

# Innovation Brief

## Logistics Cost Scenario Lab

### **Addressing the Challenge of Predictive Logistics Planning**

Traditional dashboards offer historical performance insights, but lack the crucial capability for predictive scenario planning regarding logistics costs and service metrics. NexGen executives needed a way to understand the "ripple effect" of operational changes, such as eliminating a product line, increasing storage costs, or anticipating demand surges, on total costs and key performance indicators (KPIs). This challenge required integrating diverse data sources and reasoning about cause-and-effect under uncertainty.

### **The Logistics Cost Scenario Lab: A Solution**

The "Logistics Cost Scenario Lab" app was developed to address this problem directly. It allows users to define granular scenarios (at the warehouse and product category level) and instantly assess their impact across the entire warehouse network. By bridging operational data with strategic planning, the app enables NexGen managers to conduct "what-if" experiments before implementing real-world decisions, such as stocking/delisting items or budgeting for rising storage fees. Essentially, the app quantifies the downstream effects of inventory and demand decisions on overall logistics costs and performance.

## Technical Approach: A Multi-Stage Process

The app's logic unfolds in several stages:

1. **Feature Preparation:** Datasets are aggregated into a unified table, keyed by warehouse and product category. For each pair, the app calculates total demand value, order count, average distance, total "order cost" (transport and delivery), total inventory, and average storage cost. If a category lacks orders, a formula estimates total cost based on stock carrying and distance.
2. **Machine Learning Model Training:** A Random Forest regressor (200 trees) is trained to predict the total logistics cost for each (warehouse, category) segment. This model utilizes features like demand, stock level, storage cost, and distance, capturing non-linear interactions among these factors.
3. **Scenario Builder:** Located in the Streamlit sidebar, the scenario builder allows users to select a warehouse and product category and then choose an "action":
  - **Remove category (qty=0):** Sets inventory quantity and demand to zero for the selected segment.
  - **Scale storage cost:** Multiplies the unit storage cost by a user-defined factor (e.g., simulating increased warehousing expenses).
  - **Scale demand:** Multiplies the demand value by a factor (e.g., modeling a spike or drop in orders).
4. **Scenario Execution and Cost Recalculation:** When a user runs a scenario, the app applies these changes to the relevant features. Inventory costs are recomputed (quantity × cost), and predicted order cost adjusts with demand and distance.
5. **Monte Carlo Simulation for Uncertainty:** To account for uncertainty, the app performs a Monte Carlo simulation. Key inputs are randomly perturbed over numerous trials (e.g., +/-15% on demand, +/-10% on storage cost, +/-5% on distance, drawn from normal distributions). For each trial, the trained model predicts total cost, and all KPIs are recomputed, yielding distributions for each KPI under the scenario.
6. **Results Presentation:** The app presents the results by comparing

baseline KPIs (sums of costs, CO<sub>2</sub> proxy, inventory turnover, etc.) to scenario averages derived from Monte Carlo trials. Users view a table of baseline versus scenario KPIs, a horizontal bar chart displaying each KPI's percentage change, and interactive histograms illustrating the Monte Carlo distribution for any KPI of interest. These visuals clearly demonstrate, for example, that "Total Operational Cost would drop by 10% (red bar) if we zero out Category X at Warehouse Y," complete with confidence intervals.

## **Business Impact**

The Logistics Cost Scenario Lab directly supports NexGen's strategic goals by making the cost structure transparent and actionable. This tool allows logistics managers to quantify the impact of proposed changes before implementation, reducing reliance on gut instinct. For instance, if rising storage fees at the Chennai warehouse threaten to erode margins, managers can simulate increasing the storage cost multiplier and see its effect on total and storage costs. Alternatively, the effect of an unexpected demand surge for Electronics in Bangalore can be explored by scaling demand.

By converting raw data into cost forecasts and KPI outcomes, the app helps identify the highest-leverage actions (e.g., which categories or locations are cost drivers). Specifically, the tool aligns with NexGen's mandate to cut operational costs by 15–20%. It can highlight inefficiencies, such as product categories with low turnover but high carrying cost, or routes where demand changes significantly impact CO<sub>2</sub> emissions. The Monte Carlo analysis brings robustness to decisions, showing not just single estimates but ranges of possible outcomes. In practice, this can lead to substantial savings; for example, if the app reveals that eliminating a low-demand category in a costly warehouse yields a 12% reduction in total costs (even after accounting for demand spread), that insight can justify strategic inventory reallocation.

In summary, by providing a predictive cost intelligence capability, the app empowers NexGen to make data-driven trade-offs—balancing service levels,

sustainability (CO<sub>2</sub> proxy), and cost. This enhances competitiveness through innovation, fulfilling leadership's vision of a forward-looking, analytics-driven logistics operation.