

## SMid Cap Industrials

## Humanoid Robotics Are Coming Off the Whiteboard

2026 *Extel*  
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Following our previously published robotics overview (see [here](#)) and humanoid market opportunity note (see [here](#)), we have received growing investor interest and feedback on the demand landscape, competitive dynamics, and scalability of the U.S. humanoid market. This note addresses structural labor shortages and end-market demand across sectors from automotive to defense, provides an overview of capacity scale and speed, and highlights ex-U.S. component competitors. In automation, we especially focus on our coverage names Regal Rexnord (RRX), Timken (TKR), and Allient (ALNT) as key companies. We conclude that humanoids, while still early in technology and adoption, are scaling rapidly, and believe the U.S. manufacturing ramp could accelerate.

- **Proof Beats Hype: Pilots Become Purchase Orders:** Automotive and industrial manufacturing are the clearest on-ramps, with broader scale most likely in 2027 to 2030 as task scope expands beyond basic material handling. BMW's pilot logged 1,250+ hours supporting 30,000+ vehicles on 10-hour shifts. Logistics and warehousing follow; economics can work at \$10-\$12/hour versus about \$30 per hour labor, but density hinges on functional safety certification and human collaboration. Defense is accelerating but niche, and healthcare/consumer are the largest structural TAMs with adoption further out.
- **From "Can It Work" to "Can It Scale":** The humanoid market is decisively shifting from proof-of-concept to scale, with U.S. producers (Figure AI at 12k units/year, Tesla targeting 11M at mass production, 1X at 100k by 2027) trying to close the gap on Asian OEMs (Agibot & Unitree shipping >20k annualized and UBTECH >10k capacity by the end of 2026) as factories come online. We are seeing an acceleration in U.S. capacity, supply chains being established, and domestic capacity working to close the gap with Asia.
- **Labor Is the Catalyst: ROI Moves from Years to Quarters:** Manufacturing vacancies run about 4.1% in the 1Q26 survey, with some projections citing 2.1M unfilled roles by 2030, driven by an aging workforce, retiring baby boomers, and immigration headwinds, creating durable demand across manufacturing, logistics, and automotive. The strong push for automation is evident across our tours and is consistently echoed, a trend we expect to accelerate further as technology matures and costs continue to decline.
- **The Knife Edge: Substitution and Competition:** Even if adoption progresses, suppliers face China's volume-driven cost curve and established Japan and broader Asia competitors with deep precision motion know-how and qualification histories. Japan's NSK, NTN, JTEKT, and THK represent a credible ex-U.S. competitive threat to our coverage as incumbent industrial robotics suppliers now pivoting toward humanoid platforms with tangible progress across actuators, precision bearings, and joint modules already in commercial use. We mitigate by favoring differentiated reliability, fast iteration cycles, and balance sheets that can invest through downturns.

## North America Small and Mid Cap Industrials

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## Executive Summary

**Unfilled Manufacturing Jobs with Strong Unit Economics: Structural Case for Humanoids:** The U.S. humanoid robotics opportunity is a structural story, not a cyclical one. With 462,000 manufacturing jobs unfilled today and projections reaching 2.1M by 2030, driven by an aging workforce, retiring baby boomers, and immigration headwinds, with demand expanding simultaneously across manufacturing, logistics, and automotive. Unit economics are already proving viable with some humanoids operating at \$10-12/hour versus ~\$30/hour for comparable human labor, establishing a clear ROI framework that should accelerate enterprise procurement. Whether humanoids serve as a complement or supplement to human labor, the underlying demand is structural and growing, making robotics adoption a durable long-term demand driver that directly supports our coverage.

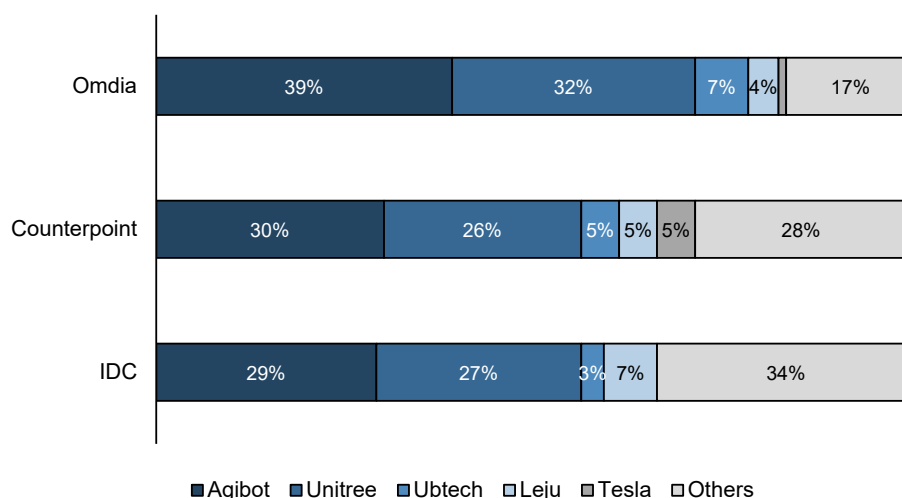
**From "Can It Work" to "Can It Scale": The Humanoid Capacity Inflection:** The humanoid robotics market is entering a critical inflection point, with the sector's challenge shifting decisively from "can it work" to "can it scale," as shown by Figure AI's BotQ facility ramping toward 12,000 units/year in just four years from founding, Tesla's Fremont and Giga facilities are forecasted to produce 1M & 10M units at mass production, and 1X Technologies' Haward and San Carlos factories targeting 100k units of capacity by end of 2027. Asian OEMs are creating a framework, with UBTECH raising Walker S shipment targets to 5k units (capacity scaling to >10k), Agibot tracking >20k units annualized in 2026 (4x its 2025 base), and Unitree targeting >20k units for 2026 while funding a facility designed for 75k units of annual output. Taken together, we are seeing an acceleration in U.S. capacity with factories coming online, supply chains being established, and domestic capacity working to close the gap with Asia.

