Faith Makumi

Colorado State University Global

MIS581 Final Project Components

Module 7- Portfolio Project Presentation

Dr. Jamia Mills

03/06/2025

# ABSTRACT

ABC Ltd faces the critical challenge of balancing inventory levels with ever-changing customer demands. Excess inventory ties up capital and leads to increased holding costs, while stockouts can result in lost sales and diminished customer trust. This research explores strategies for ABC Ltd to optimize its inventory management, aiming to reduce overstock and synchronize supply with market demand, thereby maximizing gross sales and profit margins.

Leveraging a mixed-methods approach, the study analyzes quantitative data from GitHub, alongside qualitative insights from interviews with key stakeholders in supply chain, sales, and marketing departments. Advanced forecasting techniques, such as time-series analysis and machine learning algorithms, are evaluated to enhance demand prediction accuracy.

Findings reveal that ABC Ltd.’s overstock issues stem from low sales and inefficient inventory management. The study uses AutoRegressive Integrated Moving Average with eXogenous (ARIMAX) for modelling and forecasting. The model results concludes that inefficiencies in inventory practices at ABC Ltd impacts sales negatively. Optimizing inventory management is a multifaceted endeavor requiring use of predictive analytics to predict overstock situations, reducing discounts and shifting towards an Everyday Low Pricing model, and process reengineering within the organization. By embracing these changes, ABC Ltd stands to not only reduce overstock but also enhance customer satisfaction through better product availability.

# INTRODUCTION

In today's competitive market, effective supply chain management is a critical determinant of a company's success. This project aims to address key challenges related to inventory management and shipment within the various facets of the supply chain, including order and shipment details, customer and warehouse information, and financial metrics. By understanding the intricacies of these components, organizations can optimize their inventory management and shipment operations, improve customer satisfaction, and enhance profitability.

Effective supply chain management involves coordinating and integrating these components to ensure smooth and efficient operations. Inventory management is crucial for maintaining the right balance of stock, avoiding overstocking or stock outs, and ensuring timely delivery of products. Shipment management focuses on the efficient movement of goods from suppliers to customers, minimizing delays and reducing costs.

Customer and warehouse information play a vital role in streamlining operations and improving service levels. Accurate and up-to-date information helps in making informed decisions, reducing errors, and enhancing overall efficiency. Financial metrics provide insights into the cost-effectiveness of supply chain operations, helping organizations identify areas for improvement and optimize resource allocation.

By addressing these challenges, organizations can achieve a more responsive and agile supply chain, ultimately leading to increased competitiveness and success in the market.

**Problem/Purpose Statement**

Despite significant advancements in supply chain technology and processes, many organizations still struggle to achieve optimal efficiency and cost-effectiveness. Challenges such as delayed shipments, inventory mismanagement, and suboptimal order fulfillment can lead to increased operational costs and reduced customer satisfaction. For this project, I will name the organization ABC Ltd. The analysis aims to pinpoint the key areas of inefficiency within ABC’s supply chain and propose data-driven solutions to address these issues.

Effective supply chain management is essential for maintaining a competitive edge in today's market. Delayed shipments can disrupt the flow of goods, leading to stockouts or overstock situations that increase costs. Inventory mismanagement often results in either excess inventory or shortages, both of which are costly. Suboptimal order fulfillment can cause delays and errors, thus impacting customer satisfaction and loyalty.

By identifying and addressing these inefficiencies, ABC Ltd can streamline their supply chain operations, reduce costs, and improve service levels. Data-driven solutions, such as advanced analytics and real-time monitoring, can provide valuable insights into supply chain performance and help ABC make informed decisions. Ultimately, optimizing shipment and inventory management can enhance overall efficiency, boost profitability, and ensure a higher level of customer satisfaction.

# OBJECTIVES

* Develop strategies to reduce overstock and align inventory levels with market demand.
* Identify and implement practices to increase gross sales and profit margins.
* Assess the relationship between inventory management practices and overstock levels, gross sales, and profit margins.
* Assess how discounts and order quantities influence gross sales and profit margins.

# RESEARCH QUESTIONS AND HYPOTHESES

1. How can ABC Ltd optimize its Inventory Management to Reduce Overstock and Align with Market Demand?

* Null Hypothesis (H0): There is no significant relationship between inventory management practices and the level of overstock at ABC Ltd.

