The Future of Warehouse Work: Technological Change in the U.S. Logistics Industry

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Executive Summary

Are "dark" warehouses, humming along without humans, just around the corner? Predictions of dramatic job loss due to technology adoption and automation often highlight warehousing as an industry on the brink of transformation. The potential elimination of many blue-collar jobs is a pressing issue for policy makers and raises important questions about how workers will fare in the economy of the future.

In contrast to reports focusing only on the number of jobs that could be lost, our research offers an in-depth, detailed look at the range of ways in which warehouse work and the industry as a whole might change with the adoption of new technology over the next five to 10 years. The findings in this report are based on in-depth industry research and extensive interviews with a broad set of stakeholders, including industry analysts and consultants, third-party logistics (3PL) operators, retailers, brands, and technology providers. Specifically, we sought to find out:

1. **What key industry dynamics are playing a role in technological change?**

2. **How will adoption of new technologies impact warehouse facilities and operations, as well as the overall organization of the industry?**
3. **What tasks and processes are the highest priorities for technological application, and how might adoption of new technologies impact jobs in warehousing?**

Many accounts of technological change portray firm decision making as purely based on a desire to automate to reduce labor costs. While labor cost reduction plays an important role, our research found a multifaceted set of factors shaping firms' decisions about how to apply new technologies in warehouses. One set of trends—tight labor markets, rising real estate costs, and increasing speed requirements—are pushing warehouse operators to explore new technologies.

On the other hand, variability and unpredictability, outsourcing dynamics, inertia, and the state of technological innovation are factors that may slow the process of technology uptake.

As a result, we project that the industry likely won't experience dramatic job loss over the next decade, though many workers may see the content and quality of their jobs shift as technologies are adopted for particular tasks. Employers may use technology in ways that decrease the skill requirements of jobs in order to reduce training times and turnover costs. This could create adverse effects on workers, such as wage stagnation and job insecurity. New technologies potentially can curtail monotonous or physically strenuous activities, but depending on how they are implemented, may present new challenges for worker health and safety, employee morale, and turnover. Additionally, electronically mediated forms of monitoring and micro-management threaten to constrain workers' autonomy and introduce new rigidities into the workplace.

These changes will have a greater impact on communities with high concentrations of warehouse workers. Warehouses typically are clustered near major transportation arteries and population centers—for example, the Inland Empire in California and the Chicago region. Two-thirds of front-line warehouse workers are people of color, most of them Black or Latinx, who stand to be disproportionately affected by technological change. Women are more likely to work in the growing e-commerce sector than in traditional warehouses, so they may benefit from growing employment opportunities, but also face lower wages and increasing pressure from changes in working conditions.

Findings

Technology Meets Shifting Industry Dynamics

1. The warehousing industry is characterized by slim profit margins and cost-sensitive competition, which leads to a cautious approach to technology adoption.

Viewed mainly as a cost center, warehousing is a low-margin industry with high levels of volatility and risk. Cost-based, risk-averse competitive dynamics lead warehouse operators to reduce exposure to cost wherever possible. This is one main reason the

industry has lagged in its adoption of new technologies.

Broadly speaking, warehouse operators have thus far moved cautiously into risky experiments with new technologies, relying instead on streamlining current processes and on workforce experimentation. Our research suggests that this trend will continue—the cost sensitivity of the dominant business model will moderate the rate of technological experimentation and uptake, though larger firms may be able to leverage volume and a strong financial position to adopt new technologies. Absent a major shift in how warehousing activities are valued, the dynamics that have created barriers to innovation and contributed to the sector's status as a laggard are likely to persist over the next five to 10 years.

2. E-commerce is driving experimentation with new technologies.

With double-digit sales growth each year, few shifts in consumption patterns have had a greater impact on the warehousing industry than the rise of e-commerce. Online shopping is leading the transformation of the warehousing industry and is poised to have substantial effects on jobs and workers, not least in the realm of adoption of new technologies. E-commerce order picking requires more labor and, given the prompt delivery expectations of consumers, the order fulfillment process is accelerated. This results in a growing need for workers in warehouses, and an increasing interest in technologies that can streamline work processes and improve efficiencies.

Additionally, Amazon's influence in the online retail arena is substantial, particularly in the context of the company's announcements of increasingly faster delivery promises. Whereas a few years ago, consumers were content for an order to arrive in a few days, the delivery window has steadily narrowed with the growing prevalence of Amazon's Prime subscription. The combination of labor-intensive order picking and the speed with which these orders must be shipped has made e-commerce a leading driver of growth in warehousing employment, and is motivating experimentation with new technologies to support the order fulfillment process. This includes technologies that de-skill or potentially displace workers, such as automated picking processes, as well as technologies that speed up, control, or streamline human labor, such as electronic productivity monitoring.

3. Technology uptake likely will be uneven.

Across firms, within firms, and across technologies, adoption likely will vary significantly. Our research confirmed that warehouses are in disparate stages of their techno-strategy development, and that most firms are cautiously exploring new innovations. The business profile of a company, including the specific activities occurring in warehouse facilities, amount of goods being moved, and product markets, all help determine the propensity for technology adoption.

