

Humanoid Robotics & Physical AI

From Industrial Automation to General-Purpose Physical Labor

Humanoid robotics is moving from technical feasibility toward commercial testing. Near-term adoption should center on industrial settings. The central economic question is straightforward: can a general-purpose machine perform useful physical work at a lower cost per productive hour than human labor or fixed automation?

Sector view	Constructive, with meaningful qualification
Base case	Industrial-first adoption; household robotics remains a longer-duration opportunity
Core economic metric	Cost per productive robot-hour
Hardware center of gravity	Actuation, at roughly 40–60% of humanoid bill of materials
Monitoring framework	Operating evidence, with emphasis on deployment quality and economics
Next in series	Part II: public-market exposure across materials, motion and control, and automation

Independent industry research on humanoid robotics and physical AI. Data as of September 2026 unless otherwise noted. See Disclosures at the end of this report.

1 EXECUTIVE SUMMARY

Humanoid robotics has reached a more consequential stage of development. Recent progress has shifted the discussion toward commercial performance. The core questions now involve autonomy, reliability, utilization, and customer economics. Industrial automation already operates at global scale, although most systems still focus on tightly defined tasks. Humanoids aim to extend automation into work that still depends on human flexibility.

The operating backdrop is favorable. Global factories installed more than **600,000** industrial robots in 2025, up **11%** from the prior year. The worldwide operational stock reached roughly **5 million** units. China installed **354,000** robots, equal to 59% of the global total. U.S. manufacturing also faces nearly 1 million production-occupation openings per year through 2034, largely because workers retire or leave occupations. Persistent replacement demand can support automation even when aggregate employment changes little.

Several technology developments are reinforcing that demand. Robot foundation models and simulation are improving machine intelligence. Hardware supply chains increasingly overlap with mature EV and semiconductor ecosystems. Manufacturers are also designing humanoids with volume production in mind. Together, these developments improve the odds that humanoids can move from custom engineering projects into repeatable commercial products.

The strongest early use cases are likely to sit inside factories, warehouses, logistics facilities, and hazardous industrial environments. These settings offer structured workflows, high utilization, and measurable returns.

Household robotics has a steeper path. Homes contain more variability, stricter safety requirements, and lower willingness to pay.

The industry remains pre-mass-market. McKinsey estimates a current humanoid bill of materials of roughly **\$30,000** to **\$150,000**. A sub-**\$20,000** threshold is often discussed for broader adoption. Actuation can represent **40–60%** of the BOM, which places motors, gearboxes, bearings, magnets, power electronics, and sensors near the center of the cost curve. This creates an investment case across the supply chain as well as among robot manufacturers.

Our sector view is constructive with clear limits. Physical AI is increasingly investable. Humanoid economics still need to prove themselves across larger fleets and longer operating periods. Section 12 sets out the indicators we would monitor. Part II of this series will apply that framework to public-market companies across strategic materials, motion and control, and automation.

Key Investment Takeaways

- **Industrial environments should commercialize first.** Manufacturing and logistics offer the clearest early use cases.
- **Cost per productive robot-hour is the core economic metric.** Purchase price alone does not capture utilization or supervision costs.
- **Actuation is the largest hardware cost block and remains one of the least standardized parts of the stack.**
- **China has a meaningful advantage in hardware scale and manufacturing depth.** Western companies retain strong positions in AI, semiconductors, high-assurance controls, and system architecture.
- **External forecasts span a wide range.** Investors should use them as scenarios and test them against bottom-up economics.
- **Physical AI can generate value across several robot architectures.** That broadens the investable opportunity beyond humanoid OEMs.

2 THE STARTING POINT: AUTOMATION IS ALREADY A LARGE MARKET

Humanoid robotics is emerging inside an established automation market. Global factories have used industrial robots for decades, and the installed base is now large enough to support mature suppliers, integrators, service networks, and customer expertise.

The International Federation of Robotics reports that annual industrial-robot installations rose from **221,000** in 2014 to **542,000** in 2024. Installations exceeded **600,000** in 2025. The worldwide operational stock reached roughly **5 million** robots that year, more than double the level seven years earlier.

This installed base matters because customers already understand the economics of automation. The next step involves expanding the range of tasks machines can perform. Conventional industrial robots usually operate inside a fixed work cell and follow highly defined processes. Humanoids are designed for a different problem: operating inside infrastructure that was built for people.

Stairs, aisles, carts, shelving, tools, workstations, and doors already reflect human dimensions. A humanoid that can use these environments may reduce the need for expensive facility redesign. Its value will depend on how many workflows it can handle and how efficiently it can move between them.