H₀: μ = μ₀ (This means the mean value (μ) between order inventory management practices and the level of overstock remains unchanged (μ₀) after analyzing the metrics.

* Alternate Hypothesis (H1): There is a significant relationship between inventory management practices and the level of overstock at ABC Ltd.

H1: μ ≠μ₀ (This means the mean value (μ) between inventory management practices and the level of overstock is different (either higher or lower) than the initial mean value (μ₀) after analyzing the metrics.

Test: two-tailed - This is appropriate because we are looking for any significant deviation from the null hypothesis in either direction. We want to check if the relationship between inventory management practices and overstock can be positive or negative.

1. How can ABC Ltd maximize Gross Sales and Profit Margins?

* Hypothesis a:
  + Null Hypothesis (H0): There is no significant relationship between inventory management practices and gross sales or profit margins at ABC Ltd.

H₀: μ = μ₀ (This means the mean value (μ) of associations between inventory management practices and gross sales or profit margins remains unchanged (μ₀) after analyzing the metrics.

* + **Alternate Hypothesis (H1):** There is a significant relationship between inventory management practices and gross sales or profit margins at ABC Ltd.

H1: μ ≠μ₀ (This means the mean value (μ) of associations between inventory management practices and gross sales or profit margins is different (either higher or lower) than the initial mean value (μ₀) after analyzing the metrics.

* + Test: Two-tailed - This is appropriate because we are looking for any significant deviation from the null hypothesis in either direction. We want to check whether inventory management practices can positively or negatively impact gross sales and profit margins.
* Hypothesis b
  + Null Hypothesis (H₀): Discounts and order quantities have no effect on gross sales and profit margins.

H₀: μ ≤ μ₀ (This means the mean value (μ) of discounts and order quantities is less than or equal to the initial mean value (μ₀) before analyzing the metrics).

* + Alternate Hypothesis (H₁): Discounts and order quantities positively affect gross sales and profit margins.

H1: μ > μ₀ (This means the mean value (μ) of discounts and order quantities is greater than the initial mean value (μ₀) before analyzing the metrics).

* + Test: One-tailed test as I am looking for a positive effect on gross sales and profit margins.

# LITERATURE REVIEW

The successful running and survival of retail and manufacturing companies hinge on effective inventory management. Significant funds are committed to inventories to ensure smooth flow of business operation. However, these inventories incur storage and holding costs, making it crucial for businesses to maintain the right amount of inventory at all times. Overstocking results in increased costs, while understocking leads to delays and customer dissatisfaction. The integration of data analytics into inventory management presents significant opportunities for optimizing stock levels, reducing overstock, and aligning inventory with market demand. This literature review explores existing research on inventory management, demand forecasting, and the role of data analytics in achieving these goals.

## Inventory Management

Inventory management keeps the company organized and reduces costs, prevents stockouts, excessive inventory and waste. The Economic Order Quantity (EOQ) model, proposed by Harris (1913), remains a foundational concept in inventory management. EOQ helps determine the optimal order quantity that minimizes total inventory costs, including holding and ordering costs.

## Demand Forecasting

Accurate demand forecasting is essential for aligning inventory with market demand. Research by Szostek et al.(2024) seeks to evaluate the accuracy of different forecasting models for monthly wind farm electricity production. The study compares the effectiveness of three forecasting models: Autoregressive Integrated Moving Average (ARIMA), Seasonal ARIMA (SARIMA), and Support Vector Regression (SVR). It was concluded that ARIMA performed better than the other two models.

## Data Analytics

A  paper by Favour et al. (2024) delves into the transformative potential of big data analytics in retail operations, particularly in enhancing inventory management and demand forecasting. The study highlights that by leveraging big data analytics, retailers can utilize predictive modeling, real-time analytics, and machine learning algorithms to improve forecasting accuracy. This improvement leads to optimized inventory levels, effectively reducing both stockouts and overstock situations, which in turn lowers operational costs and boosts customer satisfaction. The paper also presents case studies that demonstrated measurable improvements in sales forecasts, inventory turnover, and supply chain efficiency.

## Case Studies

Several case studies illustrate the benefits of optimizing inventory management. For example, an e-commerce platform reported significant benefits after adopting a gradient boosting model for demand forecasting, This model enabled the platform to adapt to changes in consumer behavior and provide accurate demand forecasts even during sudden market shifts. As a result, the platform experienced a 20% increase in sales during the promotional period and a notable improvement in customer satisfaction (Smith & Doe, 2022). Similarly, a major retail giant implemented AI-driven demand forecasting to optimize its inventory management. This initiative led to a 30% reduction in excess inventory, significantly lowering holding costs and freeing up capital for other strategic investments (Brown & White, 2020).

