

Inventory Costs Analysis through lean concepts in the Mattress Industry

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Abstract: Successful inventory management is essential in the mattress business because of problems of fluctuating demand, high storage capacity, and supply chain complexity. Inefficient inventory management is sure to bring about expensive storage, stockouts or overstocking, affecting profitability and customer satisfaction. This study considers the existing practice of inventory management in the mattress business, following major challenges and opportunities for enhancing efficiency.

The paper cites some inventory control methods such as Just-in-Time (JIT), Economic Order Quantity (EOQ), and vendor-managed inventory (VMI), and their potential applications for mattress makers and retailers. It also specifies the technology role to enhance inventory management, i.e., demand forecasting solutions, real-time tracking by means of IoT, and Enterprise Resource Planning (ERP) software. Drawing comparisons between industry trends and case studies, the research emphasizes the worth digital solutions bring in reducing costs, improving stock accuracy, and optimizing supply chain coordination.

Besides, the paper also recommends pragmatic steps, such as predictive analytics for demand forecasting, automated warehouse management, and environmentally friendly inventory practices. The research identifies that implementing a strategic and technology-based approach to operations can make the inventory more efficient, maximize the utilization of resources, and enhance business competitiveness in general. The research is an important reference guide for manufacturers, suppliers, and retailers to streamline the inventory functions and better meet market demands.

Keywords— Mattress, inventory management, inventory efficiency, lean concept, tally software, clearance stock, reorder point

I. INTRODUCTION

The mattress market is an important one in the consumer products segment as it caters to various consumer requirements such as cost, comfort, and health. The complex process of inventory management in the company includes raw material procurement, production planning, warehousing, and product distribution. Successful

inventory management equates supply with demand so as not to result in overstocking but also not cause shortages. Companies adopt diverse practices such as real-time monitoring, ABC analysis, and Just-in-Time (JIT) ideologies to ensure ideal levels of inventory. Inventory control plays a paramount role within the bedding sector due to quality product output and on-time delivery. Companies can trace material, auto-re-stock, and forecast demand into the future using more modernized systems such as Enterprise Resource Planning (ERP) and Integrated Management Systems (IMS). Inventories are computerized with latest-generation inventory control software that helps firms gain a competitive edge, cut costs, and enhance customer satisfaction.

This discussion views the application of lean practices in calculating the cost of inventories within the mattress industry, examining how the application of strategies such as Just-in-Time (JIT) minimizes cost and improves the effectiveness of operations.

By reducing excess inventory and aligning production with customer demand, mattress companies can reduce the cost of storage, prevent waste, and satisfy customers earlier. Leanness also encourages a culture of continuous improvement, which forces companies to innovate and react quicker in a changing environment. To a greater extent, environmentally friendly practices are now given more importance while handling inventories. To remain in line with environmental demands and customer need, mattress businesses have begun to pay attention to recyclable products, eco-friendly products, and waste reduction processes. By using innovative inventory management strategies, mattress businesses can maximize profit, improve efficiency, and facilitate a sustainable value chain. The results of the current research lead manufacturers toward sustainable development by adopting efficient inventory management.

II. PROBLEM STATEMENT

The mattress industry has inventory control problems because its products are extremely large, its demand patterns vary, and it relies on multiple raw materials such as foam, fabric, and springs. Ineffective inventory management incurs excess costs, clogged warehouses, and

inability to meet customer needs. The business's seasonal demand pattern and low product shelf life add complexity to stock level control. Traditional inventory practices are likely to overlook these specific needs, and thus issues like excess, shortages, and waste. Excess inventory is more expensive to hold and ties up working capital, whereas shortages can lead to disruption of the supply chain and reduced customer satisfaction. In addition, growing sustainability and cost-consciousness have heightened the need for lean inventory practices, i.e., JIT systems, that save waste but rely on good suppliers and strong logistics networks. New technologies, such as automated inventory systems, forecast tools, and IoT-based monitoring, bring new options to make inventory management in the mattress sector even more efficient.

