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OVERVIEW OF ROBOTIC ACTUATOR MODULE TECHNOLOGY INDUSTRY

Actuator Modules as the Core Foundation of Robotic Systems

Robotic Actuator Modules are integrated functional units used in robots that comprise motors, drive systems, and control components. Their core function is to provide precise power output and motion control for robotic joints or motion structures. As a key core component, actuator modules directly determine a robot's motion performance and precision, while significantly influencing payload capacity, energy efficiency, and response speed.

Technology Pathways of Robotic Actuator Module Development

Direct drive technology pathway**,** Direct drive technology eliminates reducers and other intermediate transmission components in traditional power systems, directly coupling the motor with the payload. This design simplifies the power transmission process, eliminates efficiency losses caused by mechanical transmission, and delivers higher precision and lower noise levels, while reducing mechanical wear and maintenance requirements. The core advantages of direct drive systems lie in their structural simplicity and high efficiency, making them particularly suitable for precision operations and human-adjacent scenarios with stringent noise requirements, such as household cleaning robots. The widespread adoption of this technology not only enhances overall robotic performance but also supports trends toward miniaturization and lightweight design.

Traditional drive technology pathway**,** Traditional drive systems rely on reducers to amplify motor torque output. This enables a stronger driving force under high-load and high-impact operating conditions. Reducers lower motor rotational speed while increasing torque, making this architecture well suited for industrial robots and heavy-duty robots requiring high power output. The key advantage of this pathway lies in its ability to significantly enhance payload capacity and impact resistance, making it suitable for industrial production lines, warehousing and logistics, and heavy equipment operation scenarios.

Difference between Direct Drive Technology Pathway and Traditional Drive Technology Pathway：

Torque motors and servo drive systems differ from direct drive motors and direct drive systems in design, function, and application:

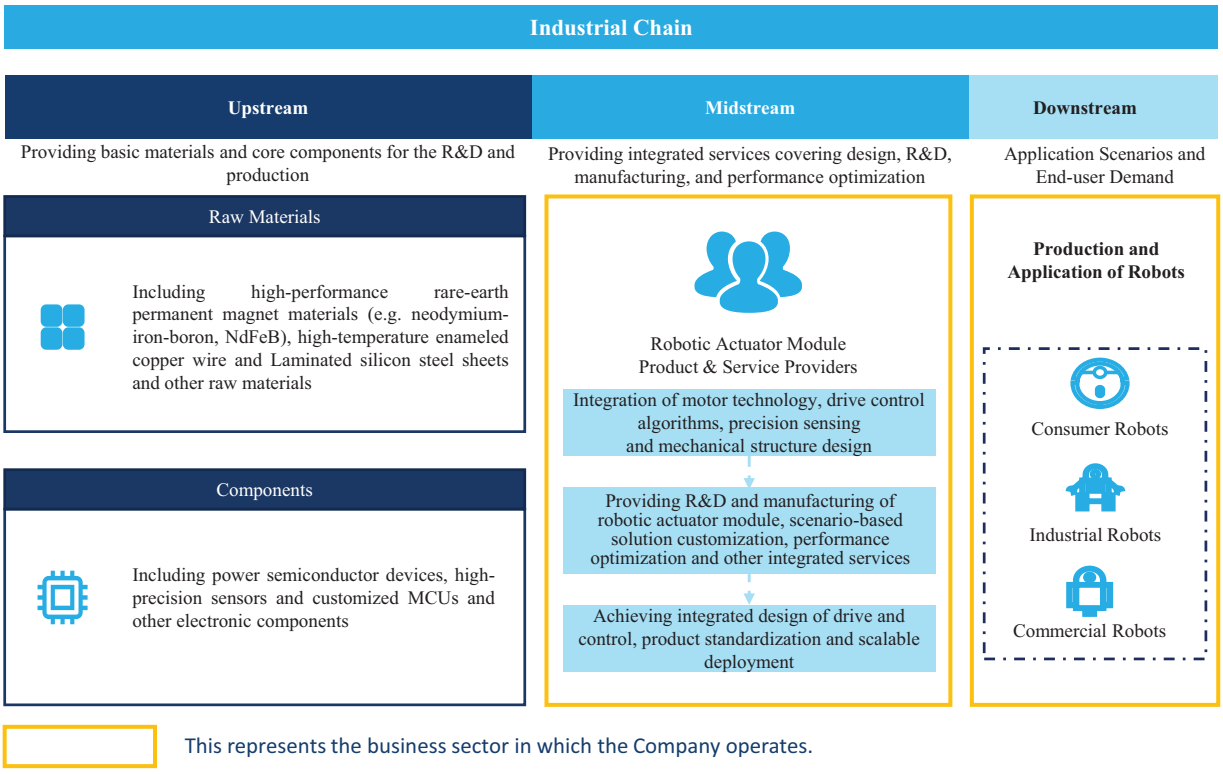
Torque motors provide high torque at low speed, often integrated with servo drive systems, and may require gearing for high-speed tasks; (i) they are optimized for torque control rather than speed or

positional precision; (ii) direct drive motors transmit motion directly to the load without intermediate transmission components (e.g., gears or belts), offering higher positioning accuracy, lower backlash, and simpler mechanical structure; direct drive motors are widely used in applications requiring high precision and responsiveness, such as CNC machines and robotic joints.

Servo drive systems consist of a motor, a feedback sensor, and a controller that regulates position, speed, or torque; (i) these systems can use torque motors or other motor types and often incorporate gearing for motion amplification; (ii) direct drive systems integrate the motor directly with the load, minimizing mechanical transmission components, reducing inertia, and improving dynamic response. These systems can operate with or without an external servo controller depending on design requirements.

Industrial Chain Analysis of Robotic Actuator Module Technology

The Company has established a presence in both the midstream and downstream segments of the value chain.



Source: Frost & Sullivan, Annual Report, Prospectus, and Other Official Disclosures of Industry Players

Policy Analysis of the Robotic Actuator Module Technology Industry

Policy Name	Release Date	Issuing Authority	Key Contents
The Guiding Opinions on the Innovative Development of Humanoid Robots (《人形機器人創新發展指導意見》)	Oct 2023	Ministry of Industry and Information Technology	The policy prioritizes the research and development of highly integrated, long-endurance power units and energy management technologies, as well as the development of high-efficiency dedicated power components.

Policy Name	Release Date	Issuing Authority	Key Contents
The 14th Five-Year Plan for Robotics Industry Development (《"十四五"機器人產業發展規劃》)	Dec 2021	Ministry of Industry and Information Technology and 14 other departments	The policy promotes the modular and general-purpose robot core components, including actuator modules and servo drive systems; encourages technological innovation, demonstration applications, and industrial clustering.
14th Five-Year Plan for Intelligent Manufacturing Development (《"十四五" 智能製造發展規劃》)	Dec 2021	Ministry of Industry and Information Technology and 7 other departments	The policy supports the development of intelligent robots and key components, including servo motors and actuator modules; emphasizes domestic technological breakthroughs and industrial upgrading.
14th Five-Year Plan for Strategic Emerging Industries (《"十四五"戰略性新興產業發展規劃》)	Dec 2021	National Development and Reform Commission (NDRC) jointly with relevant ministries	The policy encourages the development of high-end intelligent equipment and key components, including robotic actuator modules and control systems; provides financial and policy support to innovative enterprises.

