

# CSCE 5320 Group 7: INVENTORY, FULFILMENT AND CUSTOMER SATISFACTION IN BRINGING WAREHOUSE PERFORMANCE

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## I. INTRODUCTION

The most powerful tool for analyzing complex and large datasets and gaining insights is **data visualization**. It is a process of presenting data using charts such as plots, heatmaps, and other graphical representations. These informational charts reveal data relationships and data-driven patterns in an understandable manner.

It's easy to see that data visualization is not just for data teams but can be utilized by a wide range of other teams. **Data analysts** and **data scientists** use tools like Tableau to discover and explain patterns and trends. **Management** uses these visualizations to communicate business implications across organizational structures and hierarchies.

Data visualization is ultimately about **visual creation, idea generation, and clear explanation** of insights to stakeholders within a company.

### Objectives of the Paper:

The main objectives of this paper are:

- To explain the role of visualization charts in maximizing the inventory for meeting the requirements of operations.
- To determine the problems faced by warehouses and inventory assets by visualization.
- To analyse and evaluate various visualization for the manner in which they yield important points.

Inventory is the main variable and a need for any firm. Without an inventory, an organization finds it difficult to run systematically. It is essential to the business continuous functioning and helps evaluating the operations for its efficiency and stable financial path of the organization. It is also considered a resource that runs a business operations smoothly and shows business growth. Inventory management is the most often used technique for obtaining, storing,

using and selling the company products. It combines item processing with the administration and storage of materials and final products. Successful inventory management requires best inventory control over the products they run. In order to prevent inventory from becoming overvalued, the management should ensure that the goods are kept in good shape that stock levels are accurate, and that storage capacity is both economical and effective. Physical counts, paper record-keeping, manual data entry, manual order processing and anticipatory response have all been part of inventory management in the past leading to various errors. Improving the warehouse's efficiency is by its metric indicators. Every warehouse will employ a different set of Key parameters for metrics. If managers can find the right parameters that fit the demands of the company which they will be able to take best action faster and more efficiently. Common inventory KPIs include inventory turnover, accuracy, shrinkage, carrying cost and inventory-to-sales ratio.

Financial performance is the first indirect measure of warehouse performance, focusing on how a company distributes its resources to satisfy stakeholders and customers by maintaining efficiency. Inventory control is required to guarantee the supply and item availability by providing consumers with the best services and a competitive edge over the three factors: financial success, customer satisfaction, and warehouse efficiency combined. Poor monitoring on products will lead to problems like high costs and irregular inventory, which keeps the company in losses. Those who are in charge of the warehouse inventory will always keep the customer happy by giving the needed products and keeping inventory expenses as low as possible.

The effectiveness of a company’s fulfillment of orders and inventory management processes will have an impact on its success or failure. This is not merely a practical problem. It becomes evident that the warehouse plays a main role in maintaining balance among the convergent outcomes of supply chain efficiency, customer happiness, and stable financial growth. Best inventory is a main component for operating costs that has a direct impact on profitability. Furthermore, it shapes the customers’ experiences so that they meet their needs continuously, resulting in better customer attraction.

## II. BACKGROUND

This study uses a real-time dataset of “Texas Wholesale.” The data is drawn from Zoho Inventory from 2015–2024 to analyze stock, order data, and customer happiness. Patterns in inventory levels and stock turnover show warehouse management problems, including stockouts and overstocking. For instance, order priority and buy channel variables offer details on how to oversee the product lines and distribution systems.

The study analysis that enhances understanding of the influence of logistics on customer happiness and warehouse management strategies reveals consistent customer satisfaction with best operations and customer service. Optimizing warehouse operations is the primary objective of this project in order to boost customer satisfaction, profitability, and productivity.

The project primarily searches for areas where there is potential to improve customer service, reduce order processing delays, and address ineffective inventory management. In order to improve the overall growth of the business and customer happiness in this competitive market, the project provides insights that result in strategic breakthroughs in warehouse management. Utilizing comprehensive data from multiple operational dimensions can enable this.

**Dataset Details:** 28169 Rows and 26 Columns.

### Column Description:

Order Date, Order Priority and Quantity Ordered are most important for analysing order completion by managing inventory and column selection gives the complete analysis of warehouse operations from all directions for improving the understanding of best operations. In order to evaluate the financial growth and profitability, selling price and cost price are also used. Additionally, a variety of customer information like ratings is used to measure the operational choices impacting customer happiness and views including item availability, offline and online booking, packing and delivery ratings. This multidirectional method gives a better understanding of warehouse operations impacting the financial growth and customer experiences.

