# Demand & Production Optimization of Construction Units

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360 DigiTMG
Digital Transformation | Management | Governance

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# Business Context

**Problem Statement**
The client is facing challenges in accurately predicting demand and planning production for various construction machinery variants. Frequent last-minute changes to product features and fluctuating order volumes lead to production delay, inventory imbalance, and difficulties in meeting dealer and customer demand efficiently.

**Business Objective**
Enhance operational efficiency by improving forecasting, production planning, and inventory management.

**Business Constraint**
Minimize stockouts and inventory imbalances while maintaining stable production.

**Success Criteria**
- **Business:** Reduce lead time by **15%** for better order fulfillment.
- **Economic:** Cut inventory holding costs by **10%** through optimization.

# Data Overview

**Order Details**

- **Order ID** – Unique identifier for each order.
- **Date** – The date when the order was placed.
- **Warehouse** – The warehouse handling the order.
- **Dealer** – The dealer responsible for the transaction.
- **Customer ID** – Unique ID of the customer placing the order.
- **Machine ID** – Identifier for the ordered machine.
- **Machine Type** – Category of the machine ordered.
- **Order Quantity** – Total number of machines requested.

**Production Insights**

- **Production Status** – Indicates whether the order was completed on time or delayed.
- **Change Type** – Reason for modifications in the order or production plan.
- **Order Volatility** – Measures fluctuations in order patterns.

**Inventory Metrics**

- **Inventory Level** – Available stock level at the time of the order.

**Delay Analysis**

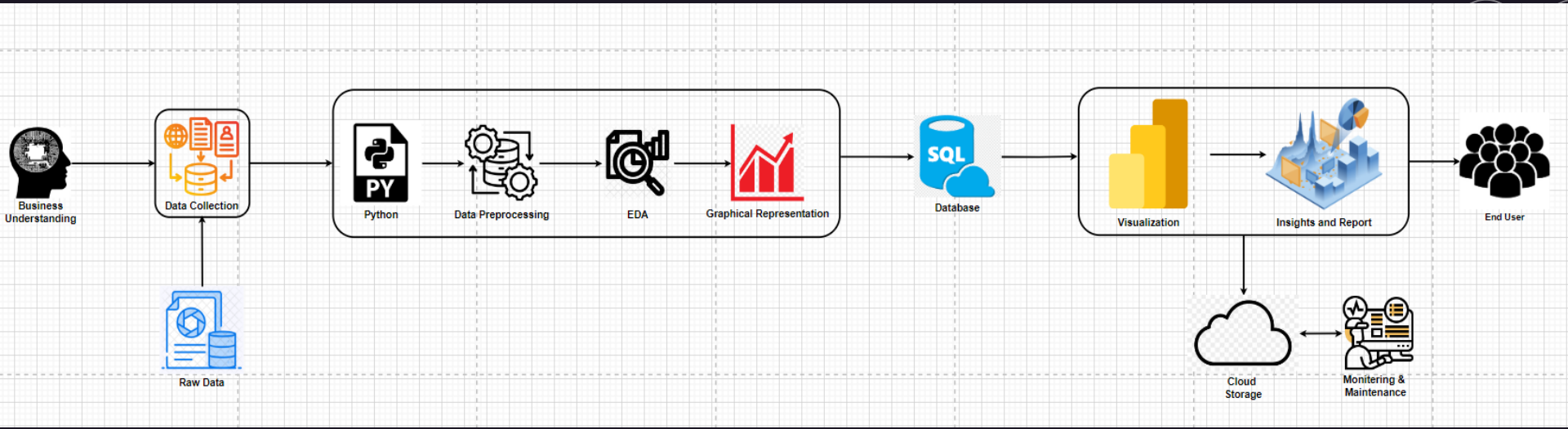
- **Lead Time Days** – Time taken to fulfill the order.
- **Delay Days** – Number of days the order was delayed beyond the expected timeline.

# Methodology

The project followed a structured approach using various tools:

- **Excel (Initial Cleaning):**
  I began by cleaning the dataset in Excel, removing duplicates, handling missing values, and formatting data for further processing.
- **Python (Data Analysis):**
  Next, I used Python for advanced data processing, applying wrangling techniques, feature engineering, and conducting Exploratory Data Analysis (EDA).
- **PostgreSQL (Storage & Querying):**
  I loaded the processed data into PostgreSQL for storage, where I used SQL queries to analyze and extract valuable insights.
- **Power BI (Visualization):**
  I imported the database into Power BI to create interactive dashboards, visualizing trends and key metrics related to order, production, and inventory.
- **PowerPoint (Presentation):**
  Finally, I summarized the findings and recommendations in a PowerPoint presentation, highlighting key insights for stakeholders.

# Project Architecture



# Statistical Insights (Numeric Data)

**Order Quantity:**

- The average order quantity is **27**, with a median of **26**.
- The data is **right-skewed (4.04 skewness)**, indicating more small orders than large ones.
- High kurtosis (**30.91**) suggests the presence of extreme values, with **83 outliers** detected.

