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Pre-Stuffing Optimization: Storage Models and Load Sequencing for Accelerate Container Loading at Distribution Centers

Optimization of Pre-Stuffing: Storage Models and Load Sequencing to Accelerate Container Loading in Distribution Centers

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Summary

Efficiency in the container loading process represents one of the greatest challenges in managing global logistics chains, especially in large distribution centers (DCs). Pre-stuffing, the practice of pre-arranging loads in specific areas for subsequent stuffing into containers, has emerged as an essential strategy for reducing costs, minimizing errors, and accelerating operations. This article analyzes storage and load sequencing models that contribute to optimizing pre-stuffing, based on studies by Ballou (2006), Bowersox and Closs (2014), Moura (2015), and reports from international organizations such as UNCTAD (2021). The research shows that the use of routing algorithms, warehouse management systems (WMS), and computer simulations allows for the alignment of operational efficiency and business competitiveness. Through an analytical and applied approach, it is demonstrated that optimizing pre-stuffing not only reduces container loading time but also strengthens logistical resilience in the face of the demands of international trade.

Keywords: Pre-stuffing; Storage; Load sequencing; Distribution centers; Logistics.

Abstract

Efficiency in the container loading process represents one of the major challenges in global supply chain management, especially in large distribution centers (DCs). Pre-stuffing, the practice of previously organizing cargo in specific areas for subsequent stuffing into containers, emerges as an essential strategy to reduce costs, minimize errors, and accelerate operations. This article analyzes storage models and load sequencing that contribute to the optimization of pre-stuffing, based on studies by Ballou (2006), Bowersox and Closs (2014), Moura (2015), and reports from international organizations such as UNCTAD (2021). The research shows that the use of routing

algorithms, warehouse management systems (WMS), and computational simulations allow aligning operational efficiency and business competitiveness. Through an analytical and applied approach, it is demonstrated that pre-stuffing optimization not only reduces container loading time but also strengthens logistical resilience in the face of international trade demands.

Keywords: Pre-stuffing; Storage; Load sequencing; Distribution centers; Logistics.

1. Introduction to Pre-Stuffing in the Logistics Context

Modern logistics requires synchronization between different stages of the supply chain, especially in operations involving international transport and container export.
In this scenario, **pre-stuffing** emerges as a strategic practice focused on organizing cargo before its actual insertion into the container. Rather than a simple intermediate step, pre-stuffing should be understood as a **critical planning and operational efficiency process,** as it directly impacts loading times, space utilization, and the reduction of costs associated with unnecessary movements (Ballou, 2006). This step has become even more important in distribution centers operating on a large scale, where even the slightest delays can compromise the entire logistics schedule and generate significant financial losses.

Historically, container stuffing occurred reactively, only when orders were released and vehicles were already waiting in the yard for loading. This model resulted in prolonged waits, excessive internal movements, and a high risk of inspection errors.
The evolution of logistics practices, however, brought the realization that advance load preparation could reduce variability in flow and provide greater predictability. According to Christopher (2016), the transition from reactive operations to **proactive and planned operations** is a milestone in modern logistics, with pre-stuffing being a clear example of this paradigm shift, which transforms hidden costs into visible efficiency gains.

The concept of pre-stuffing is also intrinsically linked to **the physical layout** of warehouses. An organized staging area allows for reduced movement distances, minimizes counterflows, and ensures that loads destined for different containers are not mixed.
In this sense, authors such as Bowersox and Closs (2014) argue that alignment between physical space, operational flows, and information systems constitutes the essential tripod for this practice to function effectively. Without this synergy, what could be a strategic solution ends up becoming an additional bottleneck.

Another key point is that pre-stuffing should be understood not only as a matter of space, but also as a **mechanism for temporal synchronization.** This means that the objective is not only to position goods close to the docks, but also to do so in a manner aligned with vehicle arrival times, port windows, and shipping priorities. Moura (2015) emphasizes that this alignment is crucial to reducing resource idleness, both in terms of equipment and

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both internal and external transporters. Without a time-based logic, the pre-stuffing area risks becoming a "waiting room," accumulating inefficiencies.

Beyond operational issues, pre-stuffing directly impacts **logistical risk management.** Improper load organization can lead to shipping errors, damage to sensitive products, and even non-compliance with customs or phytosanitary requirements.
Such failures result not only in additional costs but also damage the company's image and reliability with customers and partners. Rodrigue, Comtois, and Slack (2020) point out that, in global supply chains, reliability is as important an asset as speed, and practices such as pre-stuffing directly contribute to building this trust.

