SUPPLY CHAIN DELAY PATTERN ANALYSIS

[1] Vijayata Ramteke, [2] B Akhil Paul, [3] P Bhuvanesh, [4] Saniya Firdous
[1]AssistantProfessor, [234]Students
Department of CSE
Siddhartha Institute of Technology & Sciences, Narapally
vijayataramteke_cse@siddhartha.co.in, 23tq1a05f6@siddhartha.co.in, 24tq5a0521@siddhartha.co.in, 23tq1a05e5@siddhartha.co.in,

ABSTRACT

The Supply Chain Delay Pattern Analysis system is a data analytics and visualization platform designed to identify, analyze, and monitor delays that occur across different stages of the supply chain. Modern supply chains involve suppliers, manufacturers, warehouses, transportation providers, and customers, making timely delivery an important factor in operational efficiency. Delays in any stage can affect inventory levels, production schedules, customer satisfaction, and overall business performance.
The proposed system collects appropriate supply-chain information such as order dates, supplier details, shipment dates, expected delivery dates, actual delivery dates, transportation modes, warehouse locations, product categories, and delivery status. The system processes this information to calculate important Key Performance Indicators (KPIs) such as total shipments, delayed shipments, average delay duration, on-time delivery rate, supplier performance, and transportation delay rate.
The dashboard presents analyzed information through interactive charts, graphs, tables, maps, and KPI cards. Supply-chain managers can compare delays across suppliers, transportation modes, warehouses, product categories, and geographic regions. Time-based filters allow users to analyze daily, weekly, monthly, quarterly, or yearly delay patterns.
The system can identify recurring delay patterns and highlight areas where delivery performance is below expectations. Trend analysis can help managers understand whether delays are increasing or decreasing over time. The system can also identify relationships between delays and factors such as transportation mode, supplier, warehouse, route, or product category, while avoiding unsupported assumptions about the cause of a specific delay.
Overall, the Supply Chain Delay Pattern Analysis system provides a centralized platform for transforming supply-chain data into meaningful operational insights. It reduces manual reporting efforts and supports better logistics planning, supplier evaluation, inventory management, and delivery optimization. Future enhancements can include AI-based delay prediction, route-risk analysis, demand forecasting, real-time shipment tracking, automated alerts, and predictive supply-chain planning.

I. INTRODUCTION

Supply chains connect suppliers, manufacturers, warehouses, transportation networks, retailers, and customers. A successful supply chain depends on the timely movement of materials and products between these different stages. Delays can affect production schedules, inventory availability, transportation costs, and customer satisfaction.
Supply-chain delays can occur because of transportation problems, supplier issues, warehouse congestion, incorrect documentation, weather conditions, route disruptions, inventory shortages, or other operational factors. Understanding delay patterns helps organizations identify areas that may require further investigation and operational improvement.
Traditional supply-chain monitoring often depends on spreadsheets, logistics-management systems, shipment tracking platforms, and manually prepared reports. Information about suppliers, orders, shipments, warehouses, and deliveries may be

stored in different systems. Combining these datasets to understand complete delay patterns can be time-consuming.

The Supply Chain Delay Pattern Analysis system provides an interactive dashboard for monitoring delivery performance across the supply chain. It can display shipment volume, delayed shipments, average delay duration, on-time delivery rate, supplier performance, transportation performance, and regional delay trends.

The main objective of the system is to help supply-chain managers understand where and when delays occur and how delay patterns vary across different operational dimensions. The dashboard supports data-driven investigation and planning rather than automatically assuming the cause of a delay. It can help organizations improve logistics visibility, resource planning, supplier management, and delivery performance.

II. LITERATURE SURVEY

Traditional supply-chain management systems focus on procurement, inventory management, order processing, warehouse operations, transportation, and shipment tracking. These systems generate large amounts of operational data but may provide limited capabilities for analyzing long-term delay patterns. Additional Business Intelligence tools are often used to transform operational data into management insights.

Supply-chain performance analysis commonly uses indicators such as on-time delivery rate, average delivery time, shipment volume, delay duration, order fulfillment rate, inventory turnover, and supplier performance. These indicators help organizations monitor logistics efficiency and identify operational areas requiring attention.

