

# Freight Volume Prediction

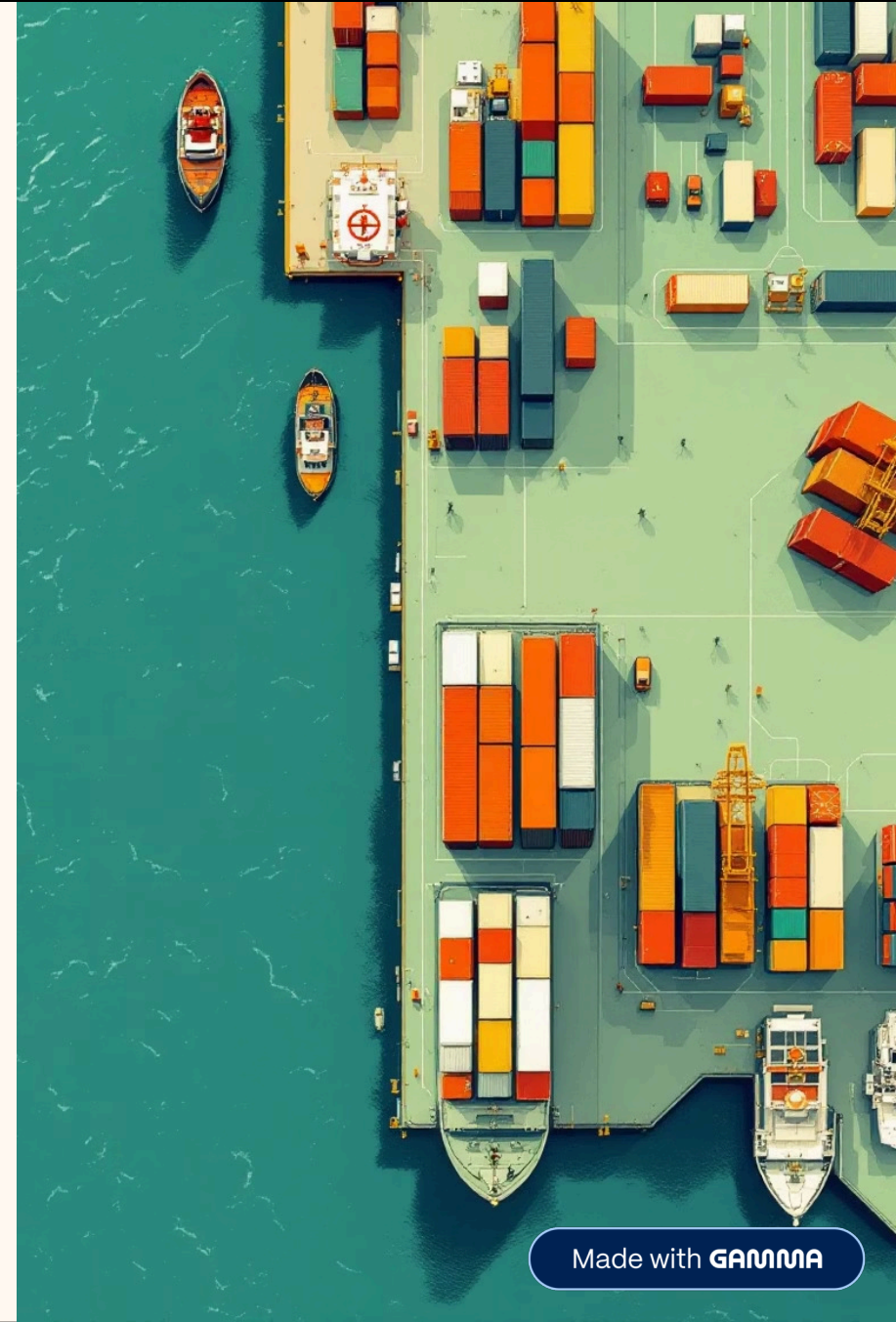
Advanced time-series forecasting for smarter logistics planning and operational efficiency

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# The Strategic Imperative

Freight volume forecasting is a mission-critical capability for logistics providers, ports, railways, and supply chain planners. Accurate predictions enable organizations to optimize container capacity, adjust fleet requirements, and plan shipping schedules with precision.