TABLE I  
DESCRIPTION OF VARIABLES

Variables	Description of the Variables
Item ID	A unique automatic number generated that is assigned to the new item
List of Items	Description of items that are in the warehouse
SKU	Bar code for scanning a product
Warehouse Name	Four places of different warehouses present in the USA
Item Type	Product of each variety of item
Purchase Invoice Channel	Invoice purchase channel via online/offline
Order Priority	Priority of order packaging
Order Date	Order date made by the customer
Order ID	Identification code or number for the order
Qty Ordered	Quantity of item ordered by the clients
Qty IN	The quantity that came to the warehouse of different items
Qty OUT	The items that are sold to the customer
Stock on Hand	The items that are to be sold or left out in the warehouse
Committed Stock	The items committed by the company to clients which is available or not available
Available for Sale	The items left after checking committed stock
Status	The item is active or inactive
Unit	Number presence of each item
Selling Price	Price sold to client
Cost Price	Price brought from manufacturer
Created By	Item creation when entered into the market
Total Money on Hold	The money that is withheld in form of stock products
Item Availability Rating	Rating by client for the item or entire order
Offline Rating	Rating by client in-store purchase
Online Booking Rating	Rating by client on online purchase
Packaging Rating	Rating by packaging given by client
Delivery Rating	Rating by the client for delivery

### Challenges Associated with Visualizing the Data:

- **1.Data Dimensionality:** It is difficult to create a charts with 26 variables which is both informative and manageable.
- **2.Outliers:** Significant outliers are present variables like cost price and total money on hold which gives skewed visual patterns and trends.
- **3.Complex Relationships:** It takes advanced techniques to find the interdependencies between factors like cost of products and selling of products price.
- **4.Categorical Variables:** maintaining clarity while preserving interpretative depth when presenting qualitative variables such as Order Priority and Item Type
- **5.Scale Differences:** For clarity, the dataset has to be normalized or have distinct visualizations because it comprises variables with wildly disparate scales.

## III. EXISTING VISUALIZATION METHODS RELEVANT TO THE DATASET

**1. Bubble Charts:** These charts is child of scatter plot on which bubble shows the size of data type representing the additional dimension. This visualization is particularly used for more than three variables present in the datasets for making audience to know the relationships and properties comparison simultaneously. It gives an inventory distribution across item types with size indicating stock levels for the dataset. It is vest suitable for visualizing item type stock predominant against each other.

**2. Bar/ Stacked Bar Charts:** Each part of the graphs represents a portion of a larger total. They is a straight method for data classification and find the sizes for products. The quantities ordered are compared among warehouses and item categories.

**3. Line Graphs:** These graphs are commonly used in finding predictive forecasting by plotting all data points over the time to explain the changes that come across changes in the quantities. While area charts give confusion and might overlap for data points with line segments stacking variables on top of each other and using colour to differentiate between variables, line graphs use lines to explain these changes. This tracks trends over time for yearly sales and profit and margins by the item type.

**4. Pie Charts:** It is represented by slices for each data type and can represent shares among the products. These charts represent a percentages among the warehouses in this case and indicates share amount of the total amount of a particular variable. It represents proportional data for share of order quantities among warehouses.

Thus, the conclusions can be drawn by visualizing using all these charts for making taking best decisions.

#### Visualization Techniques and Ethical Framework

The dataset from “Texas Wholesale” is visualized using advanced techniques to get the insights from the following:

- **Bubble Chart:** This chart will represent the distribution of item types among the warehouse types. This will show stock levels graphically with bubbles with different sizes indication the total items of that particular item type. The highest bubble size indicates the large item type and smallest being the small item type.
- **Bar Charts:** The order priorities by year is displayed and also profits of purchase channel is noted for warehouses and item types. The clear trend is seen from the categorical differences.
- **Line Graphs:** The trends are analysed for order quantity, profit margins and customer demand over time. The patterns are captured for getting the insights from seasonal variations and shifts.
- **Interactive Dashboards:** All the visualizations are kept in the dashboard where it gets updated every time if the original visualizations are changed. This combined multiple visualizations are on a single interface. It allows stakeholders to filter the data by year, other variables for the detailed analysis.
- **Pie Charts:** The proportional data is analysed like order quantity distribution among warehouses. The workload balance and operational efficiency is estimated by these charts.
- **Story Boards:** This helps to build the structure for flow of data visualization project making sure each visualization connects logically to the next and tells story.

