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Mapping and Evaluating Warehouse Process Phases: A Mixed-Method Study on Operational Priorities and Neglected Activities

Andrea Payaro[1*], Anna Rita Papa[2]
[1]Department of Business Management, eCampus University Novedrate Italy.
[2]P&P Consulting & Service, Italy.

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***Corresponding author:** Andrea Payaro, Department of Business Management, eCampus University Novedrate Italy.

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Abstract:

The operational management of a warehouse is a crucial component in a company's supply chain, directly influencing the efficiency and competitiveness of the entire organization. A well-managed warehouse not only optimizes logistics costs but also enhances customer service quality by reducing delivery times and increasing overall satisfaction.

The fundamental elements of warehouse operations include the receiving and storage of goods, inventory management, picking, and shipment preparation. Each of these stages requires careful planning and effective execution to ensure operations are carried out efficiently and without errors. Warehouse organization involves not only establishing an effective and efficient process but also designing an environment suitable for such operations.

In this context, the paper aims to provide both academics and professionals with:

- A review of the warehouse process, highlighting the key activities necessary for the effective and efficient management of all operations from goods receipt to dispatch.
- An evaluation, conducted through a survey of a sample of companies, to identify which phases of the warehouse process are most optimized and monitored.

Based on a literature review aimed at identifying the core activities carried out in warehouses, the paper presents a comprehensive and adaptable process suitable for various business models, from manufacturing firms to commercial enterprises. The proposed new process was submitted to a sample of 25 companies to assess its robustness and to investigate which phases are most frequently monitored.

The study seeks to offer a practical guide for logistics managers and warehouse supervisors, supporting them in improving process management and achieving efficiency and effectiveness objectives, while also serving as a resource for academics interested in exploring warehouse operations in greater depth.

Keywords: warehouse management; warehouse process; warehouse performance

Introduction

In recent years, the warehouse is no longer viewed merely as a space for storing goods but has become a true profit center. The idea that a warehouse can generate value for the customer is now widely accepted (Richards, 2017; Ghosh & Shah, 2015). Errors in operations, incorrect picking, damaged goods, and delays in order preparation are just a few examples of process non-conformities that originate within the warehouse and can compromise the trust-based relationship with customers (De Koster, Le-Duc & Roodbergen, 2007).

The economic crisis and emerging international dynamics have driven companies to seek greater efficiency and flexibility. Lean and agile philosophies have led organizations to focus on effective inventory management as a way to reduce overall business costs.

The warehouse now faces multiple trends: on one hand, customers demand more frequent and smaller deliveries; on the other, sourcing from the Far East requires holding inventory that cannot be minimized. Furthermore, the shift in the production center of gravity toward Asian countries has transformed many manufacturing sites into distribution hubs. As a result, globalization has led many companies to evolve from production-focused entities into storage and shipping centers. The role of the warehouse has thus become fundamental.

Most definitions describe a warehouse as a facility where goods are received, stored, handled, and organized for subsequent shipment. Once received from a supplier, goods may remain in the warehouse for a certain period until they are needed (Kocifaj, 2019). A warehouse is also a space where various activities take place, depending on its function and its position within a company's logistics system or supply chain (Marasová & Šaderová, 2018). This implies the execution of one or more processes aimed at ensuring the physical flow of materials and products.

According to Gu et al. (2010), warehouse design problems involve five groups of decisions: defining the overall structure (conceptual design), determining size, calculating layout, selecting storage equipment, and choosing the operational strategy. Furthermore, warehouse planning must also include policies related to order fulfillment/picking, storage, and inventory turnover (Koster et al., 2007; Chan & Chan, 2011).

Warehouse management is an integrated process encompassing several key functions. Among its main objectives is to ensure an efficient and secure flow of goods from receipt to customer delivery. Another essential aspect is inventory management, which involves implementing strategies to maintain optimal stock levels and avoid both shortages and surpluses. Warehouses are increasingly seen as opportunities to improve operational and informational flow optimization, reduce inventory levels, and enable more agile distribution (Vrijhoef & Koselka, 2000).