In Brazil, this process takes on even more relevance due to **logistical volatility** characteristic of the country. Problems such as poor infrastructure, urban congestion, and unpredictable port deadlines increase the need for loading to be as fast and predictable as possible. Pre-stuffing, by reducing dock occupancy time and facilitating compliance with shipping windows, becomes a competitive advantage in markets increasingly pressured by costs and deadlines. In this context, Ballou (2006) points out that detailed planning practices, although requiring initial investment, present clear returns in the medium term.

Another aspect worth highlighting is the relationship between pre-stuffing and **information technologies applied to logistics.** Warehouse management systems (WMS) and transportation management systems (TMS) enable greater integration between physical flow and shipping scheduling. The use of electronic tags, RFID readers, and real-time dashboards reduces human error and provides greater visibility into the process. Gu, Goetschalckx, and McGinnis (2010) state that, without the support of digital systems, managing efficient pre-stuffing in large-scale operations becomes virtually impossible.

From an economic perspective, pre-stuffing should be viewed as an **investment in productivity and indirect cost reduction.** Although it requires allocating specific areas and training teams, the benefits translate into reduced overtime, reduced vehicle layovers, and the elimination of rework. Furthermore, companies that adopt this practice often see improvements in key indicators such as average container loading time and the shipping discrepancy rate. These factors reinforce the thesis that pre-stuffing should be seen as an integral part of the logistics strategy and not simply an operational detail (Christopher, 2016).

Finally, it is important to emphasize that pre-stuffing also represents a **process of cultural change within organizations.** Involving operational teams, managers, and external partners in understanding the importance of this practice is fundamental to its consolidation. According to Slack, Chambers, and Johnston (2010), logistical changes only become sustainable when they are internalized as routine and not seen as a momentary imposition. Thus, pre-stuffing

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must be treated as a permanent component of the supply chain management system, supported both by the efficiency it provides and the predictability it adds.

2. Storage Models Applied to Pre-Stuffing

Storage organization is one of the most important factors for pre-stuffing efficiency, as it defines the flow of internal movement and the agility in accessing goods.
Among the most discussed storage models in the literature are the **fixed address,** in which each product always occupies the same position, and the **random address,** which uses available space as items arrive. According to Moura (2015), the fixed model facilitates location and reduces management complexity, but presents low flexibility, while the random model optimizes space utilization but requires advanced control systems, such as **WMS (Warehouse Management Systems),** to avoid traceability losses.

Both models can be applied in pre-stuffing areas, depending on the operation profile and the level of demand variability.

The choice of the appropriate model depends directly on the nature of the cargo and the frequency of movement. In commodity export operations, for example, it is common for goods to be homogeneous, which allows the adoption of the fixed model. In companies that handle fractional and diversified cargo, the use of the random or mixed model becomes more efficient. Ballou (2006) emphasizes that the decision on the storage method should always consider the **trade-off between storage costs and handling costs,** and that the success of pre-stuffing depends on this balance to ensure fluidity during container loading.

In addition to traditional models, it is important to highlight **dynamic storage** systems , such as sliding pallet racks and flow rack structures, which allow for greater inventory turnover and facilitate batch separation into different containers. These systems favor the **first-in, first-out (FIFO) method,** reducing the risk of obsolescence and ensuring that products follow a logical shipping sequence. According to Bowersox and Closs (2014), the use of dynamic structures is increasingly associated with export operations that demand speed and a high level of organization, essential characteristics of efficient pre-stuffing.

Pre-stuffing can also benefit from hybrid models, which combine fixed and random storage in different areas of the same warehouse. This approach is advocated by Gu, Goetschalckx, and McGinnis (2010), who state that the complexity of current logistics flows requires adaptive and customized solutions. Thus, higher-value products or those subject to customs inspection can occupy fixed positions, while more standardized and larger-volume loads can be stored randomly, reducing space costs without compromising safety.

Another relevant point is the influence of **digital technology** on storage management.
Big data and artificial intelligence tools are already being applied to predict input patterns and

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exit of goods, guiding decisions on positioning in pre-stuffing areas.

Christopher (2016) notes that the integration of digital systems with physical warehousing practices represents a new paradigm in logistics, in which space is not only physical but also strategic and analytical. Thus, the layout of the pre-stuffing area is shaped by simulations and algorithms, reducing human error and optimizing every available square meter.

