Pandemic-Related Trends in Warehouse Technology Adoption

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Key Findings

- E-commerce grew rapidly during the pandemic and continues to be a significant factor influencing growing interest in warehouse technology and automation.
- E-commerce warehouses require more workers than traditional warehouses, which increases labor demand and puts upward pressure on wage rates across the industry. Warehouses now spend more on labor than ever.
- Many warehouses are operating at or near capacity, and vacancy rates are low.
- Supply chain and labor market disruptions caused by COVID-19 increased interest in the adoption of new technologies in warehouses; the pandemic accelerated preexisting dynamics driving technology adoption in warehousing.
- Despite interest in new technologies, warehouse operators focused on immediate operational challenges and largely relied on labor strategies to deal with pandemic-related uncertainty rather than making major investments in technology.
- During the pandemic, warehouse operators examined and optimized technologies already in use—especially software systems—and made modest investments in scalable technologies.
- Just as the COVID-19 pandemic led to increased order volumes, third-party logistics firms (3PLs) providing warehousing services also experienced expanded business opportunities. However, 3PLs continue to face disincentives to technology investment that are unique to the outsourcing relationship: namely, short-term contracts and low profit margins.

Section 1:
Introduction

In "The Future of Warehouse Work: Technological Change in the U.S. Logistics Industry" (Gutelius & Theodore 2019), we examined trends in the adoption of warehouse technologies and their potential impacts on both the content and organization of work. The report identified leading industry-wide factors that spur warehouse operators to invest in new technologies: (a) the rise of e-commerce and the market dominance of Amazon, both of which have made hiring and retaining a workforce especially challenging; (b) increasing throughput requirements, which have pushed warehouse operators to seek greater speed and efficiencies; and (c) rising real estate costs, which have heightened cost pressures in an already margin-sensitive sector. Together, these factors have prompted many warehouse operators to investigate whether technological advances can help ease labor shortages, manage demands for greater throughput, and mitigate rising operational costs.

Our earlier report was published in the fall of 2019. During the first month of the new year, the World Health Organization declared the COVID-19 virus a global health emergency, and by March of 2020 the world was plunged into a full-blown pandemic. Warehouses, previously seen as unremarkable components of the system of goods movement, were thrust into the spotlight by changes in consumer shopping patterns brought on by widespread stay-at-home orders, supply interruptions, and shipping delays. As e-commerce sales skyrocketed—increasing as much in the early weeks of the pandemic as in the entire previous decade (Kohli et al. 2020)—warehouses emerged as vital infrastructure for the economy.

Even before the pandemic, mounting market pressures had convinced most warehouse managers that their future profitability lies in keeping pace with technological change. At the same time, however, our research has suggested that the very structure of the warehousing industry imposes impediments to investments in new technologies which in turn has led to an overall sluggish rate of technology adoption. In this research brief, we reconsider the operating environment for warehouses in the context of the COVID-19 pandemic. We argue that while the industry encountered a common set of factors during the pandemic, third-party logistics firms (3PLs) that provide outsourced warehousing operations to shippers faced unique challenges due to their positioning along supply chains. As a result of this positioning and the constraints it imposes, 3PLs have been especially challenged when it comes to making significant investments in cutting-edge technologies.

The pandemic's myriad effects on the U.S. economy will be the subject of research and attention for many years to come. In this report, we delve into some of the pandemic's impacts by focusing on one question: How did the COVID-19 pandemic affect technology adoption in U.S. warehouses? We update our earlier analysis of industry change, and present new findings about technology uptake among 3PLs. Data are drawn from a program of interviews undertaken between 2020 and 2022 as well as attendance at industry conferences. Semi-structured interviews were conducted via Zoom with 45 warehouse operators and industry experts. The conference proceedings are drawn from four events comprising 84 individuals in 35 sessions. Other key sources include government data, industry reports, and trade publications.

In Section 2, we re-examine the factors we identified in 2019 to be central to understanding change in warehouse technology adoption. Section 3 explores three emerging themes in technological change across the industry, including dynamics that are unique to the 3PL segment of warehousing, while emerging technology trends are covered in Section 4. Section 5 considers the impacts of technology adoption on frontline workers. We conclude in Section 6 with thoughts about the trajectory of technological change in the wake of the COVID-19 pandemic.

Section 2:

Key Factors Affecting Technological Change in Warehouses: An Update

In "The Future of Warehouse Work: Technological Change in the U.S. Logistics Industry," we identified a wide range of factors that influence warehouse operators' approaches to technology adoption. Here, we focus on four factors that increased in importance during the pandemic: labor, real estate, demand variability, and speed of throughput.

Labor Conditions

Long before the emergence of COVID-19, labor scarcity was cited as one of the primary drivers of warehouse operators' interest in new technologies (Litwin et al. 2022), and the pandemic served to increase staffing challenges. According to a report released midway through the pandemic, fully 100% of warehouse operators surveyed reported facing moderate or significant challenges in hiring and retaining workers (Korn Ferry 2021). In the words of one industry conference attendee, the CEO of a leading 3PL, "It's probably more competitive for warehousing labor than it's ever been in my 30 years in third-party logistics." The surge in online shopping was a major factor in tightening the labor market, as e-commerce warehouses are estimated to use three times the number of workers as traditional warehouses (Armstrong & Associates 2021). In fact, e-commerce has been responsible for driving a 10% annual increase in demand for warehouse labor (ibid.).

