

Embodied Intelligence: Humanoids – the new productivity frontier

- ▶ Humanoids represent a structural, multi-decade theme that intersects with geopolitics, demographics, and technological innovation.
- ▶ The convergence of national security priorities, private investment, and advances in AI means that humanoids are becoming industrial reality.
- ▶ For investors, this marks a profound shift in the global productivity frontier – and a thematic opportunity that warrants close attention.

Kishore Muktinutalapati

Head - Investment Strategy

+971 (0)2 812 6457

kishore.muktinutalapati@adcb.com

Mohammed Al Hemeiri

Senior Specialist

+971 (0)2 812 6450

mohammed.alhemeiri@adcb.com

www.adcb.com/marketinsights

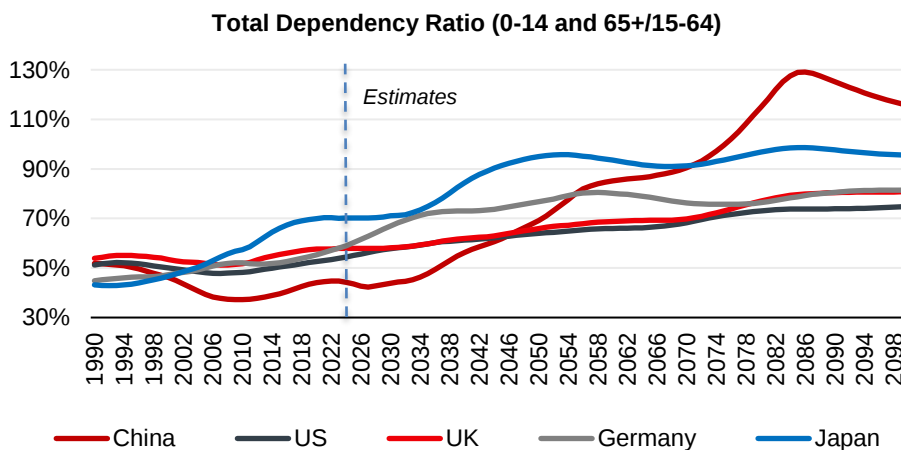
A new productivity frontier

The global economy is approaching a structural turning point. For decades, growth has been supported by a combination of abundant labour, falling energy intensity, and the ability to offshore production to lower-cost regions. That model has arguably reached its limits. Demographic ageing is tightening labour markets across the developed world, reshoring is reversing decades of globalisation, and the physical economy remains constrained by the slow pace of productivity gains. While Artificial Intelligence (AI) has transformed digital work, it has barely touched the physical layer of economic activity. Goods still need to be moved, assembled, repaired, and maintained. Infrastructure still requires construction and servicing. Warehouses still depend on picking, sorting, and replenishment.

Without major productivity improvements, GDP per-capita growth could fall by 40 %, from 1 % annually (2006–2019) to just 0.6 % (2024–2060)

~ OECD Employment Outlook 2025

Exhibit 01: Demographic support is fading as dependency ratios rise



Sources: UN Department of Economic and Social Affairs, Population Division (2024). World Population Prospects: The 2024 Revision, custom data acquired via website, and ADCB Asset Management

The next major productivity breakthrough will come from bringing intelligence into the physical world. Humanoid robotics represent a step-change in this direction. Unlike traditional industrial robots, which are task-specific and require workflows to be redesigned around them, humanoids are designed to operate in the same environments built for humans. They are biomimetic, adaptable, and capable of performing a wide range of physical tasks without bespoke infrastructure. If they scale successfully, the addressable market is not a single industry but the entire surface area of physical labour.

The case for humanoids is often framed in aspirational terms: freeing humans from repetitive, low-satisfaction tasks and enabling a reallocation of time toward higher-value pursuits. Yet the more compelling argument is structural. Ageing populations are shrinking the available labour pool at precisely the moment when economies are attempting to rebuild domestic manufacturing capacity. In the US, older adults will outnumber children by 2034, according to the Census Bureau. Europe and Japan face even steeper demographic headwinds. China's fertility rate has fallen to historically low levels, setting the stage for the largest absolute population decline of any major economy over the coming decades.

