Proceedings of the 3rd International Conference on Financial Technology and Business Analysis
DOI: 10.54254/2754-1169/128/2024.18269

Research on the Application of Warehouse

-Distribution Integration under Vendor Managed Inventory Strategy

Jingzhe Sun[1,a,*]

[1]*School of Transportation and Logistics, Southwest Jiaotong University, Chengdu, 150000, China*
a. sjz724@163.com
**corresponding author*

Abstract: The advent of globalization and technological advances has driven the logistics industry into a period of rapid transformation, bringing new challenges and opportunities in the area of supply chain dynamics and operational procedures. In this evolving scenario, the Warehouse-Distribution Integration (WDI) through strategies such as the Vendor Managed Inventory (VMI), has emerged as a key factor in enhancing efficiency and competitiveness. Therefore, the paper explores the integration of WDI into VMI strategies, emphasizing their implementation and the potential for enhancing logistics efficiency. Existing studies related to VMI and WDI are reviewed, focusing primarily on the operational procedures, impacts, and benefits associated with such integration. And the logistics operations and challenges faced by a particular company, Yonghui Superstore, are examined to illustrate the necessity for efficacious warehouse and distribution integration under a VMI strategy. Through VMI cost modeling, it provides strategic insights for improving logistics efficiency and reducing costs. The results indicate that logistics strategies must be aligned with the changing global environment and provide avenues for future research into the benefits of VMI integration.

Keywords: Vendor Managed Inventory (VMI), Warehouse-Distribution Integration, Supply Chain, Logistics Efficiency.

1. Introduction

The global economy is currently in a complex and dynamic phase, driven by both emerging markets and developed countries. In this context, the logistics industry, a key pillar of global trade, has seen China's total logistics volume grow by 5.2% in 2023, with a declining proportion of logistics costs to GDP, indicating improved efficiency. However, further optimization of logistics costs remains a pressing issue.[1] In supply chain management, two key strategies for reducing logistics costs are VMI and WDI. It is shown that VMI can enhance supply chain coordination and reduce inventory risks, though its implementation requires balanced interests among stakeholders, and WDI, an emerging service model, can shorten response times and lower inventory costs but also faces challenges that need to be addressed[2]. Improvements in these management methods allow enterprises better adapt to market changes and achieve sustainable growth[3]. VMI can significantly reduce inventory costs and improve supply chain efficiency, while WDI can speed up delivery to enhance customer experience[4]. This paper explores the role of integrated warehousing and distribution within the VMI strategy in reducing logistics costs, with the aim of helping enterprises

DOI: 10.54254/2754-1169/128/2024.18269

build a sustainable supply chain system and strengthen industry competitiveness. The research show that VMI model and WDI strategy can serve to reduce logistics costs, while simultaneously building a robust and sustainable supply chain management system to ensure the efficient and stable operation of the supply chain.

2. Overview of Vendor Managed Inventory and Warehouse-Distribution Integration

VMI and WDI are two complementary supply chain management strategies designed to enhance efficiency, reduce costs, and mitigate risks such as the bullwhip effect[5]. VMI means that suppliers are responsible for inventory management, using real-time data sharing and demand forecasting to optimize inventory planning and replenishment strategies, which minimizes inventory backlogs and stock-outs, improves order processing speeds, and boosts customer satisfaction by giving suppliers a better understanding of customer needs and more timely responses[6]. At the same time, WDI coordinates warehouse management and logistics to meet customer demand more effectively, including demand forecasting, inventory management, order processing, and distribution management, all of which supported by a unified information system that enables data sharing and collaborative operation. The alignment of inventory levels with actual demand enables enterprises to reduce the capital tied up and ensure the delivery of goods in a more accurate and timely manner[7]. When VMI and WDI are combined, powerful synergies are created. Such integration helps companies further reduce logistics costs, enhances supply chain efficiency, and builds stronger relationships between suppliers and customers. Effective information transmission, optimized replenishment processes, and coordinated warehousing and logistics operations are essential at the operational level to achieve these benefits.