Ethics play an important role in making sure about the visualizations that provide accurate and unbiased insights. The various ethical concerns and corresponding implications include:

- **Data bias:** The visuals might unintentionally reflect biases present in the dataset like over representations and under representations of item types and the customer ratings skewed by various external factors. The use of balanced datasets which accounts for account of variability in categories like avoiding high focus on warehouses performance. The limitations are highlighted during the presentation.
- **Misrepresentation:** The scale charts are manipulating and omitting the data points to highlight trends and cover outliers. The use of consistent scales and make sure about the proportional representations indication bubble sizes reflecting the data values. The inclusion of all relevant data points are clearly labelled.
- **Over Simplification:** The summary of all data points too much can result in loss of context leading to confusion. The mitigation is done by providing tool tips, annotations or legends to provide the suitable background. Prevention of simplifying the complex data in excess especially when using dashboards.
- **Ambiguity:** The unclear and complex visual elements by similar colours can create confusion among viewers. We can avoid these by adopting user friendly design principles like distinct colour schema and formatting of consistent charts. The interactive chart features for data is used for better exploration.
- **Privacy Concerns:** The sensitive information might violate the privacy guidelines and compliances. This will overcome by aggregating the data for prevention of identification of individuals. The visualizations should be adhered for data prevention standards.
- **Selective Presentation:** The focus on favourable data to support a decision is biased. It presents a thorough analysis for finding positive and negative insights. The raw data, reports access by ensuing transparency.

#### IV. VISUALIZATION METHODS AND EFFECTIVENESS

A detailed and understandable overview of the data is provided by multiple visualization techniques. These techniques were selected for better information like order patterns, inventory levels, customer happiness and financial success.

#### Ethical Considerations in Data Visualization

##### 1) Inventory distribution by item type.

The stock levels of several item categories at a warehouse are clearly shown by this bubble chart. Inventory amounts from January 1, 2015, to December 30, 2024, are shown. While smaller bubbles in categories like Novelties and Office Supplies imply lower stock levels, larger bubbles in well-known categories like Glass Items and Cosmetics suggest larger inventory volumes.

An interactive date range selector that allows users to filter and analyze inventory patterns across certain durations enhances the chart’s usefulness. Colour coding is used to make it easier to identify each sort of item. This visualization facilitates quick comparison analysis and decision-making about inventory management, optimizing storage utilization, and improving supply chain operations in general.

It is a multi-dimensional representation that helps to optimize storage and procurement strategies.

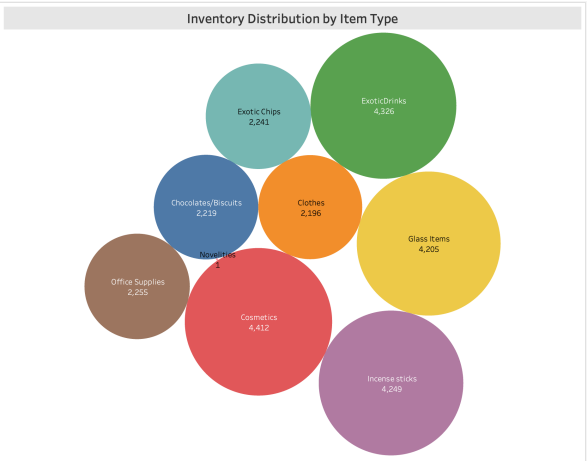


Fig. 1. Inventory distribution by item type.

**2) Order quantity distribution across warehouses.**

The balanced distribution of order quantities throughout Texas Wholesale’s four warehouse locations is shown in the pie chart. About 25% of all orders are represented by each chart section. With around 25.04% and 25.01% of all orders, respectively, *TX Boyz Wholesale A#103* and *TX Boyz WHOLESALE-khaled* are the two sectors that perform slightly better than the rest.

The next closest rivals are *TX Boyz Wholesale* and *TEXAS DISTRIBUTION*, which possess roughly 24.96% and 24.99% of the total orders. This image suggests that ordered products are handled consistently by showing how the responsibilities are distributed equally throughout the warehouses. Maintaining operational and service level uniformity across multiple sites is facilitated by this.

