

# Inventory Modeling: A Five Step Approach

D Thamaraiselvi, Shanmukha Sai Ganesh Sripada, Pisupati Srinivasa Pranav



**Abstract:** Inventory is the array of finished goods, spares, raw materials, and other substances required in the production of the finished goods and it is a major asset to a typical manufacturing company. When utilized properly, it can yield great profits for an organization and when not managed in an optimized way, it can incur big losses. There are various methods for inventory control, some of them being JIT (just in time inventory), cross-docking, and cycle counting. But these methods never yielded dividends to companies in getting control over their inventories. Therefore the need for proper inventory models to help maintain optimal stock keeping in mind the specific constraints of each company/organization is essential, say the least. This paper presents a generic version of an inventory model for raw materials, finished goods, and spares in a stock-keeping unit (SKU) where the overall stock is considered as a dependent variable and it is expressed as a function of various parameters or independent variables such as seasonality, demand and lead times (to name a few). The model allows the prediction of inventory levels of raw materials, finished goods, and spare parts of the machinery with a very high degree of accuracy and can subject the predictive model to various sensitivity and scenario analyses thus being able to gauge the opportunities and risks involved. As a result, there will be all-around improvements in vendor performance, procurement of raw material, handling the finished goods, and spare stocks resulting in an optimized environment in the inventory.

**Keywords:** Demand Forecasting, Inventory Coverage Ratio, Inventory Modeling, Predictive Modeling

## I. INTRODUCTION

Supply chain management includes the movement of finished goods, raw materials, and spares and it covers the full value chain from procuring the raw materials to the distribution of finished goods. The flow of materials, information, and finances goes from supplier to producer to wholesaler to retailer and finally, to the customer. Supply chain management is the oversight of these materials and finances. It includes three flows:

- Product flow
- Information flow
- Finance flow

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These flows occur across three main stages namely strategy, planning, and Operation. The management of supply chain orders includes some important features like the profitability of orders, long-term cooperation with the company, long-term order earnings, and increased customer loyalty. In this paper, we highlight the importance of inventory management in a supply chain. Inventory refers to the array of finished goods and the raw materials required to produce those finished goods.

The importance of these raw materials, spares, and engineering consumables in a typical buy-make-sell environment cannot be over-emphasized. With GATP as the primary driver and capacity maximization also playing a major role for most of the companies striking a perfect balance between the quantity holdings, the value in terms of production, lead times, supplier's constraints, logistics constraints, and the price changes determines majorly the profitability of the company.

An inventory is considered to be a core component of the supply chain and is where all areas of the supply chain converge. Satisfaction is one of the main goals of customer experience. It ensures loyalty and that customers keep coming for more. Inventory management is concerned with ensuring the right amount of stock at the right time and right cost. But for ages, finding the right stock levels of raw materials, finished goods, and spares have always posed challenges, and the methods like EOQ, EBQ, ABC, and XYZ Analyses are only serving limited purposes. The procurement strategy, procurement planning, and procurement operations need high levels of focus. Intuitive ways of managing stocks are a real dent in the operations and on profits.

The impact of no stock, low stock, excess stock, lack of traceability and tracking coupled with rudimentary ways of computing the raw material life cycle and the inability to study the impact on the working capital management and impact on the profits due to suboptimal ways of procurement require maximum attention and adoption of latest methods and technologies.

There are multiple inventory control methods in a multi-product environment. The total cost in these control methods can be divided into two components:

- Cost of preparation/ordering cost
- Maintenance cost
- The cost of ordering items can also be composed into two components:
  - The cost of order which is independent of order quantity.
  - Variable order costs that depend on the order of various products.

Now, let us rewind to the vitality of having proper inventory control and the proposed system.

## II. LITERATURE SURVEY

Paper 1: “Case Study on Inventory Management Improvement”

Authors: Darya Pliner, Arkady Borisov

Description: The authors focused on identifying the factors influencing inventory optimization and proposed a twofold system in which the inventory management is done first and then an agent system is applied to automate the inventory modeling process, where the agent system learns from the past inventory history and changes inventory control constants if needed. [1]

Paper 2: “Inventory Management Using Machine Learning”

Authors: Praveen KB, Pradyumna Kumar, Prateek J, Pragathi G, Madhuri J

Description: While discussing the challenges faced by companies in efficiently tracking their inventories, the author proposes a machine learning algorithm that uses the XGBoost regression model to perform demand forecasting for future business demand. [2]

Paper 3: “Demand Forecasting Using Neural Network for Supply Chain Management”