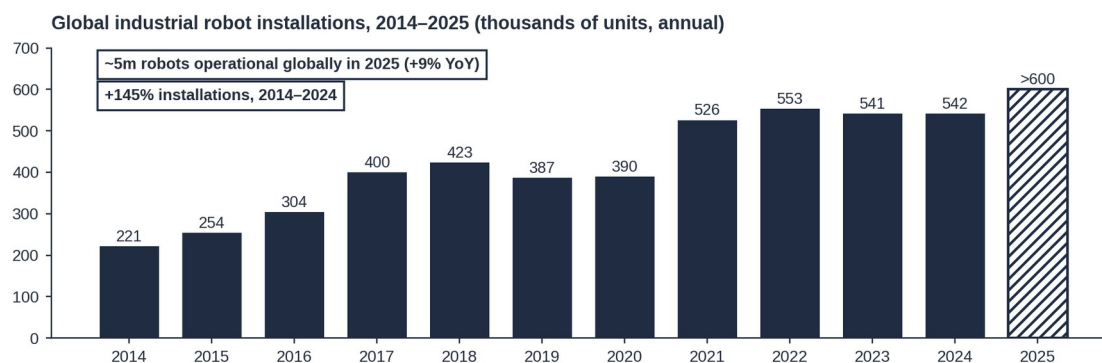


Exhibit 1 | Global Industrial Robot Installations Have More Than Doubled

Source: International Federation of Robotics, World Robotics 2025 and World Robotics 2026. IFR reports 2025 as “>600k”; the exhibit uses 600k as a lower bound. The 2014–2024 change is Fayd arithmetic on IFR data.

China's position adds another layer to the industry structure. The country installed **354,000** industrial robots in 2025, or **59%** of global deployments. Installations increased **20%** year over year. That scale supports a large domestic market for automation equipment and creates faster learning across suppliers, engineers, and end users.

China share of 2025 global industrial robot installations



Exhibit 2 | China Is the Center of Gravity in Factory Robot Deployment

Source: IFR, World Robotics 2026. The 59% share is reported by IFR. Global installations are stated as greater than 600,000, so the share should not be recomputed from a 600,000 floor.

3 WHY NOW? FOUR FORCES ARE CONVERGING

3.1 Labor replacement demand is structural

Labor scarcity remains one of the clearest demand drivers. The mechanism extends beyond wage growth. U.S. manufacturing employed more than **12.8 million** workers in 2024. BLS expects aggregate manufacturing employment to remain broadly stable through 2034. Even with limited net job growth, production occupations are expected to generate nearly **1 million** openings each year.

Most of those openings reflect retirements, occupational transfers, and other workforce exits. That creates recurring replacement needs. Employers may therefore face meaningful hiring pressure even when total headcount is stable.

Automation competes with the full cost of labor. That cost includes wages, benefits, recruiting, turnover, training, absenteeism, and workplace injury. Overnight shifts and hazardous environments can raise the

hurdle further. Humanoids only need to become economical in selected occupations to create a significant market.



3.2 Flexible automation addresses the long tail

Traditional automation performs best in stable environments with high task repetition. Returns can deteriorate when product cycles shorten or facilities contain many lower-volume workflows.

Humanoids are designed for this gap. A general-purpose machine may be able to move across material handling, machine tending, inspection, and light assembly. That flexibility could improve facility-level economics in situations where several dedicated automation cells would be too expensive.

The human form also has practical value. Existing facilities represent large sunk investments. A robot that can use the same workstations and tools may allow customers to automate parts of an operation without rebuilding the entire plant.

3.3 Physical AI is improving the intelligence layer

Robotics hardware is well established. The harder problem has been machine intelligence. Perception, control, and edge-case handling have historically limited general-purpose deployment.

The physical-AI stack is improving quickly. Vision-language-action models, reinforcement learning, simulation, and synthetic data can expand the range of tasks a robot can learn. NVIDIA's Isaac and GR00T ecosystem offers a useful example. Foundation models can be trained in simulation, refined with real-world data, and deployed through edge-compute platforms.

This software layer can also increase the value of existing hardware. A robot may gain new capabilities through improved models and control software without requiring a complete mechanical redesign.

The investment opportunity therefore reaches beyond the robot itself. Training compute, simulation software, data infrastructure, edge inference, networking, and fleet management all participate in the stack.

3.4 Cost curves are becoming more important

Early humanoids were prototype-heavy machines. Many relied on low-volume components and expensive manufacturing methods. Commercial systems are increasingly shifting toward processes used in automotive and consumer electronics manufacturing, including stamping, injection molding, and die casting.

Goldman Sachs (Feb. 27, 2024) said its revised path to profitability for humanoid robots reflects a 40% reduction in materials cost. McKinsey estimates a current humanoid BOM of approximately \$30,000 to \$150,000.

The remaining gap is still large. Broad labor substitution will require lower hardware costs, higher utilization, and lower service expense. The industry is increasingly focused on repeatable manufacturing and field economics, which is the correct direction for commercialization.

4 THE VALUE CHAIN: ACTUATION IS THE MECHANICAL CENTER OF GRAVITY

A humanoid is a dense electromechanical system. It combines joints, motors, reducers, encoders, force sensors, batteries, compute modules, and structural components. All of those systems must operate under tight limits on weight, power draw, heat, and reliability.

A fixed robot arm solves a narrower motion problem. A humanoid must balance, move through space, and manipulate objects while maintaining control of the whole body. This places unusual demands on motion systems.

McKinsey estimates that actuators represent roughly **40–60%** of humanoid bill of materials. Sensing and perception account for about **10–20%**. Compute and control account for roughly **10–15%**. Structural components and batteries each represent about **5–10%**.

These are component ranges, so they should be interpreted as directional. The important point is the size of the actuation cost pool.