**3) Order Quantity Trend by Item Type.**

This line graph provides a comprehensive overview of the changes in Texas Wholesale’s order volumes for various item kinds from 2015 to 2024. Clothing, cos-



Fig. 2. Order quantity distribution across warehouses.

metics and chocolates/biscuits are the main categories with important count shown in the chart.

These categories exhibit same stable pathways with slight fluctuations over order years. For instance, sales of clothing and chocolates/biscuits have somewhat declined in the years that have followed the 2017 and 2018 peaks. Furthermore, Categories with incense sticks and office supplies have far smaller volume sales. For example, office supplies are declining in 2024 sales. The visual appearance is composed of multiple colour lines examining the dynamic changes in inventory demands and customer needs over years makes it easy to compare various product categories. This information is used to guide operations and process planning decisions for the company.

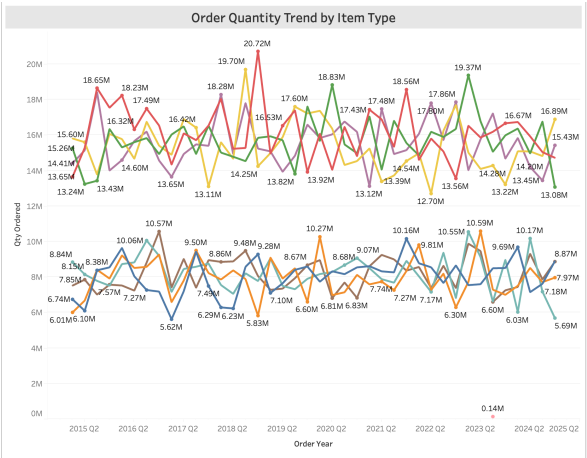


Fig. 3. Order Quantity Trend by Item Type.

**4) Quantity trends across years.**

The Figure 4 is a yearly inventory movement which is divided into "Qty in" and "Qty out" from 2015 to 2024. The chart shows the inventory patterns over the past ten years in a somewhat stable pattern, with 'Qty in' consistently surpassing 'Qty out' year, indicating a net positive stock growth. This could indicate

successful restocking steps depending on additional demand analysis and possible overstocking issues. It is interesting to find that both indicators reached their highest point in 2018 before falling or dropping off in the years that followed.

The visual representation of data by different colours of green and blue gives a best view of stock management patterns on yearly basis. Adjusting sales and purchase plans to maximize the inventory and lower the shortages and can be greatly aided by this division. Finally, it facilitates the reading and comparison of incoming and departing numbers.

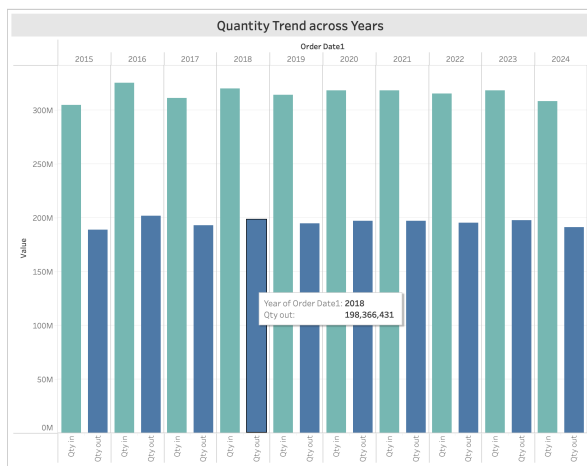


Fig. 4. Quantity trends across years.

### 5) Profit Margin Trend across Years by Item Type.

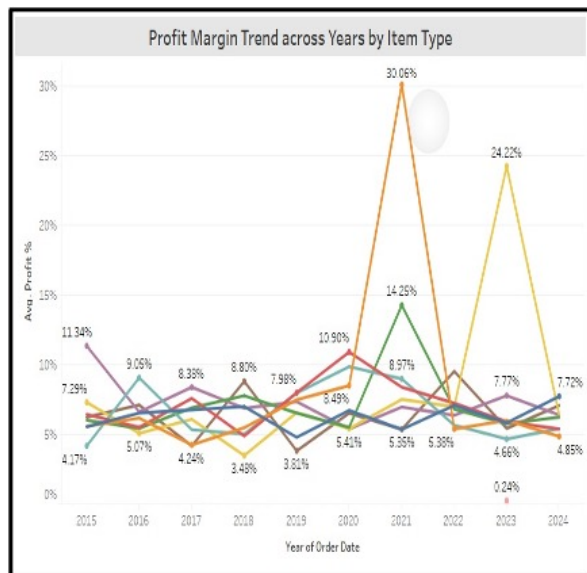


Fig. 5. Profit Margin Trend across Years by Item Type.