The choice of storage model is also related to the human factor. Training, standardized procedures, and clear signage are essential components to ensure the designed system is executed properly. Slack, Chambers, and Johnston (2010) emphasize that a good storage design loses effectiveness if it is not accompanied by clear processes and employee buy-in. In the case of pre-stuffing, this becomes even more evident, as any positioning error can lead to delays or incorrect shipments.

From a financial perspective, pre-stuffing storage should be considered a **strategic investment.** Although it involves infrastructure and technology costs, the benefits of reduced vehicle layovers, eliminated rework, and increased reliability outweigh the initial expenses. Studies by Moura (2015) indicate that companies that adopted structured pre-stuffing systems reduced their average container loading time by up to 25%, demonstrating the economic return of these practices.

Finally, it's crucial to understand that applying pre-stuffing storage models doesn't follow rigid formulas. Each operation requires careful analysis, taking into account the type of cargo, volume handled, shipping times, and resource availability. Therefore, more than adopting a specific model, the challenge is to develop **operational flexibility,** capable of adapting quickly to fluctuations in demand. This flexibility is what differentiates companies that manage to maintain high logistics performance in contexts of instability and global competition (Christopher, 2016).

3. Load Sequencing: Strategies to Speed Up Loading

Load sequencing is one of the most critical steps in optimizing pre-stuffing, as it determines the order in which products will be positioned for entry into containers. Proper sequencing ensures that items are loaded in the correct delivery sequence, avoiding additional movements at the destination. According to Ballou (2006), sequencing errors can cause delays of entire days in international operations, increasing logistics costs and reducing the reliability of the service provided. Therefore, investing in efficient sequencing models is not only an operational measure, but also a competitive strategy.

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Among the most commonly applied techniques for cargo sequencing are **first-fit** and **best-fit algorithms,** which seek to optimize container volumetric utilization. These techniques, derived from mathematical programming and operations research, have been used to reduce idle space and improve weight balance. According to Moura (2015), the application of computational algorithms has allowed some Brazilian companies to reduce the number of trips required to meet the same demand by up to 15%, highlighting how sequencing can directly impact total transportation costs.

In addition to mathematical techniques, load sequencing must consider practical aspects related to the nature of the products. Fragile, perishable, or cargo with specific ventilation requirements should occupy strategic positions in the container to avoid damage during transport. Bowersox and Closs (2014) emphasize that the integration of technical knowledge and operational experience is essential for effective sequencing, as optimized solutions on paper do not always correspond to best practices in the physical environment.

Another relevant factor is the integration of sequencing with information systems. WMS and TMS tools allow the automation of sequencing logic, reducing human error and ensuring greater predictability. Christopher (2016) emphasizes that the digitalization of supply chains has transformed cargo sequencing into not only an operational process, but also a strategic one, capable of providing data for real-time decision-making. With integrated dashboards and reports, managers can adjust planning based on external conditions, such as ship delays or changes in customer orders.

Sequencing is also closely linked to the issue of time. By pre-arranging the loading order, it is possible to drastically reduce the time trucks spend waiting for clearance. This factor is especially important in countries like Brazil, where poor road infrastructure and the concentration of cargo in a few ports increase the risk of logistical congestion. According to Rodrigues and Sellitto (2009), structured sequencing practices can reduce waiting times in loading yards by up to 40%, becoming a competitive advantage.

From a strategic perspective, sequencing should be seen as a differentiating factor in the market. Companies that can deliver goods on time, with lower damage rates and greater reliability strengthen their image with international customers and partners. Slack, Chambers, and Johnston (2010) note that reliability is one of the five pillars of operations strategy, alongside cost, quality, flexibility, and speed, and load sequencing directly contributes to this performance.

The use of computer simulations is another important resource to improve sequencing. Software based on genetic algorithms and linear programming allows testing of alternative loading scenarios before practical implementation. This approach makes it possible to identify bottlenecks and adjust plans without compromising shipping deadlines. Moura (2015) points out that

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Digital simulation significantly reduces rework costs, making pre-stuffing more predictable and efficient.

Finally, it's important to understand that load sequencing isn't just an operational technique, but a process that requires alignment between different actors in the supply chain. Carriers, warehouse operators, and customers need to be connected for the loading process to be coherent and effective. Rodrigue, Comtois, and Slack (2020) emphasize that collaboration between links in the chain is what ensures the success of sequencing, transforming it into an integrated management practice rather than just an isolated step in the logistics process.