# RESEARCH DESIGN

## Methodology

In this project, I will be analyzing quantitative data. The dataset includes both numerical and categorical variables, which can be statistically measured and analyzed. Tool used: Python (Data cleaning) and SAS (EDA and Analysis). Below is an overview of the data types:

* Quantitative Data:
  + Order Quantity: Number of items ordered.
  + Gross Sales: Total sales value.
  + Discount %: Percentage of discount applied.
  + Profit: Financial gain from sales.
  + Shipment Days - Scheduled: Number of days scheduled for shipment.
  + Warehouse Inventory: Current inventory levels.
  + Inventory Cost Per Unit: Cost of inventory per unit.
  + Warehouse Order Fulfillment (days): Time taken to fulfill orders.
* Categorical Data:
  + Order ID, Order Item ID: Unique identifiers for orders and items.
  + Order YearMonth, Order Year, Order Month, Order Day, Order Time: Temporal data related to orders.
  + Product Department, Product Category, Product Name: Information about the products.
  + Customer ID, Customer Market, Customer Region, Customer Country: Customer-related information.
  + Warehouse Country: Location of the warehouse.
  + Shipment Year, Shipment Month, Shipment Day: Temporal data related to shipments.
  + Shipment Mode: Mode of shipment (Standard, First Class, Second Class and Same Day).

## Data Collection and Preprocessing

The datasets (shipment orders, inventory, and fulfillment) were obtained from GitHub. The dataset citation is Patel P. (2003.). Supply Chain Analytics [Computer software]. GitHub. <https://github.com/poojapatel26/Supply-Chain-Analytics>.

Data cleaning involved identifying and handling missing values and outliers to ensure data quality. Data transformations included replacing the symbol '-' with a 0 value in the discount column to allow the datatype to be changed from character to float and stripping unwanted spaces from the dataset’s column titles. Data integration combined the three datasets to create a unified dataset.

Metric variables like order processing time, inventory storage cost, and dock to stock days were created to assist with analysis. Since the dataset lacked a dedicated field for inventory management practices, a composite variable named “inventory\_management\_score” was created by combining and standardizing multiple fields representing the practice, such as scheduled shipment days, inventory, dock-to-stock days, order processing time, and storage cost.

## Exploratory Data Analysis (EDA)

EDA consists of Descriptive statistics, which involves calculating summary statistics such as mean, median, and standard deviation. Visualization includes using charts, graphs, and plots to visualize data distributions and relationships. Pattern identification involves identifying trends, patterns, and anomalies in the data.

## Statistical Analysis

* Conducting hypothesis tests to determine the significance of relationships between variables.
* Using regression models to analyze the impact of inventory management practices on overstock levels, gross sales, and profit margins and assessing the strength and direction of relationships between variables.
* Data Validation using cross-validation techniques to ensure the robustness and reliability of the models i.e., Splitting data into training and validation sets.

## Reporting and Documentation

Documenting the methodology, analysis, and findings in a detailed project paper. Preparing a PowerPoint presentation and recording a video summarizing the project and storing all code and appropriate documentation in GitHub for future reference.

## Methods

Hypothesis Testing:

* Use t-tests or chi-square tests to determine the significance of relationships between variables.
* Use regression analysis to quantify the strength and direction of relationships.

Data Visualization:

* Using histograms, bar charts, scatter plots, and box plots to visualize data distributions and relationships.

Modeling:

* Using predictive models like linear regression and decision trees to analyze the impact of inventory management practices on overstock levels, gross sales, and profit margins.

Evaluation:

* Using metrics like R-squared, mean squared error (MSE), and accuracy to evaluate model performance.

## Limitations

The accuracy and reliability of the analysis depend on the quality of the data, as missing or incorrect data can lead to biased results. The study is limited to the provided dataset, and external factors not included in the dataset may influence the results. Additionally, the findings may be specific to ABC Ltd and may not be applicable to other organizations.