However, the application of these technologies is uneven, especially in the emerging economies, due to shortages of capital, culture of resistance, and deficiency in proper technical capabilities. All these challenges are compounded by external factors including raw material shortages, rising operation costs, and supply chain problems at the global level. Overcoming such challenges is important to increase operations efficiency, reduce costs, and increase the competitiveness of mattress companies overall. This study is intended to review current inventory management practice, identify key challenges, and look at new ways of enhancing inventory control, reducing waste, and optimizing supply chain performance. By bridging the gap between theoretical concepts and real-world applications, this study is intended to provide practitioners' experiential insights.

III. OBJECTIVES

For supply chain functions to be maximally efficient and cost-effective, efficient inventory management is crucial. Keeping the right volume of goods in inventory to meet demand without resulting in shortages or excesses is enabled through optimisation of inventory levels. Demand planning, Economic Order Quantity (EOQ), and Just-in-Time (JIT) inventory are some of the methods that provide for this balance. Priority items are listed using ABC analysis, and interruptions are avoided using safety stock management. These actions assist in on-time order delivery, reduced carrying costs, improved cash flow, and enhanced customer satisfaction.

Lean thinking enhances stock processes by eliminating waste and enhancing productivity. Proper stock system is maintained by the 5S process (Sort, Set in Order, Shine, Standardise, Sustain), which also reduces inefficiencies. Through managing stock replenishment based on actual demand, kanban systems prevent overproduction. Value Stream Mapping (VSM) maximizes supply chain processes by identifying bottlenecks. Problem-solving culture and effective culture is developed by Kaizen, which is continuous improvement.

Lean practices and strategic inventory management can be used together to assist companies in saving money, enhancing turnaround time, and creating a more efficient workplace. Additional research can explore how automation and AI-based analytics enhance the productivity of employees and inventory optimization.

IV. LITERATURE REVIEW

In 2018, Gupta, A., and Sharma, M. reviewed sustainability initiatives in India's mattress sector, reporting on existing practices and future directions. Their study assessed the efforts of mattress companies to improve recycling, reduce waste, use environmentally friendly materials, and reduce their carbon footprint. The results indicated increasing consumer demand for sustainable products and increased awareness of environmental concerns among industry players. But due to financial, complex supply, and shortage-of-capability-related issues, the adoption of sustainability values went beyond a couple of companies at a mass level. The research indicates that the policy makers, nature conservancy NGOs, and industry actors need to come together and support green practices in Indian mattress companies.

S. Verma and A. Kumar in 2019 made a comparative analysis to study how competitive strategies were applied and how rival brands positioned the brand in Indian mattresses. Their study examined determinants of market share and brand image, including price policy, product differentiation, brand image, and promotion. The findings showed differences in brand positioning strategies across various markets where inexperienced players addressed niche markets with innovative products and penetration promotion, and established players emphasized premium services. The study provides valuable insights to players in the market to craft sound brand positioning strategies and compete favourably in the Indian mattress market.

Cristoforetti, de Araujo, and Cherri (2020) study focuses on the combination of cutting stock and lot-sizing problems in the mattress market to optimize output and usage of material. The research focuses on minimizing cuts of raw materials to curb waste and ensuring the balance of manufacturing efficiency and stock control. By integrating these issues, the proposed mathematical model minimizes costs, maximizes resource utilization, and facilitates production planning. In the application to the mattress manufacturing sector, the model has significant implications in controlling production limitations and uncertain demand. The study offers valuable insights with the aim of optimizing operation efficiency in manufacturing industries.

Rivera Perez investigated in 2022 how Puerto Rican mattress producers coped with issues brought about by low demand. The industry is confronted by economic pressures, changing consumer tastes, as well as

competition forces, the report says. Since qualitative analysis, the research formulates effective strategies that include cost-reduction initiatives, product line diversification, and internet marketing for the promotion of customer interactions. The findings also suggest that maintaining profitability during the low-demand times calls for innovation, planning, and responsiveness. The research provides actionable advice for mattress companies to become more competitive and resilient in business.

