

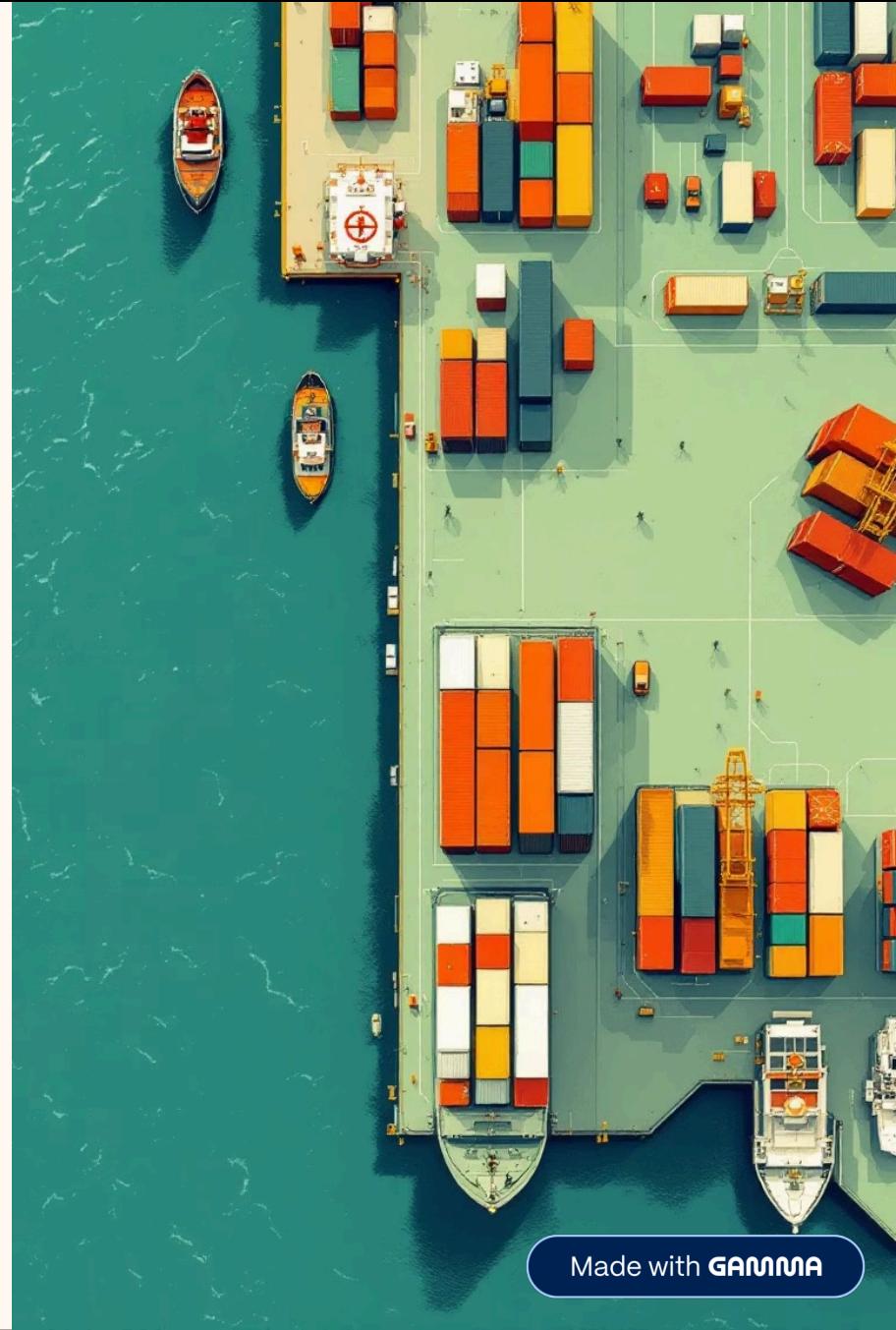
Freight Volume Prediction

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

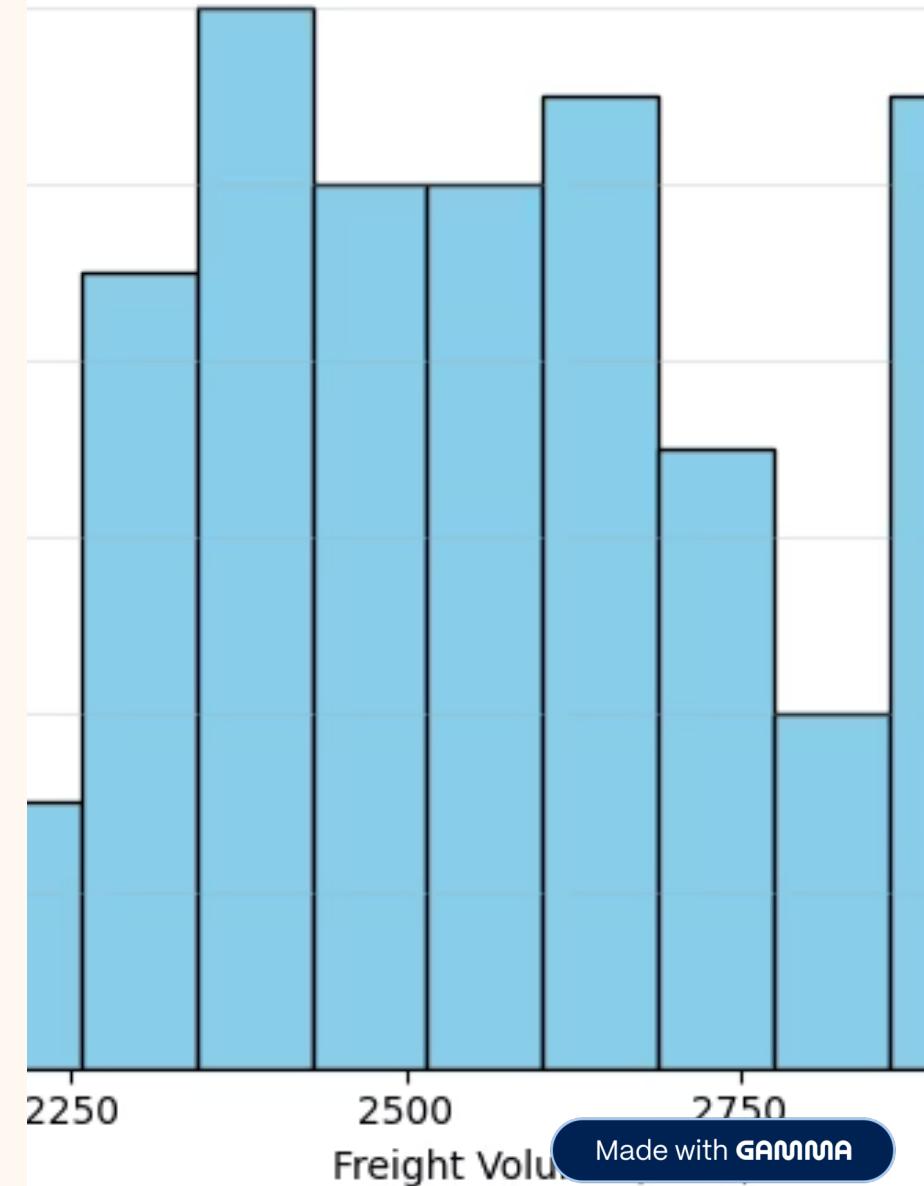
- ❑ **Why SARIMAX?** The data exhibits non-stationary behavior combining trend and seasonality, making SARIMAX the ideal forecasting approach for capturing complex temporal patterns.