In this context, warehouse operators implemented various strategies to recruit and retain workers. Employee incentives have included sign-on bonuses, higher hourly wage rates, flexible scheduling, accolades for good performance, and other incentives. Our research indicates that warehouse operators have adopted these methods to contend with the tightening of local labor markets, while also charging their human resource departments with identifying groups of workers who previously were not employed in warehouses in large numbers. These include older workers; displaced workers who formerly were employed in food service, hospitality, and other industries heavily impacted by the pandemic; veterans;

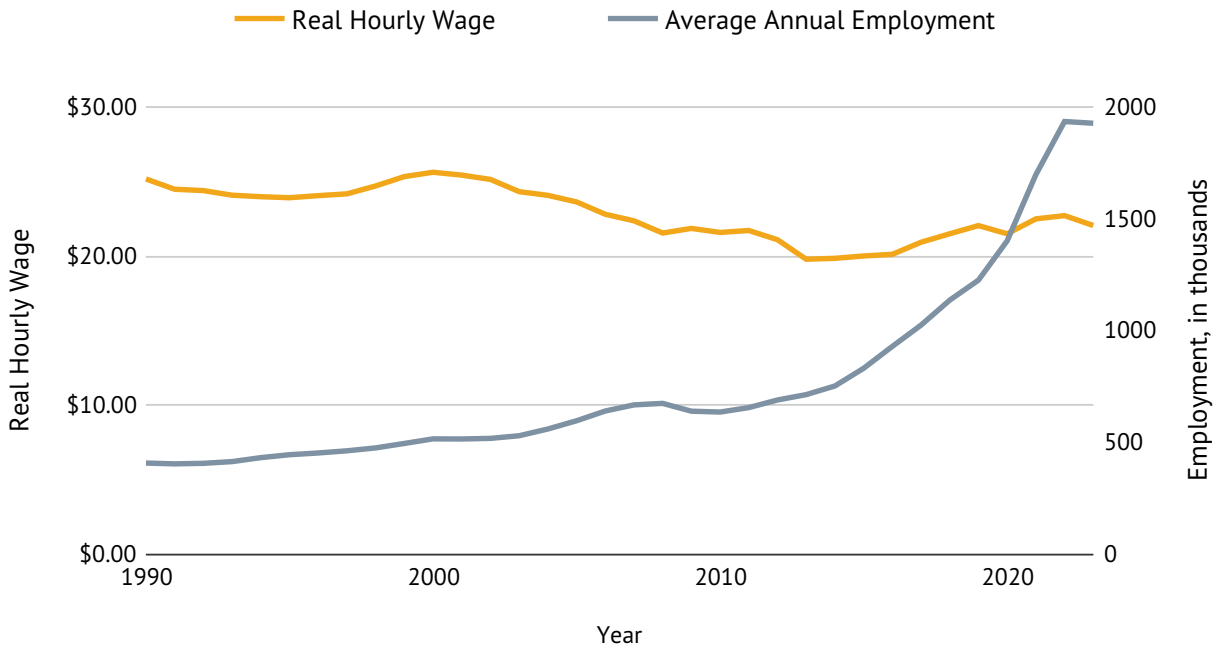
workers with disabilities; and migrant farm workers whose employment was disrupted due to pandemic-related changes to harvest seasons.

Temporary staffing agencies have long played a role in providing labor to the warehouse sector (De Lara 2018; Gutelius 2015), though accurate data tracking the ebbs and flows of contingent workers do not exist. Evidence from our research regarding how managers coped with pandemic-related labor scarcity is mixed. Some warehouse operators reported increasing reliance on workers hired through temporary staffing agencies. However, increases in agency markup rates during the pandemic combined with rising pay rates made agency-supplied temporary workers considerably more expensive than they previously had been—for a workforce widely seen by managers as otherwise "unemployable." The increased cost of temporary labor led some firms to re-evaluate their reliance on staffing agencies while simultaneously redoubling their in-house hiring efforts.

Following three decades of stagnation, absolute wages for warehouse workers have been on the rise (though these gains were swamped by rising inflation, evident in Chart 1; see also 3PL Central 2020); this, in turn, is altering the cost-benefit calculus when managers assess returns on technology investments. Warehouse operators we interviewed indicated that rising labor costs (measured both in terms of wages and employee turnover costs) are shortening ROI timeframes, thereby increasing the likelihood that they will make investments in new technologies. Adding to the appeal of technology adoption, some interviewees essentially viewed technology investments as a way to convert variable labor costs into (relatively) fixed technology costs.

Chart 1.