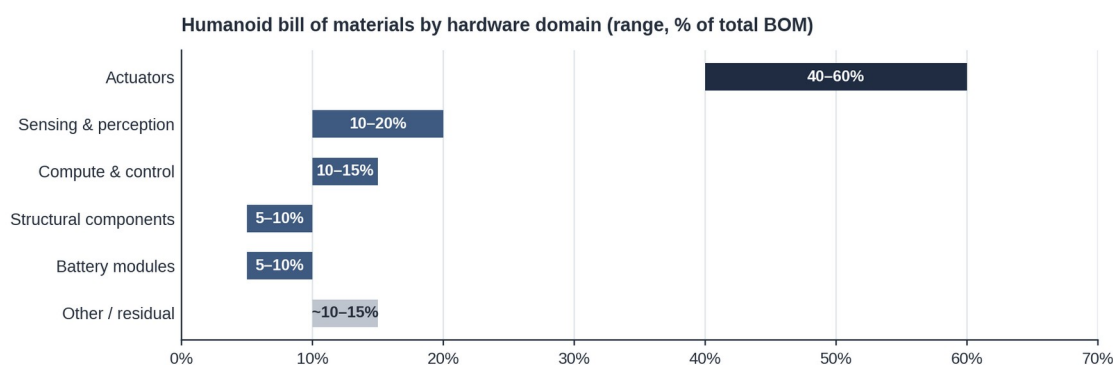


Exhibit 4 | Humanoid Hardware Cost Is Concentrated in Actuation

Source: McKinsey & Company, Apr. 17, 2026. Bars show component ranges and are not additive.

Inside the actuator, the gearbox or reducer is typically the largest component cost. McKinsey estimates a **30–50%** share of actuator cost. Drivers and power electronics account for roughly **15–20%**. Motors and mechanical components each account for roughly **10–20%**. Sensors add another **5–10%**.

Each subcomponent influences performance. Gearboxes affect torque density, backlash, and durability. Motors determine power density and thermal behavior. Sensors provide the feedback required for precise control.

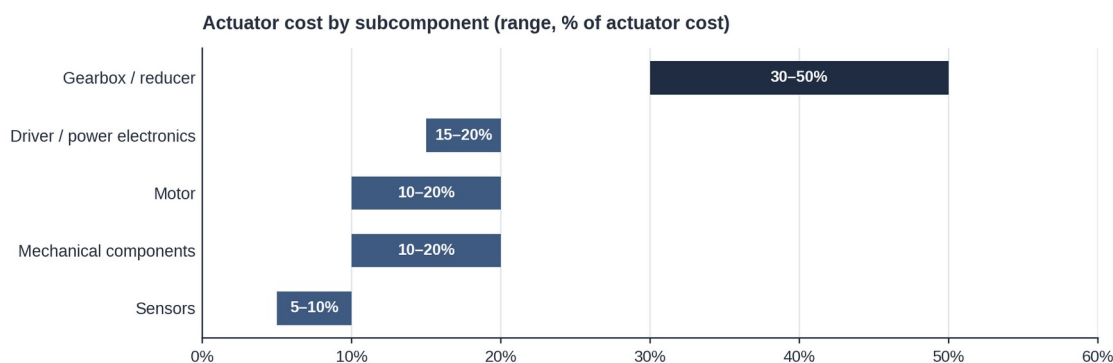


Exhibit 5 | Inside the Actuator

Source: McKinsey & Company, 2026. Bars show component ranges and are not additive.

Hands create an even harder engineering problem. Human manipulation relies on more than 20 degrees of freedom plus dense tactile feedback. Compact robotic hands can require many small actuators and sensors. This makes general household dexterity a difficult target.

Early deployments may therefore favor workflows with predictable grasping requirements. That lowers technical complexity and improves the odds of reliable commercial use.

Motors, reducers, bearings, permanent magnets, power electronics, tactile sensors, and control systems can serve multiple humanoid manufacturers, and many of them also benefit from wider robotics growth.

What the BOM implies for investors

The concentration of value in actuation creates the clearest quantitative bridge into Part II. Applying McKinsey's **40–60%** actuation share to its **\$30,000–\$150,000** humanoid BOM range implies an illustrative actuation content pool of roughly **\$12,000–\$90,000** per robot (Fayd arithmetic on McKinsey BOM ranges). The range is intentionally broad and should not be interpreted as supplier revenue. It does show where a large portion of hardware value is likely to sit if unit production scales.

We view this as one of the more durable ways to approach the theme. A component supplier can participate across several robot OEMs and, in some cases, across humanoid and non-humanoid architectures. Part II will test which public companies have enough content per system and enough revenue sensitivity for that exposure to become financially material.

5 THE ECONOMIC GATE: COST PER PRODUCTIVE HOUR

Commercial success will depend on economics in real workflows. Productive autonomous hours are a useful denominator because they measure time spent completing useful work without human intervention.

Purchase price can be misleading on its own. A lower-cost robot that needs frequent supervision may produce poor economics. A more expensive system can still generate attractive returns if it operates across long shifts with high autonomy and low downtime.

A complete cost model should include capital recovery, financing, maintenance, energy, software, integration, supervision, downtime, and residual value. The human comparison should use employer compensation, which combines wages and benefits.

The crossover point will vary by geography and task. Utilization is especially important.