The variations seen in average profit margins for various product categories is evident in the line graph of Texas Wholesale "Profit Margin Trend across Years by Item Type," which is from the years 2015 through 2024. This visualization shows the dynamic financial

growth among several item classes, revealing an important diversity. With a 30.06% profit margin, the clothing category saw major peaks in 2021 and 2023. These profitable periods could be explained by favorable market circumstances or successful marketing methods. However, the Incense Sticks category experiences a sharp decline in 2023, indicating possible issues or pressure on prices in that market.

With occasional ups and downs brought on by shifts in customer demand, fluctuations in costs or operations, the majority of other categories tend to maintain extremely constant profit margins throughout time. This chart is crucial for identifying which product categories consistently increase profitability and which requires a best methods to reassess for to enhancing financial growth. It helps to keep the count of products more for more profit margins.

### 6) Profit across Warehouses & Purchase Channels.

The profits of all four Texas wholesale locations are shown in the bar graph based on offline and online sales channels. For a certain period of time, each warehouse, including TEXAS DISTRIBUTION, TX Boyz Wholesale, TX Boyz Wholesale A#103, and TX Boyz WHOLESALE-khaled, displays the distribution of profit from both channels. The profits average between \$337,000 and \$350,000 per channel for each warehouse, and the charts indicate that offline sales generate marginally larger profits than online sales across all products. It also suggests that the traditional offline method is the most profitable sales channel rather than online sales. These ideas can guide decisions much better in marketing methods and operational changes for earning more profits.

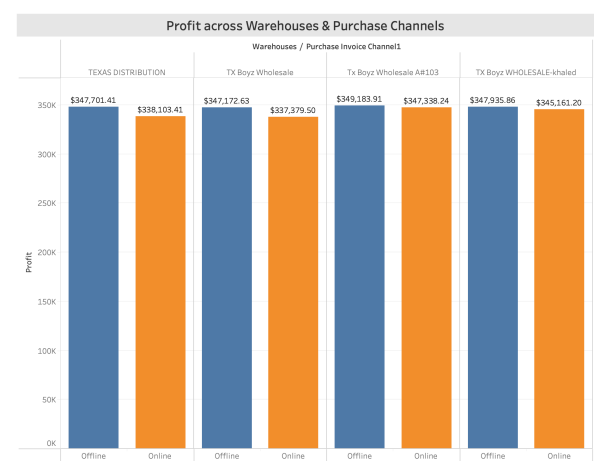


Fig. 6. Profit across Warehouses & Purchase Channels.

### 7) Order Trend across Years by priority.

The "Order Trend across Years by Priority" bar chart shows the amount of orders processed annually from 2015 to 2024 by five priority levels: LOW, LOW/MEDIUM, MEDIUM, HIGH, and MOST PRIORITY. The chart shows a consistent trend in the

distribution of order priorities, with a considerable number of orders consistently classified as MEDIUM and HIGH priority. Over time, there has been a slight increase in the number of orders designated as MOST PRIORITY, suggesting that the company should work on more urgent orders or that there has been a shift in company procedures to satisfy more urgent demands. The LOW priority category is the least prevalent across all years, which may suggest a targeted concentration on more important orders in order to improve customer satisfaction and better operational processes. This chart also offers information that influences workflow improvement and resource methods to meet the demands of urgent orders. It is achieved by suitably documenting the products in the warehouse for easy order processing priority.

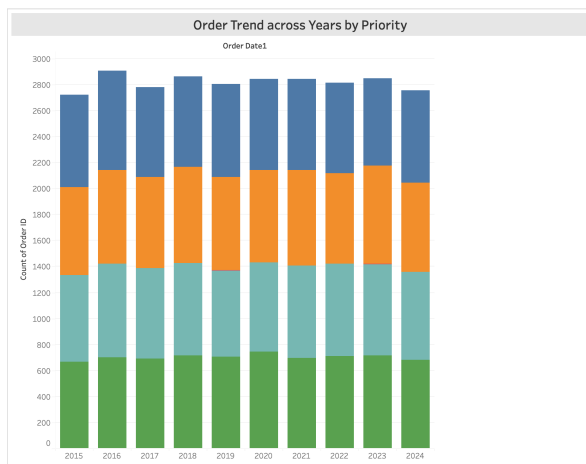


Fig. 7. Order Trend across Years by priority..