**From Pilots to Procurement: Commercial Deployment Begins to Show Across Verticals:** We split U.S. humanoid deployment across six verticals at varying stages of maturity. Automotive is the most advanced, with BMW's Figure AI pilot logging 1,250+ hours supporting 30,000+ vehicle builds, and Agility, Tesla, and Appronik all expanding deployments in 2026. Warehousing & Fulfillment is the second commercially validated vertical, with Agility's Digit achieving a 98% task success rate at Amazon at \$10-12/hour versus ~\$30/hour human labor, with ISO functional safety certification a key pending catalyst. Core Industrial (Persona AI targeting welding and shipbuilding) and Defense (Foundation with \$24M in contracts) are progressing. Healthcare remains a structural TAM, while Home & Consumer is the largest TAM, though will mature later.

**Precision Manufacturing Competition: Asia's Actuator & Component Incumbents Offering Competition:** Asia represents the most credible ex-U.S. competitive threat to our coverage in the actuator and motion layer. NSK, NTN, JTEKT, and THK are incumbent suppliers to the global industrial robotics market now pivoting toward humanoid platforms, backed by precision manufacturing depth, vertically integrated supply chains, and deep OEM relationships. Progress is tangible with NSK developing humanoid-applicable actuators targeting 2028 commercialization, NTN's i WRIST module already in use, JTEKT having developed a bearing offering ~1.3x longer life for humanoid applications, and THK's FRED platform achieving 13.8 km/hour in a May 2025 running test. Most notably, NSK and NTN signed an integration MOU on May 12, 2026 targeting an October 2027 effective date, a combination that could meaningfully amplify competitive pressure on U.S.-exposed suppliers through greater scale and qualification breadth.

**Market Share Dynamics: Chinese Manufacturers Leading:** Approximately 13k-18k humanoid robots were installed globally in 2025, depending on the source ([IDC](#), [Counterpoint](#), [Omdia](#)). While large in isolation, the market is still overwhelmingly in the pilot phase and early-commercial deployment. Chinese manufacturers, led by Unitree and Agibot, dominate on volume, with the remaining market still being spec'd into enterprise contracts. Demand is accelerating with targeted shipments for Agibot, Unitree, and Ubtech >4x 2025 shipments, alongside capital funding interest with IPO of Unitree alongside private funding with some U.S. players having valuations exceeding 30bn.

Figure 1: 2025 Market Share by External Data Source



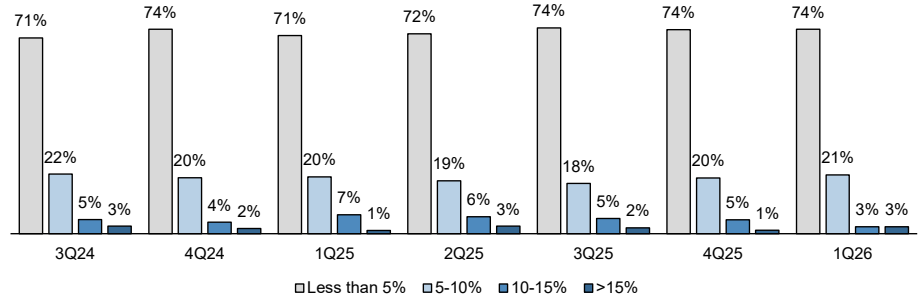
Source: Omdia, Counterpoint, IDC, Bloomberg Finance L.P.

## U.S. Labor Market as a Structural Demand Driver:

**Labor Needs Meet Robotics: A Structural, Not Cyclical Demand Story:** Humanoid robotics adoption in the United States is ultimately a labor market story. The country faces a structural, worsening shortage of workers in precisely the industries (manufacturing, logistics, healthcare) where humanoid and cobots are technically suited for near-term deployment. We view this as not a cyclical demand signal, but rather, it is demographic and structural.