Our illustrative sensitivity shows how strongly economics can change with productive hours. The model assumes five-year straight-line capital recovery and annual operating expense equal to **15%** of purchase price. The **15%** ratio is a Fayd base-case assumption and is not an externally sourced industry figure.

Under those assumptions, a **\$100,000** robot operating **6,000** productive hours per year costs about **\$5.83** per productive hour, and a **\$50,000** robot operating 2,000 hours costs about \$8.75 per hour. Both figures exclude financing, integration, and supervision.

The model becomes more useful when placed against labor costs. BLS data for June 2026 put average manufacturing employer compensation at **\$48.62** per hour, including **\$32.50** of wages and **\$16.12** of benefits. Production, transportation and material-moving occupations across private industry imply a lower benchmark of roughly **\$36.70** per hour, while union manufacturing averages \$59.23. These figures provide a reasonable compensation range for industrial labor, although they do not capture recruiting, training or turnover costs.

Our robot-cost sensitivity remains narrower than a true substitution model. It excludes financing, integration and human supervision, and it does not adjust for differences in output per hour. The relevant commercial threshold is therefore productivity-adjusted cost per productive hour.

The **6,000-hour** case should be read as an upside utilization scenario. Current commercial deployments remain materially below that level. BMW reported approximately **1,250** operating hours for Figure 02 over its ten-month Spartanburg deployment, despite scheduled ten-hour weekday shifts. Reliability, charging, maintenance and workflow availability will determine how quickly commercial fleets can move toward multi-shift utilization.

Purchase price	2,000 hrs / yr Single-shift proxy	4,000 hrs / yr Two-shift / higher-utilization proxy	6,000 hrs / yr Three-shift / high-utilization upside case
\$30,000	\$5.25/hr	\$2.63/hr	\$1.75/hr
\$50,000	\$8.75/hr	\$4.38/hr	\$2.92/hr
\$75,000	\$13.13/hr	\$6.56/hr	\$4.38/hr
\$100,000	\$17.50/hr	\$8.75/hr	\$5.83/hr
\$150,000	\$26.25/hr	\$13.13/hr	\$8.75/hr

Exhibit 6 | Fayd Cost-per-Productive-Hour Sensitivity

Source: Fayd Capital Group illustrative scenario; not external market data. Assumes five-year straight-line capital recovery and annual maintenance, software, and operating expense equal to 15% of purchase price (a Fayd base-case assumption). Excludes financing, integration, supervision, and residual value. Labor benchmarks: U.S. Bureau of Labor Statistics, Employer Costs for Employee Compensation, June 2026. Note: 6,000 hours approximates 24 operating hours across 250 days, so that column assumes very high uptime, sufficient battery availability or swapping, and limited downtime.

Annual operating expense (% of price)	Annual opex	Annualized cost	Cost per productive hour
10%	\$10,000	\$30,000	\$5.00
15% (Fayd base case)	\$15,000	\$35,000	\$5.83
20%	\$20,000	\$40,000	\$6.67

Exhibit 6A | Operating-Expense Sensitivity: \$100,000 Robot at 6,000 Productive Hours

Source: Fayd Capital Group arithmetic. All three cases exclude financing, integration, supervision, and residual value. The 15% case is the base assumption used in Exhibit 6.

Hardware cost remains a major constraint. McKinsey's current **\$30,000** to **\$150,000** BOM range sits above the sub-**\$20,000** benchmark often discussed for large-scale adoption.

A decline from **\$30,000** to **\$20,000** implies roughly **33%** cost compression. A decline from **\$150,000** implies about 87%. Some architectures may reach those levels faster than others. The burden of proof remains meaningful.

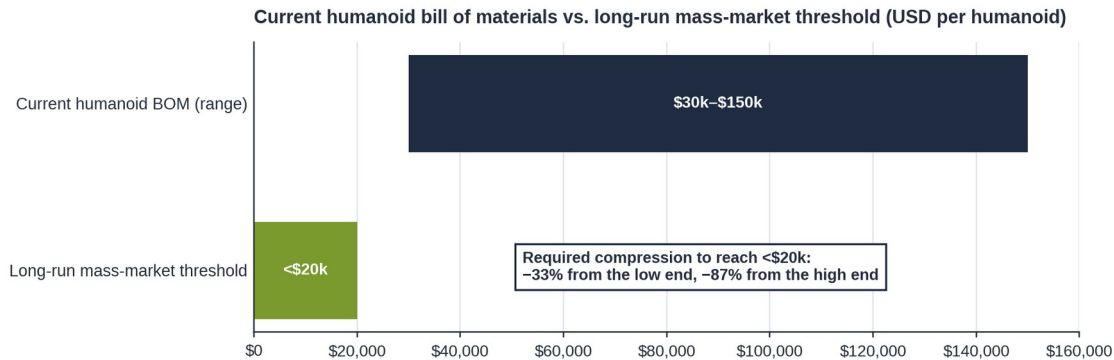


Exhibit 7 | Current Cost Still Needs Material Compression

Source: McKinsey & Company, 2026. The sub-\$20,000 figure is a commonly discussed mass-market benchmark. It is not a forecast. Compression figures are Fayd arithmetic.