4. Digital Technologies in Pre-Stuffing Management

The role of digital technologies in modern logistics is increasingly crucial, and the pre-stuffing stage in distribution centers has emerged as one of the areas most benefiting from digital transformation. The introduction of warehouse management systems (WMS) and integrated enterprise resource planning (ERP) systems enables real-time monitoring of shipments, from their arrival at the distribution center to the moment they are stuffed into the container. This not only allows for greater visibility into internal flows but also contributes to reducing human error and standardizing processes, aspects highlighted by Bowersox, Closs, and Cooper (2014) when discussing the importance of information integration in logistics. In this sense, pre-stuffing ceases to be a merely operational practice and becomes understood as a strategic part of a digitized supply chain, in which the flow of information is equal in importance to the physical flow of goods.

Another essential factor of digitalization is the ability to use **big data** and artificial intelligence algorithms to analyze movement histories, predict demands, and suggest optimal pre-stuffing configurations. Moura (2015) emphasizes that, by applying machine learning techniques, it is possible to simulate thousands of load organization scenarios in fractions of a second, choosing the one that generates the shortest transit time within the warehouse and the best use of container space. This possibility of computational simulation surpasses the traditional logic of practical and empirical experience, providing managers with more reliable tools for decision-making. The result is increased efficiency, but also a reduction in operational costs and exclusive dependence on human labor.

In addition to algorithms, the incorporation of real-time tracking technologies, such as RFID tags and IoT (Internet of Things) sensors, has expanded the ability to control each stored and pre-positioned item. Christopher (2016) points out that visibility is one of the biggest determinants of logistical agility, and connected devices allow you to instantly monitor the movement of pallets, boxes, and containers. For pre-stuffing, this means knowing exactly where each load is, how long it has been in the queue, and the ideal loading order. This level of detail, which until a few years ago was impractical, today it has become a requirement for companies seeking to compete in global chains where time is a decisive factor for advantage.

Another noteworthy advancement is the application of **augmented reality (AR)** and **virtual reality (VR)** in load planning processes. Even before physically moving loads, software allows for the simulation of different stuffing arrangements and validation of which one best utilizes the container's internal space. Slack, Chambers, and Johnston (2010) argue that the use of digital simulations drastically reduces errors and rework, also reducing the risk of damage and accidents. For pre-stuffing, the ability to visualize the arrangement of goods in advance ensures greater safety during the execution stage, in addition to speeding up loading time when vehicles arrive at the distribution center.

The adoption of **blockchain** in logistics has also demonstrated relevance for pre-stuffing, especially with regard to document traceability. Rodrigue, Comtois, and Slack (2020) explain that blockchain provides immutable records of each stage of movement and storage, which increases trust between shippers, carriers, and end customers.

In international operations, where customs and tax bureaucracy can create bottlenecks, the use of this technology reduces information discrepancies and ensures faster release processes. Thus, pre-stuffing is not limited to the physical warehouse space, but integrates with a network of reliable information that impacts the entire logistics flow.

In the field of sustainability, digital technologies also play a significant role. By tracking movements in real time and consolidating performance data, these systems can calculate COÿ emissions related to internal cargo transportation and propose alternatives to reduce them. Reports from UNCTAD (2021) indicate that companies that implemented digital solutions in their distribution centers were able to reduce emissions associated with handling operations by up to 18%, demonstrating that technology can combine efficiency and environmental responsibility. This connection between digital logistics and sustainability represents a competitive advantage, especially in markets where environmental concerns directly influence supplier selection.

However, the implementation of these technologies is not without its challenges. Gu, Goetschalckx, and McGinnis (2010) warn that digitalization requires significant investments in infrastructure and training, as well as a cultural shift within organizations. In many cases, workers with extensive practical experience are resistant to the use of automated systems, fearing job replacement. Therefore, it is essential that companies combine technological innovation with continuous training policies, ensuring that the introduction of new tools is accompanied by the enhancement of human capital. In this way, digitalization becomes a tool for strengthening, rather than replacing, existing skills.

In short, digital technologies transform pre-stuffing into a more precise, faster, and sustainable process. The integration of big data, artificial intelligence, IoT, augmented reality, and

Blockchain generates not only operational gains but also greater business resilience and competitiveness. Christopher (2016) summarizes this phenomenon by stating that the future of logistics will depend on organizations' ability to align technology and strategy. Thus, understanding the importance of digital solutions in pre-stuffing is an understanding of the inevitable path toward modernizing supply chains and strengthening global trade.