Sihle Mankazana and Sambil Charles Mukwakungu examine how the Just-in-Time (JIT) inventory management affects the performance of suppliers in the mattress manufacturing industry in South Africa. In their article, they identify JIT as a lean philosophy that aims at minimizing inventories, wastage, and maximizing production efficiency. It focuses on the importance of coordination among suppliers on delivery timing and efficient operation. The study finds constraints such as unreliable supply chains and inadequate infrastructure, but it illustrates how JIT enhances cost-effectiveness, resource use, and reliability of suppliers. The findings are informative in improving inventory practice in South Africa's manufacturing industry.

Mankazana and Mukwakungu (2018) investigate the impact of the Just-in-Time (JIT) system of inventory management on supplier overall performance in the South African bed mattress production sector. JIT is researched as a technique that helps reduce wastage, achieves optimal inventory levels, and enhances organizational efficiency by aligning the production flow with supply chain flows. The impact of the implementation of JIT on the supplier performance in terms of timely delivery, cost reduction, and quality improvement is discussed. The research also identifies issues like infrastructure constraints and supply chain disruption. Overall, the research suggests the need for suppliers' cooperation and customized JIT processes to improve industrial efficiency and competitiveness.

Agarwal, R., & Gupta, S. (2018). Agarwal and Gupta conducted a comprehensive market survey of consumer behavior in India's mattress market. The research employed quantitative as well as qualitative research approach to gather data on consumers' behaviour, purchasing motivations, and brand perceptions. Results revealed increasing demand for specialty mattresses among Indian consumers owing to enhanced awareness regarding sleep wellness as well as changes in lifestyle patterns. The research also proposed the influence of product quality, brand image, and prices on customers' buying decisions. The research findings are useful for mattress producers and sellers to examine and satisfy evolving needs and desires of Indian consumers.

Singh, A., & Sharma, R. (2020).

Singh and Sharma conducted a comprehensive study to analyse the growth trend and challenges of the Indian mattress industry. The studies were aimed at identifying market trends, forces of competition, and regulatory impacts guiding industry growth. Results indicated good prospects for growth of Indian mattress industry fueled by rising disposable incomes, urbanization, and sleep health consciousness. Yet, research also indicated restraints in terms of dominance by the unorganized sector, lack of normalized regulation, and environmental considerations. This research offers valuable insights for industry players, policymakers, and investors to navigate the competitive environment and capitalize on growth opportunities in the Indian mattress industry.

R. Kapoor and S. Verma (2017). Kapoor and Verma empirically researched to determine the economic factor impact on the Indian mattress industry. The research evaluated macroeconomic measures such as GDP growth, inflation, and consumer expenditures to find out how they influence industry trends and demand. The findings showed that there was a relationship between mattress sales and economic growth with urbanization and increasing disposable income responsible for driving the demand for high-end mattress products. However, the report also identified the responsiveness of the mattress business to economic shocks and interest rate and exchange rate fluctuations. Participants in the business can apply the results of this report to take advantage of growth prospects in the Indian mattress market while hedging and forecasting risks from economic volatility.

V. FACTORS INFLUENCING THE GROWTH OF THE MATTRESS INDUSTRY

A. *Shifting Consumer Habits and Trends*

Consumer lifestyle and behavior also have significant drivers of demand for mattresses. Sleep has become part of one's health because lifestyle trends, including more working hours, urbanization, and increased stress levels, have set sleep at the pinnacle of one's quality of life. Consumers are hence on the lookout for mattresses that can be comfortable, supportive, and relaxing, paving the entry for demand for mattresses with specialty features, including latex, memory foam, and hybrid mattresses.

