

## Autonomous Mobile Robots for Warehouses: Rising U.S. Production and Competition

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*The United States is the leading producer of autonomous mobile robots (AMRs) for warehouse (including fulfillment center) automation. Production is rapidly increasing, driven by technology improvements and automation investments.<sup>1</sup> Import competition is also rising, as foreign producers enter the U.S. market.*

### Autonomous Mobile Robots (AMRs)

AMRs for general warehouse automation are robots programmed to automate material movement-related tasks (figure 1). AMRs are a type of collaborative robot (co-bot), because of their ability to work side-by-side with people. AMRs are the latest in a series of material handling technologies, which also include automated guided vehicles (AGVs). AGVs require a guidance system in the floor that limits their routing flexibility. AMRs learn alternative routes to avoid obstacles, providing maximum flexibility. However, the boundaries between AMRs and AGVs are blurred.<sup>2</sup>

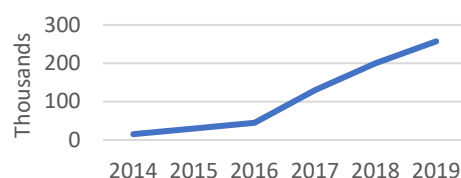
### Growing use of AMRs in U.S. warehouses

The market for AMRs in U.S. warehouses is growing due to improvements in the technology, general availability, and consumer demand for faster product shipments.<sup>3</sup> Advances in artificial intelligence, sensors, vision technology, machine learning, and mobile networking technology have enhanced the mobility, connectivity, and collaboration of AMRs.<sup>4</sup> At the same time, U.S. e-commerce and warehousing firms have made large investments in increasing the connectivity of their warehouses with network-connected technologies. Since AMRs rely on digital data and a high-speed network, these changes make AMR adoption more viable. AMR demand is also driven by e-commerce and warehouse firms expanding their footprint, realizing quick returns on AMR investments, and responding to customer expectations for convenience, cost, selection, and quick delivery speeds.<sup>5</sup>

### Significant U.S. manufacturing and commercialization activity

The United States is the leading global manufacturer of AMRs for warehouses, accounting for the majority of 2018 production.<sup>6</sup> This is primarily driven by Amazon, which acquired Kiva in 2012 and produces robots in the United States for internal use (figure 1).<sup>7</sup> Amazon produced more than 50,000 robots annually during 2017–19, and plans to invest more than \$40 million in a new R&D and manufacturing facility.<sup>8</sup>

**Figure 1:** Amazon, robots in use, 2014–19



Source: Media reports/staff estimates.

<sup>1</sup> A warehouse is a large storage center designed to house inventory in bulk that is geared mainly for wholesale or business orders. A fulfillment center is more specialized, providing warehousing and order picking, packing, and shipping.

<sup>2</sup> IFR, *World Robotics Service Robots 2018*, 2018, 117; Santagate, John, “[NextGen Supply Chain](#),” Jan. 25, 2018.

<sup>3</sup> Santagate, John, “IDC MarketScape: Worldwide Autonomous Mobile Robots for General Warehouse Automation,” May 2019.

<sup>4</sup> For more on technologies: Casanova, Robert, “[Industrial Robot](#),” Sep. 2019; Gracia, Fernando, “[Machine Vision](#),” Oct. 2019.

<sup>5</sup> E-commerce and logistics firms signed more than half of the 100 largest leases each year during 2017–19. Further, the number of U.S. warehouse and storage establishments rose from 16,408 in Q1 2015 to 18,862 in Q3 2019. Wiggers, Kyle, “[Amazon’s Pegasus](#),” *Venturebeat*, Jun. 5, 2019; Burnson, Patrick, “[CBRE Analysis](#),” *Logistics Management*, Feb. 27, 2019; BLS [Website](#); IFR, *World Robotics Service Robots 2018*, 2018, 121; Berman, Jeff “[CBRE Research](#),” *Logistics Management*, Jan. 27, 2020.

<sup>6</sup> Staff estimates of U.S. production; IFR, “[World Robotics Presentation](#),” Sep. 18, 2019, 27. According to IFR data, the Americas accounted for about 88 percent of production in the broader category of logistics systems in 2017 and 91 percent in 2018. IFR, *World Robotics Service Robots 2018*, 2018, 45; Cowen, *Deus Ex Machina, Part II*, Nov. 14, 2019, 17.

<sup>7</sup> Rusli, Evelyn M., “[Amazon.com to Acquire](#),” *The New York Times*, Mar. 19, 2012. For more on U.S. manufacturing by Amazon, see, for example, CBRE [Website](#); Chapman [Website](#); González, Ángel, “[Amazon’s Robots](#),” *The Seattle Times*, Aug. 11, 2017.

<sup>8</sup> Kapadia, Shefali, “[Amazon to Invest](#),” *Supply Chain Dive*, Nov. 6, 2019; staff estimates of U.S. production by Amazon.

