Optimizing Demand Forecasting and Pricing Strategy for Dairy Mart

A Proposal report for the BDM capstone Project

Submitted by

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Declaration Statement

I am working on a Project titled “Optimizing Demand Forecasting and Pricing Strategy for Dairy Mart”. I extend my appreciation to Kaggle, for providing the necessary resources that enabled me to conduct my project.

I hereby assert that the data presented and assessed in this project report is genuine and precise to the utmost extent of my knowledge and capabilities. The data has been gathered from primary sources and carefully analyzed to assure its reliability.

Additionally, I affirm that all procedures employed for the purpose of data collection and analysis have been duly explained in this report. The outcomes and inferences derived from the data are an accurate depiction of the findings acquired through thorough analytical procedures.

I am dedicated to adhering to the principles of academic honesty and integrity, and I am receptive to any additional examination or validation of the data contained in this project report.

I understand that the execution of this project is intended for individual completion and is not to be undertaken collectively. I thus affirm that I am not engaged in any form of collaboration with other individuals, and that all the work undertaken has been solely conducted by me. In the event that plagiarism is detected in the report at any stage of the project's completion, I am fully aware and prepared to accept disciplinary measures imposed by the relevant authority.

I understand that all recommendations made in this project report are within the context of the academic project taken up towards course fulfillment in the BS Degree Program offered by IIT Madras. The institution does not endorse any of the claims or comments.

Signature of Candidate: (**Digital Signature**)

Name: Kunwar Arpit Singh

Date: 13 July 2025

Executive Summary and Title

The Dairy Mart is a dairy-focused distribution and retail operation which is based on the Dairy Goods Sales Dataset hosted by Suraj520 on Kaggle which is a real-world inspired dataset, spanning 2019, 2022. It includes data on dairy product suppliers, processed SKUs, inventory levels, and both B2B and B2C transactions across Indian states.

The business struggles with volatile weekly sales, which results in frequent stockouts of high-demand items and overstock of slow-moving SKUs and a uniform pricing strategy fails to capture potential revenue in segments that are highly sensitive to price. This has resulted in working capital being locked in excess inventory and lost opportunities during periods of high demand.

To address these issues, we will begin by forecasting weekly demand by region and sales channel using time-series models such as ARIMA and Prophet. This will allow the company to better align procurement, production, and distribution with expected sales peaks. Next, we will use log-log regression to estimate price elasticities for each Region-Channel combination, enabling targeted pricing, discounts in elastic markets and premium pricing in inelastic ones. Together, these insights will help Dairy Mart reduce inventory costs, enhance service levels, free up working capital, and maximize revenue across planning horizons.

Organization Background

The business I will be working for this project is a Dairy Mart, a privately owned dairy distribution and retail operation modeled on Suraj520's Kaggle dataset, which operates across multiple states and union territories of India. The company sources raw milk and other dairy products from regional dairy farms, recording farm size, cow population and production dates and processes it into an array of products including milk varieties, butter, cheese and yogurt. Branded SKUs are monitored end-to-end from production and storage conditions to expiration dates and inventory levels across multiple outlets. The business serves in a hybrid B2B/B2C model and supplies the products via retail, wholesale and online channels. Comprehensive transaction logs record customer location, sales channel (retail, wholesale, online), quantities sold, and unit prices. By maintaining minimum stock thresholds and reorder quantity rules, the business continuously monitors inventory health, aiming to balance product availability with shelf-life constraints and working-capital efficiency.

Problem Statement

Problem statement 1:

We observe fluctuations in demand which results in a lack of precise weekly demand forecasts by region and channel. This leads to mismatches between production schedules and actual sales, resulting in frequent stockouts of fast-moving SKUs and overstock of slow-moving items. This results in blockage of working capital and customer satisfaction is reduced.

Problem statement 2:

Uniform pricing across all regions and channels fails to account for varying price elasticities, leading to revenue losses in highly elastic markets and forgone margin opportunities in inelastic segments.