B. *Rising Disposable Incomes:*

Economic growth, in the guise of increased disposable incomes and enhanced lifestyle, is driving the market for mattresses. With increased disposable incomes, the buyer is willing to spend more on better quality mattress products with improved comfort and longer lifespan. With increased ability to spend, the buyer also wishes to spend on mattresses that will provide better sleep quality.

C. Material of mattress:

Increased concerns about well-being and health have fuelled the demand from consumers for healing beds that treat sleeping disorders and well-being. Orthopedic mattresses to realign the spine and treat backache have been popular buys among consumers with specific health conditions. Second, technologies like antimicrobial treatment, hypoallergenic fiber, and temperature control appeal to health-oriented purchasers who desire a hygienic and comfortable sleeping environment.

D. Technological Advances

Technology innovation has revolutionized the mattress industry to provide technologically advanced products, manufacturing methods, and technological integration that optimizes sleeping comfort and sleeping quality. Technology-friendly smart mattresses with embedded sensors, sleep tracking, and adjustability are sought after by technology-oriented consumers who prefer technology-enabled sleeping experience customized to their personal needs. Apart from this, technological advancements in mattresses like memory foam and latex are offering pressure relief, motion isolation, and temperature regulation, encouraging customers to compromise with high-quality mattress products.

E. E-commerce and Omnichannel Retailing:

Emergence of Internet-enabled e-commerce websites has enhanced the visibility and popularity of direct-to-consumer business models of mattress manufacturers. Online shopping is convenient, provides enormous options, and low prices, and hence the customer surfs, browses, and buys beds over the Internet. Apart from this, even physical stores have taken a page from their books and implemented omnichannel to blend online and offline shopping experiences in a manner that customers' purchasing process is simplified and sales are generated in the channel.

VI. METHODOLOGY

A. Assessment and Inventory Analysis

The first step of the methodology is with respect to analyzing and assessing the current inventory system. This entails analyzing quantities on hand, calculating excess or aged inventory, and understanding patterns of demand. An accurate analysis helps to determine inefficiencies, such as overstocking or stock deficiencies, that may hinder operational productivity as well as costing efficiency. Through historical analysis and current trends, firms can make informed decisions regarding the optimization of inventory.

B. Developing a Strategic Plan

After evaluation, a strategic plan is prepared to address the identified problems. This entails the creation of detailed objectives for managing inventory, determination of reorder levels, and planning efficient procurement systems. The strategic plan is also meant to bring inventory management into conformity with corporate goals in such a way that cost savings are balanced against improving the service level. Organizations maximize their supply chain efficiency and minimize disruptions by a systematic approach.

C. Lean Principle Feasibility Studies

Feasibility studies are conducted to evaluate the feasibility of applying lean principles in an attempt to further optimize inventory control. Lean practices such as Just-In-Time (JIT) inventory, reduction of waste, and process optimization via standardization are examined to determine if they can provide improved benefits in the form of process optimization. This study determines if lean strategies can be implemented in the existing system with ease, leading to greater efficiency and reduced inventory holding costs.

D. Inventory Tracking

Regular tracking of inventory is important in maintaining maximum stock levels and preventing inaccuracies. This involves tracking inventory in real-time, automated notification of stock levels, and routine audits to confirm accuracy. Successful tracking of inventory enables business firms to react swiftly to shifts in demand, prevent stock shortages, and enhance supply chain transparency as a whole. Sophisticated technologies such as barcode scanning and inventory management software greatly improve precision and efficiency in tracking processes.

E. Measuring Performance

To measure the effectiveness of inventory management strategies, performance is tracked with respect to key performance indicators (KPIs). Performance factors like inventory turnover ratio, order fulfillment rate, and carrying cost are analyzed in order to analyze the effectiveness of strategies implemented. Periodic performance check-ups pinpoint areas where corrective actions are needed and make inventory management practices coherent with organizational goals. By tracking performance on a regular basis, firms can make informed decisions and enhance operational efficiency.