At the same time, the global energy system is struggling to keep pace with the demands of electrification and data centre expansion. Grid bottlenecks, long lead times for transformers and switchgear, and slow permitting cycles are constraining supply. Capital remains abundant, but capital alone cannot solve a labour shortage. In this environment, productivity becomes the only scalable lever. Humanoids therefore shift from being a desirable innovation to an economic necessity – an essential tool to sustain growth, stabilise debt dynamics, and rebuild industrial resilience in a multipolar world.

The Geopolitical race

The rise of humanoid robotics is not occurring in a vacuum. It is unfolding within a broader geopolitical contest between the world's two largest economies. The US and China are now engaged in a race to develop embodied intelligence – the fusion of advanced AI models with physical robotic systems capable of performing human level tasks. This competition is no longer purely commercial; it is increasingly viewed as a determinant of national power.

China has embraced humanoids as a strategic priority. Robotics has been central to its industrial policy for more than two decades, and the country now accounts for the majority of global industrial robot installations. Its national AI strategy seeks to embed intelligent systems across every major sector of the economy, with humanoids positioned as a solution to both productivity challenges and demographic decline. Large scale state-guided funds, policy backed financing, and coordinated provincial initiatives are accelerating the development and deployment of humanoid platforms. China's approach

China now deploys over 52% of all industrial robots installed globally, while the US leads in frontier AI compute with more than 70% of the world's advanced AI training capacity concentrated in American data centers.

~ International Federation of Robotics – World Robotics Report 2024; and Epoch AI Compute Index 2024 / SemiAnalysis 2024

is characterised by scale, speed, and a willingness to fund dozens of competing companies simultaneously to maximise experimentation and compress development cycles.

Exhibit 02: China and US have different Humanoid strategies

ELEMENT	CHINA	US
STRATEGIC FOCUS	Humanoids as a national priority within industrial policy.	Humanoids as part of private-sector innovation under federal guardrails.
POLICY ENGINE	State-guided funds, provincial coordination, and policy-backed financing.	Federal agencies enabling autonomous systems and advanced manufacturing.
ECONOMIC OBJECTIVE	Solve productivity and demographic decline through humanoid deployment.	Preserve frontier computing leadership via export controls and innovation incentives.
EXECUTION MODEL	Scale + speed + parallel experimentation – dozens of firms funded simultaneously.	Dual-track strategy – accelerate domestic innovation while restricting adversarial access.
OUTCOME	Rapid industrial integration and mass deployment.	Regulatory clarity and sustained technological leadership.

Sources: ADCB Asset Management

The US is pursuing a different model – one anchored in private sector innovation, supported by strategic federal guardrails. Recent policy actions have accelerated data centre permitting, expanded access to federal lands, and established a national AI regulatory framework designed to reduce compliance burdens. Federal agencies are increasingly directing resources toward autonomous systems, advanced manufacturing, and embodied intelligence. Export controls on advanced semiconductors and AI chips are intended to preserve US leadership in frontier computing. The result is a dual-track strategy: enabling rapid domestic innovation while constraining adversarial access to critical technologies.

Venture capital dynamics reflect this divergence. The US has concentrated capital into a small number of well-funded potential winners, often backed by major technology companies. China has adopted a broad-based funding model, supporting dozens of Original Equipment Manufacturers (OEMs) and component suppliers across the humanoid value chain. This bifurcation is shaping the global competitive landscape: the US emphasizes cognitive sophistication and breakthrough innovation, while China prioritizes cost compression and manufacturing scale.

For investors, the geopolitical framing is essential. National security imperatives reduce the risk of a boom-bust cycle by creating a durable policy backstop. Humanoids are becoming a strategic asset class, similar to semiconductors and electric vehicles, with governments increasingly incentivized to support their development and deployment. Therefore, it is important for investors to have exposure to tech ecosystems of both China and the US.

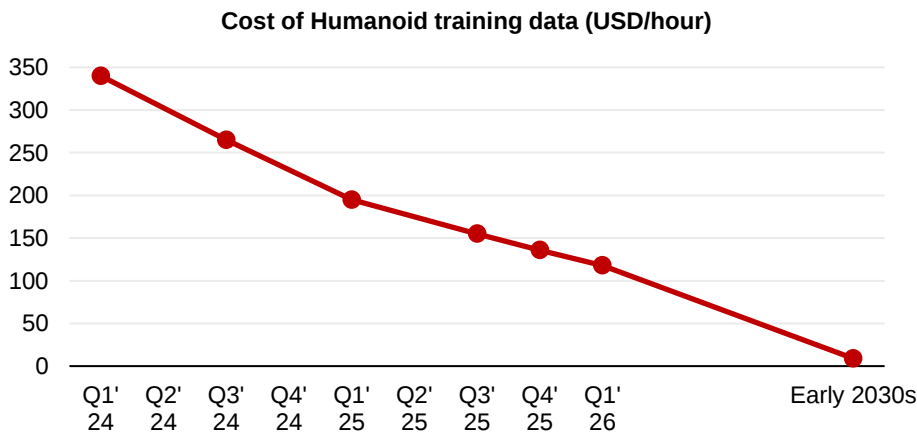
Bottlenecks, breakthroughs, and the path to scale