These national policies deliver targeted support to the robotic actuator module sector. The 2023 humanoid robot guidelines advance power system and component technologies transferable to actuator products. The three 14th Five-Year Plans collectively prioritise modular, general-purpose robot core components including actuator modules and servo drives, push for domestic technical breakthroughs, foster industrial clustering, and offer financial and policy incentives for innovative enterprises engaged in actuator and control system development.

Market Size of the Robotic Actuator Module Technology Industry

In 2025, the global robotic actuator module market reached RMB110.0 billion, representing a CAGR of 7.0% from 2021 to 2025. The market is expected to expand to RMB206.3 billion by 2030, with a CAGR of 13.9% from 2026 to 2030. From an application perspective, consumer application scenarios are expected to maintain relatively strong growth momentum. In 2025, the consumer-segment market size was approximately RMB30.9 billion and is projected to grow to RMB74.2 billion by 2030. The accelerated forecast growth of the robotic actuator module market is supported by national policies that specifically target breakthroughs in core robotic components. In 2025, the global consumer robotic actuator module market reached RMB30.9 billion, with a CAGR of 23.9% from 2021 to 2025. As the range of high-end consumer robotic products continues to expand, the market is expected to grow to RMB74.2 billion by 2030, representing a CAGR of 15.5% from 2026 to 2030. Driven by the performance advantages of direct drive technology, the direct drive actuator module segment is expected to experience explosive growth, with a CAGR of 97.4%, reaching RMB9.5 billion by 2030.

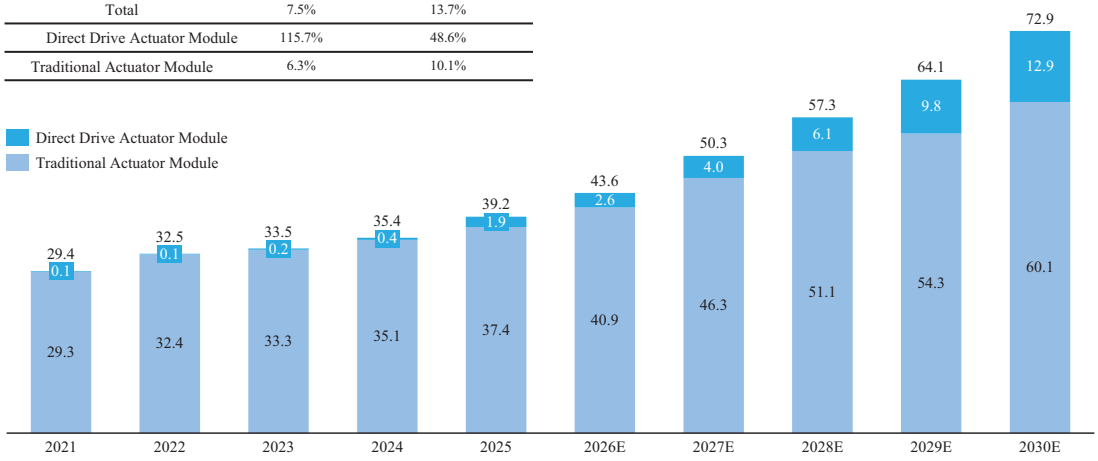
By technology pathway, in 2025, the global traditional actuator module market reached RMB107.9 billion, while the direct drive actuator module market stood at RMB2 billion. Going forward, driven by performance advantages such as high responsiveness, high precision, low noise, and compact structure, the direct drive actuator module market is expected to grow to RMB17.9 billion by 2030. China's robotic actuator module market reached RMB29.4 billion in 2021, expanding to RMB39.2 billion in 2025 amid steady growth driven by rising robotics adoption, and is projected to further grow to RMB72.9 billion by 2030, with distinct growth trajectories emerging by technology type. The traditional actuator module segment, which dominated the market in 2021, grew at a CAGR of 6.3% from 2021 to 2025 and is forecast to maintain a 10.1% CAGR through 2030, reaching RMB60.1 billion. In contrast, the direct drive actuator module segment surged at a 115.7% CAGR between 2021 and 2025 (from RMB0.1 billion to RMB1.9 billion). This momentum is expected to

continue at a robust 48.6% CAGR through 2030, with direct drive modules projected to hit RMB12.9 billion by the decade's end.

Market Size of China's Robotic Actuator Module, by Revenue, by Technology Pathway

Market Size of China's Robotic Actuator Module, by Revenue
RMB billion, 2021-2030E

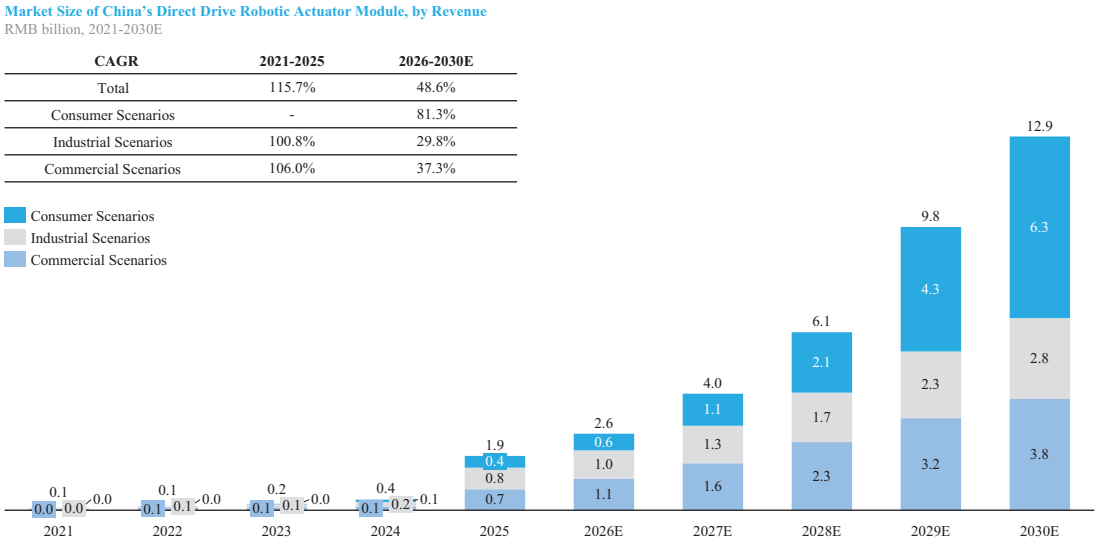
CAGR	2021-2025	2026-2030E
Total	7.5%	13.7%
Direct Drive Actuator Module	115.7%	48.6%
Traditional Actuator Module	6.3%	10.1%



Source: Frost & Sullivan, Annual Report and Other Public Disclosures of Industry Players

China's robotic actuator module market is segmented into consumer scenarios and industrial and commercial scenarios, both showing steady expansion. The industrial and commercial segment accounted for RMB25.3 billion in 2021, increasing to RMB28.9 billion in 2025, and is projected to reach RMB46.8 billion by 2030, maintaining stable growth driven by industrial automation demand. The consumer segment grew more rapidly, expanding from RMB4.1 billion in 2021 to RMB10.3 billion in 2025, and is expected to surge to RMB26.1 billion by 2030. Within China's robotic direct-drive actuator modules market, industrial applications currently capture the largest share at 40.0%, followed by commercial scenarios at 38.4%, while consumer use cases make up the remaining 21.5% of total market volume. Looking ahead to 2030, consumer segments are set to emerge as the highest-growth vertical, forecast to deliver a CAGR of 81.3% through 2026 -2030. Commercial applications trail with a projected 37.3% CAGR over the same period, and industrial use cases are expected to post a 29.8% CAGR.

