Streamlining Supply Chain Dynamics: Data-Driven Solutions for Cost Efficiency and Customer Satisfaction

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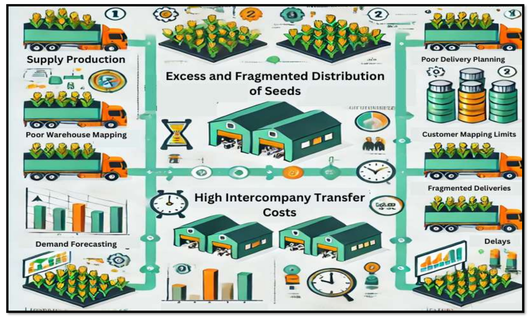
ABSTRACT

This study analyzes supply chain inefficiencies at an Indiana-based seed manufacturer focusing on excessive shipments, warehouse mapping, and inventory transfers. Using data-driven analysis, we propose optimizations to reduce costs and improve reliability, enhancing overall efficiency.

INTRODUCTION

Supply chain inefficiencies, such as excessive shipments, poor warehouse utilization, and frequent intercompany transfers, increase costs and disrupt operations. Despite technological advancements, challenges like fluctuating demand, contract-based manufacturing, and unpredictable conditions complicate supply planning. Optimizing inventory distribution and delivery processes through data-driven strategies is essential for improving efficiency and maintaining competitiveness.



PROJECT OBJECTIVES

Production	Distribution	Fulfillment
1. **Overlap of Supply Planning Cycle with Sale Seasons** - Misaligned supply planning with peak sales seasons causes stockouts or overstocking.	1. **Intercompany Transfers** - Excessive transfers between company locations result in logistical inefficiencies and increased lead times.	2. **Delivery Inefficiency: Excess Shipments** - Frequent, fragmented shipments increase costs and disrupt customer operations.
2. **Reliance on Contractors for Seed Production** - Overdependence on contractors introduces variability in quality and supply timelines.		3. **Warehouse Mapping to Customer** - Inefficient mapping of warehouses to customers leads to delays and higher transportation costs.

These problems are within project scope

All the problems identified above lead to declining customer retention due to perceived inefficiencies and dissatisfaction with delivery and service

- **Minimize costs** by optimizing consolidation and reducing excessive deliveries.
- **Improve warehouse-to-customer mapping** to decrease transportation expenses
- **Reduce intercompany transfers** for better inventory management and cost control.
- **Leverage data-driven analysis and optimization modeling** to enhance overall supply chain performance

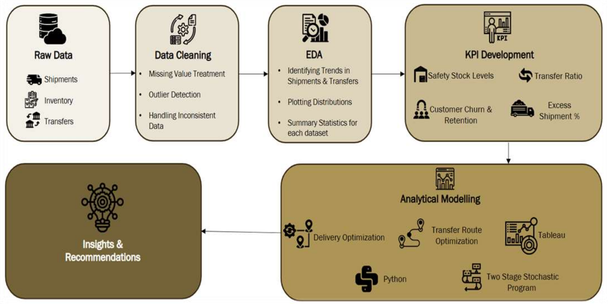
LITERATURE REVIEW

This literature review examines supply chain challenges in agriculture, focusing on inefficiencies in seed supply that drive high costs and customer dissatisfaction. It discusses two-stage decision-making in network optimization, involving pre-season production allocation and post-demand interfacility transfers. Established techniques include two-stage stochastic linear programs. The integration of demand forecasting with optimization (joint prediction optimization) is emphasized as crucial for improving decision quality.

Study	Aim	Technique
Nagrahi et al, 2024	Quantifying and managing risk in a supply chain	Mixed integer quadratic programming, mixed integer linear programming
Basciftci et al, 2024	Capacity expansion at a plant	Adaptive two-stage stochastic linear program
Elmachtoub and Grigas, 2020	Improving Predict-then-Optimize Framework	Smart loss function adapting optimization solution structure
Kotary et al, 2024	Replacing Predict-then-Optimize Framework	Learning-to-Optimize framework

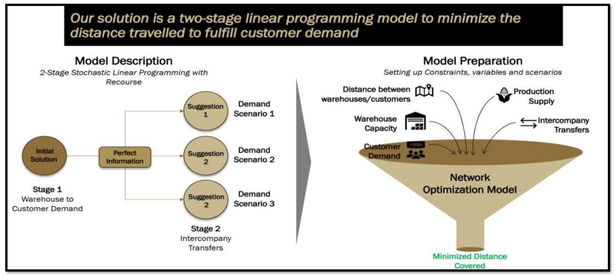
METHODOLOGY

- **Data Collection & Preparation**: Collect raw shipment, inventory, and transfer data; perform data cleaning (missing value treatment, outlier detection, handling inconsistent data).
- **Exploratory Data Analysis**: Identify trends in shipments & transfers, plot distributions, and generate summary statistics for each dataset.
- **KPI Development**: Establish key metrics including safety stock levels, transfer ratio, customer churn & retention, and excess shipment percentages.
- **Two-Stage Optimization Model**: Implement stochastic program with Stage 1 (warehouse-to-customer optimization) and Stage 2 (warehouse-to-warehouse transfers) with appropriate constraints.
- **Analytical Modeling Tools**: Develop delivery optimization and transfer route optimization using Python notebooks and Tableau visualizations.
- **Results Validation & Recommendations**: Evaluate impact (5% reduction in excessive shipments, 4.5% lower intercompany transfers, 3% cut in travel distance) and identify future improvements.

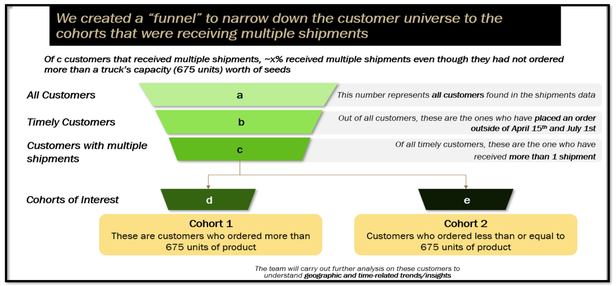


PROJECT OUTCOMES

Network Optimization – Self Serve Python Notebook



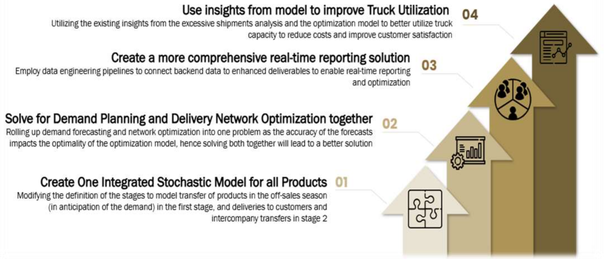
Excessive Shipments Analysis



Intercompany Transfers Analysis

EXPECTED IMPACT

FUTURE SCOPE



CONCLUSION

We were able to help our client improve the efficiency of their supply chain processes like intercompany transfers and number of shipments made to customers though the following deliverables:

- **Tableau dashboard** that they could use to excess shipments to customers and number of intercompany transfers at a warehouse level
- **Self-serve Python notebook** with a linear program to help them optimize deliveries to customers and intercompany transfers

ACKNOWLEDGEMENTS

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