Freight Volume Trends Over Time

Key Observations

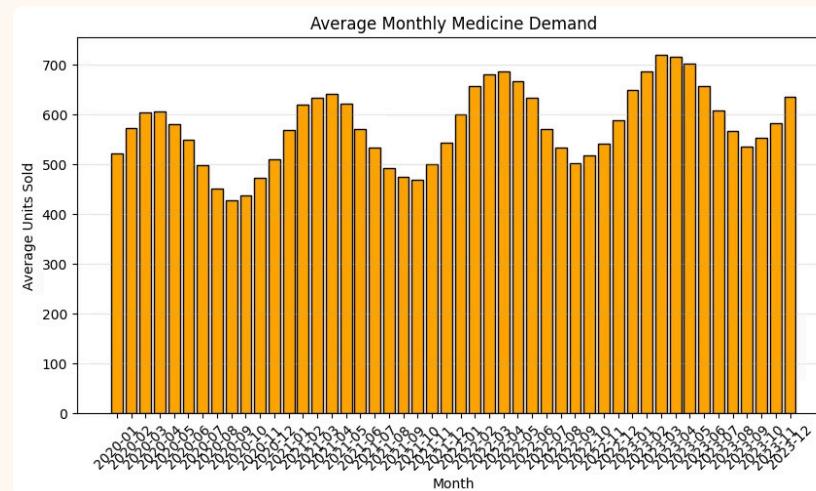
- Sustained upward growth from 2015 to 2024
- Regular seasonal peaks and troughs
- Accelerating growth in recent years

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.