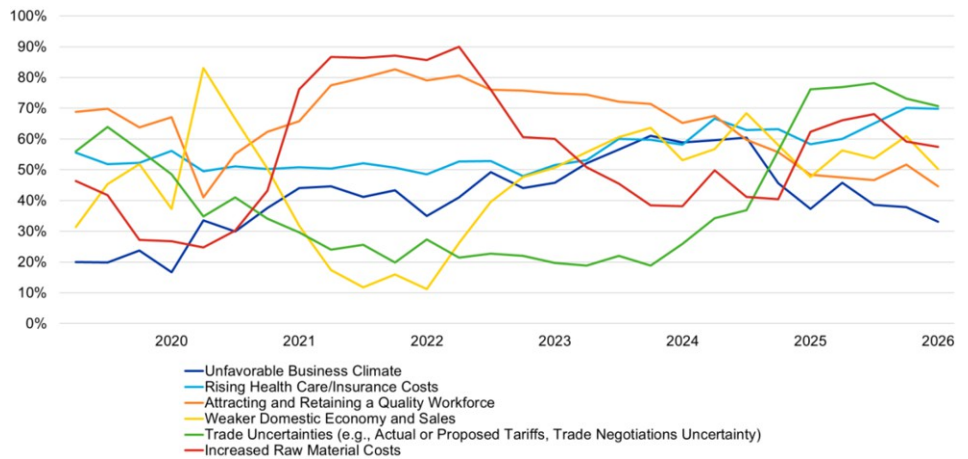
**Unfilled Current Jobs With Aging Workforce: Need for Robotics Increasing:** As of March 2026, 462,000 U.S. manufacturing jobs remain unfilled despite competitive wages (averaging close to \$40/hr). In 1Q26, NAM survey data showed ~4.1% of manufacturing roles unfilled on average, with over 1 in 4 manufacturers reporting vacancy rates above 5% ([link](#)). The manufacturing workforce skews older than the national average, baby boomers are retiring faster than younger cohorts can replace them, and immigration restrictions under the current administration are adding to the shortfall. Some projections cite 2.1M unfilled manufacturing positions by 2030 at a cost of ~\$1T annually ([link](#)). Separately, the U.S. Chamber projects 193,100 registered nurse openings per year through 2032 ([link](#)).

Figure 2: Percentage of Jobs Remaining Unfilled in Your Company NAM Survey Results



Source: National Association of Manufacturers (NAM).

Figure 3: Primary Current Business Challenges for Select Responses (1Q19-1Q26)



Source: NAM.

**Complement or Supplement: Demand Environment Remains:** Fundamentally, it is this demand context that makes robotics a structural investment thesis in the U.S., rather than a pure novelty. The labor gap remains within manufacturing (NAM previously didn't track vacancies) with attracting and retaining a quality workforce historically one of the greater business challenges. While some argue that robots need to outperform humans to justify adoption, we argue that regardless of whether they serve as a complement or supplement, the underlying need is there and demand exists, supporting the long-term demand within our coverage.

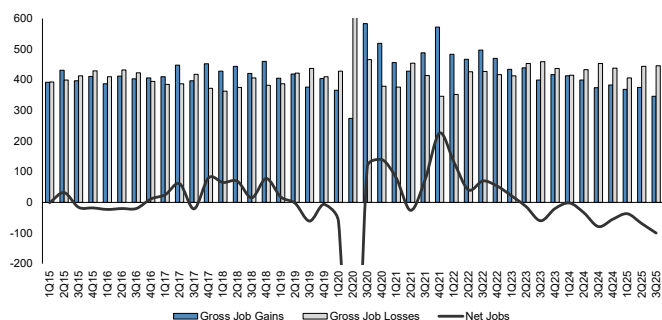
## End Market Overview:

**Automotive: Material Handling Today, Complex Assembly Tomorrow:** The leading commercial vertical and one of the only end markets with publically verified, productive deployments at scale. BMW's 11-month pilot with Figure AI's Figure 1 robot (working 10 hour shifts, Monday through Friday on the main assembly line) supported production of 30,000+ vehicles and logged 10,000+ hours. BMW has since established a Center of Competence for Physical Production and is expanding deployments. Agility Robotics' Digit 1 is deployed at a U.S. facility. Hyundai's robot business is shipping its Atlas robot in the U.S. facilities Mind, with broader customer availability targeted for 2026.



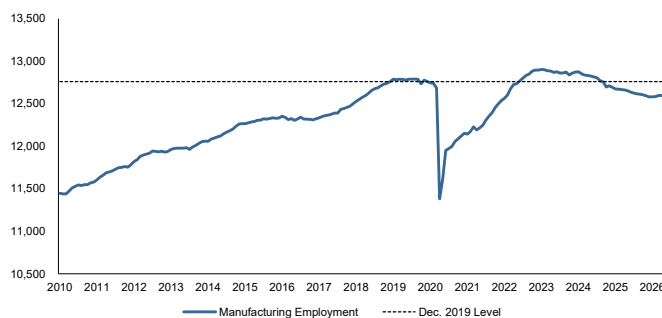
converting its Fremont, CA facility to Optimus production, targeting a ramp through the summer of 2026. Apptronik has a partnership with Mercedes-Benz, with current task scope across all live deployments remaining narrow (material handling, parts transfer, and quality inspection). Complex assembly work looks like a later unlock, trending into 2028-2030. Yet, the demand is structural, with 462,000 unfilled manufacturing jobs (March 2026), and the shortage continues to worsen rather than improve.