VII. WORKFLOW OF THE MATTRESS INDUSTRY

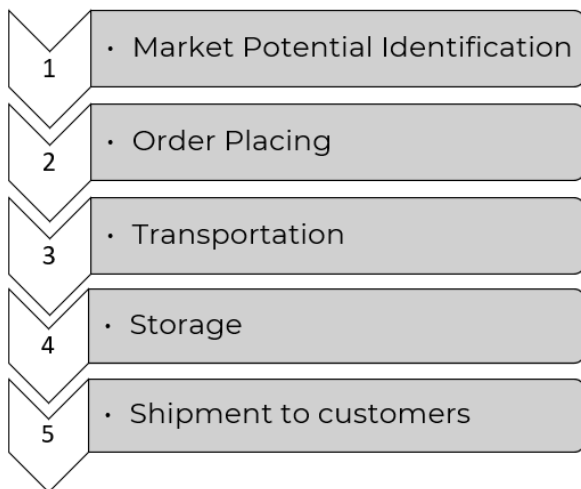


Fig 1: workflow of the mattress industry

VIII. INVENTORY DATA

The inventory figures for April 2024 to September 2024 indicate fluctuations in the movement of stock by month. April had the greatest movement of stock coming in with 1,602 units compared to the outflowing stock at 771 units. This indicates a predominance of inventory excess at the beginning of the period being observed. Stock activity was more evenly balanced between May and August, with Stock In only marginally ahead of Stock Out each month. This suggests a more controlled movement of inventories than in April. Stock In (859) and Stock Out (819) increased through September, suggesting higher movement of inventories and implying greater demand or smarter utilization of stock. Overall, the figures point to a phase of excess stocks in the initial phase followed by a steady phase, spurring a better inventory management strategy in the coming months.

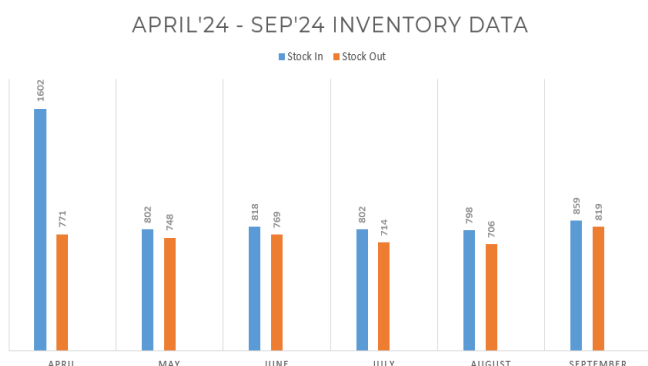


Fig 2: Bar chart of inventory data

The total number of beds received into inventory is 5,690, while the total number of beds distributed or utilized is 4,527. This results in an average outstanding stock of

1,163 beds, indicating the remaining inventory that is yet to be utilized or dispatched.

Inventory Turnover Ratio =

$$\begin{aligned} & \text{Units sold in a period} / \text{Average Stock of Units} \\ & = 4527 / 5690 \\ & = 0.795 \end{aligned}$$

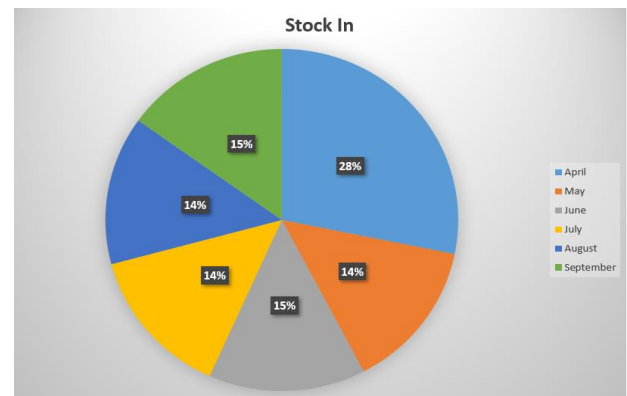


Fig 3: Stock in data for each month

The Inventory Turnover Ratio can be calculated by dividing the number of units sold in a period by the average units in stock. Here, the number of units sold (or beds out) is 4,527 and the average units in stock (beds in) is 5,690. The resultant turnover ratio of inventory is 0.795, indicating the use of the inventory at a moderate rate. The decline in turnover ratio indicates that the inventory is not selling rapidly, and stock management procedures might need to be realigned to maximize efficiency.