**Inventory Level:**

- The mean inventory level is **299**, with a median of **257**.
- A high standard deviation (**375.63**) shows significant variation in stock levels.
- The data is highly skewed (**6.61**) and has **117 outliers**, indicating frequent stock fluctuations.

**Lead Time (Days):**

- The average lead time is **29 days**, with a median of **27 days**.
- A high kurtosis value (**45.27**) indicates extreme variations in lead time.
- The presence of **102 outliers** suggests inconsistency in delivery timelines.

**Delay Days:**

- The average delay is **3 days**, but the data is highly skewed (**9.33**) with extreme outliers (**1127 detected**).
- The presence of orders with delays up to **152 days** highlights inefficiencies in production and logistics.

# Statistical Insights (Categorical Data)

- **Warehouse**: Four unique warehouses with nearly even distribution; WH002 is the most frequent (24.65%).
- **Dealer**: Five unique dealers; Dealer D appears the most (19.88%).
- **Customer ID**: Five unique customers; Cust002 has the highest frequency (19.74%).
- **Machine ID**: Five unique machine variants; MC004 is the most frequent (19.72%).
- **Machine Type**: Five unique types; Type 4 is the most common (19.95%).
- **Production Status**: Three categories; delays are frequent, with "Delayed" being the most common (32.12%).
- **Change Type**: Four unique categories; high missing values (23.93%), with "Delayed Approval" being the most frequent (19.6%).
- **Order Volatility**: Three categories; "Medium" volatility is the most frequent (32.33%).

# 01

# Order Trends & Demand Analysis

Key Questions & Insights

## 1. What is the overall trend in order volumes over time?

The order volume shows a relatively stable trend over the years, with slight fluctuations across quarters. The highest order volume was observed in Q4 2023 (524 orders), while the lowest was in Q1 2023 (478 orders).

## 2. Which months or seasons see the highest and lowest demand?

**Highest Demand:**

- January, March, October, December (2021-2023)
- April (Peak in Q2)

**Lowest Demand:**

- February (Lowest in all years)
- June (Consistently low)

**Insights:**

- Q1 and Q4 have the highest demand.
- Q2 sees a dip in June.
- Q3 experiences a drop, especially in September.

## 3. How does demand vary across different warehouses?

**Highest and Lowest Demand Across Warehouses:**

- **Highest Demand:** WH002 with 41,993 orders.
- **Lowest Demand:** WH003 with 37,111 orders.

## 4. Which machine type has the highest order frequency?

**Machine Type 4** has the highest total order frequency with **32,864 orders**.
**Machine Type 1** follows closely with **32,613 orders**, showing a balanced order distribution.
**Machine Types 2, 3, and 5** also show significant demand but with slightly lower total orders (**31,444 to 31,992 orders**).

## 5. Which dealers or customers contribute most to demand variability?

**Dealer E** consistently has the highest order volume across all customers, especially for **Cust003 (7,529 orders)**, indicating a strong preference for Dealer E.
**Dealer B** shows relatively lower order volumes across most customers, particularly for **Cust005 (5,442 orders)**, which suggests potential areas to increase engagement.
**Cust004** places significant orders with **Dealer D (7,590 orders)**, indicating a preference for this dealer.
**Cust003** places the highest order volume overall, particularly with **Dealer D and Dealer E**, highlighting strong customer loyalty or high demand.

## 6. What are the most common reasons for order changes?

**Delayed Approval (26.1%)** is the primary change type within our control, highlighting a focus area for improvement.
**Urgent Order Change and Supplier Delay (49.6%)** are largely driven by external factors.
**Feature Update (24.3%)** also represents a notable portion of order modifications.

## 7. What is the average production lead time, and how does it impact order fulfillment efficiency?

With an **average production lead time of 29 days**, it suggests that there is a significant waiting period before orders are fulfilled. This could lead to delays in meeting customer expectations and may be an area for improvement to enhance overall order fulfillment speed and customer satisfaction.

## 8. What is the on-time delivery rate?

The **On-Time Delivery Rate is 32.83%**, indicating that only about **a third of orders are delivered on schedule**.

## 9. What percentage of available inventory is being used based on the inventory utilization rate?

With an **inventory utilization rate of just 8.84%**, it indicates that a large chunk of the available inventory remains untapped. This underutilization points to an opportunity for **more efficient inventory management and optimizing stock usage**.

02

# Production & Delay Insights

Key Questions & Insights

1. **What is the average production lead time?**

The average production lead time is 29 days, indicating the time required to fulfill an order.

2. **What are the primary reasons for production delays?**

Production delays are largely influenced by external factors (supplier delays) and internal inefficiencies (urgent modifications and approvals). Optimizing supply chain coordination and streamlining internal processes can significantly reduce delays.

3. **What proportion of delays were due to supplier issues?**

36.3% of delayed orders (1448 out of 3987) were caused by supplier-related problems.

4. **How frequently do urgent order changes occur?**

25.2% of total orders (1496 out of 5928) required urgent modifications.

5. **What percentage of total orders were delayed?**

67.2% of the total orders (3987 out of 5928) faced delays.

**6. What is the count of on-time delivered orders?**

1952 orders were delivered on time.