Figure 4: Manufacturing Job Losses Outpacing Gains...



Source: U.S. Bureau of Labor Statistics

Figure 5: ...With Employment Levels Now ~150,000 Below 2019 Levels Despite 462,000 Unfilled Jobs



Source: U.S. Bureau of Labor Statistics

**Warehousing: Deployment and Unit Economics:** Warehousing is the second U.S. vertical with preliminary, but real, ROI data. Agility Robotics' Digit is live at Amazon's Sumner, WA facility, where an 18-month test produced a 98% task success rate and a reported operating cost of \$10-12/hour, against ~\$30/hour for comparable human labor. At GXO's Flowery Branch, GA facility, Digit crossed 100,000 totes moved as of November 2025. Throughout 2025, Agility has sold approximately 100 Digit units with many in active workflows, all while constructing a dedicated manufacturing facility in Salem, OR. There is a pending catalyst around ISO functional safety certification allowing Digit to operate alongside human workers without segregated zones, targeted for mid to late 2026. Current deployments operate in separate zones. Similarly, we see structural demand in this segment, with warehouse vacancy rates struggling and increased regulatory scrutiny across the sector.

**Industrial: Dangerous Work, Structural Demand:** While automotive and logistical applications are already being deployed, new startups and pilots are targeting dangerous and specialized roles within core Industrial. Persona AI's humanoid, while still in early pilot stages, is focused on heavy and hazardous jobs, including welding, construction, shipping, and energy and fabrication. The company has established partnerships with SSE Steel Fabrication and HD Korea Shipbuilding & Offshore Engineering (KSOE), with its robots designed for rugged, high-difficulty environments such as shipyards and fabrication facilities where labor attrition, retention, and cost remain persistent challenges.

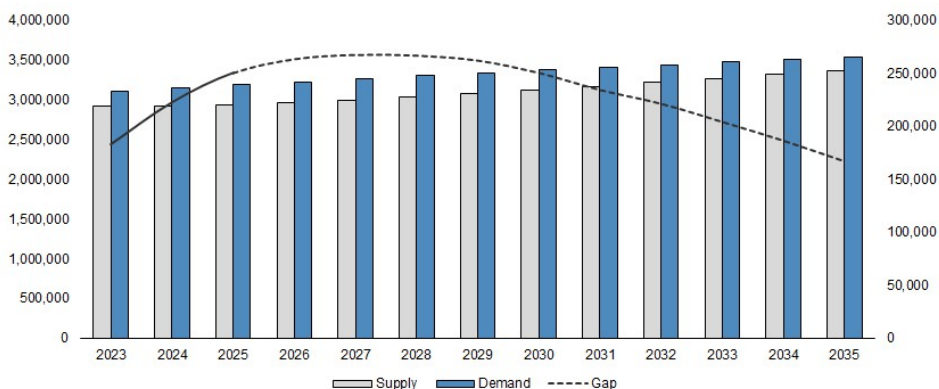
**Military & Government: Long-Term Opportunities Established:** An opportunity for our coverage specification and long-term demand is the defense sector. The U.S. Army's xTechHumanoid competition is systematically routing defense-oriented startups into procurement channels. Foundation holds \$24M in confirmed contracts across the Army, Navy, and Air Force. Two Phantom MK-1 units were deployed to Ukraine in February



2026 for frontline reconnaissance, with Foundation targeting 50k in unit sales by 2027.

**Elder Care & Hospital: Demand in Theory with Pathway Undefined:** The structural demand case in healthcare is compelling, with nursing unemployment averages 1-2%, the U.S. Chamber projects 193,100 annual RN openings through 2032 ([link](#)), and the HRSA forecasts a demand/supply gap of over 200,000 RNs through 2030 ([link](#)). The current U.S. deployed base is in logistics robots with Diligent Robotics' Moxi, deployed across 24+ US health systems, completing nearly 1M supply deliveries and saving an estimated 1.5bn steps. Full humanoid deployment in patient-facing healthcare systems is limited, and the regulatory path through FDA is undefined. A 2026 review of 59 studies ([link](#)) of humanoid robot-assisted support for older adults concluded the evidence is "promising yet methodologically constrained" with user acceptance and safety in unstructured clinical environments remaining the primary barriers. A separate review of 44 papers ([link](#)) on humanoid assistance for physical disabilities reached a similar conclusion that applicability is evident, but "insufficient level of technical readiness" remains a key obstacle.

Figure 6: HRSA Forecasts Registered Supply/Demand Gap Remains >100,000 out to 2035



Source: Health Resources and Services Administration (HRSA).

**Home & Personal Use: Largest TAM with Preorder Signaling Consumer Demand:**

The highest optionality and longest duration end market. 1X Technologies' NEO humanoid opened U.S. preorders on October 28, 2026 and booked production capacity for the next year in 5 days ([10k units](#)). First deliveries are targeted for 2026 and the initial rollout is focused on the U.S. The speed of the ramp is best demonstrated by NEO, with the San Carlos coming online in 2027, with the company targeting 100,000 units by year end. NEO's design prioritizes safety for residential use at 66 lbs versus 125-196 lbs for industrial humanoids; it is intentionally built for use around children, elderly, and pets.

