Driving Continuous Improvement and Value Generation Through Labor Optimization in Manufacturing and Warehouse Environments

Nishchay Selot

Abstract:
Labor utilization remains one of the most controllable levers for improving throughput in manufacturing and warehouse operations. Despite advances in automation, human labor continues to represent the backbone of many production and distribution environments, particularly in food manufacturing. This paper examines labor optimization strategies drawn from operations research, industrial engineering, and lean management, and applies them through two practitioner case studies. The first case involves a food distribution warehouse where time studies and facility redesign were used to reduce forklift cycle times and minimize non-value-added driving. The second case addresses a leafy greens production facility where end-of-line packaging labor was redistributed to increase output per line and reduce the total number of production lines required. The findings suggest that structured time studies, layout redesign, and task rebalancing can deliver meaningful throughput gains without adding headcount - shifting the focus from labor cost reduction to labor value maximization.

1. INTRODUCTION:

Manufacturing and warehouse operations face persistent pressure to produce more with the same or fewer resources, especially with the added tariff costs. While capital-intensive solutions like automation receive significant attention, labor optimization offers an accessible and often faster path to improvement, especially in environments where human workers remain central to operations (Stevenson, 2021). The challenge is not simply reducing labor costs but making the existing workforce more productive – increasing output of more product per labor hour by eliminating waste, shortening cycle times, and redesigning workflows.

Operations research provides a rich set of tools for this challenge, including time and motion studies, facility layout planning, line balancing, and simulation modeling. These methods have been applied in diverse manufacturing contexts for decades, yet their practical application in food manufacturing warehouses and perishable goods production lines can be further explored (Tompkins et al., 2010). This paper contributes to that gap by presenting two applied case studies alongside a review of relevant literature.

2. LITERATURE REVIEW

2.1 Time and Motion Studies in Manufacturing

Time and motion studies remain a foundational tool for understanding labor utilization in manufacturing settings. Meyers and Stewart (2002) documented how structured time studies break down operator tasks into discrete elements, measure each element, and establish standard times that serve as benchmarks for improvement. More recently, Nallusamy and Majumdar (2017) demonstrated that applying time study techniques in a manufacturing plant revealed idle time and unnecessary motion that, once addressed, improved productivity by over 20%. The essential idea is straightforward: you cannot improve what you have not measured, and time studies provide the measurement foundation for labor optimization.

2.2 Facility Layout and Warehouse Design

Facility layout directly governs how much time workers and material handling equipment spend in transit rather than performing value-added work. Tompkins et al. (2010) established the framework most widely used in practice, arguing that an optimally designed facility minimizes total travel distance, reduces handling costs, and supports smooth material flow. In warehouse environments specifically, the Systematic Layout Planning (SLP) method has been widely applied. A recent study on a food warehouse using SLP and Flexsim simulation achieved a 23.5% improvement in handling efficiency and a 12.8% reduction in labor costs through layout reconfiguration alone (Li et al., 2025). Similarly, Kembro et al. (2022) found that warehouse layout is a primary driver of picking and loading efficiency, with poorly designed facilities creating significant non-value-added travel time for forklift operators and pickers.

2.3 Line Balancing and Labor Distribution

On the production floor, line balancing addresses how work is distributed across stations so that no single station becomes a bottleneck. Aslan et al. (2023) used worker position data from indoor localization sensors to build data-driven process models for a manual assembly line and found that even small capacity reallocation adjustments – shifting 20% of labor from a fast task to a bottleneck task – reduced completion time by over 7% without adding any workers. Costa et al. (2023) extended this by showing through simulation that heterogeneous labor assignment strategies, particularly the "bowl" configuration where more capable workers are placed at central stations, can outperform fully balanced or fully flexible staffing configurations. These findings confirm what practitioners have long observed: where you put people matters as much as how many people you have.

2.4 Lean Principles and Continuous Improvement

Lean manufacturing provides the philosophical framework for labor optimization through its focus on waste elimination. Womack and Jones (2003) identified seven forms of waste, several of which – transportation, motion, and waiting – directly relate to labor utilization. Garza-Reyes et al. (2023) applied the Lean Six Sigma DMAIC framework to warehouse operations and found that process cycle efficiency was only 40% before intervention, with the majority of labor time consumed by non-value-added activities. After applying lean tools, significant improvements were achieved in both productivity and cycle time. Tortorella et al. (2020) further showed that lean manufacturing and digital tools have a complementary effect on operational performance, suggesting that labor optimization benefits from both process redesign and technology enablement.

3. METHODOLOGY

Both case studies employed a structured operations research approach grounded in time study methodology and zero loss thinking (Rolo et al., 2022). The general framework followed four phases:

1. **Baseline Measurement**: Conducting time studies to capture current-state cycle times for each task element. In the warehouse, this meant timing how long forklift operators took to travel to a pick location, pick up a pallet, travel to the loading dock, and load a pallet onto a truck. On the production line, this meant timing how long each of the five to six end-of-line workers took to pick product from the conveyor, place it into cases, seal cases, and stack cases onto pallets.
2. **Golden Cycle Identification**: From the time study data, a "golden cycle" was identified – the best observed cycle that represented the theoretical minimum time for each task under current conditions. This served as the benchmark against which all other cycles were compared to quantify the gap between actual and ideal performance.
3. **Root Cause Analysis**: Non-value-added time was categorized. In the warehouse, this included excessive travel distances caused by poor facility layout, waiting time at docks, and inconsistent pallet staging. On the production line, this included uneven task distribution where some workers were idle while others were overloaded, and unnecessary movement between stations.
4. **Redesign and Optimization**: Solutions were designed to close the gap between actual performance and the golden cycle. In the warehouse, this involved redesigning the facility layout to place high-velocity SKUs closest to the loading docks and creating dedicated forklift travel lanes. On the production line, this involved redistributing packaging tasks across workers and redesigning the physical flow of product at the end of the line.

