

Contents

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Key Takeaways

- **The bots:** Humanoids remain early-stage systems, constrained by power, dexterity, and reliability rather than AI capability.
- **The macro case:** Structural labor shortages and aging demographics support demand, but adoption will be gradual and task specific.
- **The investment implication:** Strong recent performance reflects expectations of long-term growth, with near-term value in supply-chain enablers and longer-term upside dependent on scaling economics and deployment.

01

Introduction

When a humanoid robot crossed the finish line of a half marathon in China in early 2026, it wasn't about speed – it was about proof. The 21km race moved humanoids from controlled lab settings onto a public course, with more than 100 robot teams running alongside roughly 12,000 human participants on parallel tracks. Compared with the previous year, when the inaugural race was marked by falls, failures and a winning robot time of around 2 hours and 40 minutes, the 2026 edition showed a clear step-up in scale and capability: several leading robots beat the human winners, and nearly half of the robot entrants used autonomous navigation rather than remote control. It was another national showcase in which China turned humanoids into public spectacle, much as it had with the humanoid robot games, Spring Festival Gala performances, and other events.

Together, these events made endurance, balance, battery management, cooling, robustness and navigation visible in a format the public could understand. But they also captured both the promise and the illusion of humanoids. They impress, but they also expose the gap between standout demonstrations and scalable, reliable value. Humanoids sit where information-era AI meets industrial automation. The test is whether digital intelligence can become useful physical work. This report looks past the spectacles to ask the more important investment question: can humanoid systems perform useful tasks reliably, safely and economically, at a cost that makes sense?

In practice, these capabilities are beginning to translate into early deployment use cases in structured environments such as manufacturing and logistics, where humanoids perform repetitive handling, transport, and basic assembly tasks.

From humanoid hype to practical value

Humanoid robots should be assessed as practical working systems, focused on whether AI can deliver value in real-world environments rather than just on screens. The human form remains relevant where tools, layouts, and workflows are already built around how people move and operate. This shifts the challenge from software to physical execution, where outcomes depend on reliability, energy usage, and cost. The key question is whether current progress can translate into scalable use. In practice, value comes down to execution: completing useful tasks safely, consistently, at the right speed, and at a cost that makes sense. Adoption will depend on whether enough tasks within a role can be automated to improve productivity, throughput, and labor efficiency.

Global humanoid shipments are currently at the low tens of thousands of units annually and could reach well over a million units annually over the next decade, but that remains a long-term scenario rather than evidence of scale today. Demos, pilots, orders and early rollouts show momentum, but broad autonomous deployment remains unproven. CES 2026 showed a mix of teleoperated, scripted, and autonomous demos. Most systems still operated in controlled conditions.

The long-term case is not that humanoids will transform every workplace soon. It is that they are a meaningful test of whether AI can raise physical productivity. Long-term scenarios estimate a market size of about USD5tn to USD25tn for the complete humanoid ecosystem, which underscores both the potential scale and the uncertainty of the path. That case will be decided by deployment results, system reliability, and economics.

What building a humanoid requires

A humanoid is a full system, not a single product feature. It combines mechanics, computing, and connectivity. Bill of material estimates show the main cost drivers: Actuation systems – motors, drives, reducers and screws – are the largest category, followed by sensing/perception, compute/control, and finally battery modules which are critical for uptime. It also needs control systems that turn sensing and planning into movement, balance, grip and completed tasks.

That system, as outlined above, brings together multiple layers – from mechanics and power to sensing and control – and must ultimately function outside controlled environments. Unlike software, a physical system operates under real-world constraints, including wear, variability, and changing conditions. The key test is whether performance can be delivered reliably and consistently in customer settings.

Intelligence is the next requirement. A humanoid must interpret its surroundings, make decisions, and execute tasks safely in dynamic environments. Achieving this depends heavily on real-world data, particularly for tasks involving touch, force, and interaction with varied objects. While simulation can accelerate development, large-scale deployment remains essential to refine performance and build the data required for broader autonomy.

Figure 1: The anatomy of humanoids

Human anatomy	Humanoid equivalent	What it consists of
Senses	Sensing and perception hardware	Cameras and depth sensors, LiDAR, force and tactile sensors, and onboard motion tracking systems
Brain and nervous system	Compute, control, communication and onboard software	CPUs, GPUs/AI chips, microcontrollers, wireless modules, perception software
Skeleton and muscles	Mechanical structure, actuation and transmission	Structural frame and joints, actuation and transmission systems, and end-effectors (hands and grippers)
Metabolism	Power and thermal systems	Battery and power systems, cooling systems

Source: Deutsche Bank AG. Data as of June 3, 2026.

