Forecast Enhanced Inventory Management
Utilizing Demand Sensing Techniques to Optimize Stocking

INFORMS BUSINESS ANALYTICS CONFERENCE

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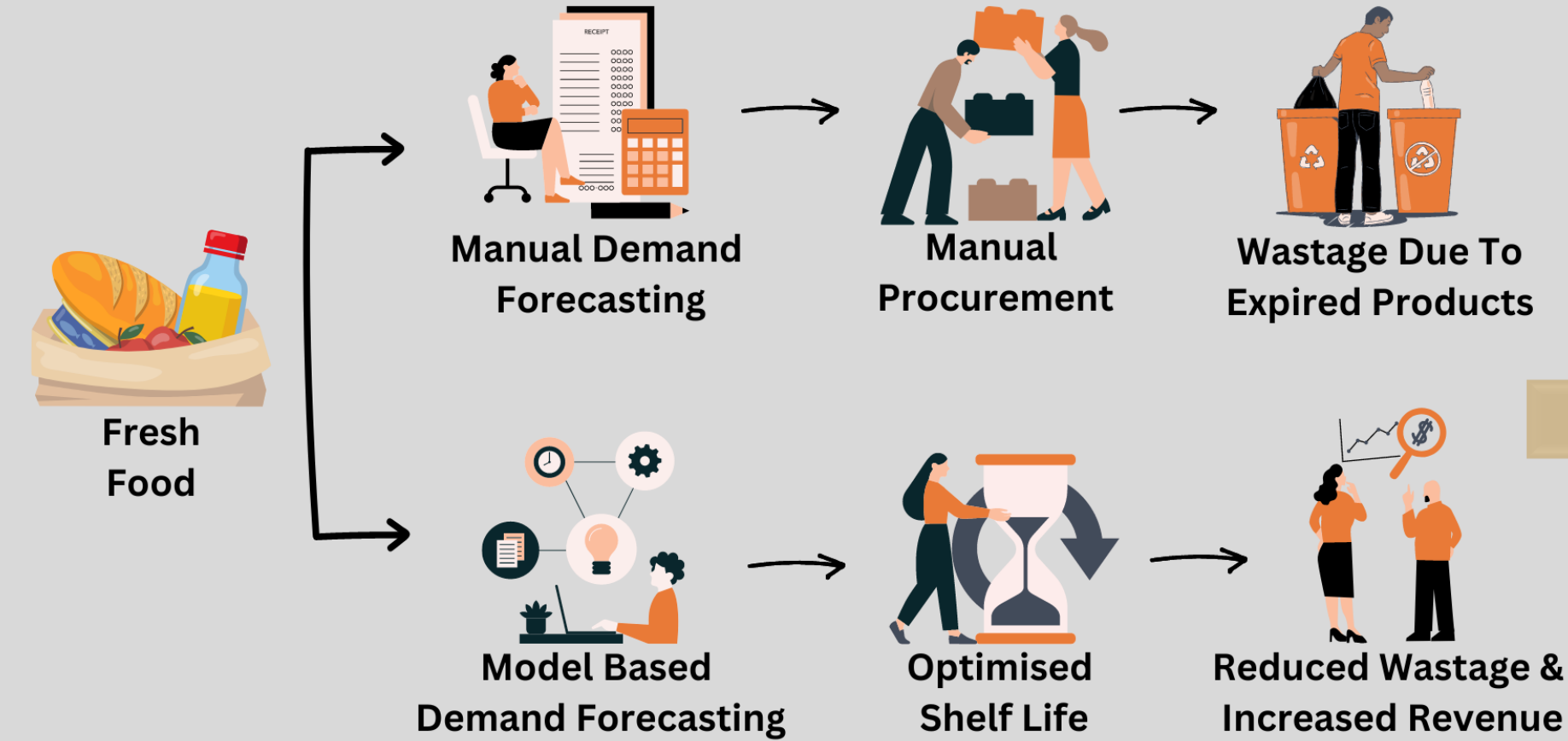Niharika Kulkarni
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BUSINESS PROBLEM FRAMING