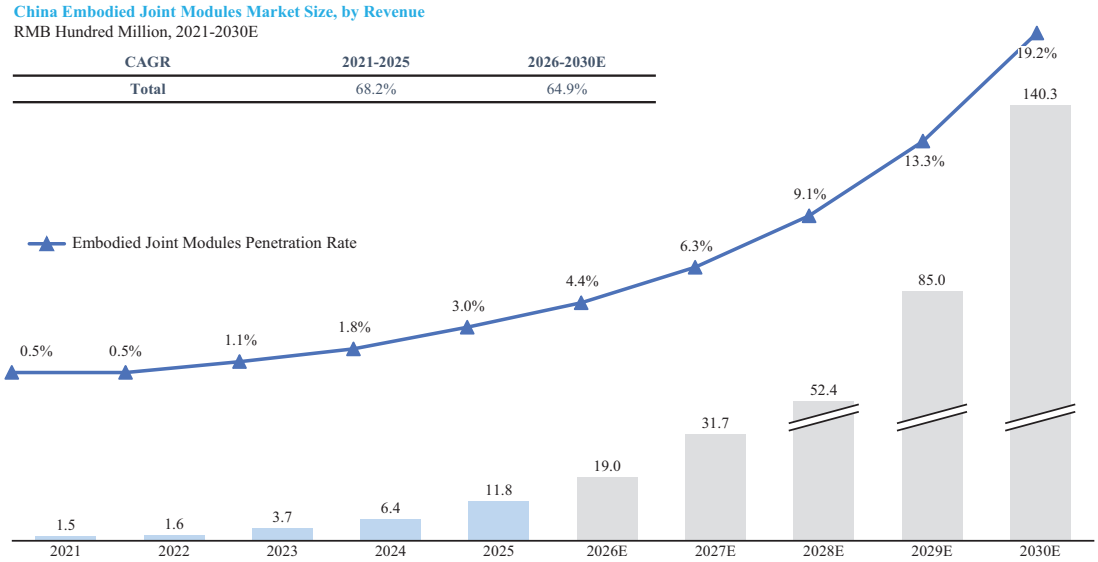
Market Size of China's Robotic Direct Drive Actuator Module, by Revenue, by Application Scenario



Source: Frost & Sullivan, Annual Report and Other Public Disclosures of Industry Players

China's embodied joint modules market, a fast-growing but still nascent subsegment of the broader robotic actuator market, expanded from RMB150 million in 2021 to RMB1.18 billion in 2025 at a 68.2% CAGR, and is projected to grow at a 64.9% CAGR to reach RMB14.03 billion by 2030, with its penetration rate rising from just 0.5% in 2021 to a forecast 19.2% by 2030. Even with this explosive growth, embodied joint modules remain a small share of the total robotic actuator market:

Market Size of China's Embodied Joint Modules, by Revenue



Source: Frost & Sullivan, Annual Report and Other Public Disclosures of Industry Players

Business Drivers of Robotic Actuator Module Technology Industry

Upgrading Downstream Demand Across Multiple Application Scenarios Drives Actuator Modules Toward Miniaturization, Low Noise, and Extended Endurance: Diversification of downstream application scenarios and rising performance requirements constitute the core growth drivers of the industry. The rapid penetration of consumer products such as household cleaning robots has accelerated demand for miniaturized, low-noise, and long-endurance products, promoting the widespread adoption of direct drive actuator modules. The compact structure and noise-reduction characteristics of direct drive modules make them particularly suitable for household environments. In commercial application scenarios such as inspection and delivery robots, higher requirements for endurance and environmental adaptability have driven the adoption of integrated power solutions, significantly improving system efficiency and operational duration. From the perspective of downstream commercialization progress, leading consumer robot brands is increasing its procurement of directdrive modules, which is expected to set an industry benchmark and encourage other players to experiment with new products.

Breakthroughs in New Materials and AI Technologies Enhance Product Performance: Through the application of new materials, domestic enterprises have achieved significant breakthroughs in torque density for direct drive motors. Some products have achieved peak torque levels surpassing traditional technology, breaking long-standing overseas technological monopolies. At the same time, deep integration of direct drive structures with AI technologies enables high-precision control, such as adaptive operation in complex terrains, through model-based control algorithm. Simplified system models further improve simulation and iteration efficiency in motor design, accelerating R&D cycles. The deployment of derivative technologies such as quasi-direct drive (PDD) systems further addresses the needs of segmented application scenarios, including humanoid robots, forming multi-layered technological synergies.

Localization and Industry Chain Collaboration Reduce Costs and Accelerate Commercialization: Stable domestic supply of upstream core components such as rare-earth permanent magnets has secured cost advantages and supply chain resilience. Midstream players have formed efficient collaborative networks in industrial clusters, significantly shortening R&D and production cycles. Downstream, domestically produced actuator modules have been adopted at scale by leading robot providers, meeting requirements for cost-effectiveness and rapid response. Continuous improvements in localization rates, supported by upstream–downstream collaboration, have laid a solid foundation for large-scale industry expansion.

Policy Focus on Core Component Innovation Supports Technological Breakthroughs and Industrialization: The government has rolled out a series of policies to support the R&D and industrialization of complete robots and key components, such as 14th Five-Year Plan for Smart Manufacturing Development. These policies align with industry-driven technological breakthroughs, providing comprehensive support for the industrial chain from research and development to application.

Development Trends of the Robotic Actuator Module Technology Industry

Expansion of Application Scenarios from Consumer to Industrial and Commercial Domains: Downstream demand is rapidly expanding from consumer application scenarios to research, commercial, and industrial applications. Household cleaning robots continue to drive upgrades in

miniaturization and noise reduction; commercial inspection and mining operations rely on integrated power systems to achieve long endurance and high reliability. Application scenario diversification has become a major growth engine for the industry.

Direct Drive Actuator Module and Model-based Control Algorithm Leading Technological Upgrading: Industry technology iteration is increasingly focused on drive–control integration. Direct drive technology, with its simplified structure, low noise, and high efficiency, is rapidly penetrating consumer and research applications. Quasi-direct drive technical approaches extend applicability to high-load scenarios such as humanoid robots. Meanwhile, a model-based control algorithm is deeply integrated into power system design and manufacturing, to help improve the performance of the actuator module.