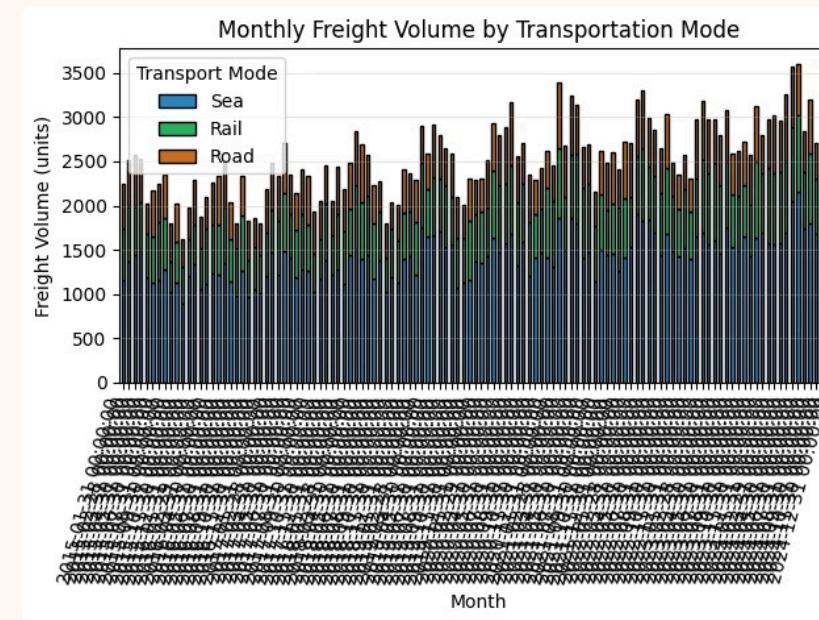
Distribution & Seasonal Patterns

Volume Distribution Analysis



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

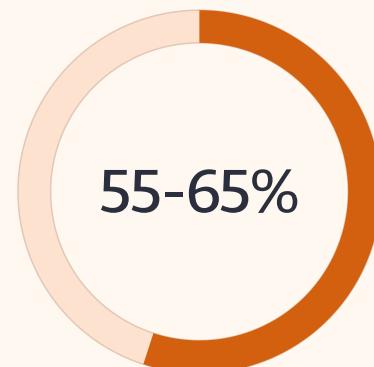
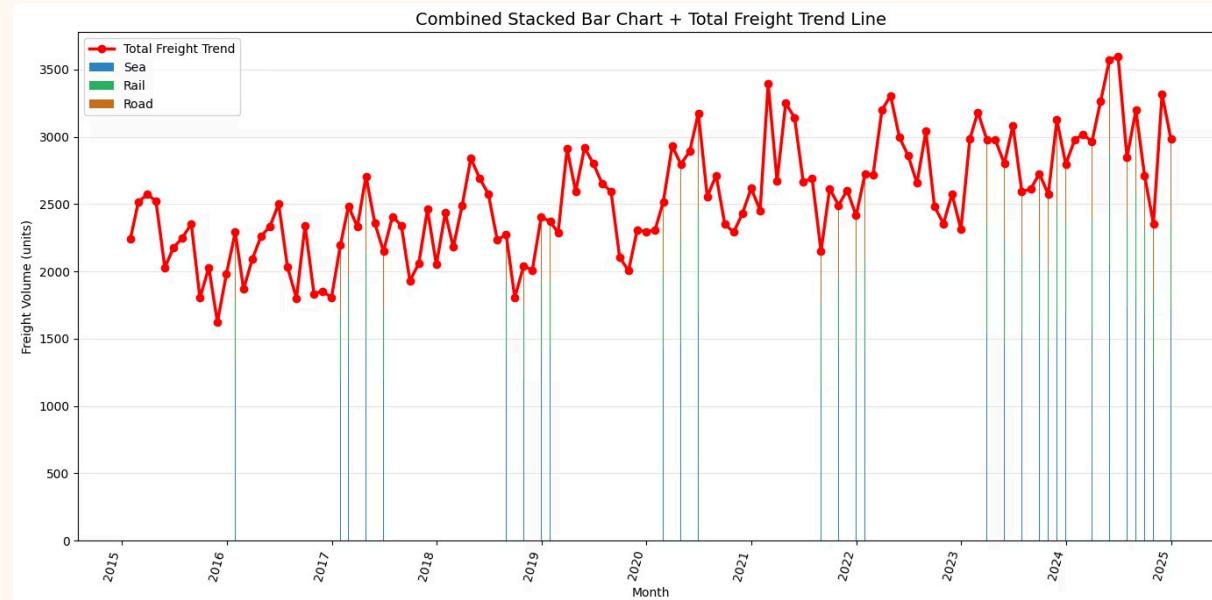
Monthly Demand Cycles



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

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

Multi-Modal Freight Analysis



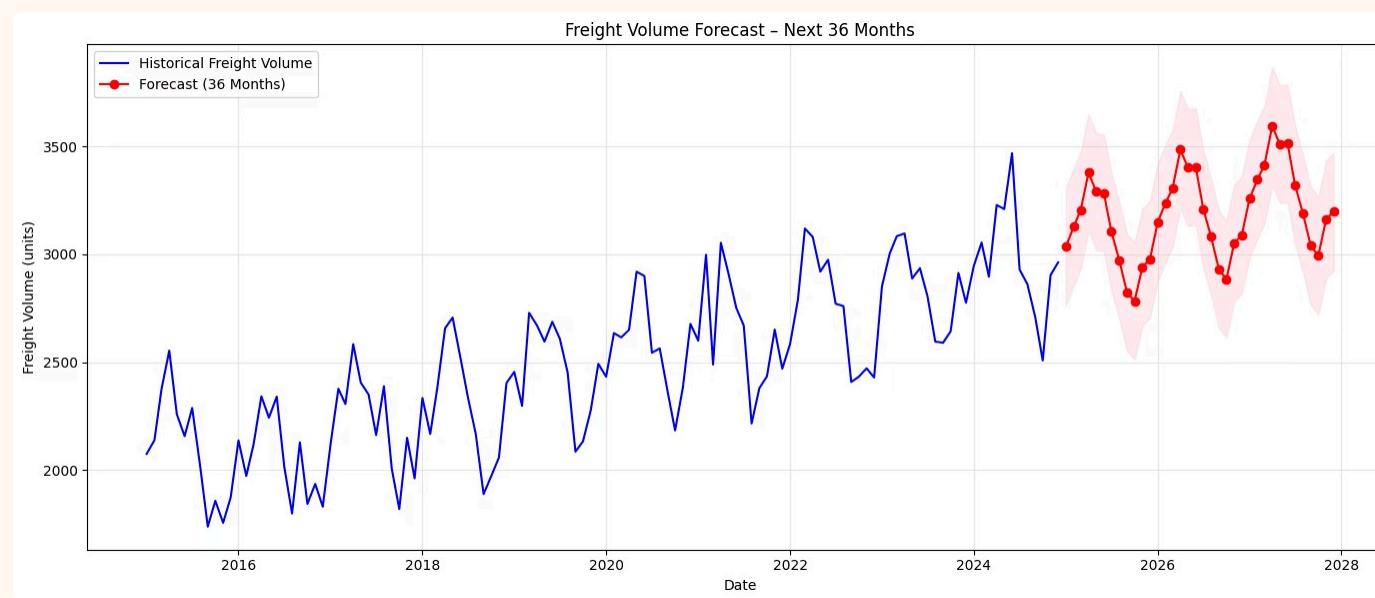
Dominates cargo movement as the backbone of international trade