- The efficiency of the inventory = 79.5%
- Room for efficiency = 20.5%

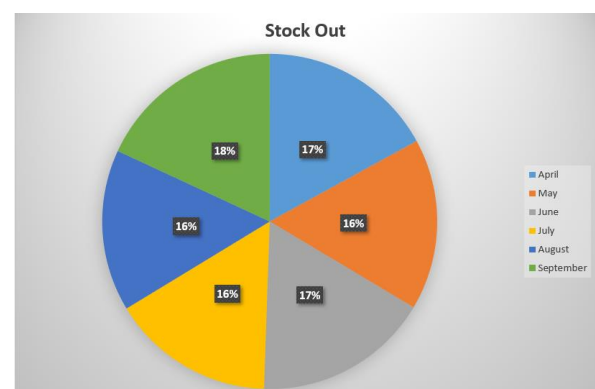


Fig 4: Stock out data for each month

IX. SOLUTION

Efficient inventory management is crucial to the smooth operation of any manufacturing industry, be it the Mattress Industry. The approach here is to eliminate inefficiencies,

bring stock to optimum levels, and implement an inventory management system that is cost-effective and scalable. The approach is in two important phases: elimination of excess stock and deployment of inventory management software by Lean manufacturing principles.

Phase 1: Clearing Excess Stock

The first and main exercise in optimizing the management of inventories is getting rid of redundant stock before the start of the next financial year. The operation is essential in creating room for new stock and enhancing the efficacy of the entire storage system. Businesses usually accumulate excess or old stock due to inaccurate demand forecasting, bulk orders, or steady movement of items. If not monitored, the same inventory can contribute to a higher cost of holding, warehouse underutilization, and greater susceptibility to material decay.



Fig 5: Clearance of unused stock

Removing unused stock offers several advantages, which include: **Reducing Holding Costs:** Inventory carrying entails the costs of warehouse space, maintenance, insurance, and possible depreciation. By eliminating unnecessary inventory, the company can significantly lower these costs.

Prevention of Overstocking: Excessive unsold stock takes up valuable space, and this makes it difficult to stock more high-valued items of higher demand.

Improving Cash Flow: Selling excess stock, even for lower prices, can unlock cash that may be invested to cut costs in operational improvements or the purchase of better-selling items.

Increasing Warehouse Efficiency: Reducing the inventory by removing outdated inventory results in improved product flow, faster pickup times, and less mishandling errors.

Thus, before any new system of inventory control is applied, this Mattress Industry must conduct a full stock audit of existing stock, identify the outdated items, and remove them in a systematic fashion. This will make it easier and systematic to have a flow of inventory.

Phase 2: Tally Software Implementation for Inventory Management

Following the clearance of the excess stock, the second step in the optimization of inventory control is to have a specialized inventory control system. As this mattress industry is a medium-scale business, the software used for this option is Tally

Why Tally?

Tally is a low-cost effective means of handling inventory and best suited for SMEs. MNCs and large companies are more interested in having sophisticated solutions like SAP or Zoho Inventory Management, which have high cost of implementation and humongous IT infrastructure at enterprise level. So far, implementing SAP or Zoho would not be an economically viable option for this Mattress Industry.



Fig 6: Tally

In contrast, Tally provides:

Cost-effectiveness as compared to high-end ERP systems.

Features that are easily accessible and are implemented by employees with no extra training.

Scalability is such that the company can scale up to high-end systems in the future when it grows into a large company.

Integration with Lean Manufacturing Practices, where inventory management becomes a system.