6 COMMERCIALIZATION: THE EVIDENCE IS IMPROVING, BUT THE BAR SHOULD BE HIGH

Humanoid robotics is especially vulnerable to demo risk. A controlled video can hide resets, teleoperation, or narrow operating assumptions.

For research purposes, we use a six-stage commercialization framework:

1. Demonstration
2. Pilot
3. Paid deployment
4. Repeat or expanded deployment
5. Scaled fleet
6. Mass production

Progress through these stages provides a better measure of commercial maturity than isolated technical milestones.

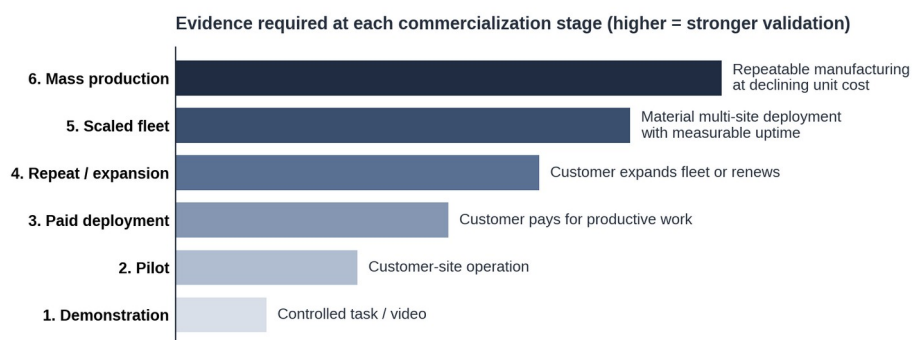


Exhibit 8 | Commercialization Evidence Ladder

Source: Fayd Capital Group framework.

Several developers have begun to show evidence beyond the pilot stage. We separate customer-confirmed evidence from developer-reported statistics, because the two carry different weight.

BMW Group has confirmed that Figure 02 worked at its Spartanburg plant for ten months on ten-hour weekday shifts. According to BMW, the robot accumulated roughly **1,250** operating hours, moved more than **90,000** components, and supported the production of more than **30,000** BMW X3 vehicles. Figure 03 returned to BMW in June 2026 for a more complex sequencing and logistics workflow. Figure also disclosed operating KPIs such as cycle time, placement accuracy, and human interventions. Those KPIs are company-reported.

Figure has also reported progress in manufacturing. In April 2026, the company said its BotQ facility had produced more than 350 Figure 03 units. Production throughput increased from one robot per day to one per hour. The company also reported more than **9,000** actuators produced across over ten SKUs. These figures are company-reported.

Those milestones show that the industry is moving into factory execution. Supplier qualification, first-pass yield, field service, and failure analysis now matter alongside model capability.

Agility Robotics provides another data point. GXO independently confirms a multi-year commercial Robots-as-a-Service deployment of Digit in live warehouse operations, which followed its pilot. In September 2026, Agility said Digit 5 was built on more than **65,000** hours of operation and commercial deployment, and it reported more than **\$300 million** of multi-year customer orders. Both figures are company-reported, since GXO does not independently verify those aggregate numbers.

The distinction matters. Customer confirmation validates that deployment and payment are real, while developer disclosures still provide most of the detailed fleet-level performance data.

What should investors demand next?

The sector needs more standardized operating disclosure. Productive autonomous hours and deployment gross margin would do the most to make platforms comparable and to let investors judge customer economics. Section 12 sets out the wider monitoring framework. Headline unit targets should carry less weight until this level of disclosure becomes common.

7 MARKET SIZE: LARGE POTENTIAL, LOW FORECAST PRECISION

Humanoid forecasts vary widely. The reason is sensitivity to a small set of assumptions.

Robot cost influences the number of jobs that can be addressed economically. Autonomy affects supervision expense. Useful life determines capital recovery. Small changes in these inputs can produce large differences in long-run adoption.

In its February 2024 work, Goldman Sachs estimated a humanoid market of approximately **\$38 billion** by 2035. Its base case includes roughly **1.4 million** annual shipments by that year. Goldman also expected more than **250,000** annual shipments by 2030, with industrial use dominating early demand.

Morgan Stanley (May 2025) uses a much longer horizon. It estimates more than **1 billion** humanoids in use by 2050. Its broader ecosystem estimate exceeds **\$5 trillion** and includes related supply chains, repair, maintenance, and support. Around **90%** of Morgan Stanley's projected 2050 installed base is industrial or commercial.