Within firms, a broad set of tasks and activities potentially could be high priority for applications of new technology and automation. Firms must make choices about which activities take precedence, leading to a variegated landscape of technological sophistication across activities in a warehouse. Our research documented that even firms at or near the leading edge of innovation in one area often lag behind in other areas. In one example, a large parcel company had made significant investments in a high-throughput conveyor and automated radio frequency barcode scanning system, but managers still were using spreadsheets and a whiteboard to schedule workers to handle package volumes. Another indication of unevenness is in the market penetration of warehouse management systems (WMS)—a common type of software used in the industry. Using a WMS is a fundamental building block for the adoption of many other technologies, and yet it is estimated that at least one-third of warehouses in the United States do not use such a system.

We project there will continue to be uneven uptake across technologies, in large part because the new technologies tend to be specialized to particular warehouse activities. The modularity of some new technologies, as well as alternative models of leasing, changes the capital investment and risk assessment scenarios in ways that could facilitate firms' technology experimentation and uptake.

4. Technology potentially will have large impacts on third-party logistics firms and outsourcing in the warehousing industry.

Outsourcing is a significant trend in the warehousing sector that affects the pace and forms of technology adoption. New technologies also have the potential to change firms' behavior with respect to outsourcing, which typically takes two forms: (1) outsourcing warehouse management and operations to third-party logistics firms (3PLs), which offer a wide range of logistics-related services, and (2) outsourcing of warehouse hiring to temporary staffing agencies.

3PLs and temporary staffing agencies are navigating an uncertain landscape of strategies. Some are exploring new roles that leverage technology, while others appear to be taking a wait-and-see approach without significantly altering their value propositions. One 3PL company, for example, coped with a tenfold increase in holiday shopping volume by switching its facility to a highly manual process during peak season and hiring hundreds of extra workers, because the conveyor system could not accommodate the influx of orders. Other warehouse operators reported exploring the use of on-demand staffing platforms, which could simplify hiring processes for the benefit of employers and workers. However, using such tools also may encourage employers to reduce the number of direct hires and increase reliance on temporary workers, who tend to be paid less and have fewer protections on the job.

Also, 3PL contracts often are short (three to five years), which makes a return on investment difficult to achieve for warehouse operators taking on major investments in new technology. Many 3PLs have avoided such investments because of the possibility of losing the customer at the end of a contract, thus eliminating any potential gains.

Despite these disincentives, some large 3PLs like DHL and XPO are piloting technologies to better meet the needs of their customers.

Similarly, the president of a mid-sized 3PL said his company was exploring how it might commingle smaller e-commerce startups in a single facility and implement automation across all of them in order to speed up order fulfillment.

Impacts on Tasks, Jobs, and Workers

1. New technologies are likely to lead to work intensification.

The highest priority for companies in the short term is to identify and implement technologies that support more efficient order fulfillment. This includes applying labor-saving technologies to high-volume e-commerce order picking and frequent, small-batch replenishments to retail stores that keep limited inventory on hand. The labor-intensive nature of picking individual items to assemble orders—so-called "each picking"—requires large numbers of workers, so warehouse operators place great value on finding ways to reduce headcount and/or increase throughput by reorganizing this activity.

Our research suggests that even though some technologies could alleviate the most arduous tasks of warehouse work (such as heavy lifting), this likely will be coupled with attempts to increase the workload and pace of work, with new methods of monitoring workers. Amazon, for example, introduced MissionRacer, a video game that pits workers against one another to assemble customer orders fastest.

The increasing pace of work in warehouses may introduce new health and safety hazards, as well as increased employee turnover due to overwork and burnout. Currently, warehouse workers experience work-related injuries at a rate nearly twice that of other private industry workers— higher than construction, coal mining, and most manufacturing industries. According to The New York Times, pregnant workers at a warehouse in Memphis managed by the 3PL XPO were denied requests for light duty and subsequently suffered miscarriages. Warehouse employees also often toil in facilities that are not climate controlled, which exacerbates the hazards created by work speed-up.

2. New technologies have the potential to de-skill some jobs.

Some warehouse technologies are designed to simplify aspects of warehouse work by breaking a job into subtasks and, where possible, removing the skills required of the workforce. Across all occupations in warehouses, viable technologies are likely to replace some human-performed decision-making tasks with machines, significantly changing the composition and quality of jobs. In some cases, the de-skilling appears to be motivated by a desire to shift labor strategy, including expanding the size of the potential labor market, increasing the use of temporary workers, reducing the workforce in certain occupations, and enhancing worker productivity.

Training workers to perform higher-skilled tasks is one potential avenue for adaptation to technological change, but this strategy appears to be underutilized in warehousing. Instead, labor reallocation likely will dominate in the short and medium term, supported

by processes of de-skilling and work intensification. For example, the Kiva robotic picking system simplifies the role of humans in picking, reducing training and skill requirements, and making it easier for companies to hire temporary labor rather than direct employees.