Figure 7: U.S. Adoption Timeline by Vertical

|                              | Near-Term<br>2026-27                                                                                  | Mid-Term<br>2028-29                                                                             | 2030-33                                                                                     | Long-Term<br>2034-40                                                               |
|------------------------------|-------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Automotive & Industrial Mfg. | EARLY - Figure AI at BMW Spartanburg. Agility at Schaeffler. Tesla Optimus internal ramp-up.          | SCALE - Complex assembly line tasks unlocked.                                                   | MASS - Standard automation layer across OEMs globally.                                      | MASS - Fully installed base, near commodity hardware.                              |
| Logistics & Warehousing      | EARLY - Digit live: Amazon Sumner WA, GXO Flowery branch GA. ~100 units sold, segregated zones only.  | SCALE - ISO human-collab certification unlocks co-worker deployment.                            | SCALE - Expanding task scope: trailer loading, complex pick-and-place.                      | MASS - Units begin to reshape fulfillment labor economics globally.                |
| Defense & Military           | PILOT - Phantom MK-1 Pentagon contracts, units deployed in Ukraine. xTechHumanoid Competition active. | EARLY - Procurement scale-up subject to regulatory outcomes.                                    | SCALE - Policy permitting, units expand across logistics, EOD, reconnaissance roles.        | SCALE - Distinct supply chain from commercial, with limited mass-market potential. |
| Healthcare & Elder Care      | PILOT - Logistics robots currently in U.S. (Moxi, ~1M deliveries).                                    | PILOT - Companion & supply roles expand. Staffing crisis (demand side) pressure.                | EARLY - Regulated patient-adjacent roles begin. Asia leads, with a lag into US/EU.          | SCALE - Aging demographics make this a large long-run TAM.                         |
| Consumer & Home              | PILOT - 1X NEO pre-orders open; 2026 expected delivery. Developer focused units available.            | PILOT - Full autonomy threshold still being crossed; early adopter segment. Prices coming down. | EARLY - Mass-market threshold price reached as COGS decrease. Regulatory frameworks evolve. | SCALE - AI enablement and compatibility deliver, long-dated optionality.           |

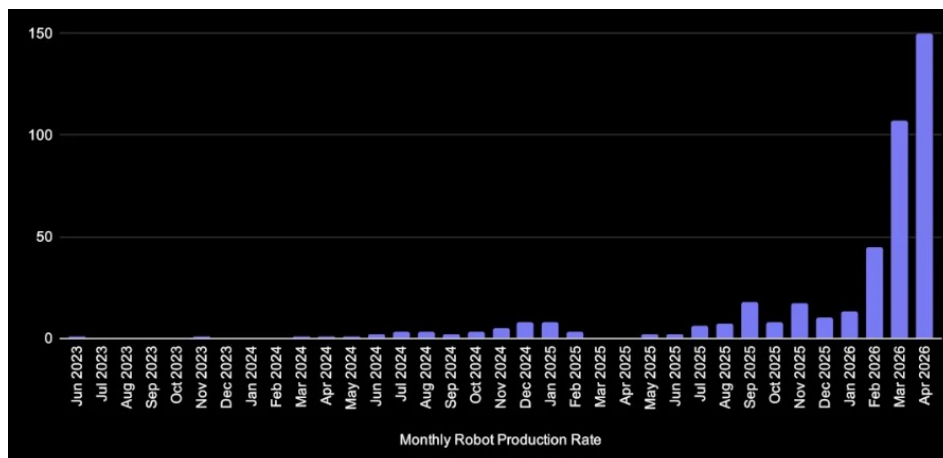
Source: J.P. Morgan estimates

## Demand Rationalization:

**Speed and Scale of Humanoids: Capacity Accelerating:** Following our recent humanoid piece (see [here](#)), we have received significant inbounds and feedback. Our unit assumptions, anchored to capacity potential, OEM commentary, and our Asia team's global humanoid TAM, reflect a strong adoption curve, albeit still materially below commentary from Elon Musk and other OEM commentary. We have received some pushback on the size and pace of capacity expansion. However, we note that we applied meaningful haircuts to certain OEMs' capacity potential (i.e., Tesla's Giga Texas plant, projected for 10M units of capacity) given uncertainty around ramp timelines and the speed of demand conversion. We want to reiterate the potential speed and scale at which these companies can produce once factories come online, using Figure AI, 1X's NEO, and scaled Chinese players as key precedents.