Leading retail store chains, recognize that a superior shopping experience is key to business growth. Demand forecasting for their fresh food service helps streamline inventory and demand planning while reducing wastage of perishable items.
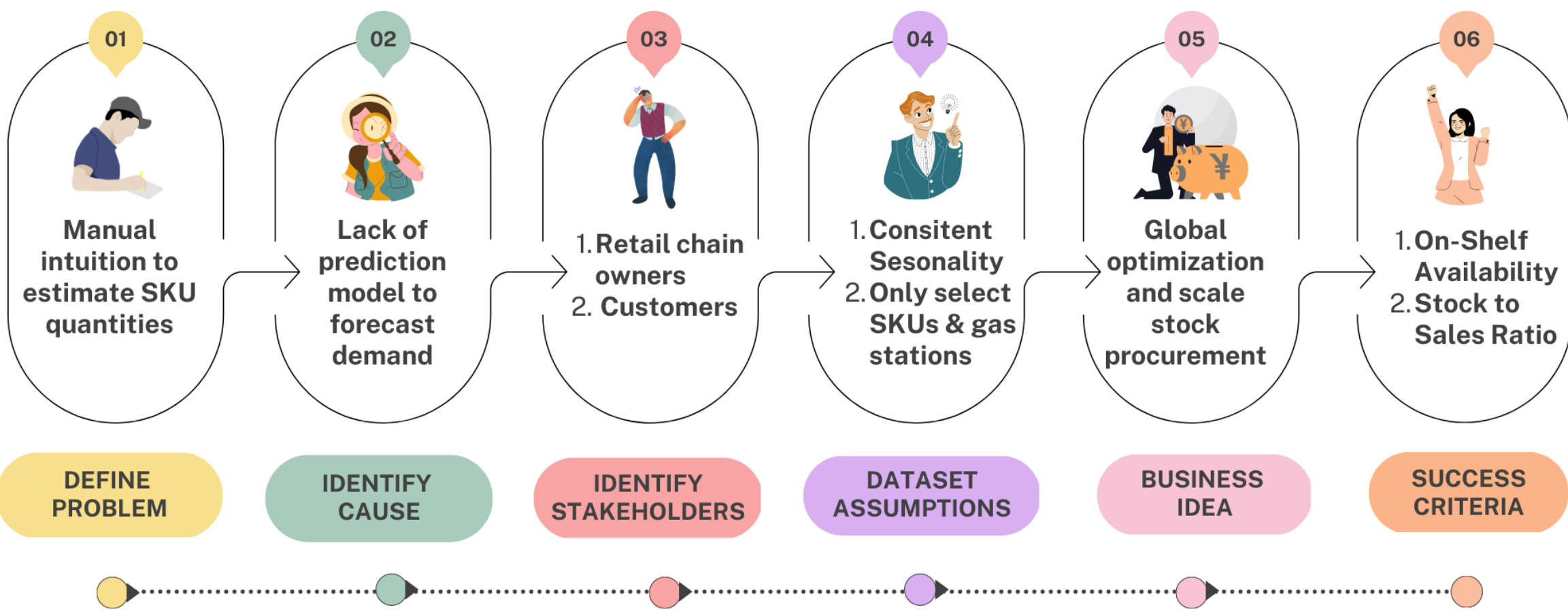
However, the effectiveness of existing inventory management system is limited by a manual recommendation of order quantity for the finished product in the Fresh Food Service. The inclusion of Digital Order Book (DOB) will improve demand planning.

Fresh Food → Manual Demand Forecasting → Manual Procurement → Wastage Due To Expired Products

Model Based Demand Forecasting → Optimised Shelf Life → Reduced Wastage & Increased Revenue

To address this challenge, this solution seeks to develop an innovative solution that leverages advanced analytics to incorporate product-level demand forecasting into the DOB. It will enable store teams to accurately plan their inventory and reduce financial losses resulting from overstocking and wastage.