Despite the accelerating momentum, humanoids face meaningful engineering, supply chain, and regulatory challenges. The most immediate constraints lie in hardware. Actuators, reducers, rare earth magnets, sensors, and batteries represent the core bottlenecks. Actuators alone account for more than half of the bill of materials for leading humanoid prototypes, and each unit requires several kilograms of NdFeB (Neodymium-Iron-Boron) magnets – an area where China dominates global processing capacity. Achieving mass-market affordability will require substantial advances in materials science, thermal management, and precision engineering. The long-term target for the industry – based on the consensus cost curves – is to reduce the cost of a humanoid from roughly USD100k today to USD20k-30k at scale.

China controls 90%+ of global rare-earth magnet processing capacity – which is essential for Humanoid production.

~ USGS Mineral Commodity Summary (2024)

Exhibit 03: Costs of humanoids and their training data are expected to continue to fall rapidly over the next few years



Sources: SVRC Research: State of Robotics 2026, William Blair Equity Research, and ADCB Asset Management

The second bottleneck is data. Humanoids require vast quantities of real-world multimodal data to train manipulation, navigation, and reasoning models. Complex tasks may require hundreds or thousands of hours of demonstration. Encouragingly, the cost

of data collection is falling rapidly as teleoperation, simulation, and self-supervised learning improve. The industry is moving toward a “flywheel model” in which deployed humanoids generate the data needed to train the next generation of systems.

Regulation represents the third major hurdle. Western markets require rigorous certification for safety, reliability, and human-robot interaction. Standards such as UL 3300 and ISO 25785-1 impose stringent requirements, and certification cycles can extend up to three years. The first meaningful approvals are expected in controlled environments such as warehouses, where workflows are more predictable and risk profiles more manageable.

The transition from prototype to industrial deployment will depend on the convergence of hardware cost compression, data-driven capability gains, and regulatory clearance. Key milestones include improvements in mean time between failure, reductions in human-to-robot supervision ratios, and the achievement of near-perfect task completion rates. The industry is moving from the prototype phase toward industrial validation, with early scale expected toward the end of the decade.

Market opportunity and investment implications

The potential market for humanoids is vast. One way to frame the opportunity is through the value of physical labour. In the US alone, the near-term addressable market for tasks that humanoids could perform is estimated at more than USD1trn, rising to several trillion as capabilities expand. Another approach draws parallels with the automotive industry. If humanoids reach automotive scale production volumes – tens of millions of units annually – at an average selling price of USD20k, the resulting market could exceed USD2trn per year.