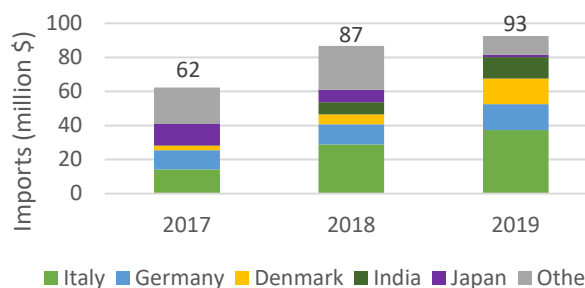
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Other companies have attracted venture capital and investments, and are at various stages of development and deployment. For example, five U.S. AMR companies (Fetch Robotics, Locus Robotics, 6 River Systems, inVia Robotics, and IAM Robotics) raised \$249 million in venture capital as of September 2019. Production at most firms was at a low volume through 2017, but some firms substantially increased output and deployment in 2018 and 2019 to hundreds of robots annually. In addition, Indian firm GreyOrange invested in U.S. AMR production in 2019. Further, firms are continuing to grow. Locus, for example, received an order from DHL for 1,000 robots in 2020, and is expanding its U.S. manufacturing.<sup>9</sup>

### U.S. imports and foreign competition in the U.S. market

There is significant foreign competition in the U.S. market. U.S. general imports of AMRs and AGVs rose from about \$62 million in 2017 to \$93 million in 2019. European countries supplied a majority of U.S. imports in the last three years. The top suppliers during 2017–2019 were Italy (33 percent of imports), Germany (16 percent), Denmark (10 percent), Japan (9 percent), and India (8 percent) (figure 2). Imports from all the largest supplies, except Japan, increased during 2017–19.<sup>10</sup>

Figure 2: U.S. AGV/AMR Imports, 2017–19



Source: USITC [DataWeb](#); IHS Markit, [Global Trade Atlas](#); [Import Genius](#) database.

Foreign AMR suppliers include both established companies and start-ups. Leading global industrial robot suppliers such as FANUC (Japan), Yaskawa (Japan), and KUKA AG (Germany, majority owned by Chinese firm Midea) are developing AMRs.<sup>11</sup> Additionally, smaller companies such as Mobile Industrial Robots (Denmark), GreyOrange (India), and Clearpath Robotics (Canada) are supplying the U.S. market.

U.S. companies also compete with foreign suppliers of AGVs. Italy is home to two firms that produce AGVs. Elettric80, which produces a laser-guided vehicle, totaled \$272 million in global revenue in 2019 and is a major supplier to the U.S. market. Comau (a subsidiary of Fiat Chrysler) produces the Agile1500, which can be programmed to run along a track on the floor, guided by magnets, or autonomously using sensors.<sup>12</sup>

Chinese AGV/AMR firms have developed a wide range of products, and experience in the Chinese market. In 2019, they were relatively small suppliers to the U.S. market. However, many are expanding sales to overseas markets, which reportedly have substantially higher prices than the Chinese market. Chinese firm Geek+, for example, raised \$150 million in 2019 to fund its overseas expansion, and exported robots to the United States in 2019 and the first quarter of 2020.<sup>13</sup>

<sup>9</sup> Shopify acquired 6 River Systems in 2019. Leonard, Matt, "[Warehouse Robotics](#)," *Supply Chain Dive*, Sep. 3, 2019; Smith, Jennifer, "[E-Commerce Platform](#)," *The Wall Street Journal*, Sep. 9, 2018; Banker, Steve, "[The Autonomous Mobile](#)," *Forbes*, Mar. 11, 2019; 6 River Systems, "[6 River](#)," Aug. 8, 2018; GreyOrange, "[GreyOrange Expands](#)," Aug. 28, 2018; *Modern Materials Handling*, "[Grey Orange Partners](#)," Aug. 22, 2019; Oitzman, Mike, "[Year in Review](#)," *Mobile Robot Guide*, Feb. 19, 2020; DHL [Website](#); Shaw, Keith, "[Locus Robotics](#)," *RBR*, Feb. 20, 2020.

<sup>10</sup> Based on HTS 8427.10.8040, 8427.10.8050, 8427.10.8060, and 8709.11.0060, as well as identified AMRs/AGVs traded in other HTS numbers. These data are a minimum estimate. USITC [DataWeb](#); IHS Markit, [Global Trade Atlas](#); [Import Genius](#) database.

<sup>11</sup> KUKA, [Mobile Robots from KUKA](#), 2019; Otto Motors, [Yaskawa and Clearpath Partner to Develop](#), Apr. 8, 2016.

<sup>12</sup> Elettric80, [Laser Guided Vehicles](#), 2019; Bond, John, "[Top 20](#)," *Modern Materials Handling*, May 18, 2020; Comau [Website](#); [Import Genius](#) database.

<sup>13</sup> Staples, "[Staples Pilots](#)," Jul. 20, 2017; Geek+, [News release](#), Apr. 2, 2019; STIQ, [G2P Robotics](#), 2019, 12, 15; [Import Genius](#) database; Demaitre, Eugene, "[Geek+ Raises](#)," *The Robot Report*, Jul. 11, 2019.

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