By leveraging data-driven insights, this analytics tool-kit aims to optimize their operations and deliver a superior shopping experience to their customers.
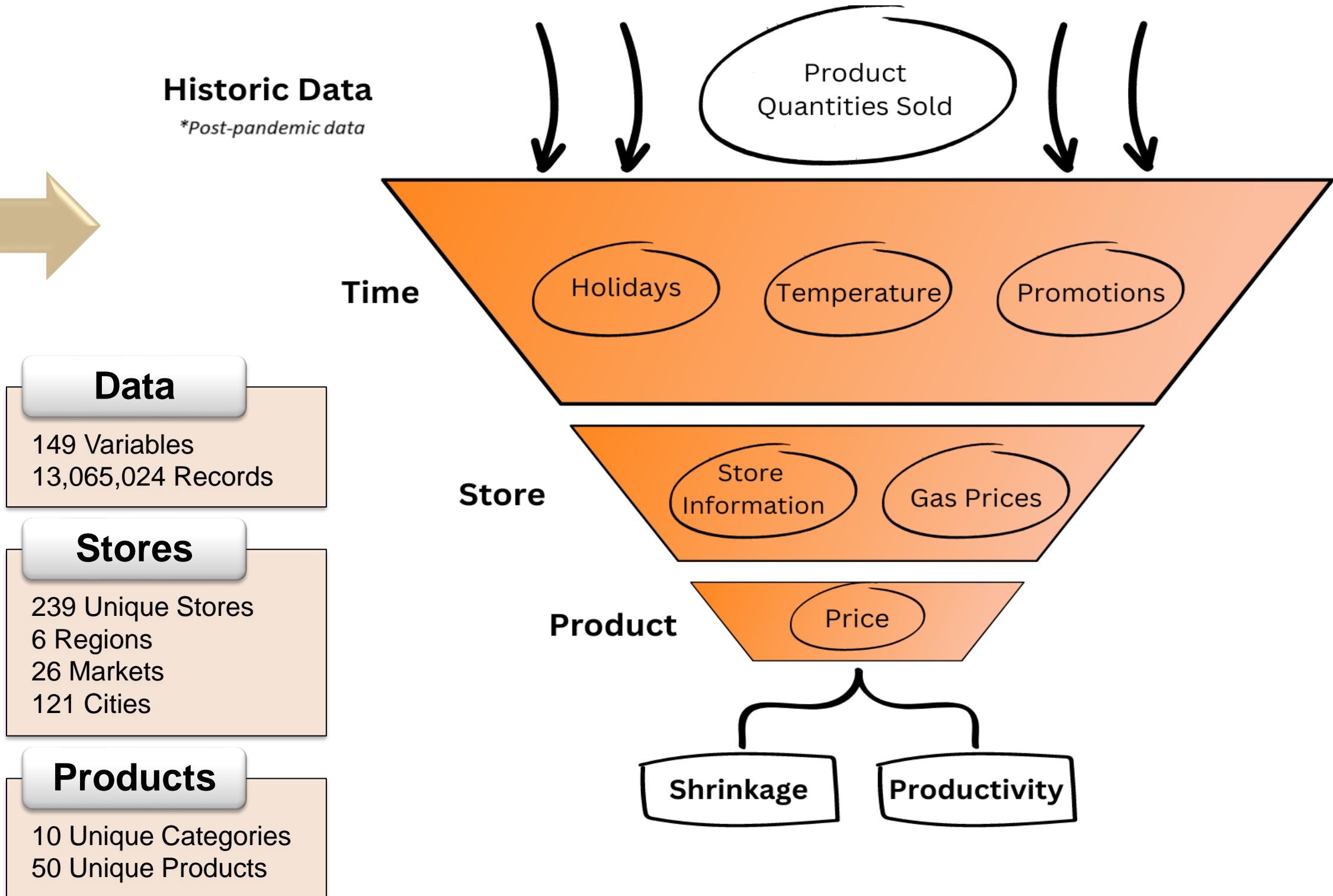
ANALYTICS PROBLEM FRAMING

