IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Inventory Replenishment Level Model Application For A Furniture Manufacturer

[1,2]Tran Minh Khai, [1,2]Tran Minh Dang, [1,2]Tran Huu Hoa, [1,2]Nguyen Thanh Dat, [1,2]Ngoc-Hien Do

[1]Department of Industrial & Systems Engineering, Faculty of Mechanical Engineering, Ho Chi Minh City University of Technology (HCMUT), 268 Ly Thuong Kiet Street, District 10, Ho Chi Minh City, Vietnam.
[2]Vietnam National University Ho Chi Minh City, Linh Trung Ward, Thu Duc City, Ho Chi Minh City, Vietnam.

Abstract: All businesses and institutions, particularly manufacturing companies, depend significantly on inventory. Effective inventory management is also a key component of supply chain management, as it can help reduce lead times, improve on-time delivery, and enhance overall supply chain performance effectively. The company, a case study, suffered significant losses in orders as a result of a lack of inventory policy. Therefore, an effective inventory model or policy would be figured out, which could help company increase profitability, eliminate stockouts, and optimize inventory levels. An efficiently implementing and managing every component of the Inventory Replenishment Level model would be introduced. In addition, the study would be applied to most items producing at this company.

Keywords - Inventory, Inventory Replenishment Level, Furniture Manufacturing, Effective Inventory Management.

Introduction

Inventory management is a critical aspect of manufacturing companies involving the control and optimization of inventory levels to ensure that the right amount of stock is available at the right time to meet customer demand. Coordination mechanisms are employed in supply chain operations and research in academics to increase the effectiveness and performance of supply chain inventory management. Braglia and Zavanella (2003) [1] presented a CS policy and collaboratively created the production and inventory plan for a vendor and a buyer in one of the first studies. Assuming a positive link between customer demand and the inventory level of goods in the display area, Zanoni and Jaber (2015) [2] optimized the inventory level at the buyer's warehouse.

Inventory management was challenging and was made more challenging by uncertainty. As a result of inventory restrictions, such as short shelf lives, and the requirement for appropriate inventory strategies to protect and minimize production costs, Taylor (2017) [3] proposed a model for an inventory of the food industries, which are more sensitive to inventory procedures than plastics manufacturers. In order to limit the effect of completed goods inventories on company value and investment choices, Cui and Sarkar (2022) [4] developed a continuous-time model. The suggested model demonstrated that the level of businesses using an inventory policy was higher than that of a traditional company. An inventory management decision support system (DSS) was suggested by Teerasoponpong and Sopadang in 2022 [5]. The DSS's objective was to demonstrate that small and medium-sized businesses supported their decisions via market uncertainty. In order to control a three-level supply chain, Taleizadeh and Noori-daryan (2016) [6] investigated an economic production quantity model taking different kinds of raw materials under consideration.

Effective inventory management is essential for business success, as it can help companies reduce costs, improve customer satisfaction, and increase profitability. By linking supply chain objectives to company strategy, decisions can be made between competing demands on the supply chain (Lummus,1999)[7].

Manufacturing companies typically deal with a wide range of inventory items, including raw materials, work-in-progress goods, and finished products. Managing these items can be challenging, as they often have different lead times, demand patterns, and storage requirements. In addition, manufacturing companies must balance the costs of holding inventory (such as storage, handling, and obsolescence) with the costs of stockouts (such as lost sales, backorders, and customer dissatisfaction).

To address these challenges, manufacturing companies use a variety of inventory management techniques and models, such as the IRL model discussed in this document. These models help companies determine the optimal inventory levels for each item, considering factors such as demand variability, lead time variability, and safety stock requirements. By using these models, companies can improve their inventory control, reduce costs, and enhance their overall supply chain performance.

Overall, effective inventory management is a critical component of manufacturing companies' operations and can have a significant impact on their success in the marketplace. By implementing best practices and using advanced inventory management models, companies can optimize their inventory levels and improve their competitiveness in the industry.