Employment and Real Hourly Wages in Warehousing, 1990-2023



Source: Bureau of Labor Statistics Current Employment Statistics, 2023

Real Estate

Real estate is the largest fixed cost for most warehouses, and during the pandemic industrial property prices rose sharply as increases in e-commerce tightened the supply of available space: in addition to requiring more labor, e-commerce warehouses also require more space than traditional warehouses, which has led to mounting pressures in property markets. Armstrong & Associates (2021, 39) projects that to accommodate continued e-commerce growth, the U.S. will need an additional 1 billion square feet of warehouse space by 2025. Fueled by the rise of online shopping, industrial real estate has become a highly profitable sector, drawing the attention of institutional investors and private equity firms and further contributing to a real estate bull market.

The strain on available industrial space has driven up lease prices. In late 2022, the national average price per square foot was $9.75, up from $7.30 just three years earlier, and average asking rents have risen at a record pace (Newmark 2022) even as new facilities are being constructed. In the second quarter of 2021 alone, more than 400 million square feet of industrial space was under construction (Newmark 2021), and more would have been built had it not been for pandemic-related disruptions. Nevertheless, according to real estate firm JLL (2022), the vacancy rate for the market hovers around 3.3% —a record low—while key markets including the Inland Empire, CA; Fort Myers/Naples, FL; Providence, RI; and Savannah, GA have vacancy rates of less than 1% (Cushman & Wakefield 2022).

Three years since the beginning of the pandemic, there are signs that property markets are cooling: leading industrial real estate firms report that leasing activity is slowing somewhat, though they predict that vacancy rates will tick up near the end of 2023 (Young 2023). Still, prevailing market conditions continue to place warehouse managers under tremendous pressure to increase operational efficiencies within their current warehouse footprint; this at a time when many warehouses are operating at capacity levels that threaten to reduce productivity. Managers report that operating above 80-85% capacity restricts the movement of employees and material handling equipment within a warehouse, creating congestion and bottlenecks and slowing throughput. A recent report found that more than half of the warehouses surveyed were operating at 90% capacity or more (3PL Central 2022). Across our interviews, 3PL providers consistently reported being at, or sometimes over, the full capacity of their buildings.

Many retailers responded to pandemic disruptions by expanding their safety stock, opting for a "just-in-case" approach to inventory management. This, in turn, led in some cases to bloated inventories—a significant shift from lean, "just-in-time" models that have dominated supply chain strategy for decades. While inventory levels have been slowly returning to normal, slow-moving stock continues to weigh down operations and add to capacity challenges within facilities. And managers of many shippers and lead firms forecast that they will continue to pad stock levels in an effort to increase supply chain resilience.

Even while space constraints are prompting warehouse operators to increase efficiencies through new hardware solutions or software optimization, most facilities are teeming with inventory, which can slow efforts to streamline operations. Further, when a fixed cost like real estate rises for warehouses, operators may seek to lower variable costs—principally labor costs. This, in turn, increases interest in labor-saving technology.

Velocity and Variability

The pandemic intensified the shift in consumer behavior toward online purchasing. Amazon and other online retailers have conditioned consumers to expect fast, low-cost shipping, which often requires orders to be fulfilled within hours of arriving at a warehouse. This need for greater throughput has spurred operators' interest in new technologies that can increase both the speed and accuracy of order fulfillment. Some warehouse operators reported that they were able to manage pandemic-related surges in demand and the need for speed by implementing practices designed for peak season operations. These include hiring additional workers, instituting longer shifts, requiring mandatory overtime, and adding technology to increase efficiencies and reduce low-value activities like walking to pick orders.

Variable demand makes it difficult for warehouses to create accurate forecasts, and uncertainty is a barrier for managers considering investments in new technology. Variability permeates warehouse operations, from swings in consumer demand to unforeseen supply chain delays. Pandemic-related disruptions brought new meaning to "unexpected" for warehouses, as some products experienced surges in demand, while others, like formal wear, dropped off entirely. Some warehouse managers report having to exclude COVID-19-era data from forecasting models because it included huge spikes in demand that distort predictive analytics. There have been periods without any logical flow to the data, and this makes it difficult to plan for the future.

Section 3:

3PL Operations During and After the Pandemic

Section 2 detailed how the pandemic compounded pressures that have strained warehouse operators for years. While these key factors affected the industry broadly, their impacts were felt differently by individual firms. This is especially true for 3PLs, which experienced new opportunities and fresh challenges during the pandemic.

The practice of outsourcing, already prevalent across the warehousing industry, increased during the pandemic. According to market analysts at Armstrong & Associates, the market for value-added warehousing and distribution (i.e., 3PLs), was $55 million in 2021, up from $47 million in 2019 (Armstrong & Associates 2021; 2022). The most common drivers of growth for 3PL warehouses during the pandemic were new customer acquisition, diversification of fulfillment types (e.g., adding business-to-business fulfillment capacity), and increased e-commerce ordering (3PL Central/Extensiv 2022). Order volumes have been rising, with 91% of respondents in one survey reporting increased volumes in 2022 (ibid.). Many 3PLs benefitted from the disruptions caused by the pandemic, a "shot in the arm" in the words of a 3PL CEO specializing in last-mile delivery.