## Capacity Optimization

Right-size container and cargo allocations based on predicted demand



## Resource Planning

Adjust fleet, manpower, and infrastructure for peak periods



## Bottleneck Prevention

Identify and eliminate operational constraints before they impact service

This project applies the powerful **SARIMAX forecasting algorithm** to model monthly freight volumes, capturing both trend and seasonal patterns inherent in logistics operations.

# Business Objectives & Expected Outcomes

## Core Objective

Forecast freight volumes for the next **24–36 months** with high confidence, enabling long-term strategic planning and tactical execution across the supply chain.

## Key Focus Areas

- Identify trend patterns and seasonal cycles
- Provide actionable insights for logistics planning
- Support data-driven decision-making



### Operational Excellence

Improved efficiency through better resource allocation and scheduling

### Cost Reduction

Reduced demurrage, detention costs, and empty container repositioning

### Supply Chain Intelligence

Enhanced inventory management and supplier coordination

# Dataset Architecture

A comprehensive synthetic monthly freight dataset spanning **January 2015 to December 2024** was engineered to replicate real-world cargo movement patterns across multiple transportation modes.

Column	Description
Date	Monthly timestamp for time-series analysis
Freight_Volume	Total monthly freight demand (tonnage, TEUs, or units)
Sea_Freight	Estimated cargo volume moved by maritime routes
Rail_Freight	Estimated cargo volume transported by rail networks
Road_Freight	Estimated cargo volume delivered via road transport

# Data Characteristics

## Clear Upward Trend


Consistent growth trajectory reflecting expanding trade volumes and economic development over the analysis period

## Strong Seasonality

Repeated annual cycles driven by festival import seasons, harvest periods, and holiday shipping demands

## Realistic Noise

Operational fluctuations that mirror real-world variability in freight operations and market conditions

 **Why SARIMAX?** The data exhibits non-stationary behavior combining trend and seasonality, making SARIMAX the ideal forecasting approach for capturing complex temporal patterns.