**Figure AI BotQ Factory: Four Years and Production Accelerating:** Founded in 2022 by Brett Adcock (co-founder of Archer Aviation), Figure AI has rapidly emerged as one of the most valuable humanoid companies, with a valuation of ~\$39bn based on its September 2025 Series C financing. Within its first year, the company launched its first-generation robot (Figure 01), followed by Figure 02 in 2024, and most recently Figure 03 in late 2025. Earlier last year, the company announced BotQ, its dedicated manufacturing facility, and has since ramped production quickly, with output accelerating materially in recent months toward a target of 12,000 robots per year (Figure 9). We highlight Figure AI's trajectory as a compelling proof of concept for the speed at which the humanoid market can scale as in just four years, the company designed, piloted, secured its supply chain (producing >9,000 actuators already), and began shipping units. In our view, Figure AI's ramp supports the case for an acceleration of capacity expansion and the corresponding component demand opportunity for our coverage.

Figure 8: Monthly Production from BotQ



Source: Figure AI.

**Changing Mindset from “Can it Work” to “Can it Scale”:** Sonny Lee hosted a Beijing robotics and auto tour from April 22-24, providing a first-hand look at the latest pilot deployments and commercialization progress (see [here](#)). One of the key takeaways is that volume growth is gated by deployment readiness rather than prototype capabilities, with conversion from proof-of-concept (POC) to commercial deployment occurring faster than anticipated. A dexterous hand supplier highlighted expected shipment volumes doubling in 2026 off a 10,000-unit base in 2025, providing a tangible baseline for the pace of commercial deployment. Sonny also noted that the sector's challenge has shifted from "can it work" to "can it scale," as OEMs transition from the conceptual stage to mass production. We believe a similar acceleration in speed and scale is increasingly likely within the U.S. market.

**Hyundai Motor Blueprint for Expansion:** J.P. Morgan hosted Hyundai Motor Group (covered by Sonny Lee) at our TMC Conference, where the companies outlined their roadmap to industrialize humanoid robotics at scale via Atlas. The strategy leverages Hyundai's manufacturing expertise and vertical integration across Mobis, AutoEver, and Glovis, underpinned by a Google DeepMind reasoning layer and Hyundai's robotics physical execution layer. In the U.S., the companies plan to launch a real-world training hub targeting millions of hours of data accumulation in summer 2026, followed by a mass production facility in 2028 with initial capacity of 30k units/year and a dedicated actuator manufacturing facility targeting 350k units/year.

**UBTech, Agibot, Unitree: Setting the Stage for Humanoid Capacity Ramp:** The acceleration in demand and capacity build is most apparent in Asia, best showcased by UBTech (covered by Karen Li), Agibot, and Unitree. UBTech reported strong demand, sharply raising Walker S shipment targets from 2-3k to 5k units with capacity scaling toward 10k, alongside a broadening product roadmap that includes retail and household robots set to launch in 2Q26, targeting another "10k capacity / 5k delivery" scenario (see Karen's note [here](#)). Agibot saw over 5k unit shipments in 2025, with a ~4x increase so far in 2026, shipping 5k units in just the first few months of the year (~20k annualized). Unitree similarly targets ~20k units for 2026, nearly 4x its 5.5k+ units produced in 2025, with its IPO to fund a new intelligent manufacturing base designed for annual output of 75k units. The speed of demand conversion and capacity expansion in China reinforces broader humanoid adoption, and we see a similar trajectory emerging in the



U.S. with our estimates reflecting a meaningful acceleration in both capacity and demand over the coming years.

Figure 9: Asia Humanoid OEM Shipments and Capacity Commentary

| Guidance in units      | 2025           |                | 2026            |          |
|------------------------|----------------|----------------|-----------------|----------|
|                        | Shipments      | Capacity       | Shipments       | Capacity |
| <b>UBTech Robotics</b> |                |                |                 |          |
| Guidance 2025          | >500           | 1k             | 2-3k            | 5-10k    |
| Guidance 2026          | 1,079 (Actual) | >6k Annualized | 5-10k           | >10k     |
| <b>Unitree</b>         |                |                |                 |          |
| Guidance 2025          | N/A            | N/A            | N/A             | N/A      |
| Guidance 2026          | >5,500         | >6,500         | 20,000          | N/A      |
| <b>Agibot</b>          |                |                |                 |          |
| Guidance 2025          | N/A            | 5,000          | N/A             | N/A      |
| Guidance 2026          | 5,168          | N/A            | >20k annualized | N/A      |

Source: Unitree, Agibot, Bloomberg Finance L.P., J.P. Morgan Asia Pacific Equity Research.

**Revised Upward as Demand/Capacity Growth Accelerates:** In our view, the pattern shows initial estimates getting revised upward with increasing cadence as pilot-scale facilities convert to automated production lines and new capacity comes online faster than anticipated. We assume U.S. OEMs follow a similar (though lagged) trajectory as dedicated factories ramp, supply chains mature, and learning curves compress unit costs.

#### End Market Demand Rationalization:

In our last humanoid note, we built the U.S. production curve bottom-up from OEM capacity, utilization ramps, and stated targets from management commentary and market expectations. Here, we reframe that curve as capacity (what can be produced) and layer demand underneath. Our focus is the near-to-mid term (2026-2030), where demand can be rationalized against verifiable labor shortages and proven unit economics rather than assumptions about structural capacity expansion potential.