The primary goals of effective warehouse management include: cost reduction; achieving economies of scale by moving large volumes between logistics centers (Rodríguez et al., 2007); managing variability caused by factors such as product seasonality (Gu et al., 2007); maintaining a high level of customer service (Parikh & Meller, 2008); and integrating flexibility into the supply chain to ensure better responsiveness to market changes (Amiri, 2006).

This study is conducted from a logistics and operations management perspective, with a specific focus on warehouse operations. It does not include inventory management, network design, location planning, or engineering aspects.

Warehouse Operations: Functional Phases and Process Overview

Warehouses can perform a variety of functions depending on product characteristics, customer requirements, and the level of service provided. According to De Koster and Warffemius (2005), the complexity of warehouse operations depends primarily on: (i) the number and variety of items to be handled; (ii) the daily workload; and (iii) the number, nature, and variety of processes required to meet the needs of both customers and suppliers. While operational differences exist—such as between storage warehouses and cross-docking facilities—there is broad consensus in the literature regarding a set of core activities: receiving, storage, order picking, and shipping (van den Berg & Zijm, 1999). This study excludes activities external to the warehouse area, such as transportation processes, inbound procurement, and final delivery.

A comprehensive process framework used to investigate how much attention companies devote to each phase is the one proposed by Tompkins et al. (2010), to which this study adds two additional stages:

Vehicle Access

This phase covers the path taken by transport vehicles from entry gate arrival to parking in the unloading area. Managing this step is essential for both safety and productivity. From a safety perspective, the heavy vehicle's access path must be designed to eliminate or minimize potential interferences—defined in Italian Legislative Decree no. 81/2008 as situations where activities by multiple parties (e.g., contractors and client companies) overlap in space and/or time, creating risk for workers. Poor scheduling of vehicle arrivals can lead to unloading bay congestion, resulting in productivity losses. Similar issues have been documented in maritime container terminals (Torkjazi, Huynh & Shiri, 2018), leading to the development of heuristic approaches (Huynh, Walton & Davis, 2004; Namboothiri & Erera, 2008), mathematical models (Guan & Liu, 2009a, 2009b; Zehendner & Feillet, 2014), truck appointment systems (Schulte et al., 2017), and slot allocation models (Azab, Karam & Eltawil, 2017; Huynh, 2009). Despite advances in technology, warehouse managers and transporters report a continued rise in lost hours due to unanticipated delays, schedule changes, and wait times. To mitigate this, many warehouses—especially distribution centers—implement appointment systems to evenly distribute truck arrivals by limiting the number of vehicles processed within a given time window.

Vehicle Unloading

This phase involves the transfer of goods from transport vehicles into the warehouse. It includes vehicle arrival planning, physical unloading, and goods registration and storage. A key activity here is the assignment of loading bays. Equipment such as pallet jacks, forklifts, or automated systems may be used to move materials. Efficiency in this phase is critical to minimizing cycle times and preventing product damage. De Oliveira et al. (2022) studied the receiving process in a warehouse, implementing improvements such as layout reorganization and workstation balancing, resulting in a 28% cycle time reduction and substantial operational savings.

Receiving

This phase includes all activities associated with the inbound receipt of goods ordered from suppliers. Products are visually inspected to verify packaging integrity and compliance with purchase orders. Accepted goods are then entered into the warehouse management system, updating inventory status (Gu et al., 2007).

Inspection and Quality Control

An extension of the receiving process, this step is necessary when supplier quality is inconsistent or when goods are subject to strict regulatory requirements. Full or sample-based inspections are carried out as needed.

Repackaging

Performed when products arrive in bulk and must be repackaged into single units, sales quantities, or combined into kits or assortments. Repackaging may involve changing packaging (e.g., from cardboard boxes to plastic totes), sorting mixed items into distinct storage locations, labeling incoming goods, or replacing damaged packaging.

