International Journal of Scientific Research and Engineering Development-– Volume 9 Issue 2, Mar-Apr 2026
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

AI-Based Supply Chain Management System (SupplyAI)

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Abstract:

Supply chain management is a fundamental aspect of modern business operations, ensuring the efficient flow of goods, information, and resources from suppliers to consumers. Traditional supply chain systems often face challenges such as inaccurate demand forecasting, inefficient inventory management, and lack of real-time insights. This paper presents an **AI-Based Supply Chain Management System (SupplyAI)** designed to address these issues using data-driven techniques. The proposed system utilizes structured datasets and machine learning-based analytical methods to predict demand patterns and optimize inventory levels. The system is implemented using **Python** and integrates data processing, visualization, and prediction modules. Experimental results demonstrate improved forecasting accuracy, reduced inventory imbalance, and enhanced decision-making capabilities. The system is scalable, cost-effective, and particularly beneficial for small and medium enterprises aiming to modernize their supply chain operations.

Keywords —Supply Chain, Demand Forecasting , Python , Reduced Inventoy Imbalance , Modernize supply Chain Operations , Enhanced Decision Making.

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I. INTRODUCTION

Supply chain management (SCM) involves the coordination of various activities including procurement, production, inventory management, and distribution. In today's highly competitive and globalized market, efficient supply chain operations are critical for organizational success. However, traditional SCM systems often rely on manual processes and static models, which lead to inefficiencies such as overstocking, stockouts, delayed deliveries, and increased operational costs.

With the rapid advancement of **Artificial Intelligence (AI) and data analytics**, there is a significant opportunity to transform conventional supply chain systems into intelligent, adaptive systems. AI enables predictive analysis, automation, and real-time decision-making, allowing organizations to respond dynamically to changing market demands.

This paper introduces **"SupplyAI,"** an **AI-Based Supply Chain Management System** that leverages data analytics and machine learning concepts to enhance forecasting accuracy and optimize supply chain processes. The system is designed to be simple, scalable, and efficient, making it suitable for real-world applications, especially in resource-constrained environments.

II. Materials and Methods

2.1 Dataset Description

The system utilizes multiple structured datasets in CSV format, each representing a different product category such as clothing, electronics, food, and

furniture. Each dataset contains over 10,000 records to simulate real-world supply chain scenarios.

The dataset includes the following attributes:

- Product ID
- Product Category
- Demand Quantity
- Supply Quantity
- Inventory Level
- Order Date and Delivery Date
- Supplier Information

The datasets are synthetically generated to ensure diversity and scalability while maintaining realistic patterns for analysis.

2.2 Tools and Technologies

The development of the system involves the following tools and technologies:

- **Programming Language:** Python
- **User Interface:** Streamlit
- **Libraries Used:**
  - Pandas (data manipulation)
  - NumPy (numerical operations)
  - Matplotlib / Seaborn (data visualization)
- **Data Storage:** CSV files

2.3 System Architecture

The architecture of SupplyAI is modular and consists of the following components:

1. **Data Input Module:**
   Handles loading and validation of CSV datasets.
2. **Data Processing Module:**
   Performs data cleaning, handling missing values, and normalization.
3. **Prediction Engine:**
   Applies basic machine learning techniques such as regression and trend analysis to forecast demand.
4. **Visualization Dashboard:**
   Displays insights using graphs, charts, and summary statistics for better understanding.

2.4 Methodology

The working of the system follows a structured approach:

1. **Data Collection:**
   Import datasets from CSV files representing different product categories.
2. **Data Preprocessing:**
   - Remove inconsistencies
   - Handle missing values
   - Convert date formats
   - Normalize data
3. **Exploratory Data Analysis (EDA):**
   Identify patterns and trends in supply and demand.
4. **Model Implementation:**
   Apply predictive techniques such as:
   - Linear Regression
   - Moving Average
5. **Visualization:**
   Generate graphs for demand trends, inventory levels, and supply distribution.
6. **Decision Support:**
   Provide actionable insights for inventory optimization and demand planning.

III. Results and Discussion

The implementation of the SupplyAI system demonstrates the effectiveness of integrating artificial intelligence techniques into supply chain management. The system was evaluated using multiple datasets representing different product categories, and the results indicate a noticeable improvement in forecasting accuracy and inventory management.

One of the major outcomes of the system is the enhancement in demand prediction. By analyzing

historical data trends, the system is able to generate more reliable forecasts compared to traditional static approaches. This helps organizations anticipate future demand and plan their resources accordingly.

Another significant improvement is observed in inventory optimization. The system maintains a balance between supply and demand, thereby reducing the risks associated with overstocking and stock shortages. Efficient inventory management directly contributes to cost reduction and improved operational performance.

The visualization module plays a crucial role in simplifying complex data. Graphical representations allow users to quickly interpret trends and patterns, making it easier for decision-makers to take appropriate actions. The use of dashboards enhances user interaction and provides a comprehensive overview of the supply chain status.

However, the system also has certain limitations. The use of synthetic datasets may not fully capture real-world uncertainties. Additionally, the predictive models used are relatively basic and can be further improved by incorporating advanced machine learning techniques. Despite these limitations, the system provides a strong foundation for intelligent supply chain management.

IV. Conclusions

The proposed **AI-Based Supply Chain Management System (SupplyAI)** successfully demonstrates the application of **Artificial Intelligence** and **data-driven techniques** in improving supply chain operations. The system addresses key challenges associated with traditional supply chain methods, such as **inefficient demand forecasting**, **inventory mismanagement**, and **lack of real-time insights**.

By utilizing **structured datasets**, **data preprocessing techniques**, and **predictive models** such as **linear regression** and **moving averages**, the system is able to generate reliable demand forecasts and support better decision-making. The integration of a **visualization dashboard** further enhances usability by presenting complex data in an intuitive and interpretable manner.

The results indicate that the proposed system contributes to **improved forecasting accuracy**, **optimized inventory levels**, and **reduced operational inefficiencies**. These improvements highlight the potential of AI in transforming conventional supply chain systems into **intelligent and adaptive systems**.

Although the system currently operates on **synthetic datasets** and basic predictive models, it provides a strong foundation for future enhancements. With further integration of **advanced machine learning techniques**, **real-time data processing**, and **cloud-based deployment**, the system can be extended to handle real-world industrial applications effectively.

In conclusion, **SupplyAI** serves as a **scalable**, **cost-effective**, and **efficient solution** for modern supply chain challenges, particularly for **small and medium enterprises (SMEs)** aiming to adopt intelligent technologies.

Acknowledgment

The authors would like to express their sincere gratitude to **Prof. A. B. Suryawanshi** for continuous guidance, valuable suggestions, and support throughout the development of this project. His expertise and encouragement played a crucial role in the successful completion of this work.

The authors also extend their thanks to the faculty members and staff of the Department of Computer Engineering, Trinity Polytechnic, Pune, for providing the necessary resources and technical support.

Special appreciation is given to all team members for their dedication, collaboration, and efforts in successfully designing and implementing the system.

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