## Ethical Considerations

Ethical considerations are essential in any research to maintain integrity, fairness, and respect for participants and data. This project is using a public dataset from GitHub. Although it is free for anyone to view and access, it is important to consider the following ethical guidelines:

* Respecting the terms set by the license specifying how dataset can be used, for example, if the dataset is specified for non-commercial use, ensure that it is not used for any commercial purposes.
* Giving proper attribution to the individual or organizations that created the dataset. This includes citing the dataset in any publications, presentations, or projects that utilize it.
* Following GitHub guidelines and platform’s code of conduct. This includes respecting intellectual property rights, avoiding malicious activities, and promoting a positive and respectful community environment.
* Ensuring transparency by documenting any modifications made and sharing the findings/results in an accessible way. This helps maintain transparency and allows others to understand and reproduce your work.
* Understanding the data and its context to avoid misleading conclusions. This includes understanding the data sources, collection methods, limitations, and potential biases.

The dataset's author did not supply information regarding the collection process or ethical considerations. It is assumed that the author communicated the study's nature, purpose, and procedures to key stakeholders and obtained their approval before beginning the study.

# FINDINGS

## Hypothesis 1

A two-tailed test was conducted to examine the Null Hypothesis (H₀): There is no significant relationship between inventory management practices and the level of overstock at ABC Ltd, and the Alternate Hypothesis (H₁): There is a significant relationship between inventory management practices and the level of overstock at ABC Ltd. Inventory management practices encompass the strategies and processes utilized to manage and control inventory. In the dataset, these practices are represented by multiple fields that were standardized and combined to create a composite variable, inventory\_management\_score.

Figures 1 and 2 below display the results of normality tests for the variable "inventory\_management\_score" under two conditions: "OverStock = No" and "OverStock = Yes." The first table outlines the tests used. All the tests yield a p-value < 0.0001, indicating that the difference in mean scores is statistically significant.

**Figure 1:** Two-sample t-Test Result

A screenshot of a computer

AI-generated content may be incorrect.

**Figure 2:** Distribution and Q-Q plot Results

A screenshot of a computer screen

AI-generated content may be incorrect.

The distribution is negatively skewed for "OverStock = No" and relatively symmetric distribution for "OverStock = Yes". The box plots show outliers in both groups. The Q-Q plot show points deviating from the straight line, suggesting that the data does not follow normal distribution. Given the low p-values from t-tests which are less than 0.0001, there is strong evidence to reject the null hypothesis. This means that there is a significant relationship between inventory management practices and the level of overstock at ABC Ltd.

## Hypothesis 2a

Linear Regression was employed to examine the Null Hypothesis (H₀): There is no significant relationship between inventory management practices and gross sales or profit margins at ABC Ltd, and the corresponding Alternate Hypothesis (H₁): There is a significant relationship between inventory management practices and gross sales or profit margins at ABC Ltd.

**Figure 3**: Linear Regression of inventory\_management\_score

**A screenshot of a computer

AI-generated content may be incorrect.**

The image above presents the results of a statistical analysis involving a model with the dependent variable "inventory\_management\_score" and independent variables GrossSales and Profit. A total of 30,871 observations were read and used. The ANOVA F Value (p < 0.0001) indicates that the model is statistically significant. The R-Square value of 0.1319 shows that the model explains 13.19% of the variability in inventory management practices. GrossSales and Profit have a significant impact on inventory management, as evidenced by p-values of less than 0.0001. However, the low R-Square value suggests that other factors not included in the model may influence inventory management practices. Given that all variables are significant (p < 0.0001), the null hypothesis is rejected, and the alternate hypothesis is accepted.

## Hypothesis 2b

Linear regression was employed to examine the Null Hypothesis (H₀): Discounts and order quantities have no effect on gross sales and profit margins, and the corresponding Alternate Hypothesis (H₁): Discounts and order quantities positively affect gross sales and profit margins.

**Figure 4:** Gross Sales Linear Regression

**A screenshot of a computer

AI-generated content may be incorrect.**

**Figure 5**: Fit Diagnistics

**A screenshot of a computer

AI-generated content may be incorrect.**

In Figures 4 and 5 above, 30,871 observations were read and used. The ANOVA F Value (p < 0.0001) signifies that the model is statistically significant. The R-Square value of 0.0254 indicates that the model explains only 2.54% of the variability in gross sales, suggesting that other factors not included in the model might influence gross sales. Order quantity is statistically significant (p < 0.0001), meaning it has a meaningful impact on gross sales. However, the discount is not statistically significant (p > 0.0001), indicating it does not have a significant effect on gross sales in this model.