Authors: Ashvin Kochak, Suman Sharma

Description: In this paper, the authors suggested that businesses should make use of predictive algorithms like Artificial Neural Networks and Batch Gradient Descent to model an efficient demand forecasting technique. [3]

Paper 4: “An Application of Xyz Analysis in Company Stock Management”

Authors: Irena Nowotynska,

Description: Showed how ABC and XYZ analyses can be used to adjust the stock in the inventory concerning the expected sales and showed how important these analyses are in categorizing the stocks and the demand parameters to increase the efficiency of the inventory management model by giving an example of an office stationery company stock. [4]

Paper 5: “Inventory Management Model and Sensitivity Analysis for Stochastic Demand”

Authors: Huangjin Cao, Yueting Chai, Yi Liu

Description: Shows how analyzing the differences between the actual and predicted values on the inventory systems where individual parameters are subject to change to predict the dependent variable, i.e. demand. And these simulations give the sensitivities of each of these parameters which provide operational insights to businesses on how to manage their inventories. [5]

## III. PROBLEM STATEMENT

Major problems faced by businesses due to the lack of proper inventory modeling:

- Excess inventory / Low inventory
- Plant shut down due to lack of raw materials
- Lost sales due to finished goods unavailability
- Unavailability of spares leading to production cuts
- Lack of storage space.

## IV. PROPOSED SYSTEM

### A. The Five-Step Approach

- Material Selection Criteria: It is practically impossible

and not conceivable to think of subjecting the materials across all types subjecting to modeling and which materials need to be probed and modeled for Inventory modeling and optimization – need very careful consideration. The selection criteria ensure that correct and requisite materials are selected for this to get maximum business benefits.

- Desired Stock level: The Statistical analysis, we do from the historical stock data and other relevant variables provides us good insights into “What should be the optimum stock level?”

- Accumulation: The Model developed explains the antecedents of stocks and the causal factors, how they are influencing the stock getting into the system. The Model allows us to do accurate prediction/estimation/ forecast for the coming months and years. The scenario and sensitivity analysis, we carry on the model, varying the variable values, provide us deep insights and enable us a deterministic approach towards fixing a preconceived value to the stock or allow us to cope with different scenarios and accordingly adjust the procurement strategy and planning.

- Liquidation: Most of the time in most-the companies, the scenario before they adopt AI/ML models for Inventory –

- Inventory pile up,
- No traceability,
- No aging analysis,
- Plenty of redundant/obsolete inventory lying all over the warehouses/plants and
- In general stock holding is far more a good inventory coverage ratio.

Our solution enables very effective liquidation measures in an automated manner.

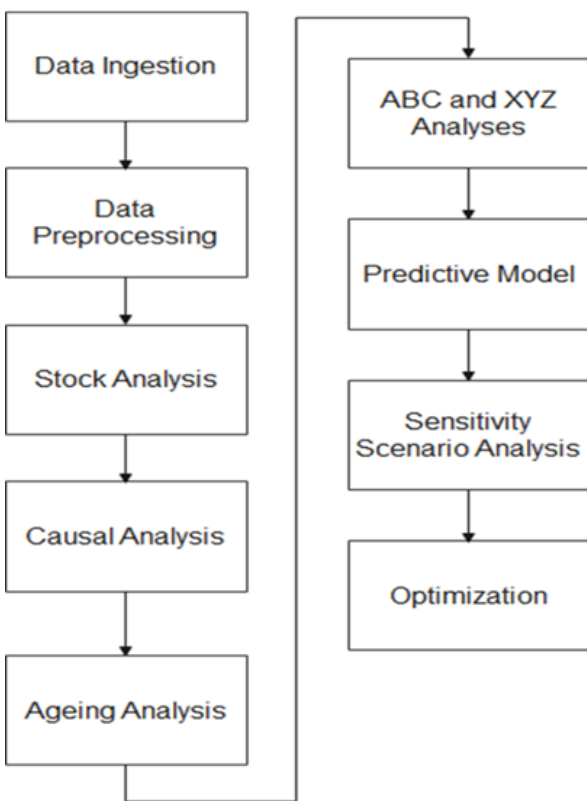
Prediction: The model developed and tested for accuracy would be operationalized for companies to forecast the inventory of the material required for a given production, demand, lead time, price, etc. The dashboard allows the management to do sensitivity scenario analysis to simulate various possibilities to gain a very good understanding. The Dashboard also allows monitoring the Key Performance Indicators – as not just aggregates but also as a Predictor and Simulator

### B. Advantages of the Proposed System

1. Taking the demand, supply, lead time, raw material costing, and the finished good costing based on raw materials and various other factors into consideration, this model can cause the business to shine to a great extent.
2. The use of predictive analysis: The Model developed and tested for accuracy would be operationalized for companies to forecast the inventory of the material required for a given production/demand/lead time/price etc.
3. Predicting the customer demand increases supply chain visibility.
4. The use of ABC and XYZ analyses: ABC and XYZ analyses can help businesses identify which items in the warehouse are the most important and should therefore consume most of the time in terms of inventory control and management.