3. Yonghui Superstore's Sales and Inventory Management: Large Appliances Case Study

3.1. Yonghui Superstore: Operational Overview and Large Appliance Inventory Management

Founded in 2001, Yonghui Superstore has grown to become a major player in China's retail sector, with over 1,000 stores across 600 cities in 29 provinces. Its strategic expansion plan included the construction of the Yonghui West Logistics Park (Chongqing) and Yonghui (Pengzhou) Agricultural Product Processing and Distribution Center, enhancing its distribution and warehousing capabilities in the Sichuan-Chongqing region. Chengdu's role as a central hub makes it crucial to understand Yonghui's operational strategies in this market.

Yonghui's approach to managing inventory for large appliances utilizes a sophisticated indicator model. This model estimates monthly sales volumes by considering factors such as population size, population growth, average income, and consumption level. These factors are weighted to reflect their impact on sales: population size (weight 3), population growth (weight 2), average income (weight 4), and consumption level (weight 5). For example, the model projects an average monthly sales volume of 357 refrigerators for Longquanyi District. This forecasting model allows Yonghui to align inventory levels with predicted sales, optimizing stock management. By reducing both excess inventory and the risk of stockouts, Yonghui enhances inventory turnover and reduces carrying costs. The model supports effective inventory management by integrating sales forecasts with supply chain operations, ensuring timely stock replenishment and efficient use of warehouse space. This data-driven approach underscores Yonghui's commitment to improving operational efficiency and maintaining a competitive edge in the retail market.

DOI: 10.54254/2754-1169/128/2024.18269

3.2. Inventory Management Models

Yonghui Superstore uses the reorder point model for inventory management, which helps maintain optimal inventory levels and prevent stock-outs[8]. The reorder point is calculated using the formula:

$$R = d \times L + S \tag{1}$$

where d is the sales volume, L is the lead time, and S is the safety stock. For constant lead times, the safety stock formula simplifies to[9]:

$$S = Z \times \sigma \times \sqrt{L} \tag{2}$$

where Z represents the standard deviation of demand and σ represents the standard deviation of demand.This approach helps in maintaining a balance between sufficient inventory to meet demand and minimizing excess stock.

In addition, Yonghui optimizes inventory management by calculating the EOQ, which helps in determining the optimal order size to minimize total inventory costs. However, challenges arise when demand forecasts are inaccurate. Such inaccuracies can lead to poor inventory and capacity planning, potentially resulting in either stock-outs or excess inventory. Overreliance on forecasted demand may also misrepresent true demand, particularly for customized products, further complicating inventory management[10]. Thus, while the reorder point model and EOQ provide valuable frameworks, their effectiveness depends on the accuracy of demand forecasts and the ability to adapt to variability in actual demand.

3.3. Supplier Selection

In implementing the integrated warehousing and distribution model, the quality control and procurement departments must refine supplier development and evaluation processes to enhance delivery timeliness, improve product quality, and ensure supply chain stability[11]. Effective supplier selection and cooperation are crucial. Enterprises should evaluate suppliers based on brand management by considering market reputation and profitability, which can guide the choice of brands to prioritize. Additionally, assessing supplier stability involves not only examining production capabilities and technical expertise but also focusing on personnel stability and requiring timely reporting of significant personnel changes to mitigate potential disruptions. Financial stability is equally important, particularly under the VMI model, where suppliers may face capital pressures and bankruptcy risks. Procurement staff must strengthen financial oversight, scrutinize upstream suppliers, and address capital chain risks promptly. Weber's review of 74 studies since 1966 highlights the importance of supplier selection as a fundamental aspect of procurement, emphasizing that maintaining a reliable supplier base is crucial for acquiring necessary materials, services, and equipment[12].