Manufacturing and scalability then determine economic viability. Systems that are expensive, difficult to maintain, or hard to produce consistently will see limited adoption. Conversely, improvements in production, standardization, and design efficiency can materially reduce costs over time – placing manufacturing learning and system iteration at the center of the investment case.

02

Macro impact: supply chains, constraints, and systemic pressures

Dexterity remains one of the primary technical barriers. While mobility tasks such as walking or carrying attract attention, many economically valuable activities depend on fine manipulation, touch, and safe interaction with people. This shifts the focus toward actuation and control systems and extends the opportunity beyond humanoid form factors to other robotic architectures.

Power and uptime are the next operational constraints. Battery life, energy use, and system reliability determine whether robots can move beyond pilot stages. While some platforms approach around 8 hours of operation, most remain closer to 4 hours, limited by battery density and actuator efficiency. Improvements such as swappable batteries and faster charging can help but add operational complexity. Without sufficient uptime and consistency, the economic case remains constrained.

Real-world data remains both a key bottleneck and a core source of value. Tasks involving touch, variable objects, and dynamic environments are difficult to replicate in simulation, making deployment essential. In practice, this creates a feedback loop: real-world use generates data, improving system performance, and enabling broader adoption.

The demand case is also supported by structural trends. Aging populations, urbanization, and shifting work preferences are tightening labor supply in physical roles, increasing interest in automation where tasks are repetitive or difficult to staff – even as technical and operational challenges persist.

Early adoption is likely to begin in structured settings

Early adoption is most likely in structured environments such as manufacturing, logistics, and warehousing, where tasks are well-defined, and outcomes can be measured. This supports a task-specific approach to deployment, particularly in areas like material handling, pick-and-place, inspection, and basic assembly, where performance in controlled settings can exceed 90%.

Adoption becomes more challenging in less predictable environments requiring fine manipulation, judgment, or close human interaction, which helps explain the slower path for consumer and service applications.

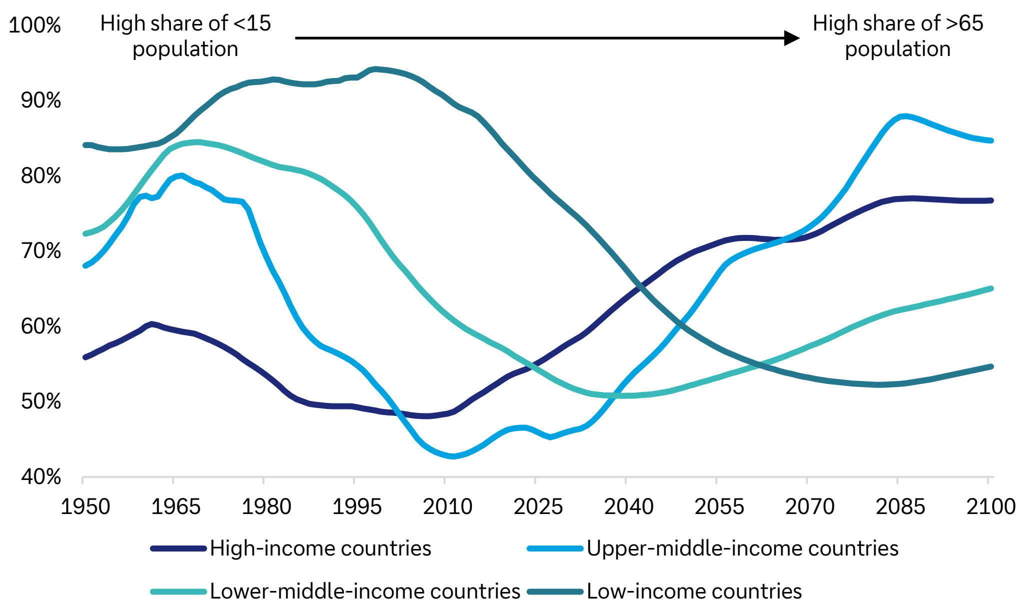
Importantly, humanoids do not need to replicate full human roles to create value – solving a single task reliably at the right cost can be sufficient to drive adoption. At the same time, early orders and pilots should be viewed with caution, as scaling depends on reliability, integration, and consistent performance rather than prototype capability alone.