I. METHODOLOGY

2.1 The IRL Model

The IRL (Inventory Replenishment Level) model is a widely used inventory management model that helps manufacturing companies determine the optimal inventory levels for each item. The IRL model is based on five stock components: cycle stock, pipeline stock, demand safety stock, supply safety stock, and policy stock (Fig 1).

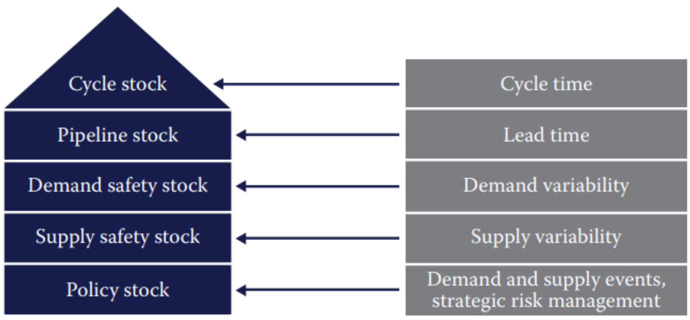

Fig 1. IRL model

Cycle Stock: This represents the inventory held to meet expected demand during the replenishment cycle. It is calculated by multiplying the average demand during the replenishment cycle by the cycle time. The cycle stock is the largest component of inventory in most companies. To optimize cycle stock, companies can use demand forecasting techniques to accurately predict demand and use economic order quantity (EOQ) formulas to determine the optimal order quantity and reorder point. Additionally, companies can implement just-in-time (JIT) inventory systems to reduce cycle stock and minimize carrying costs.

Pipeline Stock: This is the inventory in transit between the supplier and the company. It is calculated by multiplying the average demand during the lead time by the lead time. Pipeline stock is important because it represents inventory that is committed to fulfilling customer orders. To optimize pipeline stock, companies can work with their suppliers to reduce lead times and improve delivery reliability. Additionally, companies can use real-time tracking systems to monitor the status of shipments and manage pipeline inventory more effectively.

Demand Safety Stock: This is the inventory held to protect against unexpected increases in demand. It is calculated by multiplying the safety stock factor by the standard deviation of demand during the lead time. Demand safety stock is important because it helps companies avoid stockouts and maintain high customer service levels. To optimize demand safety stock, companies can use statistical forecasting techniques to more accurately predict demand and reduce variability. Additionally, companies can implement safety stock policies that balance the cost of carrying inventory with the cost of stockouts.

Supply Safety Stock: This is the inventory held to protect against unexpected delays in supply. It is calculated by multiplying the safety stock factor by the standard deviation of lead time. Supply safety stock is important because it helps companies avoid stockouts and maintain production schedules. To optimize supply safety stock, companies can work with their suppliers to improve delivery reliability and reduce variability. Additionally, companies can implement contingency plans to manage supply disruptions and reduce the need for safety stock.

Policy Stock: This is the inventory held to achieve specific company objectives, such as providing a high level of customer service or taking advantage of quantity discounts. It is not based on specific demand or supply requirements. To optimize policy stock, companies can use inventory optimization software to analyze the trade-offs between inventory costs and service level targets. Additionally, companies can negotiate better with suppliers to take advantage of quantity discounts and reduce the cost of carrying inventory.

Cycle stock refers to the inventory that is held to cover expected demand within one production cycle or multiple of it. Pipeline stock covers situations in which orders are not delivered in full or on time, such as when there is a delay in manufacturing or transportation. Demand safety stock and supply safety stock are used to buffer demand and supply variability during the cycle time and lead time, respectively. Policy stock covers exceptional demand and supply events, such as special marketing campaigns or tender orders, and can also be used for strategic risk management.