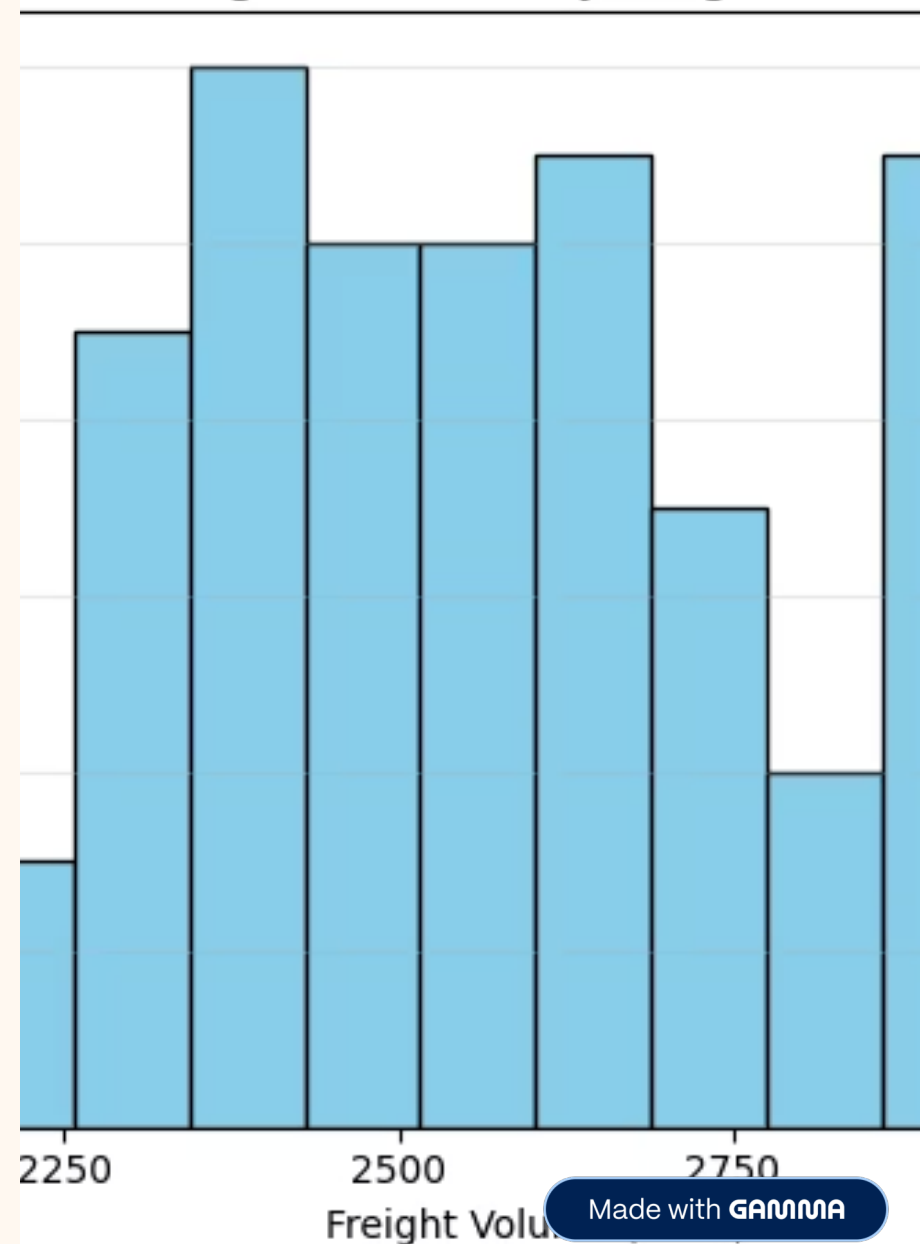
# Freight Volume Trends Over Time

## Key Observations

- Sustained upward growth from 2015 to 2024
- Regular seasonal peaks and troughs
- Accelerating growth in recent years

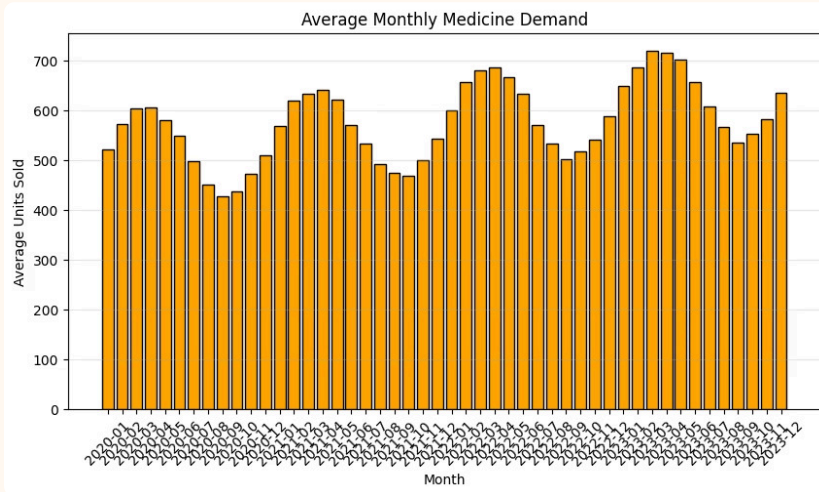
The time-series visualization reveals consistent year-over-year growth with pronounced seasonal variations. This pattern reflects increasing global trade volumes and recurring demand cycles tied to economic activity and seasonal commerce.