Transportation and logistics analytics are widely used to examine shipment routes, transportation modes, delivery locations, and carrier performance. Geographic visualization can help organizations identify regions or routes where delivery performance differs. However, observed patterns should be investigated further before assigning a specific cause to delays.

Data visualization provides an effective way to understand large supply-chain datasets. Line charts can display delay trends over time, while bar charts can compare suppliers and transportation modes. Maps can represent regional shipment activity, and KPI cards can summarize important delivery-performance indicators.

Machine learning and Artificial Intelligence are increasingly being explored for predictive supply-chain analytics. Predictive models can estimate delivery times, identify potential delays, forecast demand, and support route optimization. However, predictive systems require reliable historical data, proper validation, continuous monitoring, and appropriate human oversight.

Existing research demonstrates the value of supply-chain analytics, visualization, and predictive techniques for improving logistics management. However, traditional reports may require manual consolidation and may provide limited interactive analysis of recurring delay patterns. The proposed Supply Chain Delay Pattern Analysis system combines KPI monitoring, delay analysis, supplier comparison, transportation analysis, trend visualization, and reporting in a centralized platform.

III. SYSTEM ANALYSIS

The **Supply Chain Delay Pattern Analysis** system is designed to analyze delivery and shipment delays across different supply-chain stages. The system collects appropriate information such as order dates, suppliers, shipment dates, expected delivery dates, actual delivery dates, transportation modes, warehouses, routes, and product categories. A data-ingestion module imports information from supply-chain management systems, logistics platforms, warehouse systems, spreadsheets, or approved APIs. The preprocessing module validates records, handles missing values, removes duplicates, and standardizes dates, locations, and shipment statuses. The system organizes information according to suppliers, warehouses, transportation modes, routes, product categories, and reporting periods. A KPI engine calculates total shipments, delayed shipments, average delay duration, on-time delivery rate, and supplier performance indicators. A trend-analysis engine examines changes in delivery delays across daily, weekly, monthly, and yearly periods. A comparison engine compares delay patterns across suppliers, transportation modes, warehouses, regions, and product categories. A delay-pattern module identifies recurring aggregate patterns that may require further operational investigation. The visualization layer presents results using KPI cards, line charts, bar charts, maps, and tables. Interactive filters allow users to select specific suppliers, routes, warehouses, products, and time periods. Finally, authorized supply-chain managers can generate reports to support logistics planning and delivery-performance improvement.

Existing System

Existing supply-chain organizations commonly use Enterprise Resource Planning systems, Warehouse Management Systems, Transportation Management Systems, shipment tracking platforms, spreadsheets, databases, and manually prepared logistics reports. These systems record orders, shipments, suppliers, warehouse activities, transportation information, and delivery dates. However, supply-chain information may be distributed across multiple systems and departments. Managers may need to manually combine shipment data before calculating delay-related KPIs. Comparing supplier or transportation performance can require separate reports and spreadsheet calculations. Historical delay trends may also be difficult to analyze when information is stored across different reporting systems. Static reports provide limited interactive visualization and filtering capabilities. Manual data processing can introduce errors and consume significant analyst time. Traditional systems may identify delayed shipments but may not provide a clear view of recurring aggregate patterns. Reports can become outdated as shipment statuses change. Therefore, existing systems provide important operational capabilities but may require an integrated analytics dashboard for comprehensive supply-chain delay analysis.

Disadvantages of Existing System

- Supply-chain data may be distributed across multiple systems.
- Heavy dependence on spreadsheets and manual reports.
- Time-consuming data consolidation.
- Manual calculation of delay-related KPIs.
- Limited interactive visualization.
- Difficult to compare supplier performance.
- Difficult to compare transportation modes.
- Limited geographic delay analysis.
- Historical trends may require separate reports.
- Manual processing can introduce errors.
- Limited automated delay-pattern detection.
- Reports may become outdated quickly.