Implementation of the Two-Bin System in Tally

To ensure highest efficiency and easier inventory monitoring, the Mattress Industry will integrate Lean Manufacturing principles within Tally as the Two-Bin System.

The Two-Bin System is an evergreen Lean inventory control practice that offers consistent availability of stocks with low amounts of excess stocks. It comprises dividing the stock into two different bins:



Fig 7: Two bin system

Primary Bin: Stores the main inventory that gets depleted first.

Secondary Bin: Stores the secondary safety inventory that is accessed when the primary bin is depleted.

The Two-Bin System's process flow is as follows:

The Primary Bin is accessed first to serve production and sales demands.

As the Primary Bin is depleted, Secondary Bin inventory is returned to the Primary Bin in a bid to prevent flow interruption.

Throughout this period, the system is caused to perform a reorder point by automatically generating a mechanical purchase order for restocking purposes.

A new incoming inventory arrives prior to Secondary Bin being depleted, thus preventing smoothness or gaps in production from being disrupted.

Advantages of the Two-Bin System in Tally

The Mattress Industry can benefit from many important things by implementing the Two-Bin System in Tally:

Prevention of Stockouts and Overstocking: Effective inventory control ensures that the company will always possess the required materials without possessing too much material.

Enhanced Reorder Point Management: Automatic reorder alert avoids the delay in replenishment, making it available at any moment.

Systematic Inventory Organization: Inventory is arranged in main and sub-levels, making it easier to track and recover.

Cost Saving: Carrying cost is minimized because unwanted inventory is eliminated, and fresh stock is purchased only when needed.

Improved Decision Making: Managers can make decisions to improve procurement, storage, and supply chain activities based on real-time tracking and inventory reports in Tally.

Future Scope: Growth to Advanced Systems

Though Tally is the best fit for the Mattress Industry now, the company must be prepared for scale-up growth in the future. When it grows to a larger market, it might have to upgrade to advanced inventory management systems like SAP or Zoho Inventory Management. These systems offer advanced features like AI-based demand forecasting, multi-location tracking, and automated supply chain optimization.

By implementing Tally during this phase and using a phased transition strategy, this Mattress Industry can be certain of a low-cost and adaptable inventory management tool in line with its growth trajectory.

X. CONCLUSION

Efficient inventory control is critical to optimize operations and achieve profitability for the mattress industry. This research highlights inefficiencies in this Mattress Industry's inventory control and proposes that a two-pronged approach—embracing Lean manufacturing principles and installing state-of-the-art inventory control software—would boost operational efficiency. A colossal inefficiency took place in April, leading to hoarding and mess in supply chain operations.

Address these challenges, the study recommends early clearance of excess stock to provide free space for storage and maximize inventory turnover. Second, Tally software together with the Two-Bin System encourages systematic inventory tracking, demand forecasting, and timely replenishment. The Two-Bin System on Tally provides a systematic structure for maintaining optimal levels of stock without incurring overstocking and stockouts.

By combining these strategies, the Mattress Industry can strengthen inventory control, reduce holding costs, and increase overall efficiency. The results underscore the significance of continuous process improvement and technology implementation for maintaining a competitive edge in the market. Future research can examine the feasibility of such strategies on other market segments and evaluate the long-term impacts of digital innovations in inventory control.

REFERENCES

- [1] T. M. Griffin, R. P. Main, and C. T. Farley, "Biomechanics of quadrupedal walking: how do four-legged animals achieve inverted pendulum-like movements?," *J. Exp. Biol. Publ. by Co. Biol.*, vol. 207, no. Pt 20, pp. 3545–58, Oct. 2004.