Provides efficient inland connectivity and intermodal solutions

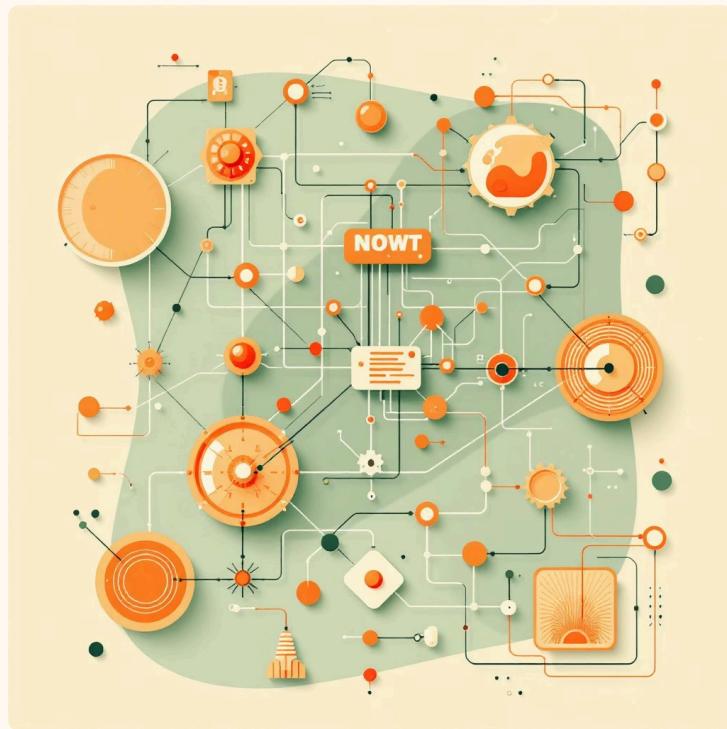


Delivers last-mile flexibility with seasonal variation



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

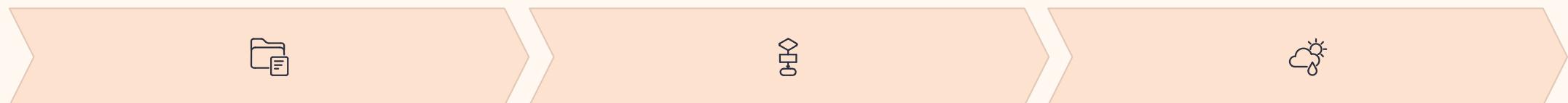
Component	Configuration
Non-seasonal order (p,d,q)	(1, 1, 1)
Seasonal order (P,D,Q,s)	(1, 1, 1, 12)

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



Historical Data

10 years of freight volumes

SARIMAX Model

Trained on patterns

Future Predictions

24-36 month forecast



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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