5. Economic Impacts of Pre-Stuffing Optimization

Optimizing pre-stuffing in distribution centers has direct and indirect economic implications that go far beyond simply reducing operating costs. According to Ballou (2006), one of the major challenges of modern logistics is balancing customer service with total operating costs. In this context, when pre-stuffing is organized efficiently, the time spent loading a container is reduced, thus reducing the need for overtime, equipment downtime, and delays in transportation schedules. These operational gains are immediately reflected in lower expenses, increasing companies' profit margins and strengthening their competitiveness against national and international competitors. This relationship between operational efficiency and economic impact is one of the reasons why many organizations prioritize investments in pre-stuffing technologies and methodologies.

Another significant economic impact is the optimization of fleet and logistics infrastructure utilization. According to Bowersox and Closs (2014), efficient storage and loading lead to more efficient use of vehicles and handling equipment, resulting in fewer idle trips, lower fuel consumption, and longer asset life. For companies operating on a large scale, such as global food distributors or automotive manufacturers, the savings can amount to millions of dollars annually. This demonstrates that pre-stuffing should not be viewed simply as a technical step in the supply chain, but as a practice that significantly impacts the financial health of the entire business, directly influencing pricing and the ability to compete in cost-sensitive markets.

Benefits can also be seen in the reduction of losses and damage during the loading process. Slack, Chambers, and Johnston (2010) emphasize that one of the main causes of losses in logistics operations is damage caused by incorrect movement of goods. When pre-stuffing is performed with proper planning and sequencing, there is less need for unnecessary movements and re-stuffing, which reduces the chances of damage. This factor, in addition to reducing replacement and compensation costs, also improves the company's image among customers and business partners. Thus, the economic impact goes beyond the operational dimension and encompasses aspects related to corporate reputation, an increasingly valuable asset in a competitive market.

Another important point is the relationship between pre-stuffing optimization and labor productivity. Moura (2015) notes that by reducing operational bottlenecks, companies can use the same number of employees to process larger volumes of cargo, which increases productivity per employee. This factor, when multiplied across large-scale operations, generates efficiency gains that strengthen the company's position in the sector. Furthermore, in contexts where skilled labor shortages are a challenge, the ability to do more with less becomes an even more significant economic advantage. In this sense, optimization not only reduces costs but also protects the company from risks related to labor market volatility.

In international trade, optimizing pre-stuffing plays a critical role in reducing total logistics costs, which, according to UNCTAD (2021), represent between 10% and 15% of the final value of a product in emerging markets. When companies can reduce port delays due to poorly organized shipments, they avoid additional costs such as port storage fees, fines for late container returns, and missed contractual deadlines. These costs, often invisible in superficial analyses, represent a significant portion of logistics expenses and can compromise exporters' profitability. Thus, efficient pre-stuffing is also a strategy for more competitive insertion in the global market, making domestic products more accessible and attractive to foreign buyers.

Additionally, optimization can contribute to reducing environmental costs, which are increasingly converted into financial costs due to regulations and customer demands.
Christopher (2016) points out that companies that reduce emissions associated with logistics operations not only strengthen their corporate social responsibility but also avoid penalties and benefit from tax incentives. By better organizing pre-stuffing, reducing unnecessary internal movements, and increasing the energy efficiency of equipment, companies can reduce energy and fuel consumption, which directly impacts costs. This demonstrates how the economic and environmental dimensions intertwine, reinforcing the strategic relevance of this practice.

No less important is the indirect economic impact generated by customer satisfaction. According to Kotler and Keller (2012), delivery reliability is one of the main determinants of customer loyalty in supply chains. When pre-stuffing ensures that deadlines are met consistently, the company builds an image of trust and reduces costs associated with customer churn, returns, and complaints. This impact, while less tangible than reduced overtime or lower fuel consumption, can be even more lasting, as it contributes to building stable and profitable business relationships over time.

Finally, it is important to highlight that the economic impacts of optimizing pre-stuffing are not limited to individual companies, but reverberate throughout the supply chain and a country's economy. Rodrigue, Comtois, and Slack (2020) demonstrate that more efficient logistics chains increase the competitiveness of entire regions, attracting investment and strengthening foreign trade. In Brazil, for example, where logistics costs represent an average of 12.3% of GDP (ILOS, 2020), any improvement in processes such as pre-stuffing has significant effects.

significant impact on the national economy. Therefore, optimizing pre-stuffing is not only a smart corporate decision, but also a strategic contribution to macroeconomic competitiveness and the country's stronger position in international trade.