While 3PLs saw increases in order volumes during the pandemic, this didn't always correlate with growth in profits. Depending on contract language, some 3PLs were locked into contracts with slim margins just as prices changed around them, particularly the cost of labor. While some 3PLs were disadvantaged by their contract terms, most warehouse operators we interviewed were able to pass on at least some of their labor cost increases—though many reported that they delayed as long as possible before contacting customers with requests for billing adjustments. As prices continued to rise, however, 3PLs reached a breaking point—in the words of the director of a small 3PL, "There's only so much cost you can eat." Fortunately, as the pandemic wore on and labor markets tightened further, clients became more willing to revisit pricing models and to compensate 3PLs for their rising labor costs.

Third-party logistics firms play an important role in providing distribution services for a wide range of companies and sectors, yet they can face substantial barriers to technology investment. 3PLs tend to operate on short contracts, many of which are three years or less, that do not allow sufficient time for operators to accrue returns on the more substantial investments in new technologies they wish to make. Additionally, 3PLs have tight profit margins that often require close attention to short-run costs. While

some 3PLs invested in technologies in an effort to manage pandemic-related disruptions, many others continued to face stubborn barriers to large-scale investments due to their position within the larger ecosystem of the logistics sector.

Short Contracts and Business Churn

A common refrain in interviews about contract terms, both in this study and in previous research, is the difficult dynamics that can result from business churn. Some of this customer turnover is related to contract lengths and some to the nature of the 3PL market—clients will often re-bid contracts when the term is up, even if they have no intention of changing providers. The consensus appears to be that this can slow the development of basic warehouse infrastructure and delay investments in new technology. Short contracts can cause missed opportunities for streamlining operations, particularly among smaller providers. As the president of a small 3PL explained, "Short-term contracts, even if they are renewed, don't optimize. You make short-term decisions. I might go with something that's more general, something that I can apply to the next [client], versus going with drive-in racking that would be highly efficient for that customer's needs."

Across 3PL warehouses, there are different levels of churn depending on the facility. On one end of the spectrum are public warehouses, with exceedingly short-term contracts and fewer value-added activities offered to clients. The president of a smaller 3PL in the food and beverage segment described his predicament: "For me in a 'public' environment without dedicated clients, [highly automated systems] will probably never happen. There's too much variation from client to client." Public warehousing facilities (those that service multiple clients, often for temporary periods or seasonal surges, and that usually offer few value-added services) tend to have less technology in place because clients turn over quickly and have distinctive needs among them. Multi-client facilities experience similar constraints, though these are less pronounced given that the contracts often are longer. This segment of the market is growing fastest because of the growth in e-commerce (Armstrong 2021). Finally, dedicated warehouses with longer-term contracts tend to have more opportunities to implement new technologies because of longer ROI horizons. Dedicated sites where the 3PL is focused on providing labor and the client owns or leases the building and purchases its own equipment could be positioned to have even higher levels of technology adoption.

During the pandemic, business churn across the industry was down substantially. Operators of 3PL warehouses of all sizes reported that clients were far less likely to switch providers amid so much supply chain uncertainty, especially given that low vacancy rates and other capacity constraints made finding a new provider with vacant space more challenging and perhaps even risky. Some predict that with the pandemic easing, this might change—buyouts and acquisitions might increase and customers who can now travel to see the conditions in their outsourced warehouses might decide to terminate some contracts. Yet there is no evidence that, overall, contracts are getting longer, or that clients are moving to end the common practice of re-bidding work when contracts reach their end. Further, even with longer-term contracts, there are often 30-day exit clauses that allow either party to terminate the agreement, in effect rendering these contracts (potentially) short term as well. In cases where 3PLs make significant technology investments, some warehouse operators report including contract agreements that assign liability for the investment to the client in the case of early termination. The upshot is that contract length and business churn will continue to create strong disincentives for technology investment and may hamper other efforts to harness greater efficiencies.

Section 4:

Technology Trends Among 3PLs

Past pandemic events have led firms worldwide to increase automation, with the greatest long-term impacts on workers in low-wage occupations (Sedik & Yoo 2021). Within the warehouse industry, 2021 was a banner year for automation, according to Interact Analysis, as the global market for warehouse automation grew by 28% (Stott 2022). While predictions for growth in the immediate term are much lower, Interact Analysis expects long-run growth in the warehouse automation market to remain strong.

The adoption of new technologies, however, remains highly uneven across the industry. We characterize the warehouse industry as becoming increasingly trifurcated in terms of operators' orientation towards technology adoption (Table 1). Among those that are most likely to make technology investments are in-house warehouses that are operated by larger, more established firms. Among subcontracted warehouses, 3PL facilities that are devoted to a single customer ("dedicated" facilities), operate with longer contracts, and have more consistency in terms of products and throughput are more likely to be candidates for technology implementation. Multi-client 3PL buildings, low-volume facilities, and those with high levels of variability and business churn are the least likely to invest in new technologies.