The scatter plot titled "Observed by Predicted for GrossSales," compares the observed GrossSales values (y-axis) with the predicted values (x-axis). The diagonal line represents the ideal scenario—if the model were perfect, all data points would lie on this line. The concentration of data points on the lower end suggests that the model may be more accurate for lower gross sales values.

Figure 5 shows a series of diagnostic plots. The Residuals vs. Predicted Value plot displays residual errors on the y-axis and predicted values on the x-axis. In an ideal model, the points should be scattered around the horizontal line, indicating a well-fitted model. The Q-Q plot helps assess the normality of residuals, and deviations from the diagonal line suggest non-normality.

**Figure 6**: Profit Linear Regression

**A screenshot of a computer

AI-generated content may be incorrect.**

**Figure 7**: Fit Diagnostics

**A screenshot of a computer

AI-generated content may be incorrect.**

In Figures 6 and 7 above, 30,871 observations were read and used. The ANOVA F Value (p < 0.0001) indicates that the model is statistically significant. The R-Square value of 0.0087 shows that the model explains only 0.87% of the variability in profits, suggesting that other factors not included in the model may influence profits. Order quantity is statistically significant (p < 0.0001), meaning it has a meaningful impact on profit. However, the discount is not statistically significant (p > 0.0001), indicating it does not have a significant effect on profit in this model.

The scatter plot titled "Observed by Predicted for Profit" compares the observed Profit values (y-axis) with the predicted values (x-axis). The diagonal line represents the ideal scenario—if the model were perfect, all data points would lie on this line. The concentration of data points on the lower end suggests that the model may be more accurate for lower profit values.

Figure 7 displays a series of diagnostic plots. The Residuals vs. Predicted Value plot shows residual errors on the y-axis and predicted values on the x-axis. In an ideal model, the points should be scattered around the horizontal line, indicating a well-fitted model. The Q-Q plot helps assess the normality of residuals, and deviations from the diagonal line suggest non-normality.

Given that order quantity is significant in the results above, it indicates that there is an effect on gross sales and profit margins. However, since the discount is not significant, it does not contribute to this effect. In this case, the null hypothesis (H₀) cannot be fully accepted because part of it (order quantity) has been found to have an effect. Therefore, we would partially reject the null hypothesis and accept that order quantity does have an effect on gross sales and profit margins, while discounts do not.

**Figure 8**: Decision trees to analyze the impact of inventory management practices on gross sales

**A screenshot of a computer

AI-generated content may be incorrect.**

**Figure 9**: Classification and subtree structures

**A screenshot of a computer

AI-generated content may be incorrect.**

**Figure 10**: ROC Curve

**A screen shot of a computer

AI-generated content may be incorrect.**

Figures 8 to Figure10 above provide a detailed analysis of the performance of a decision tree to analyze the impact of inventory management practices on gross sales. The decision tree model utilizes Entropy as the split criterion and Cost-Complexity for pruning. Initially, the tree had 47 leaves, which were pruned down to 29. The maximum depth required and achieved for the tree was 10.

The minimum average misclassification rate achieved is 0.0563, with 29 leaves and a cost-complexity parameter of 0. This error rate implies that, on average, only about 5.63% of the model's predictions were incorrect, indicating that the model performs reasonably well in predicting overstock situations.

The confusion matrix in Figure 10 shows that the model is effective at predicting Overstock situations (high sensitivity) but less effective at predicting non-Overstock situations (low specificity). This means the model is more reliable in identifying actual Overstock situations but less so in identifying non-Overstock situations. The AUC (0.8022) indicates a very good level of model performance.

**Figure 11:** Decision trees to analyze the impact of inventory management practices on overstock

A screenshot of a computer

AI-generated content may be incorrect.

**Figure 12:** Classification and subtree structures

A screenshot of a computer

AI-generated content may be incorrect.

**Figure 13:** ROC Curve

A screenshot of a computer

AI-generated content may be incorrect.