5. Causal analysis helps find the correlation between the stock level and the different independent variables hence helping businesses in identifying their high priority variables.
6. Ageing analysis helps find the age of every individual unit in the inventory hence contributing to preventing dead stock in the inventory.
7. The Model helps in:
  - a. Selecting the Materials for modeling,
  - b. Determines the Desired Stock level of these selected materials,
  - c. Models the past historical stock levels with the corresponding data of the variables identified,
  - d. Helps in liquidating the stock
  - e. Helps in predicting the stock levels and
  - f. Helps in the prevention of inventory piling.

**C. Flow of the Solution**



- Use Data Ingestion: Data Ingestion is the process by which data is gathered from sources like databases, CSV or excel sheets, web sources, cloud, etc., into a single data repository.
- Data Pre-processing: In this step, all the different forms of data are transformed into a single uniformed format which the machine can understand and easily parse. The data is cleaned to get rid of outliers, null, duplicate, and missing values which may affect the efficiency of the model.
- Stock Analysis: It is one of the most crucial steps of this inventory modeling solution where we analyze the opening and closing stocks in the inventory, the stock that was issued to production, and the stock receipts in the inventory. The stock levels of the previous months, quarters, and years are also taken into account and the measures of central tendency are calculated and

visualized to get insights from the data. Through this step, the stock behavior over time is studied which helps in analyzing how the daily production demand is being met.

- Ageing Analysis: In aging analysis, we find which part of the inventory is how many days old. It determines the storage duration of an item and helps in preventing inventory stagnation.
- Causal Analysis: In causal analysis how much stock to maintain concerning different dependent variables is seen and experimented on. In other words, the effect of different parameters on the stock is studied and the target stock is determined in the later stages. This stage puts priorities into perspective.
- ABC and XYZ Analyses:
  - ABC Analysis: This is an important stage of the system as it determines what percentage of stock accounts for how much value, i.e.,
    - Class A denotes the little amount of stock that accounts for maximum value. 20% of inventory accounts for 80% of the total revenue.
    - Class B indicates a slightly average level of stock that accounts for less value than Class A and. About 30% of the items in the inventory account for about 15% of the total revenue.
    - Class C represents the bulk of the inventory that accounts for a very lesser value in the inventory. These items require minimum inventory control as they have a very less impact on the overall activity of the inventory. About 50% of the items in the inventory account for about 5% of the total revenue.
  - XYZ Analysis: As ABC analysis is performed on raw materials, XYZ analysis is performed on the finished goods. It shows what fraction of the inventory has a stable demand and what fraction has no stable demand as in the case of made-to-order products.
- Predictive Model: Predictive modeling uses data and statistics to predict outcomes with data models. The independent variables that influence the dependent variable are selected and then an equation is formed using those variables. In this step, effective machine learning algorithms are used to predict the dependent variable, i.e., stock in this case.
- Sensitivity Scenario Analysis: In this phase, using the predictive model the independent variable values are changed/played with to create scenarios where if certain variables are set to certain values, the predicted output can be seen. The ultimate goal of this phase is to see which variables affect the predicted value and in what way. This is a manual process.
- Inventory Optimization: This step is based on the business as is. Each business is unique in its way and has variable constraints. Taking all those constraints into account, the optimal stock that is to be maintained at different times, considering a wide variety of scenarios is determined.

## V. CONCLUSION

Efficient methods such as demand forecasting will help small to large industries reduce manual labor and make them avoid investing heavy capital being tied up on inventory. The need to move into inventory modeling from inventory management cannot be over-emphasized. The traditional inventory management techniques never yielded anything substantial for companies in getting control over their inventories. Striking a balance between procurement, production, and demand and accordingly sourcing raw materials optimally ensures a clinical way of managing raw materials and finished goods that in turn increase supply chain visibility (The ability to know what the demand will be like shortly, implying that the amount of stock that is to be maintained is known and how much to procure becomes clear) and plant shutdowns due to over/under stocking can be avoided.

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