Value may sit below the surface

The key investment question is not which humanoid looks most advanced, but which underlying systems make useful work possible. Those systems include computing, sensors, actuators, batteries, software, data, factory processes and repair support. The machine is what people see, but the main limits often sit in the layers underneath. This favours exposure to bottleneck technologies and repeatable support models over simply backing the most visible platform.

Figure 2: Need for humanoids: Increasing dependency ratio due to ageing populations

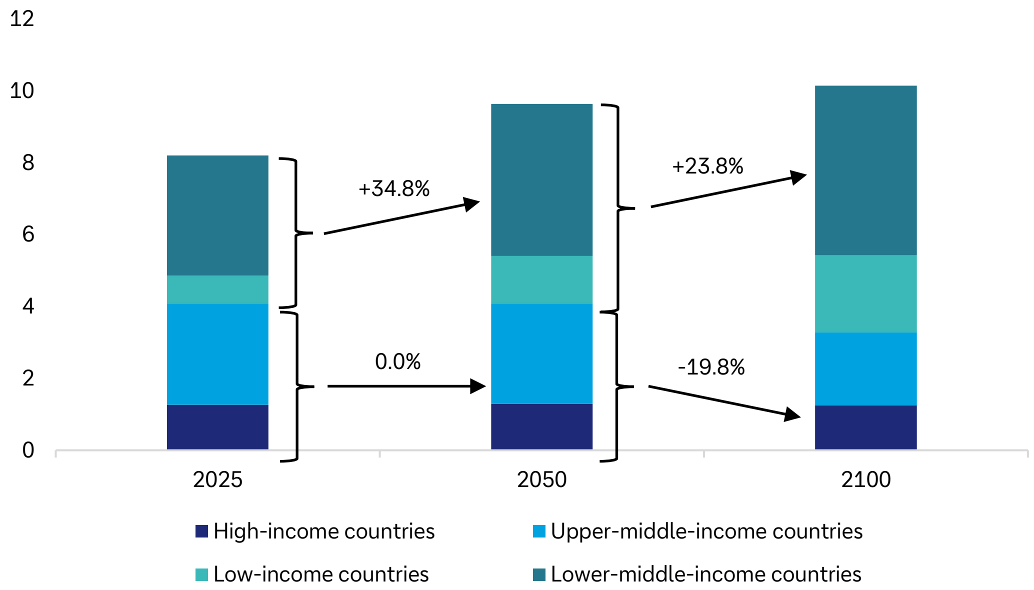
Share of population dependent on working age population



Source: United Nations, Deutsche Bank AG. Data as of July 12, 2024.

Figure 3: Need for humanoids: Shrinking population in certain parts of the world

Population in bn



Source: United Nations, Deutsche Bank AG. Data as of July 12, 2024.

When it comes to building humanoids, not every supplier is an attractive investment. A company can provide an important component and still face weak profits if the market becomes crowded, customers switch suppliers, designs change or capacity expands too quickly. The better approach is to identify where the bottlenecks are most durable and where companies can keep pricing power as the market develops.

The opportunity also extends beyond humanoid makers. Suppliers of sensors, motors, control systems, software, repair services and manufacturing processes may benefit as adoption grows. By 2050, the global humanoid fleet could exceed one billion units, with demand for cameras and motors likely to run into multiple billions of units, alongside megatons of rare-earth magnets and vast edge-computing capacity. The likely winners are therefore not only the companies building humanoids, but also the wider ecosystem that enables them to perform reliably and scale.

Service and support are a related but later-stage opportunity. If humanoid deployment grows, demand should also rise for maintenance, spare parts, software updates, charging, battery replacement, safety checks and end-of-life handling. The auto dealer analogy is imperfect but useful: fixed operations are a small share of revenue but a much larger share of gross profit; service and parts exceeded USD164bn in 2025 and are often cited at roughly half of dealership gross profit. Those businesses may become attractive over time, but only if deployment moves well beyond today's early stage.

The competition for humanoid leadership

No region leads equally across all previously mentioned layers. The US appears strongest in the intelligence layer, while China's advantage is strongest in the physical stack and production system. Specialist industrial economies also remain important: Japan in robot manufacturing and precision components, South Korea in semiconductors, batteries and electronics, and Europe in industrial automation and factory integration.