3. New technologies are poised to transform how workers are managed.

Algorithmic management introduces new forms of workplace control, where the technological regulation of workers' performance is granular, scalable, and relentless. Newly available devices
—such as "wearable" warehouse technologies, autonomous mobile robots, and increasingly sophisticated labor management software—allow close tracking of workers' movements, including walk speed, routes, bottlenecks, and break time.

These technologies have the potential to improve efficiency by urging workers to increase speed and accuracy. These same technologies also can function as a form of surveillance over workers, reducing the little autonomy they already have and further intensifying the pace of their work.
Without interventions to ensure the transparency and fairness of the algorithms used in these technologies, the conditions of work in warehouses may be heading toward more rigid forms of monitoring and management.

4. In the short to medium term, new technologies likely will not cause widespread job loss.

With continued growth in demand, aggregate employment levels in the warehousing industry will likely continue to rise over the next five to 10 years. That said, job growth may be tempered by the increased use of labor-saving technologies in e-commerce warehouses in particular, such as autonomous mobile robots, autobaggers and autoboxers, and sensors or RFID tags applied to goods. Honeywell, for example, has developed robotic unloading machines that reduce the offloading time and concomitantly the role of workers in the process.

Many workers may see the nature of their working conditions shift as technologies are adopted for particular tasks over the next five to 10 years. Over the long term, in the absence of major shifts in the economy or context of firms' technological adoption strategies, the increasing use of technology points to a labor reduction.

5. Technology is likely to have uneven impacts across demographics and occupations.

Because of the overrepresentation of workers who are young, male, Latinx and Black in the warehousing industry, these groups of workers will be affected disproportionately by technological change. In particular, Latinx and Black workers are overrepresented in the industry compared with the total U.S. workforce: both groups are employed in warehousing at twice the rate of all other industries. Latinx workers alone compose the largest single race/ethnic group in front-line warehousing jobs, at 35%. Black workers make up one-quarter of the workforce in both warehousing and e-commerce. Overall,

workers of color constitute 66% of warehousing industry workers and 55% of workers in e-commerce, even though workers of color account for just 37% of the total U.S. labor force.

Other groups also will experience specific consequences from technological change in warehouses. Some technologies will disproportionately impact the employability of older workers, such as engineered productivity standards that penalize workers for not reaching exacting targets, or newer forms of technology for which older workers do not have training or experience. Women are more likely to be employed in e-commerce warehouses versus traditional warehouses, so the growth in e-commerce offers new employment opportunities for female workers. However, jobs in e-commerce warehouses typically have lower wages and less predictable schedules, and they are even more vulnerable to pressure to increase speed.

Finally, technological change will have different effects at the occupational level. Front-line occupations such as order pickers will likely see the content and quality of their jobs change with the application of new technologies that reduce low-value activities like walking and such automatable tasks as boxing orders. Forklift drivers may work alongside partially automated forklifts, and shipping clerks might see their work increasingly replaced by artificial intelligence.

Conclusion

Our findings raise a number of questions for policy makers, worker organizations, and industry
leaders in the warehousing sector:

- How can policy makers, equipped with forward-looking information, help to plan and prepare for changes in job quality and the potential unequal distribution of the costs and benefits of technology adoption?
- How can workers be included in the process of technology implementation to improve employment and operational outcomes?
- What measures can be put in place to track the physical and psychological impacts of technologies on workers, and to mitigate any negative effects on workers' health and safety?
- How can policy makers involve employers in systematically identifying within-industry job opportunities for displaced warehouse workers, including on-the-job training?

In short, how the gains from technological change will be distributed is a pressing question for all of the industry's stakeholders. While large retailers may be able to leverage their sizeable order volumes and strong financial positions to secure first-mover advantages through early adoption of new technologies, many 3PLs and smaller firms will face challenges, primarily the cost-based competition that is prevalent in the warehousing industry. Consequently, widespread automation of the warehousing

industry is unlikely in the near to medium term. Experimentation with a variety of new technologies—including but not limited to those that may de-skill and intensify work—appears to be led by the widespread desire to compete with Amazon and other major online retailers.

Technologies are neither inherently good nor bad, just as the effects on employment are not inevitable. Ultimately, warehouse operators have latitude in determining how new technologies will be implemented. For example, when the wholesale retailer Boxed introduced cutting-edge automated processes into its warehouses, it retrained existing workers to fill new roles around these processes instead of laying them off.

The warehousing industry could realize significant operational improvements through technological advances—and it is imperative that productivity gains be shared, that workers be involved in identifying which efficiencies should be prioritized and what hazards are being introduced, and that experimentation unfolds with regard for more than just productivity increases and cost-cutting. Absent this, the process of technological change in warehousing likely will resemble a win-lose proposition, where the short-term benefits are captured by the industry and the long-run costs are borne by workers.