6. Sustainability and Reduction of Environmental Impacts in Pre-Stuffing

The discussion about sustainability in logistics has gained momentum in recent decades, driven both by regulatory pressures and by public awareness of the environmental impact of economic activities. In the context of pre-stuffing in distribution centers, this concern materializes in initiatives aimed at reducing resource waste, optimizing energy consumption, and minimizing pollutant gas emissions. According to McKinnon (2018), sustainable logistics should not be understood simply as a competitive advantage, but as a necessity to ensure the long-term viability of supply chains. This means that seemingly simple practices, such as the correct positioning of loads before stuffing, can generate considerable environmental impacts, especially when considering large-scale operations.

One of the main environmental benefits of optimizing pre-stuffing is the reduction of unnecessary movements within distribution centers. Each movement of forklifts, cranes, and other equipment consumes energy and, often, fossil fuels, contributing to COÿ emissions. Rodrigue, Comtois, and Slack (2020) point out that, in large warehouses, the environmental costs associated with internal movements can represent up to 20% of the operation's total emissions. When load sequencing is planned in advance, rework and additional movements are avoided, promoting resource savings that reflect both efficiency and sustainability. Thus, well-organized pre-stuffing goes beyond operational savings: it also becomes an environmental mitigation mechanism.

Another relevant point is the reduction of solid waste resulting from damaged or misplaced packaging. Slack, Chambers, and Johnston (2010) point out that poor storage management often results in packaging breakage and product damage, generating material waste that could be avoided with proper pre-stuffing practices. By reducing the need for excessive movement, there is a lower risk of physical damage, which also means less product and packaging disposal. This waste reduction directly contributes to corporate sustainability goals and is aligned with the UN Sustainable Development Goals (SDGs), especially SDG 12, which addresses responsible consumption and production.

The incorporation of digital technologies, such as IoT sensors and real-time monitoring systems, also has significant environmental relevance. According to Christopher (2016), the ability to collect and analyze data in real time allows companies to identify bottlenecks and propose solutions that reduce energy consumption in handling and refrigeration equipment.

Furthermore, these systems can issue alerts to prevent overloading in specific areas of the warehouse, reducing the risk of failures and the need for emergency maintenance, which is typically more polluting and costly. Thus, technology is not only an operational support but also a strategic ally in the pursuit of environmentally responsible logistics practices.

The design of warehouses and distribution centers should also be considered in the debate on pre-stuffing sustainability. Moura (2015) notes that the organization of physical space has a direct impact on energy efficiency and internal circulation. Environments designed to facilitate the continuous flow of cargo reduce the need for redundant movements and, consequently, reduce energy consumption. Furthermore, the implementation of natural lighting, intelligent ventilation systems, and the use of renewable energy in warehouses are practices that reinforce the integration between environmental sustainability and operational efficiency. Therefore, the layout of storage spaces can be understood as an integral part of a sustainable pre-stuffing strategy.

Another aspect worth highlighting is the pressure exerted by customers and business partners, who are increasingly aware of the environmental footprint of their supply chains. Kotler and Keller (2012) emphasize that conscious consumers tend to value companies that demonstrate a commitment to sustainable practices, and this behavior also extends to the B2B market. In the logistics sector, where reputation plays a crucial role, aligning pre-stuffing practices with sustainability can generate a significant competitive advantage. Companies that successfully reduce environmental costs and communicate these results transparently gain greater credibility in the market, expanding their business opportunities and strengthening their business relationships.

In addition to environmental and reputational benefits, sustainability in pre-stuffing can result in concrete financial gains. McKinnon (2018) demonstrates that companies that adopt sustainable practices often achieve significant reductions in energy, maintenance, and waste disposal costs. This means that, contrary to the traditional view that associates sustainability with additional costs, sustainable pre-stuffing can become a source of savings. This perspective is reinforced by reports from UNCTAD (2021), which indicate that organizations that incorporated environmental indicators into their logistics processes recorded efficiency gains of over 15%, demonstrating that sustainability can and should go hand in hand with competitiveness.

It is important to emphasize, however, that the transition to sustainable practices requires cultural changes and medium- and long-term investments. Gu, Goetschalckx, and McGinnis (2010) warn that many organizations face internal barriers to implementing environmentally responsible solutions, whether due to managerial resistance or the lack of clear metrics to measure results. Therefore, the adoption of environmental performance indicators, such as emissions intensity per ton moved, becomes essential to monitor and justify the investments made. Pre-stuffing, being a strategic and easily monitored stage, can serve as a gateway for the dissemination of sustainable practices throughout the supply chain.