These differences are already reflected in deployment. In the US, platforms are being tested on tasks such as component handling, parts movement within warehouses, and basic assembly and inspection, alongside progress in mobility and manipulation in less structured environments. This highlights strength in software and system integration, even as deployment remains more limited, with leading platforms operating at pilot to early scale – ranging from over 1,000 units deployed within single manufacturing environments to factory-based trials where humanoids can handle loads of up to 50 kg and perform autonomous sorting and handling tasks in live production settings.

The US-China competition is therefore less about which country produces the most visible humanoid platform and more about control of the full physical-AI stack: models, compute, batteries, manufacturing capacity and exportable system architectures.

China has the clearest production-scale and real-world deployment advantage. It accounts for roughly half of global industrial robot installations and for more than 4 out 5 global humanoid installations in 2025. This matters not only for manufacturing economics, but also for data: the countries with the largest deployment opportunities are best positioned to generate large volumes of physical interaction data, including failures, edge cases, maintenance events and task-performance feedback. China's advantage is reinforced by deep supply chains, domestic deployment opportunities, state-backed industrial policy, rare-earth and magnet inputs, battery ecosystems, component manufacturing and an active push to develop humanoid robot standards.

The US remains highly relevant because raw deployment data alone does not determine leadership. The long-term value layer may shift toward autonomy, software, simulation, edge compute and the ability to transform heterogeneous real-world and synthetic data into generalizable robot behaviour. The key US opportunity is to use its strengths in AI models, compute and software infrastructure to compensate for a smaller physical deployment base.

Beyond the US and China, leadership in humanoids will also depend on countries that control critical parts of the value chain, especially those that scale with robot volumes, raise switching costs, or reduce deployment risk. Europe, Japan, South Korea and Taiwan are relevant because their factories are already automation-intensive and their companies control critical parts of the value chain. South Korea, Germany and Japan for example have the highest robot density worldwide. Europe offers high-quality industrial adoption environments, especially in automotive, machinery and regulated manufacturing. Japan matters through robot manufacturing, motion control and precision components. South Korea is exposed through memory, batteries, power electronics and advanced electronic components. Taiwan is central to advanced semiconductors, electronics manufacturing, testing, packaging and factory digitalization.

03

Investment trends and opportunities for humanoids

1. Commercialization inflection, but still early-stage scaling

Humanoid robotics is moving decisively from prototype to early commercial deployment, but scale remains limited. Industry revenues still marginally remain upwards of USD1bn in 2026, despite high growth rates nearing 90% YoY in some segments, underscoring how early the market remains. Deployment data reinforces this: global installations are roughly 2,500 units in 2026 (vs. 500 in 2025), while total shipments reached 18,000 units in 2025, marking a breakout year but not yet broad adoption.

Adoption is concentrated in manufacturing and logistics, where tasks are repetitive, making ROI easier to quantify. Most deployments remain pilot-driven, with enterprises focused on reliability and integration. Scaling is expected to be gradual, likely pushing more meaningful commercialization into the post-2027 timeframe. Cost is a key constraint, with industrial systems priced at USD50k-USD250k per unit, while consumer models are trending toward sub-USD25k, pointing to improving but still challenging economics.

2. Ecosystem-driven value: hardware today, software over time

The humanoid opportunity is fundamentally an ecosystem story spanning hardware, AI, and supply chains. In the near term, value remains skewed toward hardware, with actuation systems accounting for roughly 50% of total system costs, placing motion at the center of both the engineering challenge and the cost curve. This is compounded by system complexity, with each platform integrating thousands of electronic and semiconductor components, reinforcing dependence on advanced manufacturing and precision supply chains.

These dynamics make supply chains a key bottleneck, particularly across actuation, sensing, and power systems, with constraints likely to persist until architectures begin to standardize over the 2027-2028 period. Capital intensity also remains elevated, with total industry funding exceeding USD6bn as of early 2026 and concentrated among a limited number of leading platforms. Over time, however, differentiation is expected to shift toward software and AI, as real-world deployment drives data accumulation and improves autonomy, performance, and system scalability.

As these constraints begin to ease – supported by falling costs, improving system capability, and gradual supply chain normalization, the adoption curve is expected to inflect. Current estimates suggest global humanoid shipments could increase roughly tenfold, rising from around 1.5 million units annually by 2030 to ~10 million units by 2035. This highlights a key feature of the opportunity: while progress today remains incremental and constrained, the transition to scale – once bottlenecks begin to clear – could be nonlinear rather than gradual, as illustrated in the following chart.