The Standardization of the Industry: The industry chain is transitioning from fragmentation to collaboration, with policies and standards acting as key enablers. Industry-wide collaboration among component companies and robot companies accelerates technological iteration through real-world validation. Meanwhile, improving international compliance systems is paving the way for overseas expansion of domestic technologies, with ecosystem collaboration emerging as a critical support for large-scale deployment.

Flexible Delivery Becoming a Key Performance Benchmark: Given the wide variety of joint module types and strong customization requirements, the industry is upgrading toward end-to-end flexibility. Enterprises are leveraging AI-assisted design to rapidly generate specifications and solutions, while building flexible production lines capable of small-batch, rapid delivery. Flexible delivery capability has become a key competitive advantage for establishing scale in fragmented markets and fostering ecosystem-based industry growth.

Key Success Factors

Building Core Technological Capabilities: Direct drive technologies require multi-physics coupled simulation and algorithm optimization to enhance torque density and reduce noise, meeting household and commercial demands for quietness and stability. Deep integration of model-based control algorithms such as reinforcement learning into drive-control systems enables adaptive, high-precision operation in complex environments.

End-to-end Supply Chain Management Balancing Cost and Responsiveness: Establishing a supply chain system, combining core component self-sufficiency and deep supplier collaboration, is critical for cost reduction and efficiency improvement. Structural simplification at the design stage, strategic sourcing of core resources, and leveraging industrial clusters to shorten logistics cycles help maintain cost advantages while enhancing response speed.

Scalable Mass Production and Flexible Delivery Capabilities: Companies must build a delivery system that combines scalable mass production with customization flexibility. Automated production lines and digital management ensure efficient, stable mass production of core products, while rapid prototyping and small-batch manufacturing capabilities enable flexible responses to diverse application scenarios such as cleaning and fitness robotics.

Deep Application Scenario Adaptation: Companies must specialize in products for various fields such as home use, scientific research, and humanoid robots, and collaborate closely with whole-machine manufacturers to validate technical performance through practical applications.

Ecosystem Synergy Capability: Ecosystem synergy is demonstrated in two key dimensions. First, it involves synergy within a company's internal business portfolio. Players that are anchored in actuator module technology and expand into adjacent upstream and downstream businesses gain stronger competitive advantage. Actuator modules provide the core motion control for robots, while robotics manufacturing experience, in turn, enhances the design and production capabilities of the actuator modules themselves. Furthermore, ecosystem synergy extends to building deep collaboration across the industrial chain by strengthening partnerships with upstream suppliers of key materials while better adapting to downstream application needs.

Analysis of Market Challenges, Threats and Entry Barriers

The commercialization depends on the level of acceptance by downstream customers, as it is a new product category. It also depends on downstream demand growth and cost reduction progress, which may be uncertain. Competition from established international suppliers and rapid technological iteration may intensify pricing pressure and increase research and development uncertainty. Significant entry barriers include multidisciplinary integration capabilities, accumulated reliability validation, customization requirements, and lengthy customer qualification processes, which may delay large-scale market penetration.

Competitive Landscape of the Robotic Actuator Module Technology Industry

The major players in China's robotic actuator module market are traditional actuator module companies. In terms of 2025 revenue, top five players collectively capture around 45% of the total market share in terms of revenue, while the top ten companies hold 58.9%. The rest of the market remains highly fragmented. In China's consumer robotics actuator module market, the Company ranked eighth in 2025 by revenue, with a market share of 2.4%. The top ten players collectively accounted for approximately 47.1% of the market.

Top Ten China's Consumer Robotic Actuator Module in 2025, By Sales Revenue

Ranking	Company	Sales Revenue (RMB100 Million)	Market Share
1	Company A	13.3	12.9%
2	Company B	6.7	6.5%
3	Company C	6.0	5.8%
4	Company D	5.3	5.1%
5	Company E	4.4	4.3%
6	Company F	4.0	3.9%
7	Company G	3.5	3.4%
8	The Company	2.5	2.4%
9	Company H	2.0	1.9%
10	Company I	0.8	0.8%
	Top 10	**48.5**	**47.1%**

Source: Frost & Sullivan, Annual Report, Prospectus, and Other Official Disclosures of Industry Players

Notes:

- Company A: founded in Dongguan in 2000, is a micro motor solutions company specializing in the research, development, production, and sales of micro motors and micro generators. Company A is not listed.
- Company B: founded in Shenzhen in 2006, is a leading domestic provider of integrated electromechanical software solutions and micro transmission modules, dedicated to the R&D and production of micro motors, micro gearboxes, micro transmission modules, and smart controllers. Company B is quoted on the NEEQ.
- Company C: founded in Dongguan in 2013, is a high-tech enterprise mainly engaged in the research, development, production, and sales of brushless DC motors and permanent magnet DC motors. Company C is not listed.

- Company D: a comprehensive motor manufacturer from Japan and founded in 1973, offers a wide range of motor products, from precision miniature motors to super-large motors. Company D is listed on the Tokyo Stock Exchange.
- Company E: founded in Hong kong in 1982, is a high-tech enterprise specializing in the design and manufacturing of plastic gears, plastic components, high-precision metal parts, and electric gearboxes. Company E is not listed.
- Company F: founded in Changzhou in 2006, is a motor product R&D, design, and manufacturing enterprise specializing in stepper motors, synchronous motors, DC brushed motors, DC brushless motors, water pumps, high-efficiency industrial motors, fans, and other motor products. Company F is listed on the Shenzhen Stock Exchange.
- Company G: founded in Dongguan in 2005, is a professional provider of compact motion units, dedicating to providing efficient and customized intelligent drive systems. Company G is not listed.
- Company H: founded in Ningbo in 2002, is a motor enterprise specializing in the research, development, and production of electric motors, carpet cleaners, personal care appliances, and home health care appliances. Company H is listed on the Shanghai Stock Exchange.
- Company I: founded in Shenzhen in 2001, is a manufacturer of micro-drive systems, primarily engaged in the research, development, production, and sales of micro-transmission and drive systems. Company I is listed both on the Shenzhen and Hong Kong Stock Exchange.

In 2025 the combined revenue of the top five China's consumer robotic direct drive actuator module companies amounted to approximately RMB309.0 million, with the Company ranking as the largest China's provider of consumer robotic direct drive actuator module technology.

Top Five China's Consumer Robotic Direct Drive Actuator Module Technology in 2025, By Revenue

Ranking	Company	Revenue (RMB Million)	Market Share
1	The Company	246.0	61.1%
2	Company C	55.0	13.6%
3	Company J	4.0	1.0%
4	Company G	2.0	0.5%
5	Company K	2.0	0.5%
	Top 5	**309.0**	**76.7%**

Source: Frost & Sullivan, Annual Report, Prospectus, and Other Official Disclosures of Industry Players

Notes:

(1) Company J, it is a subsidiary under the same corporate group that is listed on the Shenzhen Stock Exchange, founded in Nanjing in 2022, it is committed to building a leading full-stack platform for general-purpose intelligent robots in the industrial manufacturing sector, covering applications across all industrial application scenarios.