Background of the Problem

I have observed two intertwined challenges which hampers the Dairy Mart's ability to meet customer demand and capture optimal revenue:

1. Volatile region-specific and channel-specific sales patterns

2. One-size-fits-all pricing strategy

In the highly perishable, demand-sensitive dairy segment, sales forecasts and tailored pricing strategies are essential to maximize operational efficiency and profitability. The challenge intensifies when a business operates across both B2B and B2C channels, each with distinct consumption patterns.

In the absence of granular weekly demand projections segmented by region and distribution channel, companies risk stockouts in peak-demand areas while overstocking slower zones. These mismatches not only elevate inventory holding costs and spoilage rates of perishables but may also force abrupt production adjustments, undermining supply chain reliability. There is a need to implement forecasting techniques and pricing models to alleviate these issues, ensuring optimal inventory levels and protecting profits.

External influences such as seasonal variations, regional festivals, competitive pricing by local entities, and variances in regional income significantly also impact consumer purchasing behavior and complicate demand patterns. In the absence of a comprehensive forecasting and pricing elasticity analysis methodology, the business cannot synchronize supply chain decisions with actual market conditions, resulting in constrained working capital, lost sales opportunities, and diminished profitability.

Problem Solving Approach

To address Dairy Mart's demand volatility and undifferentiated pricing, I propose a dual analytical framework, demand forecasting and price elasticity analysis which is complemented by an integrated decision support system. The following is a systematic procedure:

1. Define Objectives and Scope of the Problem:
    a. Clarification of objectives to improve forecast accuracy by region/channel and derive segment-specific pricing to maximize revenue.
    b. A macro-level analysis will contextualize Dairy Mart within the cyclical patterns of production, distribution, and consumption, emphasizing how misaligned inventory levels and static pricing mechanisms lead to increased holding costs, perishables wastage, and reduced customer satisfaction.
2. Data Ingestion, Cleaning & EDA
    a. Transform raw logs into a weekly dataset with metrics: Total Quantity Sold, Average Price per Unit, and Sales Channel vs. Customer Location cross-tabs.
    b. Handle missing values and duplicates via imputation and domain-informed carry-forward methods.
    c. Apply inventory ledger: Closing Inventory = Opening Inventory − Sales + Incoming Stock.
    d. Analyze demand-supply patterns, apply Pareto analysis, assess seasonality, and compute inventory turnover to identify bottlenecks.
3. Demand Forecasting (ARIMA and Prophet)
    a. Feature Engineering: Incorporation of calendar-based covariates to capture trend and seasonality patterns.
    b. Baseline Modeling: Simple Exponential Smoothing will serve as a benchmark for performance evaluation.
    c. ARIMA Forecasting:
        i. Series differencing to ensure stationarity.
        ii. Parameter tuning using ACF/PACF plots and AIC minimization.
        iii. Rolling-origin cross-validation for backtesting model stability.
    d. Prophet Modeling:

i. Use of automated changepoint detection for capturing abrupt trend shifts.
ii. Integration of holiday effects to improve temporal sensitivity.

e. Model Evaluation:
i. Comparative validation using MAPE and RMSE.
ii. Target: Achieve ≥10% improvement over baseline accuracy.
iii. Improvement over baseline.

4. Price Elasticity Analysis (Log-Log Regression & Panel Methods):
a. Period Aggregation: Align Price and volume on weekly or monthly intervals.
b. Model Specification:
Fit :

$$\ln(Q)=\alpha+\beta \ln(P)+\gamma_1 \text{ Seasonality}+\gamma_2 \text{Holiday}+\epsilon$$

,where β yields elasticity.

c. Panel extensions: Fixed effects for regions and sales channels to account for unobserved heterogeneity.
d. Diagnostics:
i. t-tests for coefficient significance.
ii. Evaluation of R^2, residual homoscedasticity, and autocorrelation.

5. **Synthesis & Strategy Development**
a. Combine forecasts and elasticity via a dashboard to simulate revenue under varied prices $P(1+\Delta P)\times Q$.
b. For segments with $|\beta|>1$, apply penetration pricing or volume tiers; with $|\beta|<1$, adopt value-based or premium pricing.

6. **Implementation & Monitoring**
a. Deploy dashboards with demand triggers (Z-score-based).
b. Use KPI-based feedback (inventory turnover, stockouts, revenue/SKU) for quarterly refinement aligned with macro trends.