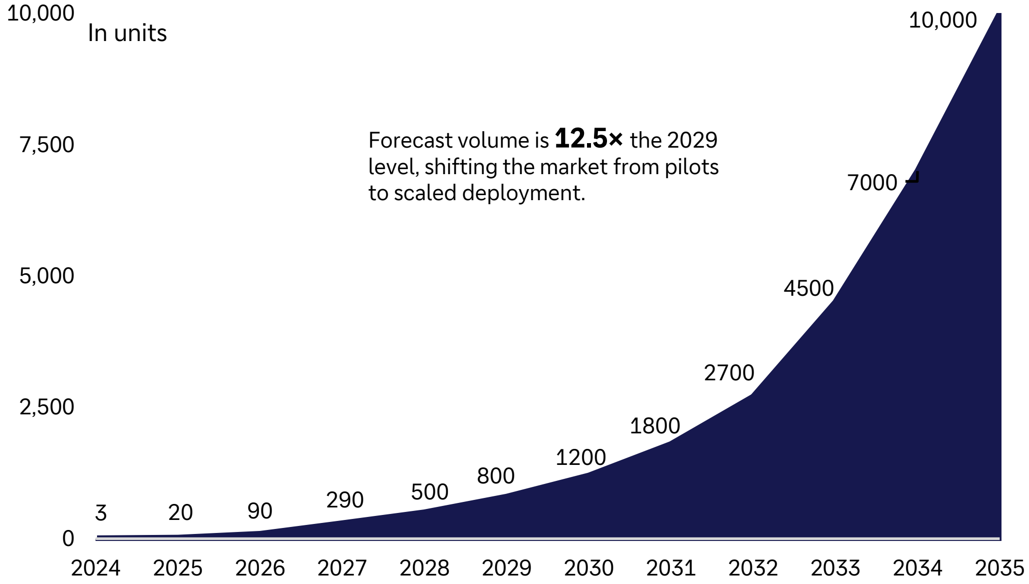
3. Economics anchored in productivity metrics and AI-driven optimization

The investment case for humanoids is increasingly framed around productivity and unit-level economics rather than broad automation narratives. Enterprise adoption is ultimately driven by whether systems can deliver consistent output at a cost that is competitive with, or improves upon, existing labor inputs. In this context, metrics such as utilization, uptime, and cost per task become more relevant than headline deployment announcements.

This reflects a shift toward capital-intensive automation models, where returns are realized through scale, repeatability, and learning effects over time. Under favorable conditions, operating costs for humanoid systems are expected to approach ~USD10-15 per hour equivalent, bringing them closer to parity with certain forms of industrial and service labor. However, achieving this level of efficiency remains contingent on reliability, integration, and sustained utilization.

At a system level, the integration of AI with robotics enables more continuous, end-to-end workflow automation, with real-world deployment generating data that feeds back into performance improvements. As a result, economic viability improves with use-reinforcing a model where early deployment drives both capability and cost efficiency over time, and where adoption ultimately depends on achieving consistent, economically viable performance at scale.

Figure 4: Annual humanoid robot sales: Shipments expected to increase tenfold between 2030 and 2035



Source: Bank of America Research, Deutsche Bank AG. Data as of June 3, 2026.

04

Investment Implications and current landscape

1. Exposure shifting toward ecosystems

Investor exposure to humanoid robotics is increasingly structured through diversified vehicles rather than single end-markets, with thematic baskets delivering 25% YTD returns in 2026. This reflects strong early interest but also the fact that investors are positioning around the broader ecosystem rather than direct monetization.