01	02	03	04	05	06
Manual intuition to estimate SKU quantities	Lack of prediction model to forecast demand	1.Retail chain owners 2. Customers	1.Consistent Seasonality 2.Only select SKUs & gas stations	Global optimization and scale stock procurement	1.On-Shelf Availability 2.Stock to Sales Ratio
DEFINE PROBLEM	IDENTIFY CAUSE	IDENTIFY STAKEHOLDERS	DATASET ASSUMPTIONS	BUSINESS IDEA	SUCCESS CRITERIA

Legacy processes for inventory management are often manual, time-consuming, and error-prone, resulting in suboptimal inventory levels and wasted resources in contrast to an automated system.
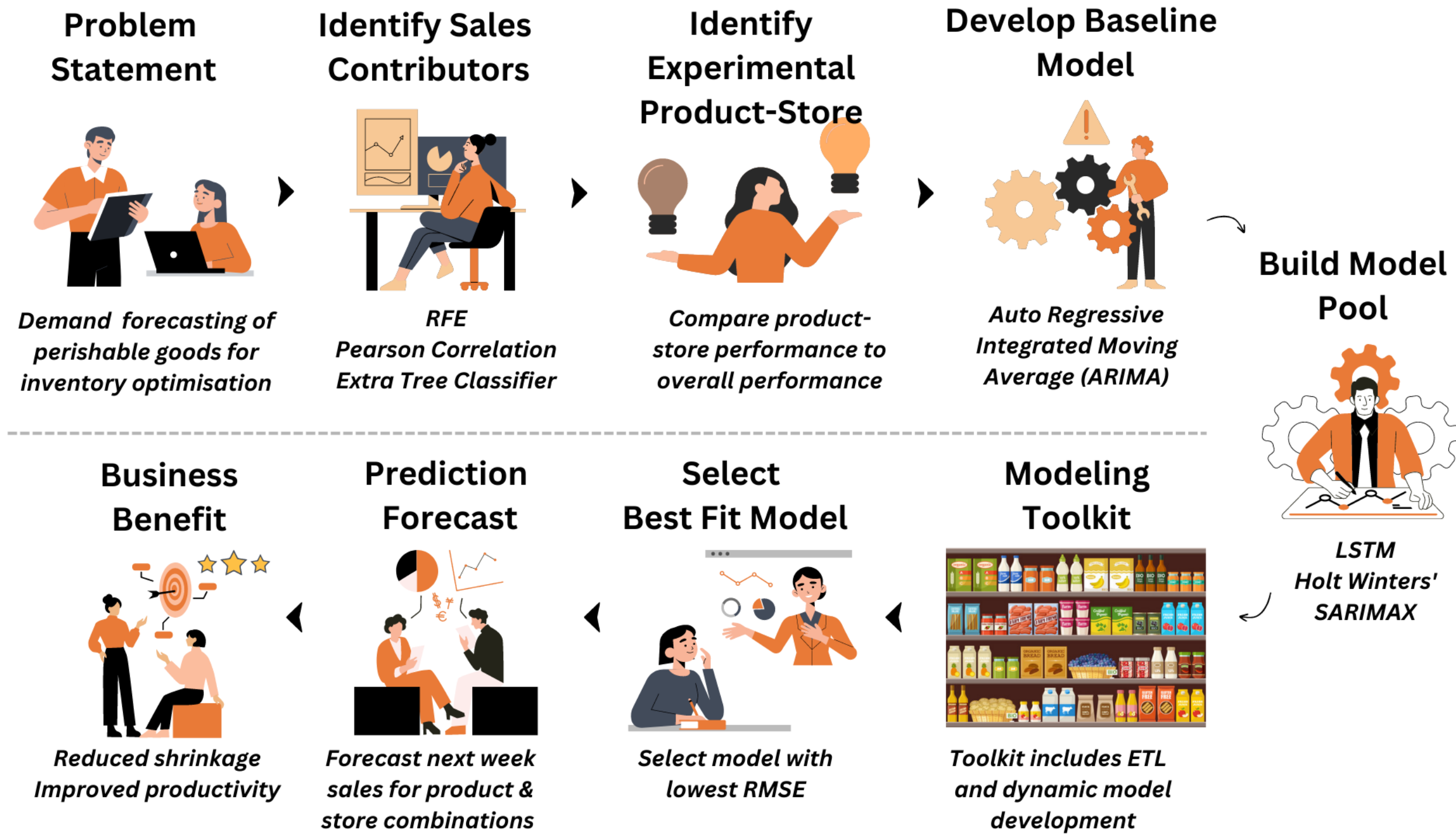
- **Sophisticated end-to-end analytics toolkit** – Data ETL, modelling and forecasting pipelines provide a one-stop solution that delivers fast and reliable inventory.
- **Leveraging advanced analytics and machine learning algorithms** - Ensures real-time insights into demand patterns, enabling store teams to make well-informed decisions and optimizes inventory.
- **Improved employee efficiency and consistent shelf availability** - Retailers can deliver a superior shopping experience, drive business growth and reduce shrinkage.