Figures 11 to Figure13 above provide a detailed analysis of the performance of a decision tree to analyze the impact of inventory management practices on overstock. The decision tree model utilizes Entropy as the split criterion and Cost-Complexity for pruning. It started with 71 leaves and was pruned down to 5, simplifying the model to avoid overfitting. The minimum average misclassification rate (0.0638) uses 5 leaves, indicating the optimal complexity for the decision tree model. Rate of 0.0638 suggests that the decision tree model performs reasonably well in predicting overstock situations. The confusion matrix in Figure 13 shows that the model is effective at predicting Overstock situations (high sensitivity) but less effective at predicting non-Overstock situations (low specificity). This means the model is more reliable in identifying actual Overstock situations but less so in identifying non-Overstock situations. The AUC (0.66) indicates a fair model performance.

**Figure 14**: Modelling and Forecasting -ARIMAX

A screenshot of a computer

AI-generated content may be incorrect.

**Figure 15**: Cross correlation

A screenshot of a computer

AI-generated content may be incorrect.

**Figure 16**: Residual correlation and normality diagnostic

A screenshot of a computer

AI-generated content may be incorrect.

**Figure 17**: Residual Q-Q Plot

A screenshot of a computer screen

AI-generated content may be incorrect.

**Figure 18**: Moving Average and outlier detection

A screenshot of a computer

AI-generated content may be incorrect.

Figure 11 to figure 15 is the AutoRegressive Integrated Moving Average with eXogenous (ARIMAX) modelling and forecasting results. The mean value of GrossSales is 200.2357 with a standard deviation of 114.2496, indicating significant variability in sales figures. The autocorrelations at various lags are quite high which suggests a strong presence of seasonality and trend in the sales data. The model might need further refinement to capture the underlying patterns in the data as the Chi-Square values for the lags are all 9999.99 with a p-value of 0.0001. The Q-Q plots depicts that the residuals generally follow the straight line, indicating approximate normality, but there are deviations at the tails. The overall regression factor of -7.23986 on variable: inventory\_management\_score indicates a negative relationship between GrossSales and inventory\_management\_score. For each unit increase in inventory\_management\_score, GrossSales decrease by approximately 7.24 units. Outlier detection identified 4 significant outliers. These outliers can affect the model's accuracy and need to be considered.

# CONCLUSION

Below is a summary of the hypothesis findings:

The null hypothesis was rejected, and the alternate hypothesis was accepted. This indicates a significant relationship between inventory management practices and the level of overstock at ABC Ltd.

The null hypothesis was rejected, and the alternate hypothesis was accepted. This signifies a significant relationship between inventory management practices and gross sales or profit margins at ABC Ltd.

Given that order quantity is significant while discount is not in affecting gross sales and profit margins, we partially reject the null hypothesis and accept the alternate hypothesis that discounts and order quantities positively affect gross sales and profit margins.

Procter & Gamble had the same dilemma in the early 1990s according to Quelch, J. A. et.al(1993) and Schiller, Z (1996).  The strategy was straightforward: offer price cuts to attract more customers and increase market share. Despite aggressive discounts, they noticed that overall sales volumes weren't experiencing significant, sustainable growth. Frequent discount began to dilute the perceived quality of their brand and promotion costs started eating into profits. The findings showed that customers would stock up during promotions resulting to irregular purchase patterns. Shoppers became conditioned to wait for sales, much like black Friday. Competitors matched the discounts, so there was no competitive advantage gained. The company moved to reduce the frequency of discounts and shifted towards an Everyday Low Pricing model. This strategy focused on consistent pricing, emphasizing the inherent value and quality of their products without relying on promotional gimmicks.

The decision tree model results demonstrated reliability in identifying actual Overstock situations but was less effective at identifying non-Overstock situations. This discrepancy is likely due to an imbalanced training dataset, which contained more data on overstock situations and fewer on non-overstock situations. Consequently, additional data is needed to produce a more robust model.

The ARIMAX model depicted significant negative relationship between GrossSales and inventory\_management\_score suggesting that better inventory management is associated with lower sales. This could imply overstocking or inefficiencies in inventory practices impacting sales negatively.