(2) Company K, founded in Changzhou in 2006, is a technology-driven and manufacturing enterprise specializing in the R&D of electric vehicle motors and controllers. Company K is not listed.

OVERVIEW OF THE GLOBAL ROBOT INDUSTRY

Definition and Classification of Robots

Robots refer to physical systems equipped with movable carriers, such as robotic arms and wheeled chassis, that enable interaction with the physical world. They can receive sensory inputs such as vision and force feedback, generate execution commands accordingly, and replace or assist humans in completing tasks across a wide range of scenarios, including production, services, exploration, and entertainment.

By application scenario, robots can be classified into consumer robots and commercial/industrial robots. Consumer robots primarily serve household or personal use cases, emphasizing miniaturization, low noise, and are mainly deployed for daily tasks such as cleaning and light transportation. Industrial and commercial robots are oriented toward commercial services and industrial production, with the core objective of cost reduction and efficiency improvement, enabling functions such as inspection, delivery, and collaborative manufacturing. With the continuous advancement of embodied intelligence technology, robots with embodied intelligence are gradually being applied in consumer, industrial, commercial, and other scenarios, and are on the verge of market explosion.

Embodied intelligence robots refer to robotic systems that integrate perception, decisionmaking, and actuation capabilities within a physical platform, enabling adaptive and autonomous interaction with complex environments. These robots combine sensors, actuators, and control algorithms to execute tasks that require physical interaction, mimicking human or animal intelligence in real-world scenarios.

By locomotion mode, robots can be categorized into wheeled robots (including wheel-legged robots), legged robots, tracked robots, aerial robots, and other types.

Robot Type	Core Design & Locomotion	Key Advantages	Primary Applications
Wheeled Robots	Wheels (2 to 4+ wheels; differential, omnidirectional, Ackermann drive)	Highest energy efficiency; high speed on flat surfaces; simple mechanics; low cost; precise indoor maneuvering	Warehouse logistics (AMRs), industrial delivery, cleaning robots, service robots, autonomous vehicles
Legged Robots	Bipedal, quadrupedal, hexapod legs (mimics animal/human gait)	Excellent terrain adaptability; climbs stairs/obstacles; traverses rubble/ rough ground; low terrain damage	Search & rescue, industrial inspection, military patrol, exploration, humanoid assistance
Tracked Robots	Continuous rubber/metal tracks (skid-steer)	Superior traction/stability on mud/sand/snow; high load capacity; excellent off-road performance	Military reconnaissance, disaster response, construction, agriculture, planetary exploration
Aerial Robots	Multirotor (quad/hexacopter) or fixed-wing; propellers/wings for flight	3D access; bird's-eye view; rapid deployment; no ground contact; long-range mapping	Aerial surveying, mapping, agriculture (spraying), surveillance, delivery, inspection (power lines, buildings)
Wheel-Legged Robots-	Integrates legs with wheels at the foot; subcategories differ by number of wheel-legged units and locomotion mode, including Dual-wheel-legged, Four-wheel-legged, and Hybrid	Combines wheel efficiency (fast on flat ground) + legged adaptability (climbs obstacles/stairs); versatile for mixed terrains; better stability than pure legged robots; flexible locomotion modes	Industrial inspection (mixed indoor/outdoor terrain), outdoor patrol, smart factories, search & rescue (mixed terrain) etc.

Policy Analysis of the Robot Industry

Policy Name	Release Date	Issuing Authority	Key Contents
Opinions of the State Council on Further Implementation of the "Artificial Intelligence Plus" Action (《國務院關於 深入實施"人工智能+"行動 的意見》)	Aug 2025	State Council	The policy defines a three-stage development roadmap. By 2027, artificial intelligence will be deeply integrated into six key sectors, with the penetration rate of next-generation intelligent terminals and intelligent agents exceeding 70%. By 2030, the penetration rate will increase to 90%, with the intelligent economy becoming a major growth engine. By 2035, China will fully enter a new stage of intelligent economy and intelligent society. The policy emphasizes the development of an "intelligent interconnection of all things" ecosystem centered on smart terminals, prioritizing intelligent robots, smart home products, and other categories to build a full-scenario intelligent interaction environment and promote high-quality development and inclusive access to AI technologies.
Notice by Twelve Departments Including the Ministry of Industry and Information Technology of Issuing the Upgraded Plan for the "Sailing" Initiative to Scale Up 5G Applications (工業和信息化部等十二部門關於印發《5G規模化應用" 揚帆"行動升級方案》的通 知)	Nov 2024	Ministry of Industry and Information Technology and 11 other departments	The policy promotes R&D and application of 5G-enabled intelligent robots, smart mobile terminals, and cloud-based devices, and encourages innovation in products integrating 5G with XR systems, naked-eye 3D, smart wearables, and smart home solutions.
Opinions on Deepening the Integration of Industry and Education in the Domestic Services Sector (《關於深化家政服務業產教融合的意見》)	Oct 2024	National Development and Reform Commission, Ministry of Education, Ministry of Finance, Ministry of Human Resources and Social Security, Ministry of Commerce	The policy encourages school-enterprise collaboration in intelligent manufacturing and domestic services, strengthens R&D and technological upgrades of smart home products and household service robots, and deepens the application of AI technologies in the domestic services industry.

Policy Name	Release Date	Issuing Authority	Key Contents
Guiding Opinions on the Innovative Development of Humanoid Robots （《人形機器人創新發展指導意見》）	Oct 2023	Ministry of Industry and Information Technology	The policy aims to promote high-quality development of the humanoid robot industry, foster new quality productive forces, and strongly support new-type industrialization and modern industrial system construction. One key target is to establish an initial innovation system for humanoid robots by 2025, achieve internationally advanced levels for complete machine products, and realize mass production. By 2027, technological innovation capabilities are expected to significantly improve, forming an internationally competitive industrial ecosystem with overall strength reaching world-leading levels.

Collectively, these national policies offer multi-tiered support for the robot industry and wheel-legged robots specifically. Robots are strategically positioned as key smart terminals under national AI and digital economy frameworks with steady policy, capital and market backing. R&D support for AI, 5G, motion control and sensors resolves technical hurdles for wheel-legged robots' movement, autonomy and connectivity. Industrial ecosystem roadmaps facilitate cost reduction, mass manufacturing and stable supply chains for wheel-legged products. Promotions for smart homes and domestic services broaden market opportunities for consumer wheel-legged robots, while industry-education collaboration mitigates shortages of skilled hardware and software development talent.

Market Size Analysis of the Global Robot Industry

In 2025, the shipment volume of global robots reached approximately 33.9 million units, representing a CAGR of 18.7% from 2021 to 2025. Among them, consumer robots recorded the most significant growth, expanding from 16.4 million units in 2021 to 32.7 million units in 2025, at a CAGR of 18.9%. Looking ahead, driven by surging societal demand for robots, the shipment volume of global consumer robots is expected to continue rapid growth, reaching 78.9 million units by 2030, corresponding to a CAGR of 17.1% from 2026 to 2030.