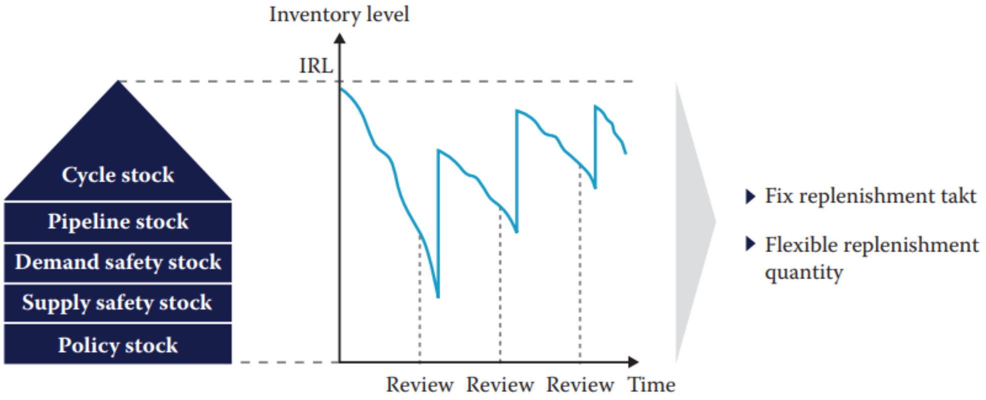

Fig 2. IRL model with the frequency ordering point

The IRL model takes its name from the inventory replenishment level, which is a predefined target stock that is built up from all five stock components. During every review of stock, the current inventory level is checked, compared with the IRL, and an order to cover a missing quantity is placed to refill the stock (Fig 2). The IRL policy fits the Rhythm Wheel production mode naturally, as during every Rhythm Wheel cycle, immediately before a product is produced, the current inventory level of that product is checked. The production quantity is then determined simply as the difference between the IRL and the current inventory level.

The IRL model is a powerful tool for inventory management, as it helps companies optimize their inventory levels and reduce costs associated with holding and managing inventory. By using the IRL model, companies can improve their inventory control, reduce storage costs, minimize waste and obsolescence, and improve cash flow. The IRL model is also a key component of supply chain management, as it can help reduce lead times, improve on-time delivery, and enhance overall supply chain performance.

Overall, the IRL model and its components provide a comprehensive framework for effective inventory management in manufacturing companies. By implementing best practices and using advanced inventory management models like the IRL model, companies can optimize their inventory levels and improve their competitiveness in the industry.

2.2 The impact of minimum order quantity requirements on inventory management

Minimum Order Quantity (MOQ) requirements are an important consideration in inventory management for manufacturing companies. MOQ is the minimum quantity of a product that a supplier is willing to sell or that a company is willing to purchase. MOQ requirements can have a significant impact on inventory levels, carrying costs, and the ability of companies to take advantage of quantity discounts.

One of the main impacts of MOQ requirements on inventory management is that they can increase inventory levels and carrying costs. This is because companies may need to order more inventory than they need to meet MOQ constraints, which can result in excess inventory that must be stored and carried for a longer period. This can increase carrying costs and reduce profitability.

Additionally, MOQ requirements can impact a company's ability to take advantage of quantity discounts. Suppliers often offer discounts for larger orders, but companies may be unable to take advantage of these discounts if they are unable to meet MOQ requirements. This can result in higher costs and lower profitability.

To manage the impact of MOQ requirements on inventory management, companies can use a variety of strategies. One strategy is to negotiate with suppliers to reduce MOQ requirements or to order in smaller quantities more frequently. This can help reduce inventory levels and carrying costs, while still allowing companies to take advantage of quantity discounts.

Another strategy is to use demand forecasting techniques to predict demand and optimize order quantities more accurately. By using forecasting models that can account for MOQ constraints, companies can better manage their inventory levels and reduce the impact of MOQ requirements on carrying costs.

Finally, companies can use inventory optimization software to analyze the trade-offs between inventory carrying costs, MOQ constraints, and order frequency. This can help companies identify the optimal order quantity and frequency that minimizes inventory levels and carrying costs while still meeting MOQ requirements.

In conclusion, MOQ requirements are an important consideration in inventory management for manufacturing companies. By understanding the impact of MOQ requirements on inventory levels, carrying costs, and the ability to take advantage of quantity discounts, companies can implement strategies to manage their inventory levels more effectively and reduce costs.