DATA
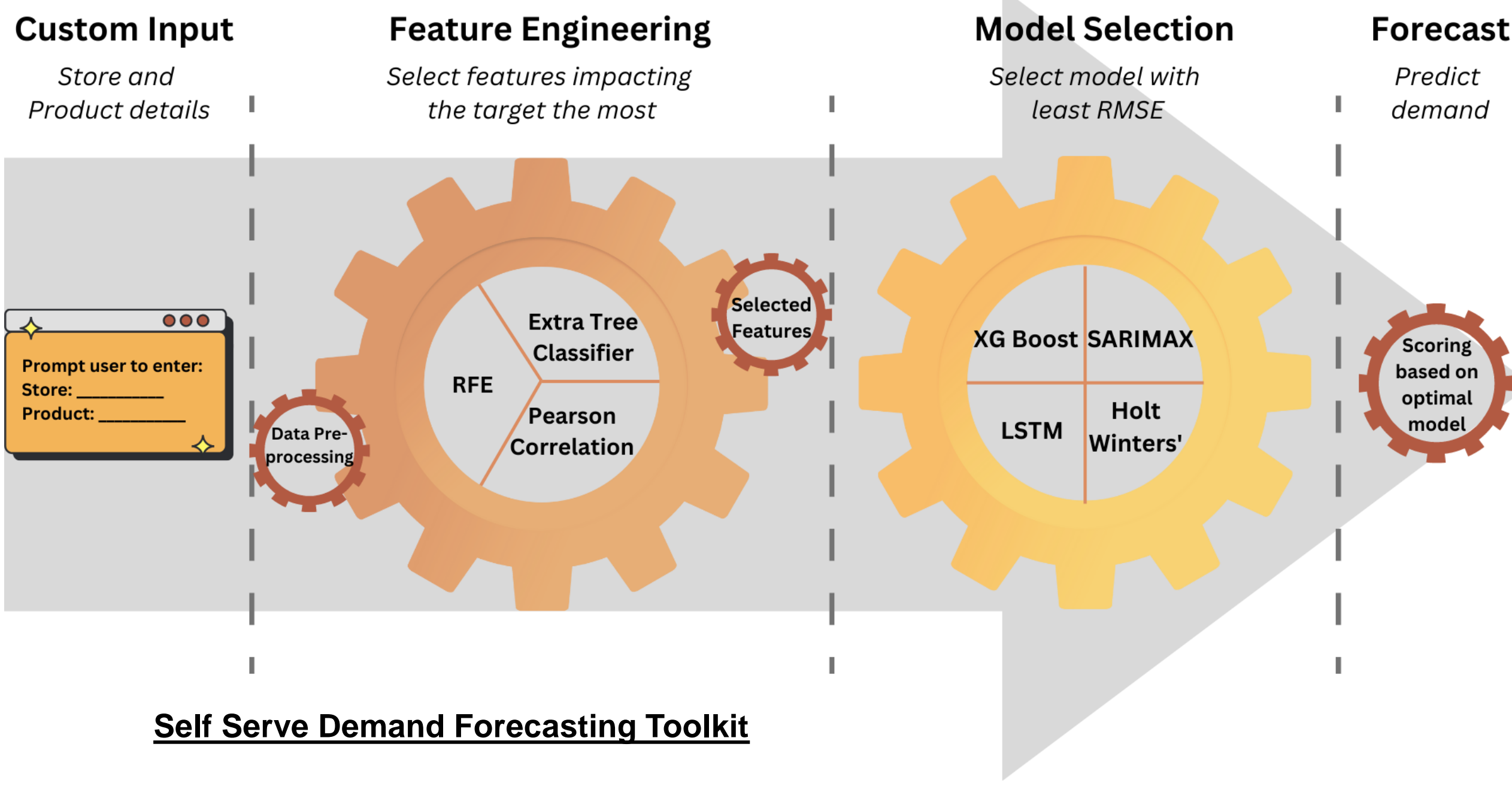

Historic Data
Post-pandemic data

Product Quantities Sold

Time: Holidays, Temperature, Promotions

Store: Store Information, Gas Prices

Product: Price

Shrinkage | Productivity

Data
149 Variables
13,065,024 Records

Stores
239 Unique Stores
6 Regions
26 Markets
121 Cities

Products
10 Unique Categories
50 Unique Products

METHODOLOGY

Problem Statement — *Demand forecasting of perishable goods for inventory optimisation*

Identify Sales Contributors — *RFE Pearson Correlation Extra Tree Classifier*

Identify Experimental Product-Store — *Compare product-store performance to overall performance*

Develop Baseline Model — *Auto Regressive Integrated Moving Average (ARIMA)*

Build Model Pool — *LSTM Holt Winters' SARIMAX*