Market Drivers and Development Trends Analysis of the Robot Industry

Accelerated Development of Robot Hardware, Where Actuator Modules Plays an Essential Role: Hardware is the core of robotic products, of which robotic actuator modules serve as the core of motion control and power output—their performance directly determines key metrics such as dynamic response, operational accuracy, and endurance. Industry competition is increasingly concentrated on upstream core components. Integrated breakthroughs in high-torque-density motors, and model-based control algorithms have become critical to overall performance upgrades. Going forward, actuator modules are expected to evolve toward higher integration, higher power density, and deeper intelligence, supporting continuous product category innovation.

Advancements in AI Algorithms and Large Models Enhance Robotic Interaction, Decision-Making, and Embodied Intelligence: Cutting-edge algorithms, combined with multimodal perception technologies such as 3D vision and LiDAR, have significantly improved robots' force control and motion precision, strengthening their environmental adaptability and enabling them to perform complex tasks in unstructured environments. Large language models have overcome the limitations of command-based interaction, enabling natural language dialogue. Continuous progress in AI algorithms and foundation models is driving robots to evolve into embodied intelligent agents capable of perception, reasoning, and action.

Modular Innovation Drives Industry Development: Modular design has become a key enabler of industry development. It allows robots to rapidly switch configurations to meet diverse operational requirements while reducing R&D and manufacturing costs through standardized component reuse and shortened production cycles. Through module disassembly and mass production, enterprises can quickly respond to diversified application scenarios while maintaining unit price, thereby accelerating robot penetration across industries.

Expansion of application scenarios: Beyond early adoption in niche or pilot scenarios, robots are expected to penetrate a wider range of consumer, commercial, and industrial use cases between 2025 and 2030, significantly expanding the addressable market and driving faster shipment growth.

New Categories of Robot, represented by Wheel-Legged Robots, are Emerging: With ongoing upgrades in actuator modules and optimization of AI algorithms, the stability, endurance, and payload capcity of wheel-legged robots will continue to improve, addressing key challenges to large-scale deployment. Wheel-legged robots are expected to become one of the growth engines of the robot industry in the future.

Analysis of Market Challenges, Threats and Entry Barriers

The robot industry involves substantial R&D investment and extended commercialization cycles. Market adoption of new-generation robots remains subject to technological maturity, customer acceptance, and capital expenditure conditions. Competition from global robotics leaders and technology companies may intensify technological substitution risks. Macroeconomic volatility and supply chain disruptions could also adversely affect industry growth. High entry barriers arise from system-level integration capabilities, proprietary technologies, and established customer relationships, all of which require sustained investment and operational experience.

OVERVIEW OF GLOBAL AND CHINA WHEEL-LEGGED ROBOT INDUSTRY

Definition and Classification of Wheel-Legged Robots

Wheel-legged robots are hybrid mobile robots that integrate the high-dynamic obstacle-crossing capabilities of legged robots with the efficient and stable mobility of wheeled robots, thereby combining the advantages of both locomotion paradigms. Typically, wheel-legged robots are equipped with actively controllable leg structures, with wheels mounted at the foot ends. This design enables them to roll efficiently on flat surfaces like wheeled robots, while also allowing them to traverse stairs, trenches, and other complex terrains by adjusting leg posture and gait, similar to legged robots.

Based on structural configuration, wheel-legged robots can be broadly classified into the following categories:

Dual-wheel-legged robots: Typically equipped with two wheel-leg composite units, these robots rely on dynamic balance control to achieve mobility and obstacle crossing. Their relatively compact structure makes them suitable for application scenario with high requirements for passability and spatial adaptability, such as inspection and operations in narrow passages.

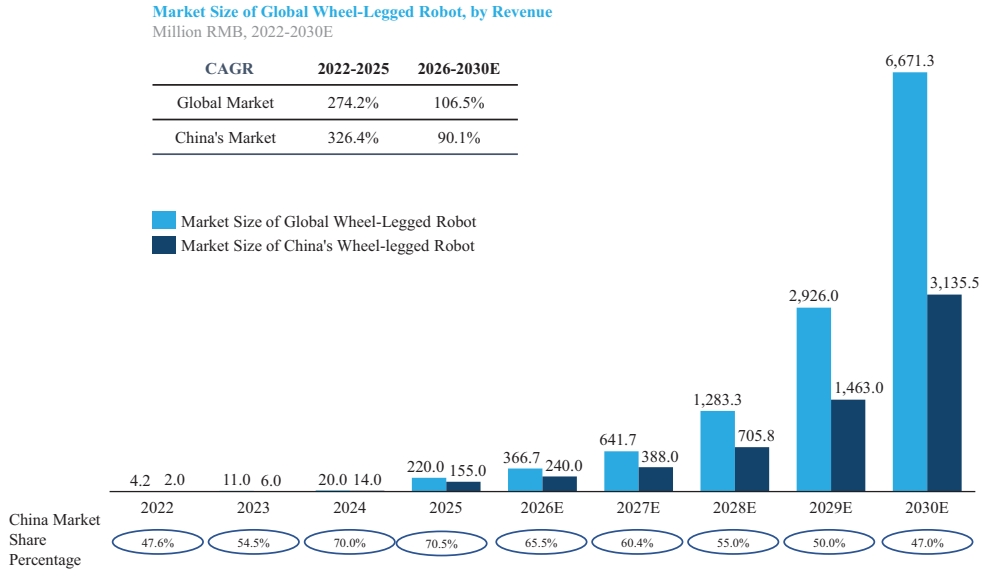
Four-wheel-legged robots: Featuring four sets of wheel-leg mechanisms, these robots offer significantly enhanced stability and payload capacity, with more robust motion performance. They are commonly deployed in industrial and specialized fields requiring long-duration operation and complex terrain adaptability, such as outdoor inspection, logistics handling, and security patrol.

Other wheel-legged or hybrid configurations: This category includes single-wheel-legged, six-wheel-legged, hybrid wheel-legged, and other mixed forms designed for specific application scenario. Most of these robots are customized products or remain in the R&D and validation.

Market Size of the Wheel-Legged Robot Industry

The global wheel-legged robot industry achieved initial commercial deployment between 2022 and 2025, with market size expanding from RMB4.2 million to RMB220.0 million, representing a CAGR of 274.2% over the period. Although the China's market entered later, it experienced more rapid growth, with a CAGR of 326.4% during the same period, leading global growth rates. Starting in 2025, supported by favorable policies and expanding application scenarios, domestic enterprises in China gradually achieved batch deliveries, marking the industry's entry into a rapid volume expansion phase. In that year, the Chinese market size reached RMB155.0 million, accounting for approximately 70.5% of the global total.