II. CASE STUDY AND DISCUSSION

3.1. Introduction to furniture manufacturing process

The furniture manufacturing company used in the case study is a small company that produces tables as its main product. The company's manufacturing process involves CNC cutting of the table components, sanding, veneering, assembly, and packing (Fig 3).

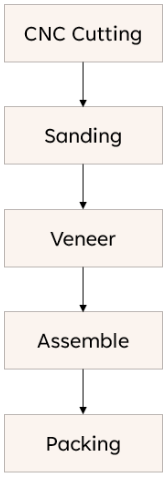

Fig 3. Table making process.

MRP (Material Requirements Planning) process, which involves forecasting demand, checking inventory levels, determining net requirements, and placing orders accordingly.

The company currently uses an Excel spreadsheet to manage its inventory, which can be a challenge as it may be difficult to track inventory levels and orders in real time (Fig 4). Additionally, manual data entry and calculations can be time-consuming and prone to errors.

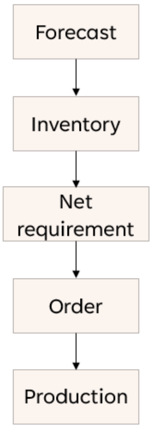

Fig 4. Current MRP process.

3.2 Problem

Production capacity is determined at 2000 units per week based on production data from the preceding year. The company simply imports raw materials to meet demand. There is no production planning or material inventory control; But there is variance because the number of orders fluctuates from month to month. 1500 units need to be produced at the minimum, while 2500 units are required at the maximum. The following table illustrates the demand and anticipated values over a year.

Table 1. The description of demand

Mean	2005.769
Standard Error	45.242
Median	2000.000
Mode	2400.000
Standard Deviation	326.246
Range	1000.000
Minimum	1500.000
Maximum	2500.000
Sum	104300.000

The demands and forecast is visualized as Fig. 5

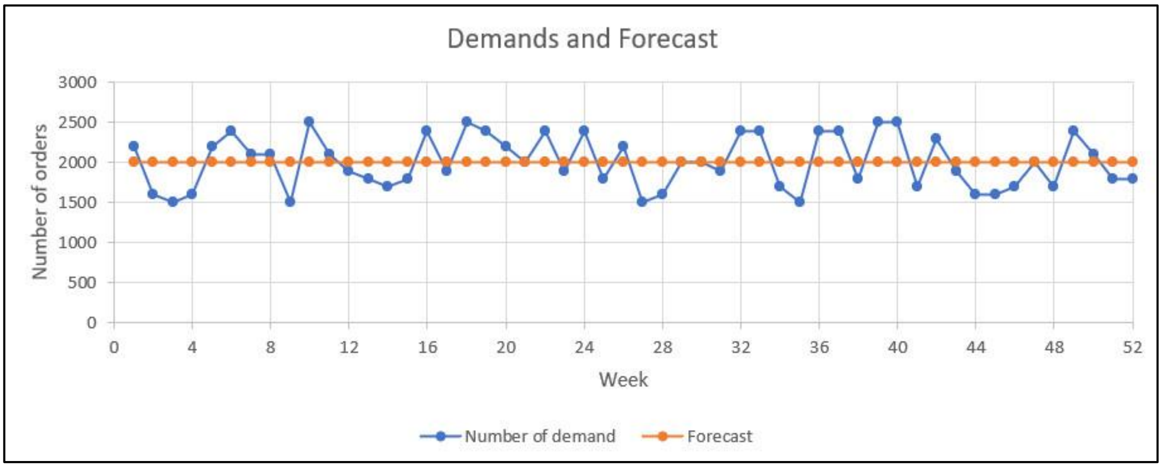

Fig 5. Demands and forecast

With only 2000 units of capacity and 2200 units of demand in the first week, the company lost 200 units. Similar to next week, the fluctuation may be higher or lower, resulting in a total product loss of 1700 units annually (Fig 6). It is the primary issue that this company needs to resolve.