The COVID-19 pandemic spurred warehouse operators to consider adding new technologies in an effort to contend with heightened cost pressures and the need for greater operational efficiencies. However, widespread economic uncertainty and, for 3PLs, the need to service current and new clients in urgent situations meant that investments often were delayed or simply not made. In cases where new technologies were adopted, we found these were in two main areas. First, investments have centered on software, as firms optimized their existing systems or identified new, more advanced platforms to meet operational needs. Second, a smaller but growing area of investment has been in hardware, mainly modular, scalable solutions that carry lower risk because of recently devised lease-financing models that reduce the need for sizable upfront capital expenditures. Notably, all 3PL interviewees reported that regardless of whether they made or planned substantial technology investments, they mainly coped with pandemic-related market shocks through changes to their workforce systems. In nearly every case, the repertoire of strategies was a familiar one: deepening reliance on contingent workers, instituting mandatory overtime, and stepping up recruitment and retention efforts. For many operators, the question became how to identify technologies that could complement their primary response to pandemic-induced surges in demand, which was increasing staffing levels. We now turn to two of the areas in which 3PLs have been moving forward with technology investments in the wake of the pandemic.

Table1.

Propensity of Warehouses to Adopt New Technologies

Dimension	HIGH	MEDIUM	LOW
Vertical integration	In-house facilities	Dedicated 3PL facilities	Multi-client/public 3PL facilities
Firm size	Large, established firms	Mid-sized, regional firms	Small, local firms
Product variability	Known variability	Less product variability	High product variability
Client relationships	Little to no business churn	Lower business churn, more stable client base	Higher business churn
Contract terms	———	Longer contracts (3+ years), mixture of short and long contracts	Shorter contracts (<3 years), at risk for the re-bidding of contracts
Labor market position	Ability to offer better pay and employment incentives	Competing for labor with in-house facilities and market leaders	Constrained in competing for labor, greater reliance on contingent workers
Appetite for risk	Risk tolerant, able to make longer-term calculations about technology investments	Somewhat risk-tolerant, able to make smaller-scale investments within ROI timelines	Very risk-averse, difficulty in realizing ROI from technology investments

Software Systems Rule

Hardware garners considerable attention in discussions about the future of warehouses, typified by interest in robotics and large-scale automated storage and retrieval systems. Yet many of the projects underway in 3PLs instead focus on software. The combination of the pressure to increase efficiency and the constraint of a conservative approach to capital expenditures has led many warehouse operators to closely examine and optimize the technologies already in use. An executive vice president of a small 3PL described it this way: "[Our transformation was] completely on the software side. It wasn't as much as going out and procuring new technology, it was refining the technology that we already had in-house and making sure that we were fully utilizing it." Others also reported focusing on back-end improvements and applying robotic process automation (RPA) to reporting, inventory management, and demand planning.

In a survey of 200 3PLs, nearly all the technologies that managers planned to implement in the near term were software solutions, including billing and invoicing, WMS (warehouse management systems), reporting and analytics, and dock scheduling, with the most common technology for a 3PL warehouse being a WMS (3PL Central/Extensiv 2022). Cost remains the primary barrier to purchasing a WMS for many 3PLs, especially smaller ones, and according to our interviewees, more shippers and lead firms

are bringing their own WMS—either off-the-shelf or proprietary—into the contracting relationship. This step could remove a source of 3PLs' competitive advantage since these systems are one of the ways they differentiate themselves from one another and from lead firms that operate in-house warehouses.

One reason WMS systems are especially critical is the growing importance of inventory tracking and management, a consequence of widespread supply chain disruptions during the pandemic that resulted in goods sometimes not being in the location where they were needed. Inventory levels remain bloated across many supply chains, which increases the importance of having "visibility" into inventories. Some 3PLs are turning the ability to track inventories in real-time into a competitive advantage. Through their inventory management systems, these 3PLs are providing shippers with accurate information to support their recovery from pandemic-related disruptions, identify faster and slower moving stock, and offer advice on repositioning products. While clearly providing benefits to their customers, this inventory-analysis strategy has the added advantage of helping 3PLs identify more- and less-profitable customers in their portfolios. In general, 3PLs are holding inventory longer, which is threatening their margins given that inventory turns produce profits. The ability to analyze the profitability of each account puts lead firms with excess or slow-moving stock at risk of losing their 3PL providers, since they are occupying valuable space in crowded warehouses that could otherwise be allotted to customers with higher inventory turnover. One interviewee, who works in collaboration with dozens of warehouses, told us:

> "I've had numerous people say, 'I can't take any more business, because I can't find the people and I can't find the space. So, we're just going to stay at our [current] square footage and associates.' And what they are doing is shedding the less profitable or more challenging clients and filling the space with higher-quality [clients]."

The challenge of finding and retaining workers has led some warehouse operators to focus on how technologies could improve workforce management. Efforts to predict labor needs based on demand forecasts, itself a labor-intensive process, are being augmented by machine learning. At some warehouses, engineers are tasked with cleaning and preparing data from historical demand patterns, activities in the warehouse, and factors—like heat—that are impacting worker productivity in an effort to develop more accurate workforce forecasts. In other facilities, warehouse operators began testing on-demand apps through which workers can sign up for partial shifts and temporary assignments. These examples are among the newer efforts to calibrate employee scheduling and management techniques to business cycles and workers' preferences.