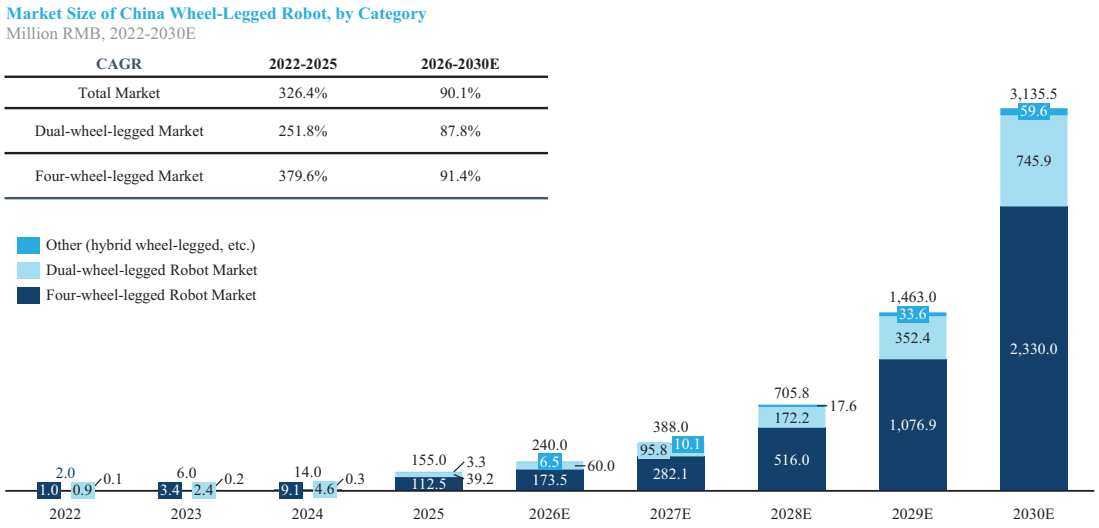
Market Size of Global and China Wheel-Legged Robot, by Revenue



Source: Frost & Sullivan, IDC

From a product structure perspective, dual-wheel-legged and four-wheel-legged robots currently dominate the market. In 2025, these two categories together accounted for approximately 98.2% of the total market, with both growing by several times. From 2026 to 2030, four-wheel-legged robots are expected to maintain a CAGR of 107.1%, slightly higher than the 103.9% CAGR projected for dual-wheel-legged robots. By 2030, the market size of dual-wheel-legged robots is projected to reach RMB1,901.3 million, while four-wheel-legged robots are expected to reach RMB4,540.0 million. China's wheel-legged robot market surged from RMB2 million in 2022 to RMB155 million in 2025 at 326.4% CAGR, and is projected to expand at an 90.1% CAGR through 2030E to reach RMB3.14 billion. By segment, four-wheel-legged robots have been the primary driver, growing at a 379.6% CAGR from 2022 to 2025 and forecast to maintain an 91.4% CAGR through 2030E to capture the majority share at RMB2.33 billion, while dual-wheel-legged robots follow closely with a 251.8% CAGR (2022–2025) and 87.8% CAGR (2026–2030E), set to reach RMB746 million by the decade's end, underscoring the segment's rapid scaling and rising adoption in industrial, logistics, and consumer applications.

Market Size of China Wheel-Legged Robot, by Revenue, by Category



Source: Frost & Sullivan, Prospectus of Industry Players, and Expert Interview

Market Drivers and Development Trends Analysis of Wheel-Legged Robot Industry

***Technology Iteration Driven by Consumer, Industrial and Commercial Application Demands, Fostering Continuous Product Innovation*:** Wheel-legged robot technologies are rapidly evolving toward enhanced environmental perception intelligence and precise motion control. To meet consumer market requirements for lightweight design, flexibility, and low noise, technological development has increasingly focused on multi-sensor fusion, real-time path planning, and low-power system design. In industrial and commercial applications, to support dynamic operations in flexible production lines, technological advancement has concentrated on high-precision localization, compact joint design, and model-based control algorithm, enabling stable material handling and precise operations within confined spaces.

Localization and Self-sufficiency of Core Components: One of the key drivers of industry development is the localization of core components. As the performance of high-torque-density motors, servo systems, IMUs, and other critical components continues to approach or even match imported alternatives, overall system costs have declined significantly, supply chain stability has improved, and R&D iteration cycles have shifted from long-term dependence on overseas suppliers toward autonomous and controllable development.

Evolution toward Modular Assembly Architectures, Enabling Multi-application scenario Adaptability: In the future, wheel-legged robots are expected to break away from traditional fixed-structure designs and evolve toward modular assembly architectures. Through standardized interfaces and system-level integrated designs, different morphological assemblies can be freely combined and rapidly switched. Leveraging standardized joint and chassis modules, robots can achieve flexible multi-form assemblies.

Integration of Direct Drive Technology and Embodied Intelligence to Strengthen Autonomous Operation Capabilities: Such integration will accelerate their evolution toward autonomous perception and decision-making. On the hardware side, integrated direct drive joints eliminate reducers and integrate drive and sensing modules, achieving high torque density, low

latency, and high energy efficiency. On the software side, by combining multimodal perception with self-supervised learning, robots can establish a closed-loop "perception–decision–execution" framework, enabling real-time terrain recognition and motion adjustment.

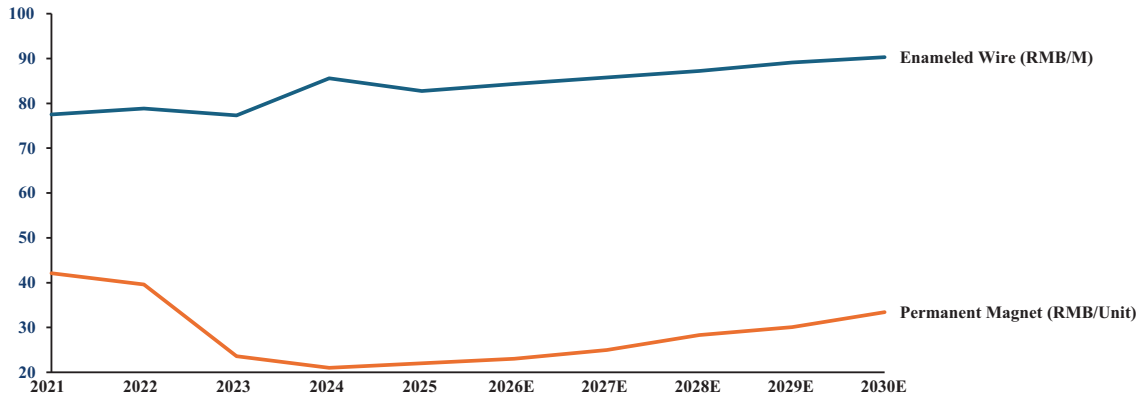
Policy Support: China's "New Generation Artificial Intelligence Development Plan" (2017) sets a target for China's AI core industry to exceed RMB1 trillion by 2030, with intelligent robotics identified as a key application direction. This provides quantified macro-level support for AI-integrated mobile robots, including wheel-legged platforms.