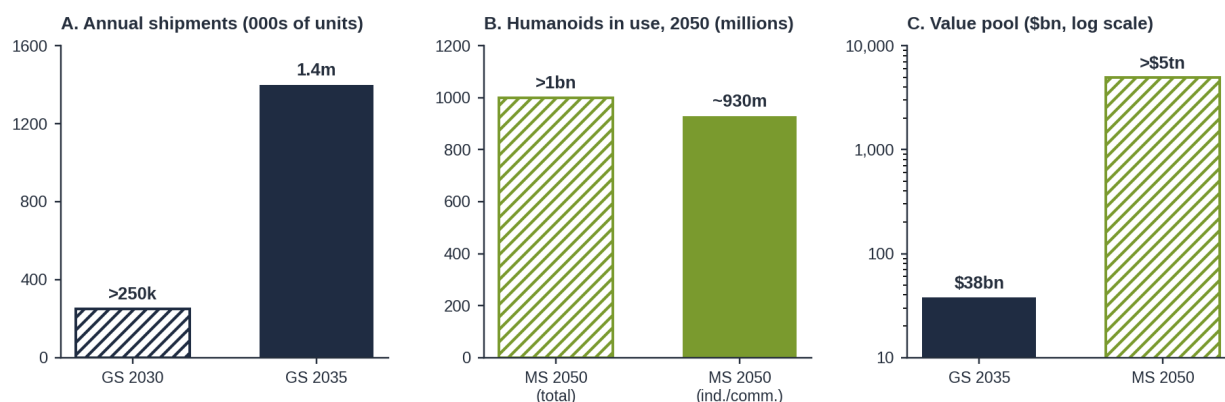


Exhibit 9 | External Forecasts Show Extreme Dispersion

Source: Goldman Sachs, Feb. 27, 2024; Morgan Stanley, May 14, 2025. The panels use different metrics, horizons, scopes, and units and should be interpreted separately. Bank of America (March 2026) and BCG (April 2026) estimates are discussed in the text and are not plotted.

The forecasts answer different questions. Goldman's work focuses on 2030 to 2035 shipments and market size. Morgan Stanley focuses on the 2050 installed base and the broader ecosystem.

Across the forecast set, industrial adoption and unit economics are the recurring assumptions. Major external research still points to meaningful industry growth, although the pace and ultimate scale remain highly sensitive to cost, autonomy, and deployment readiness.

More recent 2026 research has widened rather than resolved the forecast range. Bank of America (March 2026) projects **90,000** humanoid shipments in 2026E, **1.2 million** in 2030E, and **10 million** in 2035E, roughly seven times Goldman's 2035 figure of **1.4 million** (Fayd arithmetic). BCG (April 2026) notes that published 2030 forecasts span from below 1 million to above 6 million annual units. We see the dispersion itself as useful information: the market is still highly sensitive to assumptions around cost, autonomy and deployment readiness.

For Fayd's purposes, long-run TAM is best used as a scenario range. A bottom-up framework is more useful for investment work. That framework should estimate productive-hour economics, identify viable occupations, apply realistic penetration assumptions, and compare the resulting unit base with external forecasts.

8 GEOGRAPHY: CHINA HAS THE HARDWARE SCALE, THE WEST HAS DIFFERENT ADVANTAGES

China's strongest current advantage lies in hardware scale and manufacturing depth. More than 400 complete humanoid products had been developed in China by mid-2026, according to official data, while dedicated production facilities are being built around five-digit annual capacity. Reuters' reporting points to a similar split: Chinese developers have moved quickly on hardware, cost and production scale, while autonomy, dexterity and sustained factory productivity remain important constraints.

The supporting evidence comes from several sources. Chinese official data reported in July 2026 counted more than 400 complete humanoid products, more than half of the global total. China's State Council Information Office reported in June 2026 that new dedicated humanoid production facilities in Beijing have initial annual capacity of roughly **10,000** units, with much larger longer-term targets. Reuters (Aug. 27, 2026) described strong Chinese hardware and state-supported manufacturing scale alongside unresolved questions on factory dexterity, intelligence and autonomous productivity. Reuters (Sept. 23, 2026) identified Unitree and UBTECH as examples of China's hardware strength and noted that the U.S. retains an advantage in cutting-edge embodied-AI software.

Product counts and announced capacity describe supply. Deployed, paid and productive fleets remain the missing evidence.

That hardware position is reinforced upstream. McKinsey (Apr. 17, 2026) estimates that China accounts for roughly **90%** of permanent-magnet processing capacity (citing IDTechEx 2026), **40%** of precision-bearing capacity and meaningful shares of motors and power electronics. That position matters because high-torque, compact motors depend heavily on NdFeB magnets.

IFR data provide supply-chain context. China's **59%** share of 2025 industrial-robot installations (Exhibit 2) reflects a large domestic automation market and established EV and electromechanical capacity. Those installations are conventional industrial robots and do not measure humanoid deployment.

China's advantage comes from supplier density, tooling capacity, process knowledge, and manufacturing speed. These capabilities can accelerate cost reduction in actuation and other electromechanical systems.

The U.S. and Europe have strengths in different parts of the stack. These include frontier AI, accelerated computing, high-end motion control, aerospace engineering, defense-grade systems, and safety-critical integration.

A bifurcated market structure is therefore plausible. Chinese suppliers may capture large portions of high-volume hardware. Western companies can still capture significant value in AI, semiconductors, controls, and specialized integration. None of this shows that Chinese humanoids have proven superior commercial economics. That test requires customer-confirmed fleets and cost per productive hour.

9 ADOPTION SHOULD MOVE FROM STRUCTURED WORK TO UNSTRUCTURED LIFE

The most plausible adoption sequence begins in structured environments where labor costs are easy to measure.

Manufacturing, automotive assembly, material movement, warehousing, inspection, and hazardous work all fit that profile. Tasks can be standardized. Workspaces can also be adapted to support robots without requiring a full rebuild.