**7. Which specific days experienced the highest and lowest lead times?**

Lead times have fluctuated, peaking in May 2023 (117 days on the 7th) and February 2023 (104 days on the 3rd).

The shortest lead time was in June 2023 (5 days on the 19th).

**8. Which machine type has the highest number of on-time orders?**

Machine Type 4 has the highest on-time orders (431 orders), indicating better production efficiency or demand fulfillment.

**9. Which machine type has the lowest number of on-time orders?**

Machine Type 2 has the lowest on-time orders (358 orders), suggesting possible production bottlenecks or supply chain issues.

**10. Which machine type experiences the highest and lowest number of delayed orders?**

Machine Type 4 has the highest delayed orders (838 orders), indicating potential inefficiencies or high demand.

Machine Type 1 has the least delayed orders (774 orders), suggesting relatively better production stability.

# 03

# Inventory Management

## Key Questions & Insights

**1. What is the overall inventory utilization rate?**
The inventory utilization rate is 8.84%, indicating that a significant portion of stock remains unused. This suggests potential overstocking or inefficiencies in inventory turnover.

**2. How well does inventory support order fulfillment?**
With Total Inventory at 2M and Total Order Quantity at 158K, inventory levels appear high relative to demand, which may indicate overstocking.

**3. Is the current inventory turnover efficient?**
The low utilization rate (8.84%) suggests that inventory is moving slowly, potentially increasing holding costs and wastage.

**4. Are there trends indicating overstocking or understocking?**
Inventory levels fluctuate significantly, with some months having higher stock retention (e.g., October 2021, August 2023), suggesting potential overstocking.
Other months show declining stock levels (e.g., February 2022, July 2023), indicating possible understock situations.

**5. Which customer frequently changes orders urgently?**
Cust004 has the highest number of urgent order changes (323).
6. Which customer has the most delayed approvals?
Cust003 faces the most delayed approvals (321).

**7. Are urgent order changes linked to supplier delays for any specific customers?**
Cust004 has the highest numbers in both supplier delays and urgent order changes, indicating a possible connection.

**8. Which day had the highest inventory utilization rate?**
August 30, 2023, had the highest utilization rate at 42.60%.

**9. Which day had the lowest inventory utilization rate?**
September 2021 had the lowest rate at 1.29%.

**10. Were there significant fluctuations in inventory utilization?**
Yes, utilization dropped below 2% in multiple months across all three years.

**11. Which month had the highest volatility (High category)?**
January 2023 (74 orders) recorded the highest high-volatility orders.

**12. Which month had the lowest volatility (Low category)?**
November 2023 (38 orders) had the least low-volatility orders.

**13. Is there a trend in order volatility over the years?**
2023 saw more frequent high-volatility order spikes (above 60).
2021 had more balanced volatility across categories.

**14. Which warehouse has the highest total inventory level?**
WH002: 472,810

**15. Which warehouse has the lowest total inventory level?**
WH004: 424,958 (Lowest among all)

**16. Which quarter had the highest and lowest number of total orders?**
2023, Qtr 4: 524 orders
2023, Qtr 1: 478 orders

# Recommendations

✓ **Reduce Delays in Order Processing**

Address frequent **delayed approvals and urgent order changes** by automating approval workflows.
Implement **supplier performance tracking** to minimize supplier-related delays.

✓ **Optimize Inventory Utilization**

Increase efficiency by analyzing **high and low utilization trends** and redistributing stock accordingly.
Leverage real-time monitoring to avoid excessive stock buildup or shortages.

✓ **Improve Warehouse Efficiency**

Focus on warehouses like **WH002 and WH001**, which experience high critical delays, to streamline logistics and stock movement.
Implement better demand forecasting to balance **on-time vs. delayed inventory levels**.

✓ **Manage Order Volatility Proactively**

Monitor and predict fluctuations in **high, medium, and low volatility orders** to adjust procurement and stock levels.
Develop supplier agreements with flexible order adjustments to handle peak fluctuations.

✓ **Data-Driven Decision Making**

Utilize **clustered column charts** and historical patterns to make informed procurement and inventory decisions.
Implement a **Power BI dashboard** for continuous tracking of key metrics like **order trends, delays, and utilization rates**.

# Conclusion

Achieving **demand and supply optimization** is essential for maintaining a **resilient, cost-effective, and agile supply chain**. This analysis highlights key inefficiencies in **inventory utilization, order volatility, and warehouse delays**, emphasizing the need for **better forecasting, strategic stock management, and supplier collaboration**.

By implementing **data-driven demand planning, AI-powered forecasting models, and dynamic inventory adjustments**, businesses can **reduce excess stock, prevent shortages, and streamline procurement cycles**. Enhancing **supplier coordination and warehouse efficiency** will further ensure that supply meets demand with **precision and minimal waste**.

**Optimizing demand and supply isn't just about balance—it's about creating a future-proof, efficient, and responsive supply chain that adapts to evolving business needs.**


“Data is the new oil. But like oil, it’s valuable only if refined into insights.”
— Clive Humby

# Thank you!

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🤝 Let's connect! Questions are always welcome.