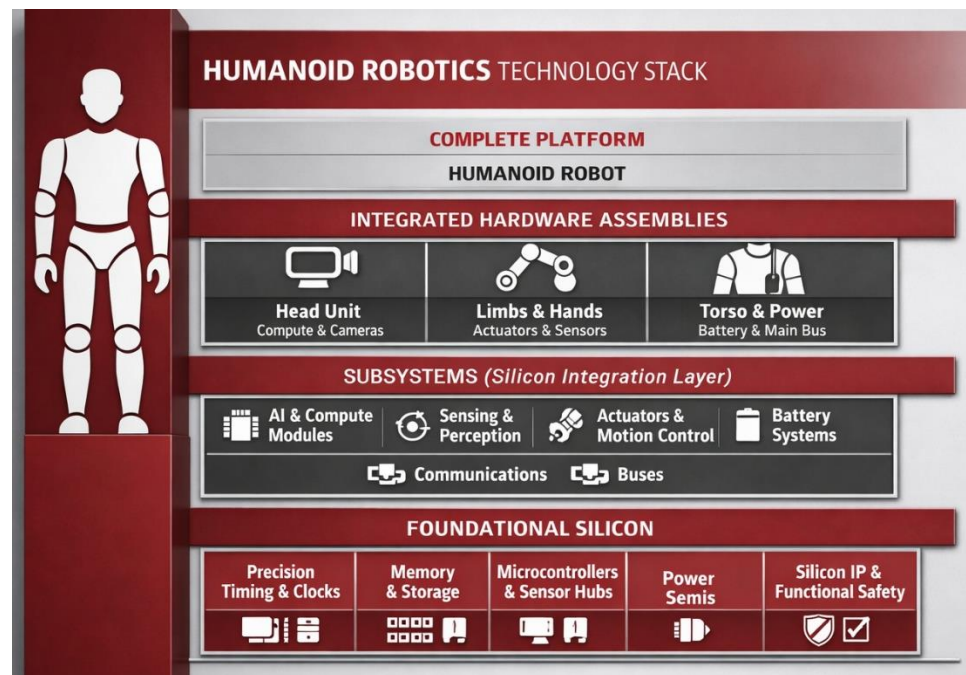
While most humanoid OEMs remain private, the investable opportunity today lies in the component supply chain. Actuators, reducers, bearings, motors, sensors, power semiconductors, memory, and AI compute represent the critical layers of the humanoid technology stack. These components are likely to experience sustained demand growth as humanoids scale. Semiconductors – particularly AI accelerators, power devices, and sensor integrated circuits – stand out as the most immediate beneficiaries. Precision engineering, advanced materials, and critical minerals supply chains will also play a central role.

For investors, humanoids reinforce several of ADCB Investment Strategy’s highest conviction structural themes: AI infrastructure, automation, industrial transformation, and the re-engineering of global supply chains. The rise of humanoids reflects a broader shift toward labour scarcity, capital deepening, and the fusion of AI with physical systems. While OEMs offer long-dated optionality, the more compelling near-term exposure lies in the “picks and shovels” of the humanoid economy.

The value of automatable physical work in the US exceeds USD1.3trn per year, with more than 50% of manual tasks in logistics, manufacturing, and warehousing considered technically automatable.

~ McKinsey Global Institute, “The Future of Work in America” (2023)

Exhibit 04: Every layer of the humanoid value chain presents opportunities for investors



Sources: ADCB Asset Management

Disclaimer

This publication is intended for general information purposes only. It should not be construed as an offer, recommendation or solicitation to purchase or dispose of any securities or to enter in any transaction or adopt any hedging, trading or investment strategy. Neither this publication nor anything contained herein shall form the basis of any contract or commitment whatsoever. Distribution of this publication does not oblige Abu Dhabi Commercial Bank PJSC ("ADCB") to enter into any transaction.

The content of this publication should not be considered legal, regulatory, credit, tax or accounting advice. Anyone proposing to rely on or use the information contained in the publication should independently verify and check the accuracy, completeness, reliability and suitability of the information and should obtain independent and specific advice from appropriate professionals or experts regarding information contained in this publication.

Information contained herein is based on various sources, including but not limited to public information, annual reports and statistical data that ADCB considers accurate and reliable. However, ADCB makes no representation or warranty as to the accuracy or completeness of any statement made in or in connection with this publication and accepts no responsibility whatsoever for any loss or damage caused by any act or omission taken as a result of the information contained in this publication. This publication is intended for qualified customers of ADCB.

Charts, graphs and related data or information provided in this publication are intended to serve for illustrative purposes only. The information contained in this publication is prepared as of a particular date and time and will not reflect subsequent changes in the market or changes in any other factors relevant to their determination. All statements as to future matters are not guaranteed to be accurate. ADCB expressly disclaims any obligation to update or revise any forward-looking statements to reflect new information, events or circumstances after the date of this publication or to reflect the occurrence of unanticipated events.

ADCB does and may at any time solicit or provide commercial banking, investment banking, credit, advisory or other services to the companies covered in its publications. As a result, recipients of this publication should be aware that any or all of the foregoing services may at time give rise to a conflict of interest that could affect the objectivity of this publication.

Past performance does not guarantee future results. Investment products are not bank deposits and are not guaranteed by ADCB. They are subject to investment risks, including possible loss of principal amount invested. Please refer to ADCB's Terms and Conditions for Investment Services.

This publication is being furnished to you solely for your information and neither it nor any part of it may be used, forwarded, disclosed, distributed or delivered to anyone else. You may not copy, reproduce, display, modify or create derivative works from any data or information contained in this publication.