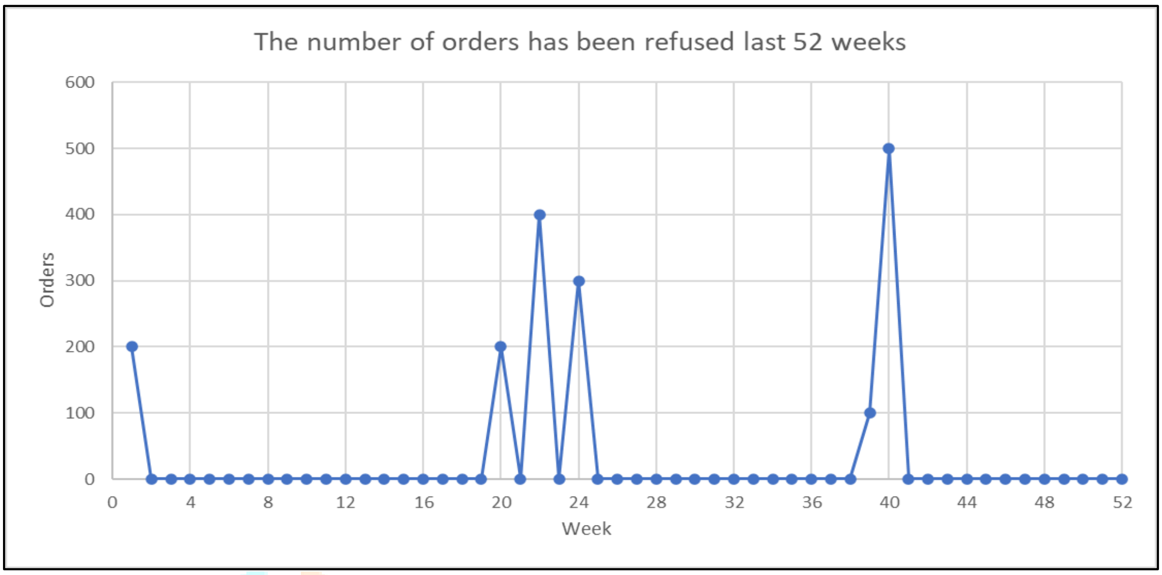

Fig 6. The number of refused orders

3.3 Applying IRL to solve the problem

Cycle stock: The table surface has an expected demand of 400 packs per day (based on mean valuation) .Cycle time is 10 days and the product is scheduled every second cycle, which means that the replenishment takt is 20 days. The required cycle stock to cover expected demand during the replenishment takt is then 400 packs/day × 20 days = 8000 packs.

Pipeline stock: The table surface has a manufacturing lead time of 2 days, a quality control time of 4 days, a transportation time of 4 days, and an inbound handling time of 2 days. The total lead time adds up to 12 days. The required pipeline stock is then 400 packs/day × 12 days = 4800 packs.

Demand safety stock: With a replenishment takt of 20 days and a lead time of 12 days, demand safety stocks need to cover uncertainty over a total period of 32 days. The required service level is 99%, which translates into a safety factor of 2.33. The standard deviation of demand is 327 packs/week = 82 packs/day. The demand safety stock is now calculated as

$$\text{Safety factor x standard deviation x } \sqrt{\text{Uncertainty period}} = 2.33 \text{ x } 82 \text{ x } \sqrt{32} = 1081 \text{ packs} \quad (3.1)$$

Supply safety stock: The standard deviation of the delivery quantity is 327 packs (meaning that, in 95% of deliveries, the quantity does not deviate more than ±327 packs). The lead time variability has a standard deviation of one day (meaning that, in 95% of cases, lead time does not deviate more than ±2 days). The required supply safety stocks for an service level of 99% are then calculated as

$$\text{Safety factor x } \sqrt{(\text{standard deviation})^2 + (\text{standard deviation}_{\text{lead time}} \text{ x demand rate})^2}$$
$$= 2.33 \text{ x } \sqrt{(327)^2 + (1 \text{ x } 327)^2} = 1078 \text{ Packs} \quad (3.2)$$

Policy stock: The packaging line is scheduled to be closed for one entire week due to scheduled maintenance work. This means that the policy stock is built up to cover the expected demand and its variability during 1 week. 327 packs/week + 2.33 × 100 × 7 = 943 packs.