Histogram of Monthly Freight Volume



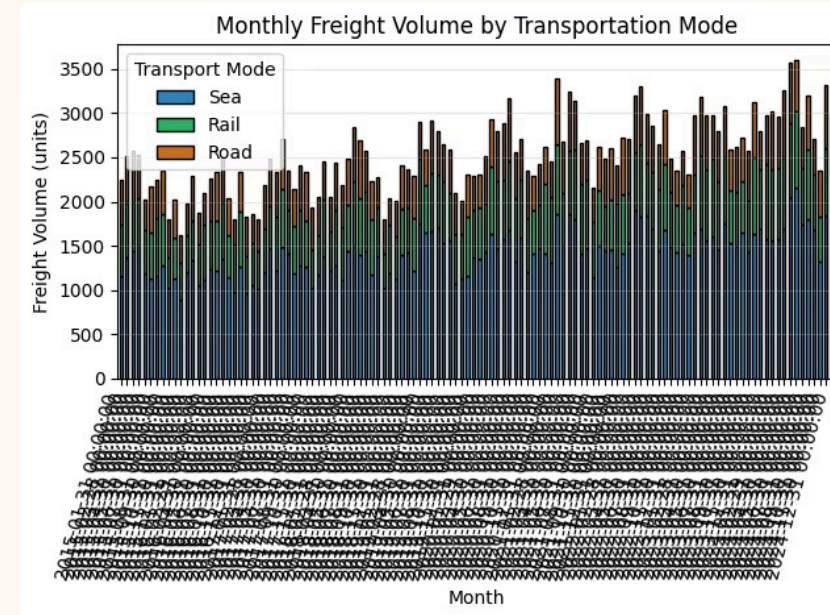
# Distribution & Seasonal Patterns

## Volume Distribution Analysis



The histogram shows concentration around moderate values with a long upper tail, reflecting growing demand and seasonal fluctuations.

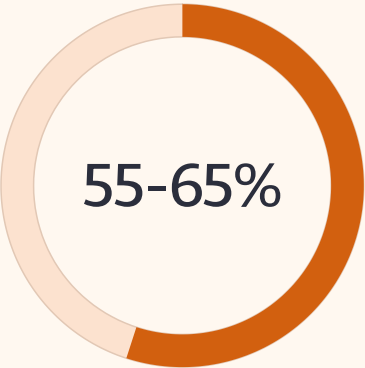
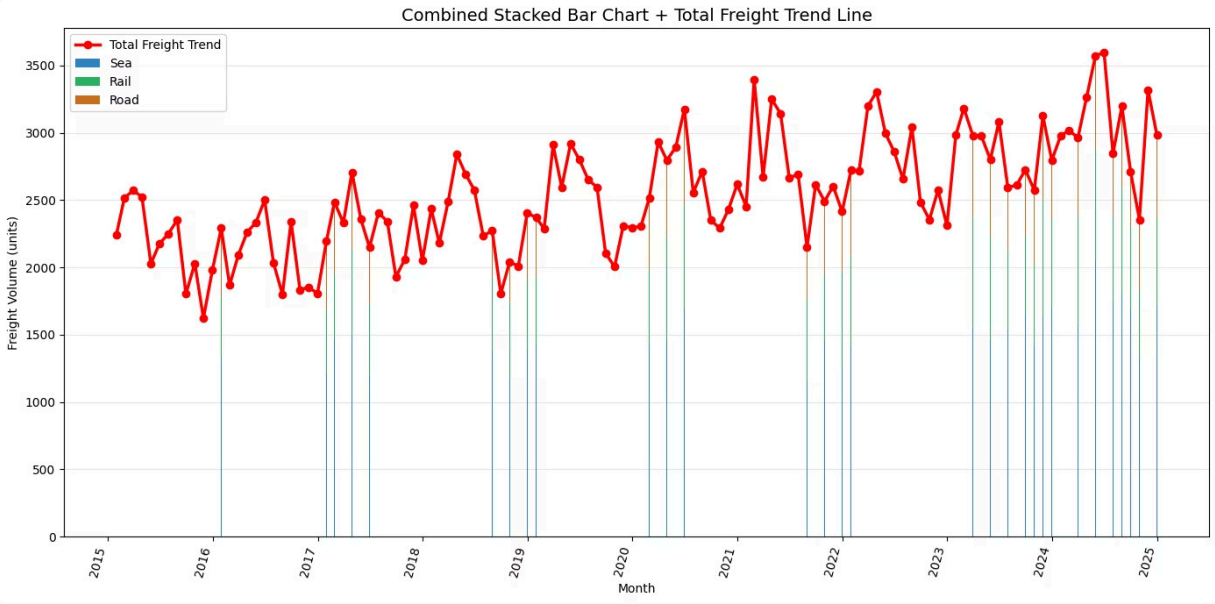
## Monthly Demand Cycles