4. Application of VMI Strategy in Yonghui Superstore

4.1. Implementation Process of VMI Strategy

The implementation of the VMI strategy at Yonghui Superstore involves adapting the EOQ model to the Economic Production Quantity (EPQ) model to align with a production environment[13]. The EPQ model modifies the EOQ model by replacing the ordering cost C with the production fixed cost C_{SC}, and substituting the holding cost with variable costs. The fixed production cost C_{SC} is calculated as:

$$C_{SC} = C_Z + C_{GI} + C_J \tag{3}$$

DOI: 10.54254/2754-1169/128/2024.18269

where, C_Z represents equipment depreciation cost, C_{G1} denotes management salaries, and C_J is maintenance cost per equipment operation. The variable cost C_B is calculated as:

$$C_B = C_{CL} + C_{G2} + C_E \tag{4}$$

where C_{CL} is the cost of raw materials, C_{G2} is wages of workers, and C_E represents the cost of electricity consumption. Based on the EOQ model, the EPQ model can be derived as:

$$Q_{SC} = \sqrt{\frac{2DC_{SC}}{C_B}} \tag{5}$$

The feasibility of this formula can be verified using dimensional analysis, ensuring consistency in units and confirming the model's applicability. The unit of D is pieces, the unit of C_{SC} is yuan, and the unit of C_B is yuan/piece, which can be obtained by substituting them into the formula:

$$\sqrt{\frac{2 \cdot piece \cdot yuan}{\frac{yuan}{piece}}} = \sqrt{2piece^2} = \sqrt{2}piece \tag{6}$$

The calculated result in terms of pieces proves that the analogized EPQ model is feasible.

In addition, selecting the optimal location for the distribution center is crucial. The initial step is to define C_j as the transportation cost from the logistics center to each store. This can be expressed as:

$$H = \sum_{j=1}^{n} C_j \tag{7}$$

C_j can be represented by the following formula:

$$C_j = h_j \times w_j \times d_j$$
$$d_j = \sqrt{\left(x_i - x_j\right)^2 + \left(y_i - y_j\right)^2} \tag{8}$$

To find the x and y that minimize H, the following conditions must be satisfied:

$$\frac{\partial H}{\partial x} = \sum_{j=1}^{n} h_j w_j (x - x_j)/d_j = 0$$
$$\frac{\partial H}{\partial y} = \sum_{j=1}^{n} h_j w_j (y - y_j)/d_j = 0 \tag{9}$$

Through calculation, the most suitable x^* and y^* can be obtained as follows:

$$x^* = \frac{\sum_{j=1}^{n} h_j w_j x_j / d_j}{\sum_{j=1}^{n} h_j w_j / d_j}$$
$$y^* = \frac{\sum_{j=1}^{n} h_j w_j y_j / d_j}{\sum_{j=1}^{n} h_j w_j / d_j} \tag{10}$$

When determining the best distribution center location, an iterative calculation method can be used to optimize the location selection. An initial logistics center location is selected and the total transportation cost from that location to all stores is calculated. This initial total transportation cost can be used as a baseline. Then, the location of the logistics center is adjusted using the centroid method formula.

4.2. Profit Model Development

In traditional inventory management, the profit model for suppliers is based on calculating annual revenue and subtracting distribution, production, and inventory costs[14]. The total cost in this model is determined by the EOQ formula, which includes both inventory and ordering costs:

DOI: 10.54254/2754-1169/128/2024.18269

$$Ic^0 = PQ - \frac{EOQ}{2} C_s - M_s Q - QC_s \tag{11}$$

where Ic^0 means supplier's profit under the traditional model, P is selling price of refrigerators at Yonghui Superstore, Q is arket demand, M_s is cost for the supplier to produce each refrigerator, and C_s is unit storage cost for the supplier.