Proposed System

The proposed **Supply Chain Delay Pattern Analysis** system provides a centralized platform for monitoring and analyzing shipment delays. The system collects appropriate information from supply-chain management systems, logistics platforms, warehouse systems, spreadsheets, and approved APIs. A preprocessing layer validates,

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cleans, and standardizes shipment and delivery information before analysis. The system organizes data according to suppliers, warehouses, transportation modes, routes, product categories, and reporting periods. A KPI engine calculates total shipments, delayed shipments, average delay duration, on-time delivery rate, and other approved performance indicators. A trend-analysis engine identifies changes in delay patterns over time. A comparison engine allows managers to compare aggregate delivery performance across suppliers, transportation modes, warehouses, regions, and product categories. A delay-pattern analysis module identifies recurring patterns that may require operational investigation. The visualization engine presents results through KPI cards, line charts, bar charts, maps, and tables. Users can apply interactive filters to explore selected suppliers, routes, warehouses, products, and time periods. The dashboard can highlight significant changes in delay rates for further investigation. Optional AI analytics can support delay prediction and logistics forecasting using validated historical data. Finally, authorized managers can generate reports to support supplier management, logistics planning, and supply-chain optimization.

Advantages of Proposed System

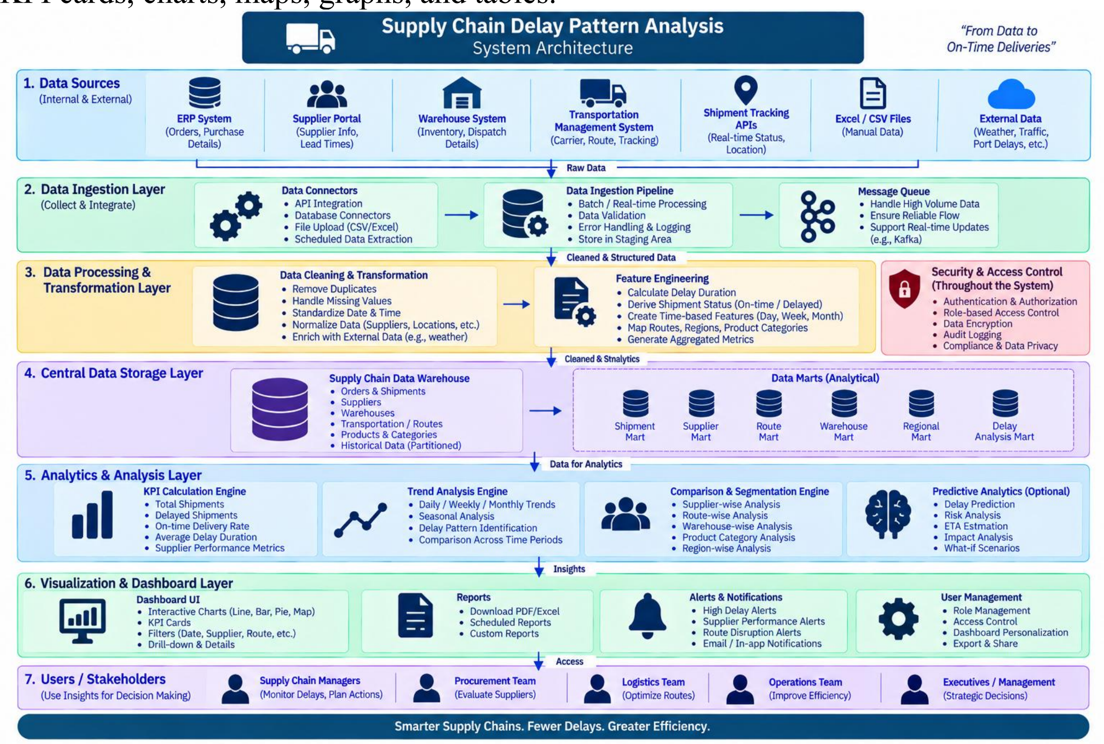
- Provides centralized supply-chain delay analytics.
- Automatically calculates delay-related KPIs.
- Supports supplier performance comparison.
- Enables transportation-mode analysis.
- Provides warehouse and regional analysis.
- Displays historical delay trends.
- Supports route and product-category analysis.
- Identifies recurring aggregate delay patterns.
- Provides interactive charts and maps.
- Reduces manual reporting effort.
- Supports logistics and inventory planning.
- Enables data-driven supply-chain decisions.