Storage (Putaway)

This involves physically placing items into storage locations and includes material handling and positioning. Goods remain stored until requested by internal (e.g., production) or external (e.g., customer) clients. Storage methods vary depending on item size, quantity, and handling characteristics.

Replenishment

This refers to refilling picking locations by retrieving goods from storage areas and relocating them to zones suited for order picking.

Order Picking

Order picking is the core warehouse service provided to customers and garners the most attention, as fast and accurate picking increases customer satisfaction (Baker & Canessa, 2006). Described as the "top-priority activity for productivity improvement" in *World-Class Warehousing and Material Handling*, it accounts for nearly 50% of operational costs in typical warehouses and is the most labor-intensive process (De Koster et al., 2006). Most warehouse personnel are dedicated to picking, which also occupies over half of total warehouse time (Tompkins & Smith, 1998). In manual-pick systems, travel time is generally a growing function of travel distance (Jarvis & McDowell, 1991; Hall, 1993; Petersen, 1999; Roodbergen & De Koster, 2001b; Petersen & Aase, 2003), making distance minimization a key design and optimization objective.

Sorting

Sorting follows picking and is particularly relevant in high-volume or batch-picking contexts. It involves classifying and separating items or orders based on predefined criteria (e.g., customer, destination, product type, or shipping channel) to streamline packing or shipping. Sorting aims to reduce delivery errors and enhance operational efficiency (De Koster et al., 2007; Boysen et al., 2007).

Consolidation and Packing

This phase follows picking and involves preparing goods for shipment. Items picked at different times, by different operators, or from various zones are consolidated by order. Products or assortments are packaged for safe and practical transportation. This phase also includes generating labels, preparing shipping documents, and weighing orders to calculate shipping costs.

Outbound Quality Check

This final verification ensures that shipped materials and packaging are complete and accurate, and that load unit labels contain the correct information.

Vehicle Loading

This phase mirrors unloading and involves transferring goods from the warehouse to the outbound vehicle.

Vehicle Departure

The same principles described for vehicle access and unloading apply here.

This detailed breakdown of warehouse operations provides a comprehensive framework for analyzing how companies structure, prioritize, and monitor each phase within their logistics systems. Building on this operational model, the following section outlines the research methodology adopted to assess the degree of attention and control applied across these processes in real-world warehouse environments (Gu et al., 2007; Ramaa, Subramanya & Rangaswamy, 2012).

Methodology

The objective of this study is to assess which activities within the warehouse process are considered by companies to be the most strategic for improving operational performance. Companies' level of interest or sensitivity toward specific process phases is monitored through reported past investments or those planned for the near future. This research aims to identify which phases of the warehouse process are most closely monitored by companies, while also drawing attention to those phases that tend to be overlooked. The proposed model offers professionals a checklist of elements to consider when conducting comprehensive performance analysis and improvement initiatives. For academic researchers, it provides a set of specific topics that can be individually explored to propose new solutions and develop improved process designs.

The study was carried out through the following steps:

Phase 1: Literature Review

A review of existing literature was conducted to define the full range of phases that make up a comprehensive warehouse process. The studies analyzed—published between 1996 and 2022—were sourced from the Web of Science and Scopus databases. Search terms were developed inductively, based on preliminary readings of articles focused on warehouse design and management. The final main keywords used were:

- “warehouse management”
- “warehouse storage automation”

Phase 2: Questionnaire Design and Field Interviews

A questionnaire was developed and distributed to supply chain and logistics managers. The initial contact was made via email, followed by direct outreach. Upon agreement, a structured interview was conducted with the manager, accompanied by an on-site visit. The visit followed, step-by-step, the activities outlined in the previously defined warehouse process model.

Phase 3: Assessment of Managerial Sensitivity to Process Phases

Inspired by Carter’s arguments regarding research relevance for managers, the literature review was complemented by interviews with industry professionals to incorporate their insights into the research agenda. Similar methods have been used by Baker and Canessa (2009), Thomas et al. (2011), and Sodhi et al. (2012), who combined literature studies with expert interviews or focus groups to define research opportunities with practical relevance. Many scholars in logistics and warehouse management work closely with practitioners in the field.