Scalable Technologies Increase in Popularity

Time and again we heard from warehouse operators that flexibility and agility—always important operational elements—became the most critical characteristics of successful warehouse operations during the pandemic. In the words of one interviewee, the head of a mid-sized 3PL, "If you are someone who has execution experience within the warehouse, what the last two years has taught you is flexibility and agility [are] critical to support all the variability in the market today." Not surprisingly, then, flexible forms of automation are top of mind for many warehouse operators. Technologies that can be quickly set

up, reconfigured as demand volumes and order profiles shift, and even redeployed to other sites when needed have received increasing interest and been prioritized for implementation. Some managers report they have begun to step up implementation of robotics and automated solutions to cope with increased demand. Included here are autonomous mobile robots (AMRs), one form of scalable technology, which are gaining in popularity, particularly among the largest 3PLs. GXO and DHL, for example, have both announced expansions of their use of this technology across some of their facilities. But AMRs require two conditions to reach their promised efficiency gains: low pick density, so that the AMRs aren't clustered in the same goods-picking location, and high pick volumes. In cases where these conditions are not met, AMRs may not result in substantial productivity gains, despite their scalability.

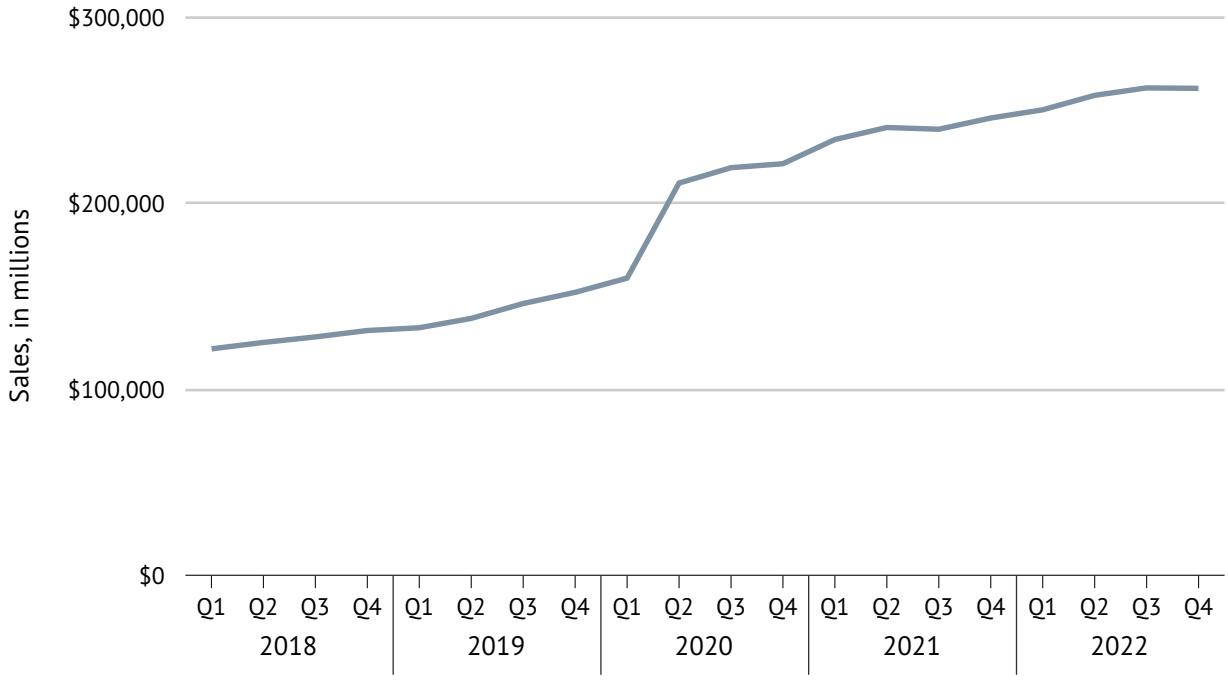
New financing models—particularly the ability to lease technology on a relatively short-term basis—are fundamentally lowering the barriers to new technology implementation. Not only does leasing reduce the risks associated with making investments in a context of heightened demand uncertainty, it also can mean shifting the investment from a capital expenditure to an operating expense, improving a warehouse's overall balance sheet. Robots-as-a-service are playing an increasingly important role in expanding access to technologies that might otherwise be out of reach of most 3PLs.

The Ongoing Impact of E-commerce

When online shopping took off during the pandemic, many heralded the onset of what they expected to be a permanent shift in consumer behavior. E-commerce sales jumped by 53% from 2019 to 2020 (Chart 2) and many firms accelerated the expansion of online fulfillment networks to meet new demand patterns. Other firms looked to 3PLs to quickly increase fulfillment capacity. Some industry analysts predicted the pandemic-driven shift to online shopping would continue apace, yet that view appears to have been somewhat misguided. E-commerce sales have plateaued, and firms are recalibrating both their expectations and their warehouse operations.