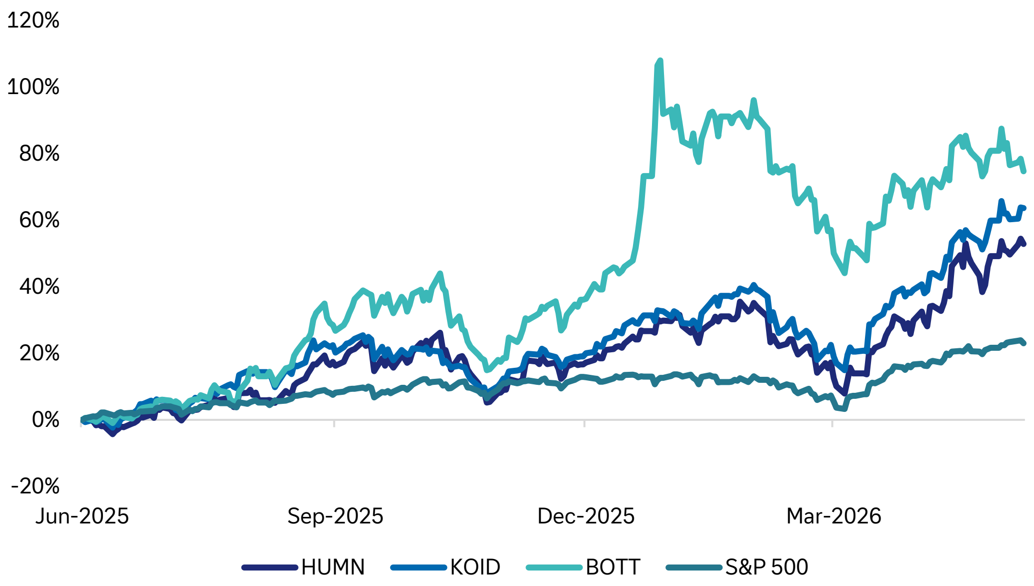
Importantly, exposure today is skewed toward supply chain enablers – particularly semiconductors, sensors, and actuators – given the component intensity of humanoid platforms. This aligns with the current stage of adoption, where deployments remain concentrated in industrial environments (logistics and manufacturing) and are largely pilot-driven. The result is a two-stage opportunity: near-term participation in infrastructure buildout, with longer-term upside tied to scaled deployment.

2. Financial profile: investment-heavy, but improving quality

The humanoid ecosystem reflects an early-cycle financial profile, with improving profitability alongside elevated investment needs. Early indicators suggest operating margins in parts of the value chain are moving from high single digits toward 20%, supported by initial revenue scaling and emerging operating leverage. At the same time, cost structures remain elevated, with SG&A and R&D spending rising materially to support commercialization and integration. This combination – strengthening operating performance but continued capital intensity – is typical of platform technologies in the early stages of adoption.

This dynamic is increasingly reflected in market performance. Over the past year, humanoid- and robotics-linked exposures have delivered price returns averaging 60%, compared to approximately 23% for the S&P 500. This outperformance suggests investors are positioning for long-term ecosystem growth, even as large-scale

Figure 5: Humanoid ETFs performance: Humanoid linked ETFs have yielded higher price returns over the S&P 500 in the past year



Source: LSEG Workspace, Deutsche Bank AG. Data as of June 3, 2026.

deployment remains limited, with performance driven more by expectations of structural change than near-term earnings visibility.

At a market level, the opportunity builds on a broader robotics industry already at scale-estimated at roughly USD80-90bn globally in 2026, with industrial installations exceeding USD16bn annually – providing a foundation for incremental expansion. However, adoption remains dependent on further improvements in cost, reliability, and system integration.

3. Market structure: capital intensity, cost curves, and bottlenecks

The current landscape is defined by high capital intensity, accelerating cost deflation, and persistent supply constraints. Total humanoid-specific funding now exceeds USD8bn across more than 100 companies, with capital highly concentrated – top rounds account for roughly half of total investment, pointing to an increasingly scale-driven market structure.

At the same time, cost curves are improving rapidly. Manufacturing costs have declined by an estimated 40%-60% as systems move from prototype to early production scale, driven by increasing volumes, component standardization, and intensifying competition. However, scaling remains constrained by supply bottlenecks, with lead times for critical components still in the 6-12 month range, limiting the pace of deployment despite improving economics.

This creates a clear structural dynamic: near-term value accrues upstream suppliers and enabling infrastructure, where capacity and component constraints persist, while end-market platforms remain in early deployment. At the same time, the broader robotics base – supported by roughly 500,000+ industrial robot installations annually and a global installed base of around four million units – provides a foundation for long-term demand expansion.

In aggregate, the humanoid robotics landscape reflects an early-stage, capital-intensive platform buildout, where falling costs and improving profitability coexist with high R&D spend, limited deployment scale, and supply constraints. Near-term value is concentrated in enabling technologies and diversified exposure, while longer-term upside remains tied to scaling, software monetization, and the transition from pilot deployments to economically viable adoption.