To optimize inventory management, it is essential to balance inventory and ordering costs:

$$\frac{\mathrm{EOQ}}{2} \mathrm{C_r} + \frac{\mathrm{Q \cdot C_d}}{\mathrm{EOQ}} \geq 2\sqrt{\frac{\mathrm{EOQ}}{2} \mathrm{C_r} \times \frac{\mathrm{Q \cdot C_d}}{\mathrm{EOQ}}} \tag{12}$$

$$\frac{EOQ}{2} C_r = \frac{Q \cdot C_d}{EOQ} \rightarrow EOQ = \sqrt{\frac{2Q \cdot C_d}{C_r}} \tag{13}$$

where C_d is ordering cost for Yonghui Superstore, and C_r is the storage cost for Yonghui superstore.

For Yonghui Superstore, the profit calculation involves subtracting ordering, storage, and raw material procurement costs from total revenue. The formula is:

$$Ict^0 = PQ - P_1 Q - \frac{EOQ}{2} \cdot C_r - \sqrt{\frac{QC_r C_d}{2}} \tag{14}$$

where Ic is supplier's profit under the VMI model, and P_1 is the rice of goods supplied by the supplier to Yonghui Supermarket after implementing VMI. After adopting the VMI strategy, the profit model is adjusted:

$$EOQ_{After} = \sqrt{\frac{2CQ}{\frac{C_r + C_S}{2}}} = \sqrt{\frac{4CQ}{C_r + C_S}} \tag{15}$$

Therefore, the profit calculation formula for Yonghui after adopting the VMI strategy is:

$$Ict = PQ - P_1 Q \tag{16}$$

The supplier's profit is the sales revenue for the year minus the costs of storage, distribution, and production. The correct calculation of the annual storage cost needs to consider the product of the economic production quantity and the annual storage cost, divided by 2.。

$$\frac{EOQ_{After}}{2} \times \frac{C_r + C_S}{2} \tag{17}$$

Substituting into the profit formula yields:

$$I_C = P_1 Q - M_s Q - C_p Q - \frac{EOQ_{After}}{2} \times \frac{C_r + C_S}{2} \tag{18}$$

where C_p is unit distribution cost for the supplier.

Comparing the profit models for traditional inventory management and VMI strategies reveals that VMI typically reduces costs and improves supplier profits[15], demonstrating the benefits of optimized inventory management.

4.3. Challenges and Issues in Implementation

It is found that implementing VMI strategies can substantially enhance inventory turnover rates and lower inventory costs. By proactively managing suppliers, companies can effectively reduce stockouts and excess inventory, which leads to improved operational efficiency. This model optimizes inventory levels and boosts the responsiveness of the supply chain, helping companies maintain a competitive edge in dynamic market conditions. However, the application of VMI strategies involves challenges. Establishing and maintaining trust between suppliers and retailers is crucial, as it influences the effectiveness of information sharing and collaboration. Additionally, VMI strategies depend heavily on advanced technology, requiring reliable IT systems for real-time data sharing and inventory management. This technological dependence can introduce risks if systems fail or are inadequately maintained. Moreover, cost concerns related to implementing and sustaining VMI systems can impact the overall feasibility and effectiveness of the model. Addressing these challenges is essential for maximizing the benefits of VMI and ensuring its successful integration into business operations.

4.4. Improvement and Optimization Measures

To address the challenges in implementing the VMI model, companies should prioritize establishing a trust-based partnership with suppliers. This involves formalizing agreements through clear contracts and data-sharing protocols, and maintaining open communication channels through regular meetings. Such measures foster a cooperative relationship, ensuring smooth information flow and enhancing decision-making efficiency. Additionally, investing in a robust IT infrastructure is fundamental. Companies need to select reliable technology providers and conduct ongoing system maintenance to minimize technical disruptions. A stable IT environment supports the effective operation of the VMI system, reducing the risk of failures. Finally, Yonghui Supermarket should focus on strengthening its cooperative relationship with suppliers to achieve long-term mutual benefits. Improved information utilization will lead to better economic outcomes for both parties. The stability and effectiveness of this cooperation will significantly influence the commitment to and success of the VMI model.