### Dashboard

The overall Tableau dashboard "Warehouse Efficiency - Inventory, Fulfilment & Customer Dynamics" provides a total overview of a number of warehouse operations-related subjects, including profit margins, order trends, inventory distribution, and sales across multiple channels and item types. This well-structured dashboard displays six key visualizations, including the following: Inventory Distribution by Item Type, Order Quantity Trend by Item Type, Order Trend across Years by Priority, Profit Margin Trend across Years by Item Type, and Profit across Warehouses & Purchase Channels. Each visualization aims to offer new business insights. For example, the Inventory Distribution by Item Type uses a bubble chart to show stock levels for various items, clearly indicating which items are most stocked, while the Order Trend across Years by Priority uses a bar chart to show the volume and priority of orders over time, reflecting shifts in operational focus.

Another component of the dashboard is a line chart that displays the Profit Margin Trend by Item Type over the years. It highlights trends and profitability peaks that could influence important company deci-

sions and displays the financial performance of different product categories over the years.

Seeing the profits from offline and online sales of warehouses provides valuable information about warehouse performance and channel efficiency. Similarly, the Profit across Purchase Channels & Warehouses graph conveys this information. The dashboard's usage for trend analysis, strategic decision-making, and identifying areas where warehouse operations need to be improved is enhanced by interactive elements such as order date filters, which allow users to customize views to specific time periods.

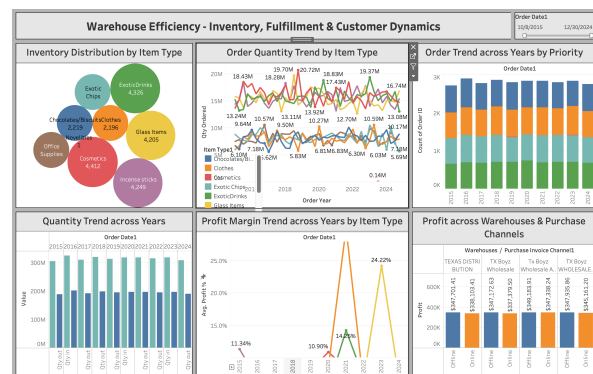


Fig. 8. Dashboard.

### Story

From January 1, 2015, until December 30, 2024, the project "Inventory, Fulfilment and Customer Satisfaction in Bringing Warehouse Performance" offers a narrative story overview of all elements of warehouse operations. The most relevant inventory categories are displayed in the "Inventory Distribution by Item Type" bubble graph that introduces the story. This chart includes cosmetics and glass items, which have a larger stock count than office supplies and novelty items. According to consumer demand and purchase efficiency, this chart indicates a main focus on cosmetics and other items.

As the story develops, the dashboard displays the "Order Quantity Trend by Item Type" line chart, which shows the changes in order volume measured year-wise. A drop in orders from customers for apparel and continuous demand for cosmetics shows important trends that could be attributed to changes in market contexts. The explanation of order prioritization over the years highlights how the company is adapting to meet urgent market demands with an increasing focus on high-priority orders. The bar chart "Order Trend across Years by Priority" further deepens the story. A strong stocking method is suggested by the "Quantity Trend across Years" bar chart, which shows a steady inflow of inventory (Qty In) that surpasses shipments (Qty Out).

The narrative continues with the "Profit Margin Trend across Years by Item Type," where notable differences are seen in profit margins, especially for



apparel and cosmetics, highlighting the operational changes and market factors impacting profits. The next conclusion is drawn from the "Profit across Warehouses & Purchase Channels" bar chart, which shows profits from physical and online channels across different warehouses. It indicates that online sales are important, while offline transactions still yield marginally better profits, as seen in the systematically improved digital sales platforms.

In addition, this overall analysis of the warehouse's operational status and strategic orientation, presented through a number of connected visualizations, offers useful insights that guide future business decisions and improvements.



Fig. 9. Story Narration.

#### Effectiveness of Methods:

- **1. Clarity and Depth:** Each visualization is presented to get the best ideas by putting the efforts, knowledge to access.
- **2. Actionability:** These chart visuals provide best insights like increasing inventory stocks, improving low rated delivery items and building better sales processes.
- **3. Customization:** The interactive dashboard helps stakeholders to explore the data according to their requirements for their teams to improve the decisions.