The medium-term opportunity includes retail stocking, healthcare logistics, construction support, security, and commercial maintenance. These environments contain more variability, although they remain enterprise-owned and tied to measurable labor budgets.

Consumer adoption requires a higher level of capability. Household environments change constantly. Safety requirements are strict. Manipulation tasks vary from one room to the next. Willingness to pay is also lower than in many industrial settings.

A domestic humanoid may eventually address a very large market. The industrial path still looks more realistic as the first commercial phase.

NEAR TERM →	MEDIUM TERM →	LONG TERM
Likely use cases	Likely use cases	Likely use cases
• Manufacturing • Automotive • Material movement • Warehousing • Inspection • Hazardous work	• Retail stocking • Healthcare logistics • Construction support • Security • Commercial maintenance	• Home cleaning • Cooking • Elder assistance • Personal robotics
Why	Why	Why
Structured; high utilization; measurable ROI	More variable but still enterprise-owned	Unstructured; high dexterity, safety and price hurdles

Exhibit 10 | Adoption Sequence
Source: Fayd Capital Group framework.

10 COUNTER-THESIS: PHYSICAL AI CAN SUCCEED ACROSS SEVERAL FORM FACTORS

Humanoid robots are one expression of physical AI. Other architectures may prove more efficient for specific tasks.

A warehouse may favor wheeled autonomous systems. A factory may use fixed robotic arms. A hospital may adopt purpose-built mobile carts. Each form factor can be optimized for a narrower environment.

Humanoids add complexity through legs, hands, balance, and whole-body control. Those systems increase cost and introduce additional failure modes. Their value depends on whether flexibility produces enough economic benefit to offset that complexity.

This matters for investors because the physical-AI opportunity extends across multiple machine types. Compute, sensors, motors, reducers, magnets, simulation software, and fleet-management systems can benefit from robotics growth even when a specific task uses a non-humanoid platform.

Exposure across the enabling stack can reduce dependence on one architecture, one OEM, or one consumer adoption timeline.

11 RISKS AND THESIS BREAKERS

The sector carries meaningful upside and material execution risk. Operating and technical risks come first. Reliability is the first industrial gate, since frequent downtime weakens labor-substitution economics. Autonomy is a second constraint, because high teleoperation requirements raise supervision costs and limit scalability. Dexterity still restricts general-purpose use, and battery performance can reduce the productive duty cycle. Safety certification and liability may also slow deployments in human-adjacent environments.

Economic and integration risks may prove more durable. Hardware cost can fall faster than total deployment cost, because integration, service, and supervision can remain expensive even as components become cheaper. Specialized robots, including wheeled platforms and fixed arms, may stay cheaper per unit of throughput for defined tasks. A rapid production ramp could also expose bottlenecks in actuators, tactile sensing, and high-precision components.

Customer validation is the final test. A large number of pilots can still produce limited commercial value if customers do not expand fleets. We view customer expansion as the cleanest commercial test: a second site or a larger fleet carries more evidentiary weight than another announced pilot. The thesis would weaken materially if pilots repeatedly failed to convert into paid, expanded deployments, or if total deployment cost stayed well above the productivity-adjusted labor benchmarks discussed in Section 5.

Risk	Economic failure mode	KPI to monitor
Reliability	Too much downtime	Mean time between failure
Autonomy	Excess teleoperation	Interventions / hour
Dexterity	Poor task generalization	Grasp / task success
Battery	Insufficient duty cycle	Productive runtime
Cost	Labor parity not reached	Cost / productive hour
Safety	Deployment delays	Certification / incidents
Form-factor competition	Specialized robots remain cheaper	Cost / throughput by task
Supply chain	Production bottlenecks	Lead times / supplier concentration
Customer ROI	Pilots fail to scale	Repeat orders / fleet expansion

Exhibit 11 | What Could Break the Humanoid Thesis?

Source: Fayd Capital Group framework. No likelihood or impact scores are assigned.

12 A BETTER WAY TO MONITOR THE INDUSTRY

Humanoid robotics will generate substantial marketing activity over the next several years. A disciplined research process should focus on the variables that directly affect economics. Exhibit 12 lists the full indicator set, and four of the indicators carry most of the information.

Productive autonomous hours show whether robots are doing real work, and human interventions per hour show how much supervision that work requires. Together they determine the denominator in cost per productive hour. Mean time between failure indicates whether uptime can approach the multi-shift levels assumed in the upside case of Exhibit 6. Customer fleet expansion, including renewals and deployment across several workflows, is the strongest commercial signal.

We would treat the remaining indicators, including hardware cost, deployment gross margin, and actuator lead times, as supporting evidence. They matter most when they move in the same direction as the four primary indicators.

KPI	Improving direction	Interpretation
Productive autonomous hours	▲ Up	More real work
Human interventions / hour	▼ Down	Lower supervision cost
Mean time between failure	▲ Up	Better industrial reliability
Throughput vs. human baseline	▲ Up	Better substitution economics
ASP / BOM	▼ Down	Broader addressable market
Deployment gross margin	▲ Up	Commercial sustainability
Repeat customers / fleet expansion	▲ Up	Stronger ROI evidence
Paid order backlog	▲ Up, with quality	Forward demand
Actuator / sensor lead times	▼ Down	Supply-chain scalability
Deployment breadth	▲ Up	Lower use-case concentration

Exhibit 12 | Fayd Robotics Commercialization Dashboard

Source: Fayd Capital Group framework. Arrows show the preferred direction of improvement and do not represent observed data.