5. Conclusion

In this paper, the challenges faced by Yonghui Superstore in inventory management are studied by selecting a large home appliance sales in Longquanyi District as a specific case study, and a comprehensive optimization plan is developed, including model formulation, theoretical analysis, production model conversion and supplier evaluation index design. The results demonstrate that Vendor Managed Inventory (VMI) is a highly effective inventory management strategy. VMI, when compared to traditional models, excels in mitigating the bullwhip effect, reducing overall supply chain costs, and fostering a mutually beneficial relationship between suppliers and customers. By leveraging real-time data and enabling suppliers to better control inventory levels, VMI enhances supply chain coordination and operational efficiency. While VMI presents certain risks, including the potential for data inaccuracy and an increased reliance on supplier performance, these risks can be mitigated through proactive forecasting, rigorous monitoring, and timely adjustments. The adaptive and forward-thinking nature of the VMI model significantly enhances distribution and productivity while reducing non-value-added activities, making it a valuable strategy that is widely adopted by companies seeking to optimize supply chain management. The VMI model has gained considerable traction among companies striving to boost their supply chain management practices.

References

[1] *Fan, D., Luo, K. and Jin, Z. (2023) Construction of Social Logistics Cost Aggregation Indicator based on Variation Coefficient Method. Journal of Highway and Transportation Research and Development, 40(1): 245-251.*

[2] *Qin, F. (2023) Company C VMI Inventory Management Research. Southwestern University of Finance and Economics,*

[3] *Wang, Y. (2019) A Study on the Integration of E-commerce Logistics Warehousing and Distribution Based on the Internet Model. Market Modernization, 10: 63-64.*

[4] Tong, D. (2023) A Study on Optimizing Inventory Management in Small and Medium-sized Leather Enterprises by Adopting VMI Model. China Leather, 52(3): 44-47.
[5] Disney, S.M. and Towill, D.R. (2023) The Effect of Vendor Managed Inventory (VMI) Dynamics on the Bullwhip Effect in Supply Chains. International Journal of Production Economics, 85(2): 199-215.
[6] Wang, X. (2021) Exploring the Application of VMI Model for Supply Chain Optimization. China Plant Engineering, 17: 146-147.
[7] Wang, H. (2021) Analysis and program design of VMI applications in the retail industry. Popular Standardization, 13: 103-105.
[8] Saad, S.M. and Bahadori, R. (2019) Introducing a Unique Inventory Control Framework for Centralized VMI and JIT Production. IFAC-PapersOnLine, 52(13): 1045-1050.
[9] Kim, S.C. and Shin, K.S. (2019) Negotiation Model for Optimal Replenishment Planning Considering Defects under the VMI and JIT Environment. The Asian Journal of Shipping and Logistics, 35(3): 147-153.
[10] Laroussi, S.H. and Memmi, I.C. (2010) Comparing periodic inventory policies applied within the framework of VMI approach. IFAC Proceedings Volumes, 43(17): 95-101.
[11] Lee, C. and Kasilingam, R.G. (1995) Vendor Selection Methods:A Survey of Industry Perceptions. Department of Industrial Engineering, University of Arkansas.
[12] Weber, C.A., Current, J.R. and Benton, W.C. (1991) Vendor Selection Criteria and Methods. European Journal of Operational Research, 50: 2-18.
[13] Roodhooft, F. and Konings, J. (1996) Vendor Selection and Evaluation: An Activity Based Costing Approach. European Journal of Operational Research, 96: 97-102.
[14] Khatun, A., et al. (2023) Enhanced environmental and economic sustainability of VMI-CS agreement-based closed-loop supply chain for deteriorating products. Results in Control and Optimization, 13: 100321.
[15] Verma, N.K., et al. (2014) Joint replenishment of multi retailer with variable replenishment cycle under VMI. European Journal of Operational Research, 233(3):787-789.