IV. METHODOLOGY

The methodology begins by collecting appropriate supply-chain information from ERP systems, warehouse-management platforms, transportation systems, shipment tracking tools, spreadsheets, or approved APIs. The data-ingestion module imports order, shipment, supplier, transportation, warehouse, and delivery information into the analytics platform. The preprocessing module validates records, removes duplicates, handles missing values, and standardizes dates, locations, shipment statuses, and delivery fields. The cleaned information is organized into structured datasets containing orders, shipments, suppliers, routes, warehouses, products, and reporting periods. A KPI engine calculates total shipments, delayed shipments, average delay duration, on-time delivery rate, and supplier performance indicators. A trend-analysis module examines delay changes across daily, weekly, monthly, quarterly, and yearly periods. A comparison engine evaluates aggregate delivery performance across suppliers, transportation modes, warehouses, regions, routes, and product categories. A delay-pattern analysis module identifies recurring patterns and unusual changes for further investigation. The visualization engine converts processed information into KPI cards, line charts, bar charts, maps, and tables. Authorized users can apply filters to analyze selected suppliers, routes, products, warehouses, and periods. The system highlights significant changes in aggregate delay patterns and provides analytical summaries. Optional AI analytics can forecast potential future delays using validated historical data. Finally, authorized supply-chain managers can generate reports to support logistics planning, supplier evaluation, inventory management, and delivery optimization.

SYSTEM ARCHITECTURE

The Supply Chain Delay Pattern Analysis system consists of several interconnected layers for collecting, processing, analyzing, and visualizing supply-chain delivery information. The User Interface allows authorized supply-chain managers and analysts to access dashboards, filters, visualizations, and reports. The Data Ingestion Layer collects approved information from ERP systems, Warehouse Management Systems, Transportation Management Systems, shipment tracking platforms, spreadsheets, and APIs. The Security and Access-Control Layer protects business and operational information and ensures that users can access only authorized data. The Data Cleaning and Transformation Module validates records, handles missing values, removes duplicates, and standardizes shipment dates, locations, and statuses. The Central Supply Chain Data Warehouse stores structured information about orders, shipments, suppliers, warehouses, routes, products, and delivery performance. The KPI Calculation Engine calculates shipment volume, delay rate, average delay duration, on-time delivery rate, and supplier performance. The Trend Analysis Engine identifies changes in delay patterns over time. The Comparison Engine compares aggregate performance across suppliers, transportation modes, warehouses, regions, routes, and product categories. The Optional AI Analytics Module can support delay prediction, risk analysis, and logistics forecasting. The Visualization Engine generates KPI cards, charts, maps, graphs, and tables.



V. RESULT AND OUTPUT

VI. CONCLUSION

The Supply Chain Delay Pattern Analysis system provides an effective and centralized solution for monitoring and analyzing shipment delays across different stages of the supply chain. The system brings important information such as total shipments, delayed shipments, delivery duration, on-time delivery rate, suppliers, transportation modes, routes, warehouses, and product categories into a single interactive dashboard.

By using data processing, KPI calculation, trend analysis, comparison techniques, and data visualization, the system transforms raw supply-chain data into meaningful operational insights. Supply-chain managers can compare delivery performance across suppliers, transportation modes, regions, routes, warehouses, and product categories.

The dashboard helps identify recurring delay patterns and changes in delivery performance over time. KPI cards, charts, tables, maps, and interactive filters make it easier to identify areas that require further investigation. These insights can support supplier evaluation, logistics planning, inventory management, route analysis, and delivery-performance improvement.

Overall, the Supply Chain Delay Pattern Analysis system reduces manual reporting efforts and supports faster, data-driven supply-chain decisions. It provides better visibility into delivery performance and can help organizations improve operational efficiency and customer satisfaction. Future enhancements can include AI-based delay prediction, real-time shipment tracking, route-risk analysis, demand forecasting, automated alerts, predictive logistics planning, and intelligent supplier-risk analysis.

The system should distinguish between observed delay patterns and confirmed causes. A high delay rate associated with a particular supplier, route, or transportation mode does not automatically prove that it caused the delay. Further operational investigation should be performed before corrective actions are taken.

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