Expected Timeline

Work Breakdown Structure (WBS)

1. Data Preparation
   1.1 Data Ingestion & Validation
   1.2 Cleaning & Imputation
   1.3 Weekly Aggregation & Feature Engineering

2. Exploratory Analysis
   2.1 Descriptive Statistics & Visualizations
   2.2 Seasonality & Trend Detection
   2.3 ABC Analysis for SKU Prioritization

3. Demand Forecasting
   3.1 Baseline Smoothing & Benchmarking
   3.2 ARIMA Model Development
   3.3 Prophet Model Development
   3.4 Cross-Validation & Hyperparameter Tuning

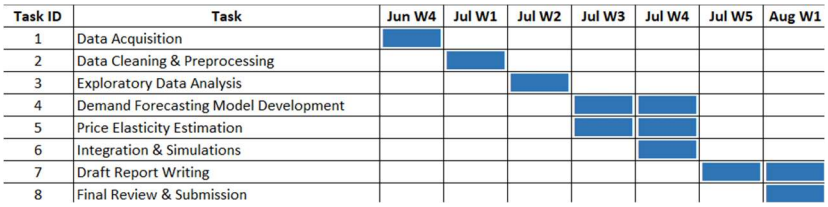
4. Price Elasticity Estimation
   4.1 Period Aggregation (Weekly/Monthly)
   4.2 Log–Log Regression Setup
   4.3 Panel Fixed-Effects Modeling
   4.4 Statistical Diagnostics & Interpretation

5. Integration & Simulation
   5.1 Combine Forecasts with Elasticity Estimates
   5.2 “What-If” Revenue Scenarios
   5.3 Threshold-Based Alert Rules

6. Reporting & Delivery
   6.1 Drafting Findings & Recommendations
   6.2 Dashboard & Visualization Build-out
   6.3 Internal Review & Revisions
   6.4 Final Report Compilation & Submission (1–3 Aug 2025)

Each Work Breakdown Structure element breaks the project into progressively detailed tasks, ensuring clear scope, accountability, and milestone tracking.

Gantt Chart



Task ID	Task	Jun W4	Jul W1	Jul W2	Jul W3	Jul W4	Jul W5	Aug W1
1	Data Acquisition							
2	Data Cleaning & Preprocessing							
3	Exploratory Data Analysis							
4	Demand Forecasting Model Development							
5	Price Elasticity Estimation							
6	Integration & Simulations							
7	Draft Report Writing							
8	Final Review & Submission							

Figure 1 Expected timeline for completion of project.

The project is anticipated to be completed within the projected timeframe, aligning with the project cycle of May 2025 term. The workflow follows the structure outlined in the Gantt chart.

Expected Outcome

1. Improved Forecast Accuracy & Inventory Efficiency: By deploying weekly ARIMA and Prophet models, FreshDairy Mart will achieve at least a 15% reduction in forecast error (MAPE), enabling more precise raw-milk procurement and production planning. This translates into fewer stockouts of high-demand SKUs and a 20% reduction in excess inventory, lowering holding costs and spoilage.

2. Data-Driven Pricing Strategies: Estimating channel- and region-specific price elasticities will reveal which segments are highly sensitive to price changes ($|\beta|>1$) and which are inelastic ($|\beta|<1$). Armed with these insights, the business can implement targeted discounts in elastic markets and premium pricing in inelastic ones—projected to lift overall revenue by 5–10%.

3. SKU Prioritization & Resource Allocation: ABC analysis will identify the "vital few" products driving 80% of revenue, focusing forecasting and pricing efforts where they matter most. This ensures that analytic resources and working capital are allocated to top-impact SKUs.

4. Interactive Dashboards & Alerts: A unified dashboard will present forecast vs. actual trends, elasticity heat maps, and "what-if" revenue simulations. Automated alerts will flag when projected demand exceeds predefined thresholds, empowering operations to respond proactively.

5. Enhanced Working-Capital Management: Together, these outcomes will unlock blocked capital tied up in inventory, improve service levels, and maximize profit margins—laying the foundation for scalable, data-driven growth.