**Peak months:** July–August and November–December (holiday, festival, harvest export seasons)

**Low months:** February–March (post-holiday slowdown)

# Multi-Modal Freight Analysis



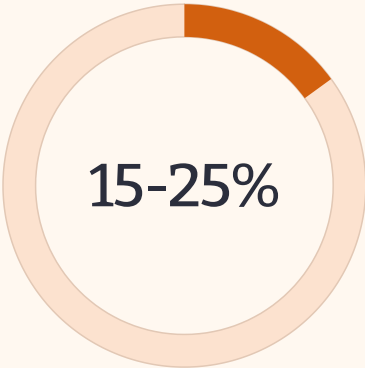
Sea Freight

Dominates cargo movement as the backbone of international trade



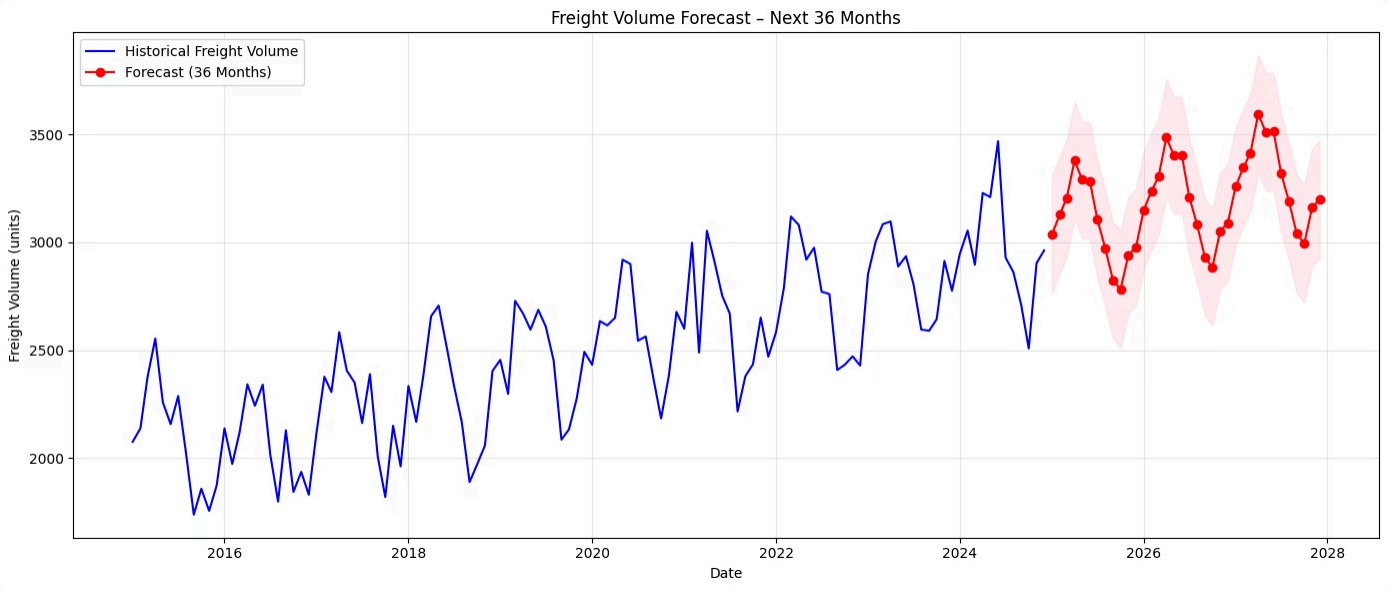
Rail Freight

Provides efficient inland connectivity and intermodal solutions



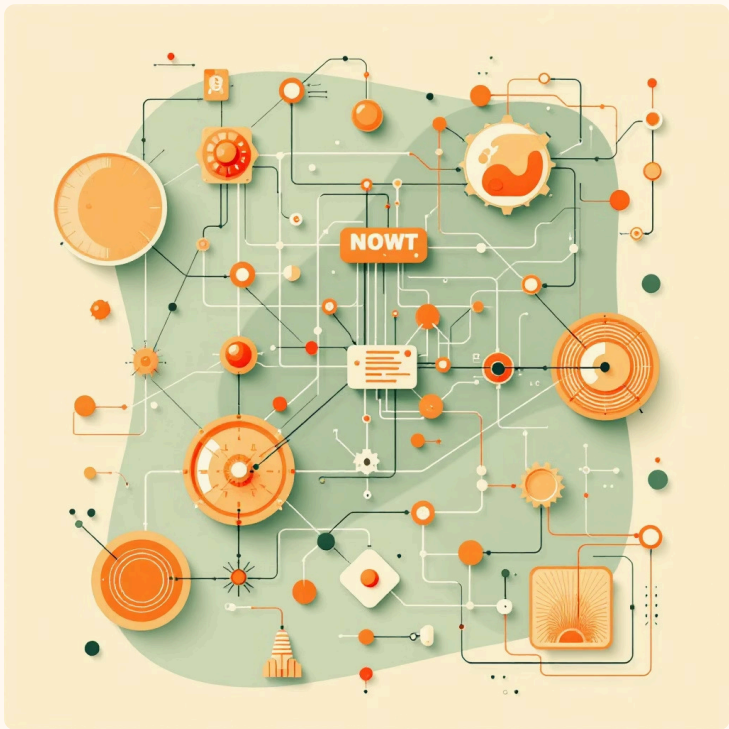
Road Freight

Delivers last-mile flexibility with seasonal variation



The combined stacked bar chart reveals total freight volume, mode-wise contributions, and clear year-over-year growth across all transportation modes.

# SARIMAX Modeling Approach



## Model Configuration

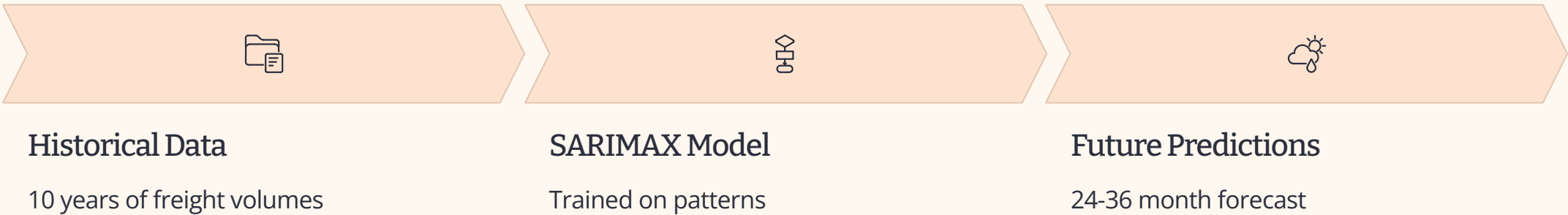
Component	Configuration
Non-seasonal order (p,d,q)	(1, 1, 1)
Seasonal order (P,D,Q,s)	(1, 1, 1, 12)

This configuration balances model complexity with predictive accuracy, capturing both short-term fluctuations and long-term seasonal patterns.

## Why SARIMAX?

SARIMAX (Seasonal AutoRegressive Integrated Moving Average with eXogenous factors) is ideally suited for freight forecasting because it captures:

- Long-term growth trends
- Clear seasonal patterns (12-month cycles)
- Confidence interval predictions





# Business Impact & Strategic Value

This SARIMAX forecasting model delivers **high-accuracy predictions** with clear visibility into trend and seasonality, providing a reliable roadmap for capacity, fleet, and infrastructure planning.

Shipping Companies

- Optimize container allocations
- Plan sailing schedules efficiently
- Balance vessel capacity

Road/Rail Transporters

- Manage fleet utilization
- Reduce empty trips and idling
- Optimize route planning

Port Authorities

- Regulate docking windows
- Reduce congestion
- Minimize demurrage charges

SCM Teams

- Predict cargo flows
- Improve supplier coordination
- Enhance inventory management

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