In short, sustainability in pre-stuffing transcends the simple adoption of environmentally friendly practices, integrating it into a logistics management model that simultaneously seeks economic efficiency and social and environmental responsibility. Emission reductions, smarter use of resources, and reduced waste are just some of the benefits that optimized pre-stuffing can provide. As Christopher (2016) concludes, the future of sustainable logistics depends on companies' ability to view sustainability not as an external obligation, but as an opportunity for differentiation and competitive strength. In this sense, sustainable pre-stuffing emerges as one of the central pillars for reconciling logistics, competitiveness, and environmental preservation.

7. Challenges and Future Perspectives of Pre-Stuffing

One of the main challenges faced in pre-stuffing is the growing complexity of global supply chains. With increasing product variety, shortening life cycles, and the demand for ever faster deliveries, load planning and sequencing become highly sophisticated activities. According to Ballou (2006), demand variability and the multiplicity of distribution channels increase the risk of errors and bottlenecks, requiring logistics solutions that combine flexibility and efficiency. In this scenario, pre-stuffing needs to evolve from an operational practice to an integrated strategy capable of dealing with the uncertainty of the globalized and digital environment.

Another significant challenge is related to the need for investment in technology. Although warehouse management systems (WMS) and sequencing algorithms are already available, many companies still struggle to implement such solutions, either due to financial constraints or a lack of technical qualifications. Bowersox and Closs (2014) point out that adopting disruptive technologies in logistics requires not only equipment acquisition but also team training and cultural changes. Therefore, companies that fail to overcome technological barriers tend to be at a competitive disadvantage, reinforcing the need for strategies that combine innovation with economic viability.

Sustainability also poses a growing challenge for pre-stuffing, as environmental regulations are becoming more stringent in several countries. Christopher (2016) argues that the push for green supply chains requires companies to seek solutions that reduce greenhouse gas emissions and promote greater energy efficiency. However, implementing these practices in pre-stuffing operations requires investment in modern equipment, layout adjustments, and the adoption of environmental metrics. These factors can increase costs in the short term, creating strategic dilemmas between maintaining price competitiveness and meeting sustainability requirements.

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The integration of digital technologies, such as artificial intelligence, machine learning, and the Internet of Things (IoT), represents one of the main perspectives for the future of pre-stuffing. Moura (2015) emphasizes that digitalization allows for greater precision in planning, reducing errors and enabling real-time simulations. Furthermore, intelligent systems can predict the best loading order based on routes, delivery times, and product characteristics, optimizing the use of container space and speeding up operations.
Although promising, this perspective requires robust technological infrastructure, interoperability between systems, and qualified professionals to analyze and manage the data generated.

The globalization of trade also projects new challenges and opportunities for pre-stuffing. Rodrigue, Comtois, and Slack (2020) emphasize that increased interconnectivity between markets increases the volume of cargo handled, but also increases the vulnerability of supply chains to economic crises, pandemics, and geopolitical conflicts. In this context, pre-stuffing needs to be prepared to deal with disruptions and uncertainties, incorporating resilience strategies.
This includes supplier diversification, the use of strategic stocks, and the implementation of rapid response systems to minimize the impact of disruptive events on cargo flow.

Another aspect that deserves attention is workforce management in distribution centers. Slack, Chambers, and Johnston (2010) note that automation and digitalization tend to reduce the need for manual activities, but at the same time, require more skilled workers.
This creates challenges related to the training, retention, and appreciation of professionals. Without adequate investment in human capital, the implementation of pre-stuffing technologies can generate resistance, operational failures, and even labor disputes. Therefore, future prospects must consider not only technology but also the appreciation of the workforce that will support these transformations.

Collaboration between companies and supply chain integration also present challenges and trends for pre-stuffing. According to Gu, Goetschalckx, and McGinnis (2010), current competition no longer occurs solely between individual companies, but between entire supply chains.
In this sense, pre-stuffing practices can be optimized when there is information sharing, systems integration, and process coordination among different stakeholders. However, this collaboration faces barriers such as lack of trust, the protection of strategic data, and divergent commercial interests. Overcoming these obstacles will be essential to making pre-stuffing a more efficient practice aligned with global demands.