One key reason for this close collaboration between academia and industry is to enhance the managerial and practical relevance of academic research. By using both literature review and practitioner insight, future research directions are not solely based on gaps in the literature but also reflect industry needs. This dual approach allows for the proposal of more practically relevant research pathways.

A total of 25 warehouse and supply chain managers were interviewed. The interviews focused on identifying the most actively monitored and managed phases within their warehouse operations (see Appendix A in the ESM). Respondents were selected to represent a diverse range of company types, enabling the identification of common process elements across various warehouse operation contexts. The sample included managers from companies operating in sectors such as food, mechanical engineering, fashion, and furniture. Convenience sampling was used, with all participants working in northern Italy. Convenience sampling is a non-probabilistic technique in which study participants are selected based on practical criteria such as accessibility, geographic proximity, availability at a given time, or willingness to participate (Etikan et al., 2016, p. 2). Most of the participating companies operate at a global level.

The questionnaire sent by email included a series of closed questions answered using a 5-point Likert scale. The follow-up in-person interview consisted of open-ended questions, allowing respondents to freely share their perspectives. Depending on their familiarity and involvement with warehouse management issues, participants were able to explore challenges from different viewpoints. All interviews were recorded, transcribed, and shared with the respondents for approval. The confirmed transcripts were analyzed to identify the key phases of managerial oversight. To identify gaps between theory and practice, the issues reported by respondents were compared with existing literature to determine whether they had already been addressed in scholarly works. Additionally, the frequency with which these issues were mentioned was compared to the prevalence of those topics in the literature, in order to assess alignment.

Research Results

The companies involved in this study are all medium and large enterprises, as defined by the European Commission. According to Recommendation 2003/361/EC, enterprises are classified based on the number of employees and their economic scale, measured through annual turnover or total assets. Specifically, a medium-sized enterprise has fewer than 250 employees and an annual turnover not exceeding €50 million, or a balance sheet total not exceeding €43 million. Large enterprises exceed at least one of these thresholds. This classification is important not only for statistical purposes, but also for determining eligibility for funding programs, incentives, and support policies promoted at the European level. It also helps companies tailor organizational strategies based on their structure and size.

The following table lists the companies that were surveyed between mid-2023 and the end of 2024. All companies are geographically located in Northern Italy, although some operate additional warehouses or facilities in other Italian regions and abroad. The companies span various industrial sectors but are all medium- or large-sized enterprises. In addition to the number of employees (if disclosed) and reported turnover, the table includes two columns highlighting:

- WMS: This column indicates whether the company has implemented a Warehouse Management System to oversee its warehouse operations.
- Warehouse Automation: This field reports whether the company has adopted any form of warehouse automation, ranging from basic solutions such as vertical storage systems to more advanced installations like Automated Storage and Retrieval Systems (AS/RS).

The table clearly shows that WMSs are implemented across both medium and large enterprises, whereas automation solutions are primarily adopted by larger companies. Based on the interviews, the limited adoption of automation is often attributed to difficulties in calculating return on investment, or to operational constraints due to the nature of goods being stored or handled, which often lack standardization. Despite the financial incentives provided by the Industry 4.0 initiative, many firms chose to prioritize investments in production systems over warehouse optimization. On the other hand, some companies in the large-scale retail sector viewed these incentives as an opportunity to pursue automation. A key driver behind automation investments among commercial firms was the need to reduce dependency on human resource variability—both in terms of skill levels and workforce availability.