- [2] D. W. Marhefka, D. E. Orin, J. P. Schmiedeler, and K. J. Waldron, "Intelligent control of quadruped gallops," *IEEE/ASME Trans. Mechatronics*, vol. 8, no. 4, pp. 446–456, Dec. 2003.
- [3] J. A. Alexander, "A dynamic similarity hypothesis for the gaits of quadrupedal mammals," *J. Zool.*, p. 201, 1983.
- [4] R. A., *Principles of Locomotion*. Princeton, New Jersey: Princeton University Press.
- [5] L. Skrba and C. O'Sullivan, "Human perception of quadruped motion," *Proc. 6th Symp. Appl. Percept. Graph. Vis. - APGV '09*, p. 130, 2009.
- [6] L. Skrba and C. O. Sullivan, "Join the dots : Insights into motion of quadrupeds," *Eurographics Ireland.*, pp. 1–8, 2009.
- [7] K. Wampler and Z. Popovi, "Optimal Gait and Form for Animal Locomotion," 2006.
- [8] M. H. Raibert, "Trotting, pacing and bounding by a quadruped robot.," *J. Biomech.*, vol. 23 Suppl 1, pp. 79–98, Jan. 1990.
- [9] Z. Bhatti, A. Shah, A. Waqas, and M. Karbasi, "Automated animation of quadrupeds using procedural programming technique," *Asian J. Sci. Res.*, vol. 8, no. 2, pp. 165–181, 2015.
- [10] E. Muybridge, *Descriptive Zoopraxography or the science of animal locomotion made popular*. 2012.
- [11] Wuehr M, Schniepp R, Pradhan C, Ilmberger J, Strupp M, Brandt T, et al. Differential effects of absent visual feedback control on gait variability during different locomotion speeds. *Exp Brain Res* 2013;224:287–94.
- [12] Herman T, Giladi N, Gurevich T, Hausdorff JM. Gait instability and fractal dynamics of older adults with a cautious gait: why do certain older adults walk fearfully. *Gait Posture* 2005;21:178–85.
- [13] Krasovsky T, Banina MC, Hacmon R, Feldman AG, Lamontagne A, Levin MF. Stability of gait and interlimb coordination in older adults. *J Neurophysiol* 2012;107:2560–9.
- [14] Zhou C, Kurths J, Kiss IZ, Hudson JL. Noise-enhanced phase synchronization of chaotic oscillators. *Phys Rev Lett* 2002;89:14101.
- [15] Kiss IZ, Zhai Y, Hudson JL, Zhou C, Kurths J. Noise enhanced phase synchronization and coherence resonance in sets of chaotic oscillators with weak global coupling. *Chaos* 2003;13:267–78.
- [16] Bartsch R, Plotnik M, Kantelhardt JW, Havlin S, Giladi N, Hausdorff JM. Fluctuation and synchronization of gait intervals and gait force profiles distinguish stages of Parkinson's disease. *Physica A* 2007;383:455–65.
- [17] Peng CK, Havlin S, Stanley HE, Goldberger AL. Quantification of scaling exponents and crossover phenomena in nonstationary heartbeat time series. *Chaos* 1995;5:82–7.
- [18] Pierrynowski MR, Gross A, Miles M, Galea V, McLaughlin L, McPhee C. Reliability of the long-range power-law correlations obtained from the bilateral stride intervals in asymptomatic volunteers whilst treadmill walking. *Gait Posture* 2005;22:46–50.
- [19] A. Murali, R. Rasheed, and R. Arsamy, "Comparative Empirical Analysis of Biomimetic Curvy Legged Bipedal Robot with Linear Legged Bipedal Robot," in *Lecture notes in electrical engineering*, 2023, pp. 147–158. doi: 10.1007/978-981-99-4634-1_12.1039
- [20] Kantelhardt JW, Koscielny-Bunde E, Rego HH, Havlin S, Bunde A. Detecting long-range correlations with detrended fluctuation analysis. *Physica A* 2001;295:441–54.
- [21] Schmitt DT, Stein PK, Ivanov PC. Stratification pattern of static and scaleinvariant dynamic measures of heartbeat fluctuations across sleep stages in young and elderly. *IEEE Trans Biomed Eng* 2009;56:1564–73.