To convert labor shortages into humanoid unit demand, we apply three assumptions per vertical: addressability (what percentage of the labor gap is suitable for current-gen humanoids), full-time equivalent (FTE) coverage per unit (how much of a human role one humanoid can cover given narrow task scope, battery constraints, and downtime), and penetration (what share of the addressable pool adopts in a given year).

**Manufacturing: Co-Adoption, Humanoids Working Alongside:** 462,000 unfilled jobs today, projected to reach 2.1M by 2030. We estimate ~35% of the current gap sits in humanoid-addressable roles (material handling, parts transfer, machine tending, and quality inspection), yielding an addressable pool of ~157,000 roles today, expanding to ~50% of the gap, or ~1M roles, by 2030. At current task scope (10-hour shifts, charging downtime, and narrow task coverage), each humanoid covers ~0.6 FTE, implying ~1.67 units per addressable role. We estimate penetration starting at 1% in 2026 and ramping to 18% by 2030 as pilots convert to commercial contracts. These estimates are relatively optimistic, implying a degree of adoption that extends beyond pure labor, incorporating co-adoption where humanoids work alongside a growing or stable workforce, a dynamic that would not be captured in a pure labor framework.

**Warehousing: Structured Environments Outlining Higher-Penetration:** Demand here is a blend of vacancy-driven and economics-driven adoption. Even filled

warehouse roles are addressable when a humanoid operates at \$10-12/hour against ~\$30/hour human labor. We estimate an addressable pool (unfilled + economically displaceable) of ~800,000 roles in 2026, growing to ~1.2M by 2030. We believe addressability is higher than manufacturing at ~45% given more structured, repetitive environments. FTE coverage per unit is ~0.7 (better task density), implying ~1.43 units per role. We estimate penetration ramps from 1% in 2026 to 15% by 2030. Similar to manufacturing, our estimates embed an optimistic underlying assumption, reflecting both unfilled labor needs and efficiency-driven adoption accelerating alongside, rather than purely replacing, current labor dynamics.

**Defense: Budget-Backed Demand With U.S. Supplier Preference as a Moat:** With defense TAM sized by budget allocation rather than labor gap dynamics, we view the opportunity as large but currently unproven at scale. Foundation's \$24M in contracts and two Phantom MK-1 units deployed to Ukraine serve as a solid early proxy for demand, though company commentary remains optimistic. Using the autonomous and robotic systems budget allocations as a baseline, we believe the demand will be below Foundation's 2027 target of 50k units deployed. We view defense as a meaningful upside scenario to our estimates and a resilient demand opportunity for our coverage, particularly given the likely preference for U.S.-based suppliers in defense procurement.

**Healthcare & Consumer: Greatest Optionality, Longest Duration:** We believe these verticals offer significant long-term value, with 1X's NEO highlighting the strength of early consumer demand, selling out 10,000 units within five days. Healthcare currently has no full commercial humanoid deployments in the U.S. and an undefined regulatory pathway, but offers meaningful upside as technology matures. As ASPs decline with scale and autonomy improves beyond current levels, we expect greater penetration in the high-income consumer market. We view broader general adoption as increasingly plausible as prices fall below the cost of a car, however, we do not incorporate this into our estimates and view widespread adoption before 2030 as unlikely. In aggregate, these end markets represent the greatest optionality in our framework, with the most meaningful upside beyond 2030, but with limited near-term adoption factored in.

Table 1: Total End Market Demand Exceeds Growth of Our Production Estimates

|                                                | 2026E     | 2027E      | 2028E      | 2029E      | 2030E      |
|------------------------------------------------|-----------|------------|------------|------------|------------|
| U.S. Humanoid Robot Units Production (k)       | 9         | 33         | 82         | 238        | 446        |
| YoY                                            |           | 289%       | 148%       | 191%       | 87%        |
| Global Total Humanoid Robot Production (k)     | 57        | 250        | 857        | 2,500      | 4,000      |
| YoY                                            |           | 339%       | 243%       | 192%       | 60%        |
| U.S. % of market                               | 15%       | 13%        | 10%        | 10%        | 11%        |
| <b>U.S. Unit Demand Across End Markets (k)</b> | <b>30</b> | <b>135</b> | <b>308</b> | <b>577</b> | <b>947</b> |
| YoY                                            |           | 355%       | 127%       | 88%        | 64%        |
| U.S. % of production                           | 350%      | 409%       | 375%       | 242%       | 212%       |
| % of global unit production                    | 52%       | 54%        | 36%        | 23%        | 24%        |

Source: J.P. Morgan estimates.

## The Asia Component Competitor

**Structural, Not Cyclical:** Japan and other Asian firms represent a credible ex U.S. competitive threat to our coverage in the actuator and motion layer, and we view this threat as structural rather than cyclical. The Japanese robotics component ecosystem is not a new entrant, but an incumbent supplier base to the global industrial robotics

market that is now pivoting established capabilities toward humanoid platforms. Precision manufacturing depth, vertically integrated supply chains, long OEM relationships, and a mature domestic robotics ecosystem collectively create durable competitive pressure for U.S. motion exposed suppliers.