### V. CHALLENGES AND SOLUTIONS

The visualizations not given insights but also gave few challenges which are

#### 1. Overlapping Data in Bubble Charts

- **Challenge:** Overlapping issue has been seen in the inventory distribution by item type chart. It is difficult to find lower stock levels because of suppression of lesser categories of item types like novelties in the chart.
- **Impact:** Minor patterns details about under-stocked products can be overlooked.
- **Solution:** The introduction of tooltips should be displayed when moving over bubbles. The separate charts can also be used for low volume

types or scaling can be used to minimize the overlap and to increase clarity.

### 2. Simplistic Representation in Pie Charts

- **Challenge:** Pie charts showing the distribution of order quantities among warehouses might ignore performance details data over the yearly changes.
- **Impact:** It is possible for workload distribution consistency among warehouses might create confusions.
- **Solution:** The pairing pie-charts show time series variations. By using the bar charts or stacked bar charts, the detailed comparison of warehouses operations workloads is seen by the time periods.

### 3. Scalability of Line charts

- **Challenge:** When visualising multiple categories at once, the line graphs for order trends by item type might get challenging to identify better conclusions for certain type of goods.
- **Impact:** The chart's usefulness and clarity are diminished by overcrowding.
- **Rebuttal/Solution:** To enhance line separation use unique colour coding and legends. For more efficient analysis restrict the display of categories that perform the best or the worst.

### 4. Interpreting "Qty In" vs. "Qty Out" in Bar Charts

- **Challenge:** The bar chart showing deviations in quantity in and out might not effectively explain the causes of shortages or overstocking without providing much details.
- **Impact:** Stakeholders might purchase the unwanted products creating imbalances in stocks leading to inefficiencies rather than external causes like changes in demand.
- **Rebuttal/Solution:** Provide further examples for linking stock movements to data on demand or client comments. Use annotations which will highlight substantial amount increases or falls.

### 5. Limited Audience Accessibility

- **Challenge:** Because of many visualisations and interactive elements. The dashboard might be a lot difficult for non-technical users to handle.
- **Impact:** Non-technical stakeholders may find it difficult to use the dashboard or overlook important conclusions.
- **Rebuttal/Solution:** Create streamlined paths for particular audiences such as warehouse managers and executives. Give training to employees and detail them by documented instructions for navigating the dashboard.

### 6. Misrepresentation of Profit Trends

- **Challenge:** Without taking outside market variables into account, the profit margin line graph may draw generalizations about underperforming categories like incense sticks.
- **Impact:** Only by concentrating financial measures without considering a wider context, the decisions may be misguided.
- **Rebuttal/Solution:** Use footnotes to highlight seasonal demand or market trends. Integrate indicators for customer happiness and profit to maintain growth.

## 7. Over-Emphasis on Priority Orders

- **Challenge:** While highlighting the increasing focus on MOST PRIORITY orders the bar chart for order trends by priority does not show effects of medium or low-priority orders.
- **Impact:** Allocating resources may favour high-priority orders at the expense of less urgent but no less important ones.
- **Rebuttal/Solution:** To demonstrate proportionate changes and percentage breakdown of all priorities. To see how resource allocation corresponds with priority levels using heat maps.

## VI. CONCLUSION

The visualizations created shows importance of improving Texas Wholesale ability to engage in overall data-driven decision making across the board. In order to help stakeholders identify trends, the growth has been assessed and identified the improvements in supply chain and inventory with the help of dashboard that converts the data into clear and useful visualization.

The strategic, logical and operational ideas seen on the dashboard improves daily operations by assisting the long-term strategic planning. More targeted measures that increases productivity to reduce costs and increase profits are made possible by keeping an eye on key performance indicators including inventory levels, order priority and profit margins. Because of this, this visualizations is crucial to Texas Wholesale's for innovation and ongoing development which helps the company achieve its objectives in a competitive market.

Overall, the charts brings balance between depth, clarity and accessibility making sure about the insights across multiple operational areas.

Potential Future Improvements are in the area of:

- Improved Predictive Analytics
- Geospatial Analysis
- Improved Customization
- Real-Time Data Integration
- Expanded Metrics
- Accessibility Features

- Storytelling Enhancements

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