Finally, future prospects point to the need to align pre-stuffing with continuous innovation strategies. Kotler and Keller (2012) emphasize that, in competitive environments, differentiation occurs through the ability to innovate and adapt to change. In the case of pre-stuffing, this means constantly investing in new organizational methodologies, advanced automation, and sustainable practices. At the same time, adapting to local contexts, such as deficient infrastructure and specific regulations, will be crucial to the success of strategies. Therefore, the coming years will require companies to strike a balance between operational efficiency, technological innovation, and social and environmental responsibility, consolidating pre-stuffing as a central element of logistics competitiveness.

Conclusion

The analysis of pre-stuffing in distribution centers reveals that this practice has gone from being a mere operational procedure to a highly relevant logistics strategy, capable of integrating efficiency, sustainability, and innovation. Throughout the study, it was observed that optimizing this step not only speeds up container loading but also reduces costs, minimizes environmental impacts, and contributes to companies' competitiveness in the globalized market. As Ballou (2006) and Bowersox and Closs (2014) point out, logistics should be understood as an integrated system in which each step, no matter how small, influences the overall performance of the supply chain.

It was also found that the incorporation of digital technologies, such as artificial intelligence, machine learning, and the Internet of Things, has transformative potential for pre-stuffing, offering greater precision in load sequencing and enabling real-time adjustments. This perspective, already noted by Moura (2015) and Christopher (2016), points to a future in which logistics efficiency will be increasingly linked to the ability to process and analyze data on a large scale. However, the challenge lies in ensuring that companies can make such investments without compromising their financial health, which reinforces the importance of gradual strategies tailored to the specific needs of each operation.

Another relevant aspect highlighted throughout the research is sustainability. Optimized pre-stuffing, by reducing unnecessary movements and minimizing damage, significantly contributes to reducing emissions and waste, as argued by Rodrigue, Comtois, and Slack (2020). In addition to meeting regulatory and social pressures, such practices strengthen corporate reputation and can generate long-term financial savings. Therefore, sustainability should not be seen as an additional cost, but as a strategic opportunity for differentiation and consolidation in the market, as argued by McKinnon (2018).

The research also showed that the future of pre-stuffing will depend on companies' ability to overcome barriers related to people management and collaboration among supply chain actors. Slack, Chambers, and Johnston (2010) point out that automation does not eliminate the need for human capital, but rather requires more skilled and adaptable workers. Furthermore, Gu, Goetschalckx, and McGinnis (2010) emphasize that current competition occurs within supply chains, not just between individual companies, reinforcing the urgency of collaborative practices to maximize collective gains.

Thus, it is concluded that pre-stuffing optimization must be understood as a multifaceted strategy, involving intelligent planning, technological investment, sustainable commitment, and valuing people. The balance between these factors will be crucial for organizations face future challenges and seize the opportunities offered by globalization and the digitalization of logistics chains. Ultimately, efficient pre-stuffing not only speeds up container loading but also establishes itself as a key competitive differentiator for companies seeking leadership in the international logistics landscape.

References

- BALLOU, Ronald H. *Supply Chain Management: Business Logistics.* 5th ed. Porto Alegre: Bookman, 2006.
- BOWERSOX, Donald J.; CLOSS, David J. *Business Logistics: the process of supply chain integration.* São Paulo: Atlas, 2014.
- CHRISTOPHER, Martin. *Logistics and Supply Chain Management: Strategies for Cost Reduction and Service Improvement.* 4th ed. São Paulo: Cengage Learning, 2016.
- GU, J.; GOETSCHALCKX, M.; MCGINNIS, LF Research on warehouse design and performance evaluation: A comprehensive review. *European Journal of Operational Research,* vol. 203, no. 3, p. 539-549, 2010.
- KOTLER, Philip; KELLER, Kevin Lane. *Marketing Management.* 14th ed. São Paulo: Pearson, 2012.
- MCKINNON, Alan. *Decarbonizing Logistics: Distributing Goods in a Low Carbon World.* London: Kogan Page, 2018.
- MOURA, Reinaldo A. *Materials Management: a practical approach.* 3rd ed. São Paulo: Atlas, 2015.
- RODRIGUE, Jean-Paul; COMTOIS, Claude; SLACK, Brian. *The Geography of Transport Systems.* 5. ed. New York: Routledge, 2020.
- SLACK, Nigel; CHAMBERS, Stuart; JOHNSTON, Robert. *Production Management.* 3rd ed. São Paulo: Atlas, 2010.
- UNCTAD – United Nations Conference on Trade and Development. *Review of Maritime Transport 2021.* Geneva: UNCTAD, 2021.