E-commerce seems to be propelling conflicting trends in the warehousing industry—increasing interest in automation and increasing interest in outsourcing. Yet in many cases 3PLs are not able to optimize efficiencies in e-commerce fulfillment because of contract lengths and client churn. These dynamics pose challenges to 3PL e-commerce fulfillment, an industry segment that has been growing more quickly than others in the last five years and yet where 3PLs have struggled to meet customer expectations while retaining adequate margins. Further, set against Amazon's proprietary and highly sophisticated software and hardware systems, it is likely that outsourced e-commerce operations could fall further behind.

Chart 2.
E-commerce Sales, 2018-2022



U.S. Census Bureau

Section 5:

Impacts on Warehouse Workers

Because of the unevenness of technology adoption across facilities, workers in warehouses find their jobs impacted in very different ways depending on their workplace. Workers in what we termed "high-propensity facilities" (see Table 1) are often the subject of media attention, and for good reason: they tend to experience work speed-ups and sharp increases in productivity quotas, which can introduce significant health and safety risks. Work intensification is often coupled with high levels of performance monitoring and worker surveillance to track the pace of work and identify those employees who are falling behind on their quotas, as well as the introduction of new software to monitor workers' movements. Workers in high-propensity facilities also are in danger of occupational deskilling as certain technologies begin to remove the need for specialized knowledge or training; deskilling is typically accompanied by downward wage pressures and a decline in job quality.

On the other hand, workers in low- and medium-propensity warehouses are less affected by technological change. Managers of these facilities pursue analog strategies such as identifying and recruiting untapped labor pools into warehouses. Often, these efforts are coupled with the introduction of new software platforms, including labor management systems, to closely track costs and manage labor allocation. Some facilities also are experimenting with labor hiring platforms, where employers seek workers on an ad-hoc basis as demand volumes shift—a kind of virtual temp agency.

Section 6:
Conclusion

In our 2019 report, we identified key trends that are catalyzing investments in new technologies in warehouses. In revisiting those trends, we found that the pandemic accelerated those dynamics, particularly in the areas of labor challenges, real estate costs, and demand variability. Yet the economic uncertainties wrought by the pandemic, as well as the operational shocks that required urgent attention from warehouse operators, meant that while interest was on the rise, for the most part there has not been a major shift in investments in new technologies. Instead, many warehouses have turned first and foremost to labor strategies to deal with the demand shocks and supply chain disruptions caused by the pandemic. In addition, we found that firms optimized the technologies already in place, in particular software systems. On the hardware side, technology investments have been focused on scalable, flexible technologies.

Across the warehousing industry, adoption of new technologies remains highly uneven, and the structure of the outsourced warehousing market serves to slow advances. Short contract terms lead to business churn (or at least the threat of churn), which impacts ROI timelines and the willingness of 3PL managers to invest in equipment that might improve efficiency for one client but that cannot be easily transferred to others. Client turnover also leads to shifting product, order, and operational profiles, which further complicates efforts to identify technologies that can accommodate these changes.

Much of the pandemic-related turmoil is now receding. Employment growth has slowed, indicating a potential softening in warehouse labor markets, yet longstanding challenges regarding labor availability may continue to beset the industry. Other factors may take longer to abate as real estate costs will likely remain elevated due to multiyear lease agreements and protracted construction lead times. The worst of the disruptions to consumption patterns and supply chains has passed, and the warehouse industry is adjusting to a new normal as e-commerce sales plateau and inventory levels even out.

Regarding the pace of change, we expect it to continue to be incremental: as the cost of technology falls, firms inch their way toward technology adoption. In the words of one interviewee, "We're seeing companies saying, 'we have to automate, we have to make that investment. We may not buy a zillion robots, but we're going to buy a couple.'" As the uncertainty introduced by the pandemic subsides, we may see some pent-up demand for technology investment begin to be released as warehouse operators authorize new capital expenditures. Our research suggests that this investment will be uneven across the industry, with warehouses ranging from low to high propensity to adopt new technologies, and spending will likely remain lower among 3PLs until the fundamental risk structure we examined in this report is addressed.

References

Armstrong & Associates (2021). The Business of Warehousing in North America in the E-commerce Era. Milwaukee: Armstrong & Associates.

Armstrong & Associates (2022). U.S. 3PL/Contract Logistics Market Size. Retrieved from https://www.3plogistics.com/3pl-market-info-resources/3pl-market-information/us-3pl-market-size-estimates/.

Chernoff, A. & Warman, C. (2020). "COVID-19 and Implications for Automation." Working Paper 27249, National Bureau of Economic Research, Cambridge, MA. Retrieved from https://www.nber.org/system/files/working_papers/w27249/w27249.pdf.

Cushman & Wakefield (2022). Marketbeat U.S. National Industrial Q3 2022. Retrieved from https://cw-gbl-gws-prod.azureedge.net/-/media/cw/americas/united-states/insights/marketbeats-images/us-marketbeats/industrial/us_industrial_marketbeat_q3_2022.pdf?rev=051e76024a5f43dcb24d4d16eabcd29a.