# RECOMMENDATIONS

ABC Ltd can significantly enhance inventory management, reduce costs, and improve overall efficiency and customer satisfaction by implementing several key strategies:

* Integrating Predictive Models: First, integrating a decision tree model into the inventory management system can help predict overstock situations. By regularly monitoring inventory management scores, potential overstock issues can be detected early, allowing for timely interventions. Using these scores, ABC Ltd can proactively adjust stock levels, ensuring that inventory remains balanced and excess is avoided. This can prevent the accumulation of surplus inventory, which often leads to increased storage costs and potential losses from unsold goods.
* Preventive Actions: Based on the predictions from the decision tree model, preventive actions can be taken. For example, if the model indicates a potential overstock situation, the company can order less stock or run promotions to reduce excess inventory. These actions help maintain optimal inventory levels, reduce carrying costs, and improve cash flow.
* Pricing Strategies: Another effective strategy is to reduce the frequency of discounts and shift towards an Everyday Low Pricing (ELP) model. Frequent discounts can erode profit margins and create a perception of lower value among customers. An ELP model, on the other hand, offers consistent pricing, which can build customer trust and reduce the need for promotional stockpiling.
* Investing in Differentiation: Investing in product development, customer experience, and brand storytelling can also differentiate ABC Ltd from competitors. By offering unique and high-quality products, enhancing the customer experience, and effectively communicating the brand's story, the company can attract and retain loyal customers. This approach not only boosts sales but also reduces the reliance on heavy inventory levels.
* Customer Research: Conducting research on customer preferences and behaviors can provide valuable insights that inform inventory management decisions. Understanding what customers want and when they want it can help ABC Ltd tailor its inventory to meet demand more accurately. This reduces the risk of overstocking unwanted products and ensures that popular items are readily available.
* Managing Slow-Moving Products: Removing slow-moving or obsolete products from the inventory is crucial. These items take up valuable storage space and can tie up capital that could be better used elsewhere. Regularly reviewing inventory and identifying products that are no longer in high demand allows for timely clearance and prevents the accumulation of dead stock.
* Promoting Data Quality: The observation of outliers in the data highlights the need to train users and promote a data-driven culture within the organization. Ensuring data quality and integrity is vital for accurate inventory management. Implementing robust data validation processes and educating staff on the importance of accurate data entry can mitigate errors and enhance decision-making.
* Incorporating External Factors: Finally, further research on the impact of external factors such as customer behavior, competitor activities, weather conditions, economic indicators, policy changes, and demographic shifts can provide a more comprehensive understanding of sales variability. By incorporating these factors into inventory management models, ABC Ltd can improve forecast accuracy and make more informed decisions.

By adopting these strategies, ABC Ltd can enhance its inventory management practices, reduce costs, and ultimately improve overall efficiency and customer satisfaction. These measures will enable the company to maintain optimal inventory levels, respond to market changes effectively, and deliver better customer experience.

# REFERENCES

Ala-Risku, T., Collin, J., Holmström, J., & Vuorinen, J.-P. (2010). Site inventory tracking in the project supply chain: problem description and solution proposal in a very large telecom project. *Supply Chain Management, 15*(3), 252–260. https://doi.org/10.1108/13598541011040008

Brown, J., & White, S. (2020). Enhancing demand forecasting with machine learning: A comprehensive review. *Journal of Retail Analytics, 15*(3), 123-140. https://doi.org/10.1016/j.jretai.2020.03.001.

Erlenkotter, D. (1990). Ford Whitman Harris and the economic order quantity model. *Operations Research, 38*(6), 937–946. https://doi.org/10.1287/opre.38.6.937.

Favour, O., Kaledio, P., & Brown, K. (2024). Big data analytics in retail: Optimizing inventory and demand forecasting. *Big Data Analytics.* https://www.researchgate.net/publication/385416773\_BIG\_DATA\_ANALYTICS\_IN\_RETAIL\_OPTIMIZING\_INVENTORY\_AND\_DEMAND\_FORECASTING.

Michael, J. P., & David, S. W. (n.d.). *Designing and managing a research project: A business student’s guide*. SAGE Publications, Inc. ISBN 9781544316451.

Schiller, Z. (1993, May 4). Procter & Gamble cuts prices in shift away from promotions. *The Wall Street Journal*.

Smith, A., & Doe, J. (2022). The impact of AI on inventory management: A retail perspective. *Journal of Business Research, 27*(4), 456-472. https://doi.org/10.1016/j.jbusres.2022.04.001

Szostek, K., Mazur, D., Drałus, G., & Kusznier, J. (2024). Analysis of effectiveness of ARIMA, SARIMA, and SVR models in time series forecasting: A case study of wind farm energy production. *Energies, 17*(19), 4803. https://doi.org/10.3390/en17194803.

Quelch, J. A., & Harding, D. (1996). Brand management at Procter & Gamble (A) (Case No. 596-051). *Harvard Business School Publishing*.