Total: The IRL parameter is now the sum of the five stock components: IRL = 15902 packs.

Note however that average stocks on hand are far lower than the IRL parameter: average stock = 0.5 × cycle stock + demand safety stock + supply safety stock + policy stock = 11902 packs. The difference in quantity between the IRL and the average stock on hand is either in transport or has already been consumed by customers.

3.4 Result

Given that the entire inventory materials have been determined previously, 173 pallets are required to store 11902 units per month. The overall additional holding cost at the price of 0.8 USD per square meter per year will be $8821. The overall value loss is also provided to allow for benefit comparison. At $100 per unit and 1700 units lost annually, the total value lost is $170.000. Applying the IRL model, the company could earn $161.179 annually. There is a tremendous value for the company when define IRL was used.

III. Conclusions

This research has successfully defined IRL for product tables to avoid stockout when the business has fluctuated demands as a case study. However, the company should review the IRL number frequently with actual future demands to adjust the IRL number based on the business's situation and consider software to real-time monitor and manage the material's purchasing to reduce human dependence.

However, the IRL model may not be applicable to all types of manufacturing companies. This is because inventory management strategies can vary depending on the industry, product type, and customer demand patterns. Additionally, the IRL model does not account for external factors that can impact inventory levels, such as changes in market demand or supply chain disruptions. Therefore, it is important to consider the limitations of the IRL model when applying it to specific manufacturing companies.

Companies should evaluate their unique inventory management needs and consider alternative models or techniques that may be more appropriate for their specific circumstances. This research is now focusing on the highest quantity of product to avoid stockout and maintain the flow of production.

One potential future direction for research is to develop models that can account for MOQ requirements and minimize the impact on inventory levels and costs. For example, a model could be developed that evaluates the trade-offs between inventory carrying costs, MOQ constraints, and order frequency. The model could also consider the impact of variability in demand and lead times on inventory levels and costs.

Acknowledgment

We acknowledge Ho Chi Minh City University of Technology (HCMUT), VNU-HCM for supporting this study.

References

[1] Braglia, M., & Zavanella, L. (2003). Modelling an industrial strategy for inventory management in supply chains: The "Consignment Stock" case. International Journal of Production Research, 41(16), 3793–3808. doi:10.1080/0020754031000138330.

[2] Simone Zanoni & Mohamad Y. Jaber (2015) A two-level supply chain with consignment stock agreement and stock-dependent demand, International Journal of Production Research, 53:12, 3561-3572, DOI: 10.1080/00207543.2014.980012

[3] Taylor, Steve L. "Food allergies-A public health dilemma how did we get here? Where are we going?." Food Protection Trends 37.6 (2017): 462-463.

[4] Taheri, M., Amalnick, M. S., Taleizadeh, A. A., & Mardan, E. (2023). A fuzzy programming model for optimizing the inventory management problem considering financial issues: A case study of the dairy industry. Expert Systems with Applications, 221, 119766.

[5] Teerasoponpong, S., & Sopadang, A. (2022). Decision support system for adaptive sourcing and inventory management in small- and medium-sized enterprises. Robotics and Computer-Integrated Manufacturing, 73, 102226. doi:10.1016/j.rcim.2021.102226

[6] Taleizadeh, A. A., & Noori-daryan, M. (2016). Pricing, inventory and production policies in a supply chain of pharmacological products with rework process: a game theoretic approach. Operational Research, 16, 89-115.

[7] Lummus, R. R., & Vokurka, R. J. (1999). Defining supply chain management: a historical perspective and practical guidelines. Industrial Management & Data Systems, 99(1), 11–17. doi:10.1108/02635579910243851

[8] Packowski, J. (2013). LEAN supply chain planning: the new supply chain management paradigm for process industries to master today's VUCA World. CRC Press.

[9] Arnold, JR Tony. "Introduction to materials management." (2020).