Business Benefit — *Reduced shrinkage Improved productivity*

Prediction Forecast — *Forecast next week sales for product & store combinations*

Select Best Fit Model — *Select model with lowest RMSE*

Modeling Toolkit — *Toolkit includes ETL and dynamic model development*

MODEL BUILDING

Custom Input — *Store and Product details*

Feature Engineering — *Select features impacting the target the most*

Model Selection — *Select model with least RMSE*

Forecast — *Predict demand*

Prompt user to enter: Store:_____ Product:_____

Data Pre-processing → RFE, Extra Tree Classifier, Pearson Correlation → Selected Features → XG Boost, SARIMAX, LSTM, Holt Winters' → Scoring based on optimal model

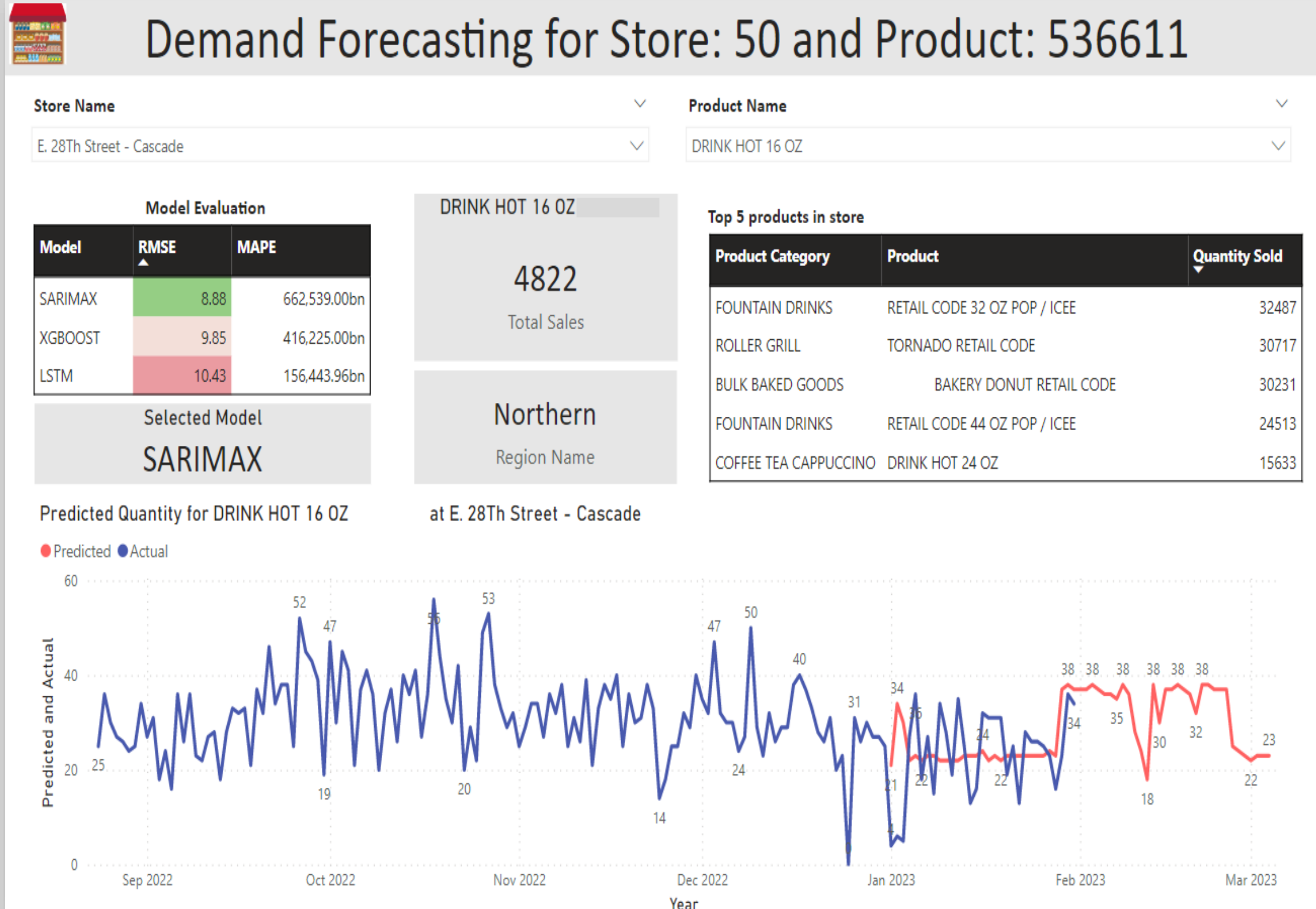**Self Serve Demand Forecasting Toolkit**