De Lara, J. (2018). Inland Shift: Race, Space and Capital in Southern California. Oakland, CA: University of California Press.

Employbridge (2022). Voice of the Blue Collar Worker 2022. Retrieved from https://www.kornferry.com/about-us/press/big-people-problem-in-retail.

Gutelius, B. (2015). Disarticulating distribution: Labor segmentation and subcontracting in global logistics. *Geoforum*, *60*, 53-61.

Gutelius, B. & Theodore, N. (2019). The Future of Warehouse Work: Technological Change in the U.S. Logistics Industry. Berkeley, CA: UC Berkeley Labor Center.

Hamstra, M. (2020). "Pandemic Trend: Seeking Efficiency and Safety, Businesses Accelerate Warehouse Automation." US Chamber of Commerce. Retrieved from https://www.uschamber.com/co/good-company/launch-pad/warehouse-robotic-automation-coronavirus-pandemic.

JLL (2022). United States Industrial Outlook Q1 2023. Retrieved from https://www.us.jll.com/en/trends-and-insights/research/industrial-market-statistics-trends.

Kohli, S., Timelin, B., Fabius, V., & Moulvad Veranen, S. (2020). "How COVID-19 is changing consumer behavior—now and forever." McKinsey & Company. Retrieved from https://www.mckinsey.com/~/media/mckinsey/industries/retail/our%20insights/how%20covid%2019%20is%20changing%20consumer%20behavior%20now%20and%20forever/how-covid-19-is-changing-consumer-behaviornow-and-forever.pdf.

Korn Ferry (2021). Big People Problem in Retail: Korn Ferry Survey Finds Significant Labor Shortages at Distribution Centers. Retrieved from https://www.kornferry.com/about-us/press/big-people-problem-in-retail.

Lucas Systems (2022). Voice of the Warehouse Worker Insights. Retrieved from https://www.lucasware.com/voice-of-the-warehouse-worker/.

Litwin, A. S., Hammerling, J. H., Carré, F., Tilly, C., Benner, C., Mason, S., Viscelli, S., Gutelius, B., & Theodore, N. (2022). A Forum on Emerging Technologies. *ILR Review, 75*(4), 807–856.

McKinsey Global Institute (2021, February). "The Future of Work after COVID-19." Retrieved from https://www.mckinsey.com/~/media/mckinsey/featured%20insights/future%20of%20organizations/the%20future%20of%20work%20after%20covid%2019/the-future-of-work-after-covid-19-report-vf.pdf?shouldIndex=false.

Muro, M., Maxim, R. & J. Whiton (2019). "Automation and Artificial Intelligence: How Machines are Affecting People and Places." Retrieved from https://www.brookings.edu/wp-content/uploads/2019/01/2019.01_BrookingsMetro_Automation-AI_Report_Muro-Maxim-Whiton-FINAL-version.pdf.

O'Brien, M. & P. Wiseman (2021, September 5). "Do we need humans for that job? Automation booms after COVID." *AP News*. Retrieved from https://apnews.com/article/technology-business-health-coronavirus-pandemic-d935b29f631f1ae36e964d23881f77bd.

Newmark (2021, July). "Making Moves: Warehouses Need Workers and are Luring them From Other Industries." Retrieved from https://www.nmrk.com/storage-nmrk/uploads/fields/1-column-with-sidebar-links/Making-Moves_July-2021-Industrial-Insight.pdf.

Newmark (2022). National Industrial Market Research Q3 2022. Retrieved from https://www.nmrk.com/storage-nmrk/uploads/fields/1-column-with-sidebar-links/3Q22-National-Industrial-Market-Report.pdf.

Prologis (2021, October). "Persistent Disruption: Prologis Research Special Report." Retrieved from https://www.prologis.com/news-research/global-insights/persistent-disruption-prologis-research-special-report.

Stott, R. (2022). "Warehouse Automation Market Grew 28% in 2021 but Will the Good Times Last?" Retrieved from https://www.interactanalysis.com/warehouse-automation-market-grew-28-in-2021-but-will-the-good-times-last/.

3PL Central (2020). "Third-party Logistics Warehouse Benchmarking Report." Retrieved from https://info.3plcentral.com/2020-third-party-logistics-warehouse-benchmark-report.

3PL Central/Extensiv (2022). "Third-party Logistics Warehouse Benchmarking Report." Retrieved from https://www.extensiv.com/resource-library/report/2022-third-party-logistics-warehouse-benchmark-report.

Sedik, T.S. & Yoo, J. (2021). "Pandemics and Automation: Will the Lost Jobs Come Back?" International Monetary Fund Working Papers. Retrieved from https://www.imf.org/en/Publications/WP/Issues/2021/01/15/Pandemics-and-Automation-Will-the-Lost-Jobs-Come-Back-50000.

World Economic Forum. (2020, October). "The Future of Jobs Report." Retrieved from https://www.weforum.org/publications/the-future-of-jobs-report-2020.

Young, L. (2023, January 5). "Warehouse leasing tumbled at the end of 2022." *Wall Street Journal*.

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