Table 1: companies involved in the research and their WMS and automation adoption

Number	Business description	Number of employees	Company dimension	Turnover	WMS	Warehouse automatio
1	Production of non-woven fabrics and related articles	n/a	LARGE	41.588.595 (2023)	YES	NO
2	Industrial laundry services	n/a	LARGE	148.261.210 (2023)	YES	NO
3	Manufacture of motors, generators and electrical transformers	n/a	MEDIUM	44.924.304 (2023)	NO	NO
4	Production of plastic packaging	n/a	MEDIUM	121.757.854 (2023)	YES	NO
5	Production of furniture for dental offices	52	MEDIUM	9.328.537 (2023)	NO	NO
6	Sheet metal processing and metal components manufacturing	183	MEDIUM	43.887.610 (2023)	NO	NO
7	Non-domestic cooling and ventilation systems	1172	LARGE	272.839.436 (2024)	YES	YES

8	Equipment for poultry farming	69	MEDIUM	17.816.500 (2023)	YES	NO
9	Manufacture of light metal packaging	n/a	MEDIUM	65.940.436 (2023)	YES	NO
10	Tanning and processing of leather	521	LARGE	318.342.384 (2023)	NO	NO
11	Wholesale trade of pharmaceuticals	1351	LARGE	2.300.661.016 (2024)	YES	YES
12	Supermarket and hypermarket chain	5102	LARGE	1.418.860.066 (2023)	YES	YES
13	Supermarket and hypermarket chain	4700	LARGE	1.400.000.000 (2023)	YES	NO
14	Tanning and processing of leather	n/a	MEDIUM	113.348.033 (2023)	NO	NO
15	Trade of iron and metal goods (hardware)	69	MEDIUM	23.484.843 (2023)	YES	NO
16	Manufacture of metal structures	62	MEDIUM	11.078.980 (2023)	YES	NO
17	Production of biscuits and pastry products	358	LARGE	60.888.111 (2024)	NO	NO
18	Manufacture of kitchen furniture	103	MEDIUM	60.724.402 (2023)	YES	YES
19	Production of industrial doors and shutters	60	MEDIUM	34.792.914 (2023)	NO	NO
20	Manufacture of metal office furniture	183	MEDIUM	36.860.646 (2023)	NO	NO
21	Production of radiators and metal containers for heating	n/a	LARGE	105.146.136 (2023)	NO	NO
22	Machines and equipment for laundries and ironing facilities	101	MEDIUM	26.592.955 (2023)	NO	NO
23	Manufacture of non-domestic refrigeration and ventilation equipment	205	MEDIUM	73.965.973 (2023)	YES	NO
24	Manufacture of other plastic products n.e.c. (not elsewhere classified)	307	LARGE	186.502.764 (2023)	YES	YES
25	Manufacture of earth-moving machinery	470	LARGE	239.000.000 (2022)	YES	NO

The questionnaires and subsequent interviews conducted with the companies enabled the creation of the following table, which assesses the actual level of interest or monitoring for each phase of the warehouse process. The data reported reflects the majority of responses received.

- Procedure Standardization: Indicates whether companies have established procedures for that phase, typically communicated through training sessions and the creation of informational documents.
- Performance Indicators: Refers to the presence of metrics specifically used to monitor the corresponding warehouse phase.
- Automation: Reflects the perceived importance of adopting automation solutions in the respective phase.
- Digitalization: Reflects the perceived importance of implementing digital solutions in the respective phase.

The following table provides a synthetic overview of the main warehouse process phases and the degree of managerial attention they receive across the surveyed companies. The evaluation is based on aggregated responses from questionnaires and follow-up interviews, reflecting the most common practices and perceptions. For each phase, the table highlights whether companies have formalized procedures, implemented performance indicators, and recognized the relevance of automation and digitalization. This framework aims to identify which phases are strategically managed and which are still underdeveloped or neglected in operational practice.

Table 2: Warehouse process and level of control of process activity

Warehouse Phase	Procedure Standardization	Performance Indicators	Automation	Digitalization
Vehicle access	No	No	No	No
Unloading	Fairly	Few	Low	No
Receiving	No	No	No	Low
Inspection and quality control	High	Many	No	Fairly

Repackaging	High	No	Low	No
Storage	Very high	Many	Very high	Very high
Replenishment	Very high	Few	Low	Very high
Order picking	Very high	Very many	Very high	Very high
Sorting (only for some companies)	Fairly	Few	Very high	Very high
Consolidation and packing	No	Few	Low	Low
Loading	Fairly	Few	Low	No
Vehicle departure	No	No	No	No

The questionnaires and subsequent interviews conducted with participating companies revealed the following insights.