The purpose of this tool is to dynamically select important features for a given combination of product and store to forecast demand for future inventory to avoid wastage of perishable goods and ensure on-shelf availability.

- When executed across the entire dataset, **XgBoost** contributes to **69.43%** of the frequency for total best performing models based on RMSE values followed by **SARIMAX** at **24.91%** and **LSTM** at **5.65%**.
- However, all models are retained in the toolkit as every combination behaves differently in terms of demand trends and store regions.

AREAS OF IMPROVEMENT

- Improve the iterations and epochs for better fit.
- Use exogenous variables such as daily footfall, shop size, promotional data, product assortment, vehicles visiting the gas station.
- Larger number of data points will lead to a more reliable forecast

DEPLOYMENT & LIFE CYCLE MANAGEMENT

Demand Forecasting for Store: 50 and Product: 536611

Store Name: E. 28Th Street - Cascade
Product Name: DRINK HOT 16 OZ

Model Evaluation

Model	RMSE	MAPE
SARIMAX	8.88	662,539.00bn
XGBOOST	9.85	416,225.00bn
LSTM	10.43	156,443.96bn

Selected Model: SARIMAX

DRINK HOT 16 OZ — 4822 Total Sales
Northern — Region Name

Top 5 products in store

Product Category	Product	Quantity Sold
FOUNTAIN DRINKS	RETAIL CODE 32 OZ POP / ICEE	32487
ROLLER GRILL	TORNADO RETAIL CODE	30717
BULK BAKED GOODS	BAKERY DONUT RETAIL CODE	30231
FOUNTAIN DRINKS	RETAIL CODE 44 OZ POP / ICEE	24513
COFFEE TEA CAPPUCCINO	DRINK HOT 24 OZ	15633