4. CASE STUDIES

4.1 Case Study 1: Food Distribution Warehouse – Forklift Labor Optimization

The warehouse handled palletized packaged food products and relied on forklift operators to pick pallets from storage and load them onto outbound trucks. Time studies revealed that the average cycle time from pick to load was significantly longer than the golden cycle, with the primary driver being excessive forklift travel distance. Operators were traveling across the full warehouse because high-demand products were scattered throughout the facility rather than positioned near loading docks.

The facility was already scheduled for a redesign, which presented an opportunity to build optimization into the new layout from the ground up. Using principles from SLP methodology (Tompkins et al., 2010) and data from the time studies, the redesign placed the highest-velocity pallets within the shortest travel paths to the docks. Dedicated travel lanes were recommended to eliminate forklift congestion, and staging areas were positioned to allow pre-staging of pallets operations decoupled from the loading of the trucks – and thereby allows for simultaneous loading and staging.

The target was what the team called "zero loss" – designing the layout so that driving time and loading time approached the theoretical limit minimum. We recommended installing a staging incline roller on the ground. This would allow for staging my placing the pallet on one end near the racking and get picked up from the other end, next to the docks, to load the truck. By collapsing the travel distance and eliminating wait-and-search time, the redesigned facility was projected to reduce average forklift cycle time by approximately 30%, enabling the same number of operators to load more trucks per shift. The point was not to cut forklift drivers but to make each driver's time count for more – more pallets moved per hour with the same headcount.

4.2 Case Study 2: Leafy Greens Production Line – End-of-Line Packaging Optimization

The second case involved a lettuce manufacturing facility producing packaged leafy greens such as spring mix and baby spinach for leading brands on the East Coast of the US. At the end of each production line, 3-4 workers were responsible for picking finished packs off the conveyor, placing them into cases, sealing the cases, and palletizing them for outbound shipment. The facility operated multiple production lines, and the hypothesis was that if we can increase packaging productivity, we could speed up the machines upstream. Thereby, the same total labor pool could support the same total output with fewer lines running – a major cost and complexity reduction.

Time studies showed significant variability in how workers distributed themselves across tasks. Some workers were consistently waiting for product while others were overwhelmed, creating micro-bottlenecks that slowed the entire line. The golden cycle analysis revealed that if workers were optimally distributed – with task assignments such as box erecting, bag packing, case sealing & palletizing – throughput per line could increase meaningfully.

The redesign involved rebalancing worker assignments so that each person had a clearly defined role matched to the line's flow rate, with cross-training to allow flexible redeployment when product types changed. Physical flow was also adjusted: a case-erecting table was repositioned closer to the pack-off point, and pallet staging was moved to reduce the distance workers had to carry sealed cases. The result was a measurable increase in cases packed per labor hour, enabling the facility to consolidate output onto fewer lines while maintaining the same total throughput.

5. DISCUSSION

Both cases illustrate a common principle: labor optimization does not necessarily boil down to working people harder – it is about removing the obstacles that prevent people from being productive. In the warehouse, the obstacle was distance and searching for pallets. In the production facility, the obstacle was imbalanced task distribution. In both cases, the solution involved a combination of measurement (time studies), analysis (golden cycle benchmarking), and physical redesign (layout changes and task rebalancing).

These findings align with the broader literature. Aslan et al. (2023) showed that even modest reallocation of worker capacity to bottleneck tasks can reduce completion times by 7% or more. Li et al. (2025) demonstrated that SLP-based warehouse redesign can improve handling efficiency by over 20%. Garza-Reyes et al. (2023) found that lean warehouse interventions can dramatically improve process cycle efficiency. The practitioner cases presented here extend these findings into food manufacturing, a sector where perishability and throughput speed create especially strong incentives for labor optimization.

Importantly, neither case study aimed to reduce headcount. The goal was value generation – making the same labor force produce more output, more reliably, with less wasted effort. This framing is critical for gaining workforce buy-in and for sustaining improvements over time.

6. CONCLUSION

Labor utilization optimization remains a powerful and accessible strategy for driving continuous improvement in manufacturing and warehouse environments. Through structured time studies, golden cycle benchmarking, facility layout redesign, and task rebalancing, organizations can achieve significant throughput gains without increasing headcount. The two case studies presented here – one in a food distribution warehouse and one on a leafy greens production line – demonstrate that these methods work in practice and that the key is removing waste from the system rather than demanding more from the workforce. Future research should explore how real-time sensor data and simulation modeling can further accelerate labor optimization in perishable goods environments.

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