Vehicle Access

Nearly all companies do not consider this phase to be a core part of the warehouse process. Only a few large distribution firms have implemented structured vehicle arrival systems, such as unloading slot reservations. To improve safety, these companies have established dedicated heavy-vehicle routes to avoid interference with pedestrians and personnel not involved in unloading operations. Drivers follow specific waiting routes and are not allowed to enter maneuvering areas. Each vehicle is registered upon arrival, and drivers are provided with conduct rules for their stay on company premises. Unfortunately, such procedures have only been fully implemented in very few cases. Most companies report difficulties in scheduling vehicle arrivals due to poor communication and collaboration with suppliers or carriers. This leads to congestion in unloading areas and queues of trucks awaiting unloading. In some cases, the lack of planning and regulation results in disorganization and chaos, which can cause operational errors.

Vehicle Unloading

The unloading phase is considered crucial for performance improvement. Companies are aware that proper infrastructure and supporting information systems can accelerate the transfer of goods from vehicles to the warehouse. Common investments include the installation of dedicated unloading bays with hydraulic platforms. Some companies have enhanced safety by installing overhead cranes in unloading zones. However, no significant adoption of automated unloading systems was observed. Key performance indicators for this phase include average vehicle unloading time, number of vehicles unloaded per day, and the number of handling units (HUs) unloaded per hour.

Receiving

Although the receiving phase is considered relatively simple, there is often a lack of formal training for personnel. Respondents noted that staff are not always trained on what to accept or reject, such as damaged or tampered goods. Without a formal receiving procedure, decisions are left to the operator's discretion. All companies dedicate appropriate space for temporary material storage, and most have differentiated areas based on material type to streamline handling. During this phase, material data is entered into the warehouse management system (WMS), making it visible to the operation. A common practice is requesting advance shipping documents from suppliers, allowing a preliminary check between purchase orders and shipped materials. This helps identify supplier errors and determine if a shipment is complete or partial. This information is passed to warehouse staff to guide acceptance decisions. The most frequently monitored KPI is the average dwell time of goods in the receiving area.

Inspection and Quality Control

Inspection activities are well-defined and assigned to trained personnel. Incoming quality inspectors are familiar with the materials and the control procedures, which are standardized and documented. Many companies use a "free-pass" system, skipping inbound inspection following agreements with reliable suppliers. Inspections are typically performed when supplier quality is inconsistent or when the product is subject to strict regulations. Controls may be performed on all items or, more commonly, on samples. Approved goods are released for subsequent operations; nonconforming goods are sent to a dedicated holding area. Performance indicators are divided into two categories: qualitative (e.g., number of nonconforming HUs and their causes) and process-control metrics (e.g., average inspection time per HU).

Repackaging

Some companies have developed formal procedures for standardizing repackaging. Most have implemented control systems to identify pallets that must be replaced due to damage or noncompliance with storage requirements. Only a few companies have automated pallet replacement. Most repackaging tasks—such as relabeling, depalletizing, or material sorting—are performed manually. No specific KPIs for this activity were reported.

Storage (Putaway)

This is one of the most closely monitored activities. Companies aim to optimize space utilization and increase storage speed. A lack of available storage space is a common challenge, especially during peak seasons, prompting some to outsource to third-party logistics providers. To address space constraints, companies have adopted solutions such as replacing storage infrastructure, using forklifts designed for narrow aisles, and investing in automated systems like vertical storage or AS/RS. In non-automated warehouses, WMS systems are considered essential for performance and for assisting operators in correct product placement. Commonly used KPIs include average saturation index (e.g., average occupied pallet positions / total pallet positions) and HUs stored per unit volume.

Replenishment

Not all companies require organized replenishment processes. However, the importance of WMS in predicting and managing replenishment—from storage to picking areas—is widely

recognized for ensuring operational continuity and avoiding delays. No performance metrics or automation investments were reported for this activity.