The Historical and Forecast Price Trends of Major Raw Materials

Robot actuator modules and robots (especially wheeled-legged robots) have a close upstream-downstream relationship with highly overlapping core raw materials — enameled wire, neodymium-iron-boron (NdFeB) magnets, and electronic components. From 2021 to 2025, their fluctuations were driven by commodity cycles, supply-demand mismatches, rare earth price changes, and the global chip shortage, along with domestic substitution progress. Looking ahead to 2026-2030, their trends will be shaped by tight copper and rare earth supply, growing demand from humanoid robots, third-generation semiconductor maturity, and industrial upgrading; NdFeB magnets will have the greatest volatility, enameled wire will correlate closely with copper prices, and electronic components will show structural differences between high-end and mid-to-low-end segments.

Price Trends of Major Raw Materials for Robot actuator modules and robots

2021 – 2030E



Source: Frost & Sullivan, Wind

Analysis of Market Challenges, Threats and Entry Barriers

Wheel-legged robots require advanced dynamic control, terrain adaptability, and structural optimization. Commercial use cases are still developing, and demand realization may be uncertain. Alternative mobility solutions and competing technological approaches may limit broader market adoption. Ongoing investments by research institutions and industry participants could intensify competition. Barriers include high technical complexity in control algorithms and mechanical design, extensive real-world validation.

Competitive Landscape of the Wheel-Legged Robot Industry

For the year ended December 31, 2025, the combined revenue of the top eight global wheel-legged robot providers reached approximately RMB 180.8 million, representing a total market share of

82.2%. Based on revenue during this period, The Company ranked sixth globally in the wheel-legged robot market.

Top Eight global wheel-Legged Robot Providers, For the Year Ended December 31, 2025, By Revenue

Ranking	Company	Revenue (RMB Million)	Market Share
1	Company L	~92.4	42.0%
2	Company M	~27.0	12.3%
3	Company N	26.0	11.8%
4	Company R	13.0	5.9%
5	Company P	12.0	5.5%
6	The Company	7.3	3.3%
7	Company O	2.0	0.9%
8	Company Q	1.1	0.5%
	Top 8	**180.8**	**82.2%**

Source: Frost & Sullivan, and Expert Interview

Note:

(1) Company L, founded in Hangzhou in 2016, is a globally renowned robot provider specializing in the independent R&D, production, and sales of high-performance general-purpose legged/humanoid robots and six-axis manipulators for consumer and industrial applications. Company L is not listed.
(2) Company M, founded in Shenzhen in 2022, is an AI-driven humanoid robot provider focused on developing full-scale general-purpose humanoid robots, with a portfolio that *includes innovative products.* Company M is not listed.
(3) Company N, founded in Hangzhou in 2017, is a national-level high-tech enterprise, focusing on embodied intelligence technology innovation and industry applications while specializing in the R&D, production, sales, and service of quadruped robots, humanoid robots, and core components. Company N is not listed.
(4) Company O, founded in Dongguan in 2016, is a leading global robot provider, providing mobile robot chassis and customized autonomous driving solutions, dedicated to enhancing productivity and efficiency across industries through innovative robotics technology. Company O is not listed.
(5) Company R, founded in Zurich in 2016, is a globally recognized robotics company specializing in the independent R&D, production, and sales of autonomous legged robots for inspection, monitoring, and industrial applications. Company R is privately held and not listed.
(6) Company Q, founded in Beijing in 2023, is an embodied robotics provider focused on the full-stack development of high-performance robots. Company Q is not listed.
(7) Company P: founded in Zurich in 2023, is a AI robotics startup specializing in the intelligent mobile robot solutions for complex outdoor and industrial environments. Company P is not listed.

For the year ended December 31, 2025, the combined revenue of the top five global dual-wheel-legged robot providers reached approximately RMB39.8 million. Based on dual-wheel-legged robot revenue during this period, the Company ranked the third globally.

Top Five Global Dual-wheel-Legged Robot Providers, For the Year Ended December 31, 2025, By Revenue

Ranking	Company	Revenue (RMB Million)	Market Share
1	Company R	16.5	25.0%
2	Company M	12.0	18.2%
3	The Company	7.3	11.1%
4	Company O	~2.0	3.0%
5	Company L	~2.0	3.0%
	Top 5	**39.8**	**60.3%**

Source: Frost & Sullivan, Expert Interview, and Prospectus of Industry Players

For the year ended December 31, 2025, the combined revenue of the top five wheel-legged robot providers reached approximately RMB124.9 million in China. Based on wheel-legged robot revenue during this period, the Company ranked the fourth in China.

Top Five Wheel-Legged Robot Providers in China, For the Year Ended December 31, 2025, By Revenue

Ranking	Company	Revenue (RMB Million)	Market Share
1	Company L	80.9	52.2%
2	Company N	18.2	11.7%
3	Company M	16.5	10.6%
4	The Company	7.3	4.7%
5	Company O	2.0	1.3%
	Top 5	**124.9**	**80.6%**

Source: Frost & Sullivan, Expert Interview, and Prospectus of Industry Players

For the year ended December 31, 2025, the combined revenue of the top five dual-wheel-legged robot providers reached approximately RMB28.8 million in China. Based on dual-wheel-legged robot revenue during this period, the Company ranked the second in China.

Top Five Dual-wheel-Legged Robot Providers in China, For the Year Ended December 31, 2025, By Revenue

Ranking	Company	Revenue (RMB Million)	Market Share
1	Company M	16.5	42.1%
2	The Company	7.3	18.6%
3	Company O	2.0	5.1%
4	Company L	~1.6	3.8%
5	Company Q	~1.4	3.8%
	Top 5	**28.8**	**73.4%**

Source: Frost & Sullivan, Expert Interview, and Prospectus of Industry Players

SOURCE OF INFORMATION

We have commissioned Frost & Sullivan, an independent market research and consulting company, to conduct an analysis of, and to prepare a report on the global robotic actuator modules industry. The report prepared by Frost & Sullivan for us is referred to in this document as the Frost & Sullivan Report. A total fee of RMB650,000 shall be paid to Frost & Sullivan for the preparation of the report, which we believe reflects market rates for reports of this type. Frost & Sullivan is a global consulting company founded in 1961 in New York and has over 40 global offices with more than 2,000 industry consultants, market research analysts, technology analysts and economists.

RESEARCH METHODOLOGY

The Frost & Sullivan Report was prepared through both primary and secondary research obtained from various sources using intelligence collection methodologies. Primary research involved discussing the status of the industry with certain industry participants across the industry value chain and conducting interviews with relevant parties to obtain objective, factual data and prospective predictions. Secondary research involved information integration of data and publication from publicly available sources, including official data and announcements from government agencies, company reports, independent research reports and data based on Frost & Sullivan's own data base.

BASIS AND ASSUMPTIONS

In compiling and preparing the Frost & Sullivan Report, Frost & Sullivan has adopted the following assumptions: (i) the social, economic and political environment in the world and China is likely to remain stable in the forecast period; and (ii) industry key drivers are likely to drive the growth of the Global and China relevant industries in the forecast period. All statistics are based on the information available as at the date of the Frost & Sullivan Report.