05

Conclusion

In conclusion, humanoid robotics should be understood as an extension of the AI development cycle, moving intelligence from digital systems into the physical world. Its long-term relevance lies in addressing structural gaps in labor availability, particularly across repetitive or constrained tasks. However, the path to scale is inherently more complex than in software-led AI. Costs remain elevated; energy requirements are material, and real-world deployment introduces constraints around reliability, safety, and uptime. As a result, the opportunity sits between industrial and technology frameworks, rather than fully within high-margin software models.

Progress is likely to remain task-specific, with adoption ultimately driven by clear productivity gains and economic viability. The key question is not whether the technology can function, but whether it can do so consistently and cost-effectively at scale. Humanoids are therefore unlikely to replace human labor in aggregate; their value will be defined by how effectively they augment it.

From an investment perspective, this points to a broad and distributed opportunity. While humanoid-linked exposures are emerging, the impact is likely to extend across multiple sectors – including industrials, semiconductors, software, and physical infrastructure – reflecting the system-level nature of technology. Capturing the opportunity is less about a single platform or theme, and more about identifying where scale, constraints, and pricing power converge across the ecosystem.

Appendix

Glossary

Actuation systems convert control signals into physical motion through components such as motors, drives, reducers and screws.
Age dependency ratio measures how many people are reliant on them and are either under the age of 15 or over the age of 64. Data are presented as the number of dependents per 100 people who are working-age.
Artificial intelligence (AI) refers to computer systems that can perform tasks normally requiring human intelligence, including perception, decision-making and learning from data.
Automation refers to the use of technology to perform tasks with limited human intervention, often to improve productivity, consistency or cost efficiency.
Autonomous navigation describes a system's ability to move through an environment and make route decisions without direct remote control.
Battery density measures how much energy a battery can store relative to its size or weight and is important for robot operating time.
Bill of materials is a list of the components and inputs required to build a product and is often used to assess system cost drivers.
Bottlenecks are constraints that limit the speed, scale or output of a process, supply chain or deployment pathway.
Capital intensity describes a business or technology model that requires substantial investment in assets, production capacity or infrastructure before scaling.
Commercialization is the process of moving a technology from prototype or pilot stage into broader market deployment and revenue generation.
Cost curve describes how production or operating costs change as scale, learning effects and process improvements develop over time.
Dexterity refers to the ability to handle, grasp and manipulate objects accurately, especially in tasks requiring fine motor control.
Edge computing is computing performed close to where data are generated, reducing latency and supporting faster decisions in physical systems.
Exchange Traded Funds (ETFs) are investment funds traded on stock exchanges.
Gross profit is revenue minus the direct costs of producing or delivering goods and services before other operating expenses are deducted.
Humanoid robotics refers to robots designed with a human-like form factor so they can operate in environments, tools and workflows built around people.
Industrial robot installations refer to the number of robots newly deployed in industrial settings such as manufacturing, logistics or warehousing.
Labor shortages describe situations where available workers are insufficient to meet demand for specific roles, skills or locations.
Operating leverage describes how earnings can rise faster than revenue when fixed costs are spread across a larger scale of activity.
Pilot deployment is an early, limited rollout used to test performance, integration and economics before broader adoption.
Pricing power is the ability of a company or supplier to maintain or increase prices without losing significant demand.
Rare-earth magnets are high-strength magnets made with rare-earth elements and used in motors and other precision components.
Real-world data refers to information generated from actual operating environments rather than laboratory tests or simulations.
Research and development (R&D) refers to spending and activity focused on creating, testing and improving products, processes or technologies.
Return on investment (ROI) measures the gain or benefit from an investment relative to its cost.
S&P 500 Index includes 500 leading US companies capturing approximately 80% coverage of available US market capitalization.
Selling, general and administrative expenses (SG&A) are operating expenses related to selling, management and administration that are not direct production costs.
Semiconductors are materials and components used to control electrical signals and are core inputs for computing, sensing and electronic systems.
Supply chains are networks of suppliers, manufacturers, logistics providers and processes that produce and deliver goods or components.
Tariffs are fees (absolute or proportional to value) levied to increase the price of imports.
Uptime is the share of time a system is available and functioning as intended.
USD is the currency code for the US Dollar.
Year-to-date (YTD) describes performance or change measured from the beginning of the current calendar year to the latest stated date.

Appendix

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