Order Picking

As discussed earlier, this is considered the highest priority activity for warehouse productivity. Companies dedicate significant analysis to this phase. The main goal is to complete order picking quickly, accurately, and at minimal cost. To achieve this, companies have adopted software solutions that guide operators or implement algorithms to minimize travel paths. WMS systems play a key role in managing FIFO, FEFO, and serial-number tracking. Very few companies still operate without software support for picking. Many have invested in automation, from AS/RS systems to "goods-to-person" technologies, pick-to-light systems, and fully automated solutions like A-frame systems (common in pharmaceutical warehouses). Frequently monitored KPIs include picks per hour, orders per hour, picking errors, and operator travel distance. Following the literature, companies have adopted different picking models—batch, wave, or zone picking—and have reorganized warehouse layouts and item placement to improve picking efficiency.

Sorting

Not all companies require a dedicated sorting phase. Those handling a high volume of orders have adopted or plan to adopt automated sorting systems. Performance is measured in packages sorted per hour or concurrent orders processed. Automation and digitalization are key enablers of efficiency in this phase.

Consolidation and Packing

Automation and digital solutions are still underutilized in this phase. Consolidation and packing are often performed manually. Few companies use software for pallet load simulation, and only a limited number use automated palletizers or packing machines. However, some have implemented automated stretch-wrapping machines to stabilize loads during transport. Performance indicators are scarce, typically limited to machine output (e.g., pallets packed per hour).

Outbound Quality Check

Companies apply procedures to verify load conditions, including packaging integrity and the presence of all ordered items. In some cases, weight checks are performed to ensure consistency between expected and actual shipment weights, helping to identify discrepancies. Some companies photograph packed goods before shipping to handle potential customer disputes.

Vehicle Loading

This phase mirrors unloading and shares the same considerations and challenges.

Vehicle Departure

This phase is treated in the same way as vehicle access, with similar processes and issues.

These findings offer a comprehensive overview of how companies manage and prioritize the various phases of warehouse operations, highlighting both areas of strong performance and those requiring further attention or investment. The following section presents the main conclusions drawn from the analysis and outlines potential implications for both practitioners and future research.

Conclusions

This study has highlighted several warehouse process activities that tend to be overlooked by companies. In particular, vehicle access, unloading, receiving, as well as vehicle loading and departure, are commonly perceived as phases that are not suitable for process standardization or for the application of specific technologies. This lack of awareness negatively affects warehouse performance, often resulting in bottlenecks at inbound or outbound stages.

Conversely, storage and order picking are the most closely monitored and studied phases. Most automation initiatives are aimed at better space utilization, increasing the speed of material flow, reducing errors, and enhancing the ability to prepare and ship orders efficiently. WMS implementations primarily support these functions by enabling higher warehouse saturation levels and shorter picking times.

Unsurprisingly, the company's business model significantly influences the level of control and technology adoption. For example, pharmaceutical distributors exhibit far higher levels of digitalization and automation than other industries. This is due to their need to guarantee very short lead times—typically three to four hours—and strict regulatory requirements related to traceability and temperature control, as all logistics operations must be carried out below 25°C.

In general, after 2020, companies have accelerated the digitalization and automation of their warehouses—both to ensure operational continuity disrupted by the pandemic and to take advantage of Industry 4.0 incentives and subsidies. Nonetheless, a significant number of companies still rely on traditional warehouse management practices. Not all have implemented WMS systems, and investments in fully automated warehouses remain limited to a small subset of cases.

In addition to providing a descriptive overview of a non-statistically representative sample, this study sheds light on process phases that are often neglected in the literature—namely, vehicle entry and exit. This omission poses both safety and efficiency concerns: the lack of proper planning for vehicle movement can create hazardous conditions for other vehicles, goods, and pedestrians. Furthermore, the absence of scheduling and control mechanisms for truck arrivals leads to congestion in loading and unloading areas, which in turn undermines operational performance.