**Avoiding Overreach: Leaders, Not “Standard Setters”:** We frame NSK, NTN, JTEKT, and THK as leading Japanese players in precision motion content relevant to robotics and humanoids. The practical investor point is not a debate over share, but that these companies often compete effectively in joint critical components where qualification history, reliability data, supply assurance, and manufacturing repeatability can matter as much as headline pricing.

**Ecosystem Tailwind, Not a Moat:** Japan also benefits from a dense domestic industrial robotics ecosystem. Global OEMs such as FANUC, Yaskawa, and Kawasaki have long maintained meaningful presence in factory automation, creating a demanding home market for motion components. Over time, this can give component suppliers more design in cycles, qualification repetitions, and field feedback in high duty applications. That said, it is not a guaranteed moat: humanoids introduce different cost targets, safety requirements, and integration stacks, and scale manufacturing and pricing power can shift quickly as architectures standardize. We treat this as a tailwind to execution, not a decisive advantage.

**Bearings and Linear Motion: Packaging and Reliability Win:** Bearings, linear motion, and joint level precision are early bottlenecks for humanoids because they constrain stiffness, repeatability, packaging, and durability. Japan maintains a strong supply base in high-specification bearings and linear motion, where miniaturization, low friction, long life, and shock tolerance are decision drivers. In these applications, customer preference often migrates from lowest cost toward stable performance under high cycle duty, predictable field reliability, and consistent lot-to-lot quality. That dynamic raises switching costs and can disadvantage late entrants.

**NSK: From Bearings to Actuators, With Humanoids Explicit:** NSK is positioning robotics as a medium- to long-term earnings pillar and is extending beyond bearings and linear products into actuators and system products. Execution is increasingly tangible. NSK established a Robot Business Division and has disclosed humanoid applicable rotary and linear actuator development, highlighting compactness, lightweighting, and backdrivability as key requirements. The company has also formalized collaboration with Delta Electronics via an MOU to advance joint level actuation and integration. NSK targets commercialization around 2028, signaling intent to capture higher value content inside the joint, not only discrete motion components.

**NTN: Use Case First, Module Oriented:** NTN is approaching robotics as a targeted growth adjacency within its longer-dated roadmap rather than a standalone humanoid narrative. The company emphasizes modules and automation building blocks that can be inserted into defined workflows, alongside condition monitoring and service solutions. Disclosures around its i WRIST wrist joint module, including adoption in automated inspection use cases, point to a pragmatic commercialization path where qualification, repeatability, and reorder behavior can develop over time. Near-term messaging remains anchored in restructuring and profitability improvement, but the medium-term direction is toward higher-value mechatronic content and solutions.

**NSK and NTN: Integration as a Potential Competitive Force Multiplier:** On May 12, 2026, NSK and NTN signed a memorandum of understanding to pursue a business integration via a joint holding company formed through a joint share transfer. The current schedule targets a definitive agreement within roughly six months, shareholder approvals in June 2027, and an effective date and listing in October 2027, subject to regulatory and shareholder approvals. The stated strategic pillars include supply chain resilience, R&D efficiency, portfolio transformation, and resource allocation toward growth areas including robotics. If executed, the combination could strengthen scale, qualification breadth, and customer coverage in precision motion, potentially amplifying competitive pressure on U.S. exposed suppliers. Importantly, both companies note the integration is not reflected in current guidance.

**JTEKT: Quantified Miniaturization and Life Extension:** JTEKT's robotics exposure is primarily component led, focused on compactness and durability rather than system level humanoid claims. A published case study highlights an ultra-thin deep groove ball bearing designed for robot applications, including factory robot arms and home humanoids. Versus a conventional reference, JTEKT cites ~50% thinner ring thickness and about 90% outer diameter, alongside roughly 50% higher ball filling rate. The company indicates this improves dynamic load rating by about 10% and static load rating by about 30%, translating to roughly 1.3 times longer life. The product is mass produced at group company Daibea and is described as already adopted in multiple robot products.

**THK: Humanoid R&D as Capability Signaling:** THK combines a strong franchise in linear motion and mechatronic modules with a visible humanoid R&D program. Its in-house humanoid platform FRED is positioned as a proof vehicle for backdrivable, shock tolerant actuation and high speed control, rather than a near-term volume product. THK discloses FRED specifications (HR S01, 1,200 mm height, 37.3 kg, 20 degrees of freedom) and reports achieving 13.8 km per hour (3.8 m per second) in a May 2025 running test. For investors, this functions primarily as evidence of actuator and control competence that can support higher value module opportunities.

**Standards and Qualification: A Quiet Advantage:** We also avoid overstating JIS as a de facto global benchmark. More precisely, standards discipline and qualification readiness can be quite advantageous in robotics supply chains. Multinational OEMs often prefer components with stable manufacturing, robust documentation, and predictable lifecycle behavior, which can reduce re-qualification friction across regions. In humanoids, where safety cases and long-term reliability are still being established, suppliers that can deliver traceability, repeatable quality, and field support may win platform positions even if headline specifications look comparable.