13 CONCLUSION: COMMERCIAL PROGRESS IS BUILDING; ECONOMICS REMAIN THE KEY CONSTRAINT

Humanoid robotics has advanced far enough to justify serious investment research.

Industrial automation already has a large installed base. Labor replacement demand remains persistent. AI capabilities continue to improve. The hardware supply chain is moving toward higher-volume production.

Commercial evidence is also becoming more tangible. Factories are running pilots and paid deployments. Dedicated manufacturing facilities are scaling. Suppliers are preparing for larger production volumes.

The industry still needs stronger proof of reliability and total cost per productive hour. That evidence will determine whether humanoids become a durable mass market.

Our working view is that the first investable wave will be industrial and supply-chain driven. Attractive opportunities may emerge in motion and control, precision components, strategic materials, compute, sensing, and automation platforms.

Part II will evaluate public-market companies using five questions:

1. Where does the company sit in the robotics value chain?
2. How much content could it capture per robot or deployment?
3. Could robotics become material to revenue or earnings?
4. Does the company have a defensible competitive position?
5. Does the core business remain attractive if humanoid adoption takes longer than expected?

Appendix A: Methodology and Source Discipline

Category discipline

Industrial robots, professional service robots, physical AI, and humanoids are distinct categories. The report labels them explicitly.

IFR statistics describe industrial-robot installations and operational stock. They do not measure humanoid deployments.

Long-horizon forecasts use different definitions and time frames. They should be interpreted within the scope defined by each source.

Lower bounds and ranges

Where a source reports a lower bound, the report preserves that convention. IFR reports more than 600,000 industrial-robot installations in 2025. Exhibit 1 therefore plots 600,000 as a floor and does not infer a more precise figure.

McKinsey BOM and actuator-cost figures are reported as component ranges. Those ranges are not additive and should not be treated as a 100% stack.

Forecast treatment

Goldman Sachs (Feb. 2024) reports annual shipment and market-size estimates for 2030 to 2035.

Morgan Stanley (May 2025) reports installed-base and ecosystem scenarios for 2050.

Exhibit 9 presents these figures in separate panels because the metrics and horizons differ. Bank of America (March 2026) and BCG (April 2026) figures appear in the text only.

Fayd analysis

Exhibit 6 is an illustrative Fayd Capital sensitivity. It is not external market data and is not a labor break-even model.

Annualized cost is calculated as:

Purchase price / five years + annual operating expense equal to 15% of purchase price

That annualized cost is then divided by productive hours per year.

Productive hours refer to autonomous useful work.

The 15% operating-expense ratio is a Fayd base-case assumption. Exhibit 6A shows 10% and 20% cases.

The utilization columns are labeled as scenarios: 2,000 hours as a single-shift proxy, 4,000 hours as a two-shift or higher-utilization proxy, and 6,000 hours as a three-shift, high-utilization upside case. The 6,000-hour case approximates 24 operating hours across 250 days.

The model excludes financing, initial integration, human supervision, and residual value.

BLS Employer Costs for Employee Compensation (June 2026, Tables 4 and 5) report employer compensation, which is wages and salaries plus benefits. The figures exclude recruiting, training and turnover costs and are not adjusted for productivity.

The \$12,000–\$90,000 actuation content pool in Section 4 is Fayd arithmetic on McKinsey BOM and actuation-share ranges. It is illustrative and does not represent supplier revenue.

The compression figures in Exhibit 7 and the 2014–2024 installation change in Exhibit 1 are Fayd arithmetic based on cited source data.

Customer-confirmed and company-reported data

BMW Group confirmed the Figure 02 deployment metrics cited in Section 6, and GXO confirmed Agility's commercial deployment. Figure's KPI and manufacturing disclosures, along with Agility's aggregate operating hours and order figures, are company-reported and have not been independently audited.

The report uses them as directional evidence of commercialization. They should not be interpreted as standardized industry data.

Regional data

Chinese official data, State Council Information Office reporting, and Reuters reports are cited as published. Product counts and announced capacity measure supply and do not measure deployed or productive fleets.

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Disclosures & Important Information

This report reflects the analysis and opinions of the author as of September 2026. It constitutes independent industry research on humanoid robotics and physical AI.

This document does not constitute investment advice, a regulated research recommendation, or an offer to buy or sell any security. It should not serve as the sole basis for an investment decision.

Industry statistics, cost estimates, and forecasts are drawn from the third-party and company sources cited above. Each estimate is attributed to its original source. Third-party estimates are point-in-time figures and may change.

Forecasts from different sources use different definitions and horizons. They should be interpreted within those limits.

Operating statistics reported by private developers are company-reported and have not been independently audited. Customer-confirmed figures are identified as such in the text.

Exhibit 6 is an independently constructed Fayd Capital sensitivity. It is not external market data and does not constitute a labor break-even model.

Forward-looking statements, including cost trajectories, adoption sequences, and market-size scenarios, are inherently uncertain. Actual outcomes may differ materially.

This report does not represent the views of any employer, client, or affiliated institution of the author.