The insights gained from this study offer valuable guidance for both practitioners and researchers. For logistics and warehouse managers, the findings suggest the need to broaden the focus of performance monitoring and investment to include phases that are currently undervalued—such as vehicle access and departure—due to their impact on safety, flow continuity, and overall efficiency. Establishing standardized procedures and adopting enabling technologies in these phases could help reduce risks and improve throughput.

For academics, the research highlights an opportunity to explore underrepresented areas within warehouse process studies. Future investigations could delve deeper into the operational design of inbound and outbound traffic flows, the role of yard management systems, and the integration of external transport planning into warehouse control systems. Additionally, comparative studies across different industries and company sizes could help validate and refine the framework proposed in this paper, ultimately contributing to the development of more resilient, responsive, and efficient warehouse systems.

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Appendix A

Warehouse activity	Questions
Vehicle Access	Each incoming vehicle is registered and authorized
Vehicle Access	The driver is informed where to unload
Vehicle Access	The entry route does not interfere with pedestrians or other handling equipment
Vehicle Access	Vehicle pathways are clearly marked
Vehicle Access	The driver waits for unloading in a designated safe area
Vehicle Access	Vehicle access is scheduled through time slots
Vehicle Unloading	Vehicles are unloaded using traditional equipment (forklifts, pallet jacks)
Vehicle Unloading	Unloading times for each vehicle are monitored
Vehicle Unloading	Automation solutions have been implemented to speed up unloading operations
Receiving	The receiving area is dimensioned based on statistical unloading data
Receiving	The receiving area must be cleared by a specific time
Receiving	Unloaded material is visible in the management system even if not yet quality checked
Receiving	Staff are trained to distinguish between acceptable and unacceptable materials
Receiving	A clear procedure exists for urgent products
Inspection and Quality Control	The information system manages quality control priorities and skip-lot logic
Inspection and Quality Control	Quality control does not constitute a bottleneck in the inbound goods flow
Repackaging	The information system notifies the operator of which items require repackaging
Repackaging	Repackaging is only applied to items with visibly damaged original packaging
Repackaging	What type of repackaging is most common in your company: Labeling
Repackaging	What type of repackaging is most common in your company: Replacement of damaged packaging
Repackaging	What type of repackaging is most common in your company: Sorting into new standardized packaging
Storage (Putaway)	Automatic storage systems are in place
Storage (Putaway)	Types of automatic storage systems adopted: Vertical lift modules
Storage (Putaway)	Types of automatic storage systems adopted: Automated small-parts warehouses (Miniload, Autostore)
Storage (Putaway)	Types of automatic storage systems adopted: Semi-automatic systems (e.g., mobile racking)
Storage (Putaway)	Types of automatic storage systems adopted: Pallet AS/RS systems
Storage (Putaway)	Types of automatic storage systems adopted: Shuttle-based systems
Storage (Putaway)	Storage policies are defined in advance to maximize operational efficiency
Storage (Putaway)	The entire warehouse is mapped
Storage (Putaway)	The information system provides operators with instructions on what and where to store
Storage (Putaway)	Stock levels are actively monitored
Storage (Putaway)	A dashboard is available for warehouse stock monitoring
Replenishment	The information system determines the timing for replenishing picking locations
Replenishment	Material is managed using FIFO / FEFO rules
Order Picking	Operators are assisted by digital systems during picking
Order Picking	The picking model has been optimized to minimize time
Order Picking	Picking performance is continuously monitored
Order Picking	The WMS provides the shortest picking path
Order Picking	Automatic picking systems are in use
Order Picking	Materials are brought to the operator for picking

Order Picking	Presence of Automated Guided Vehicles (AGVs)
Order Picking	Presence of Autonomous Mobile Robots (AMRs)
Order Picking	Use of Voice Picking systems
Order Picking	Installation of Pick-to-Light systems
Order Picking	Adoption of Augmented Reality (AR) systems
Sorting	An automatic sorting system is in place
Outbound Quality Control	Random outbound quality checks are performed
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