Predicted Quantity for DRINK HOT 16 OZ at E. 28Th Street - Cascade

IMPACT

Shrinkage / Stock Out Metric

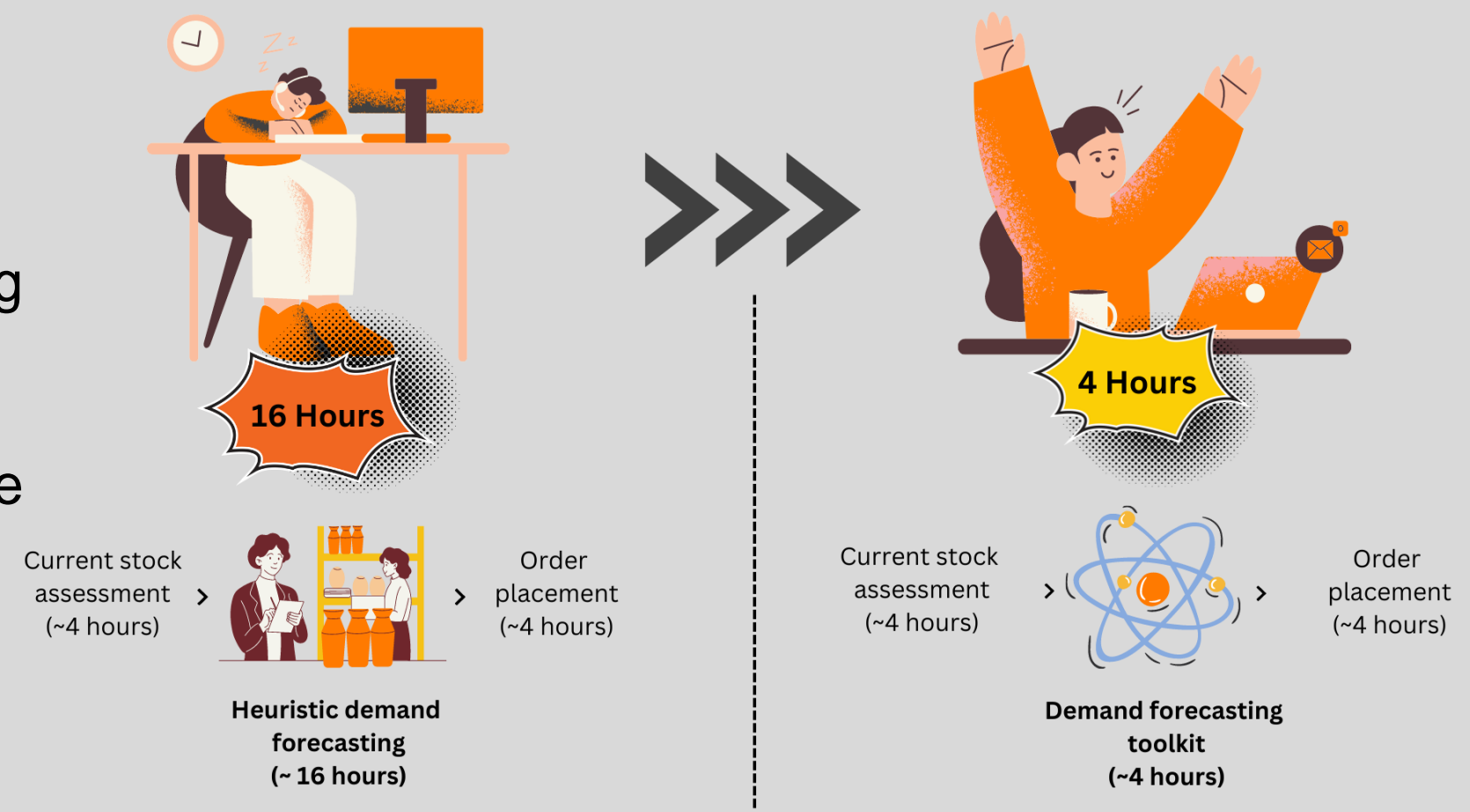| Category	Value
Baked	0.35
Cold Beverage	0.13
Dairy	0.62
Fruit Bowl	3.26
Fruits	0.41
Grab and Go	0.41
Grills	0.34
Hot Beverages	0.28
Hot Sandwich	0.39
Hot Snacks	0.82
Sandwich	0.47

Optimized shrinkage:
- Percentage of inventory that is lost due to spoilage or expiration
- Value of spoiled inventory/the total value of inventory on hand
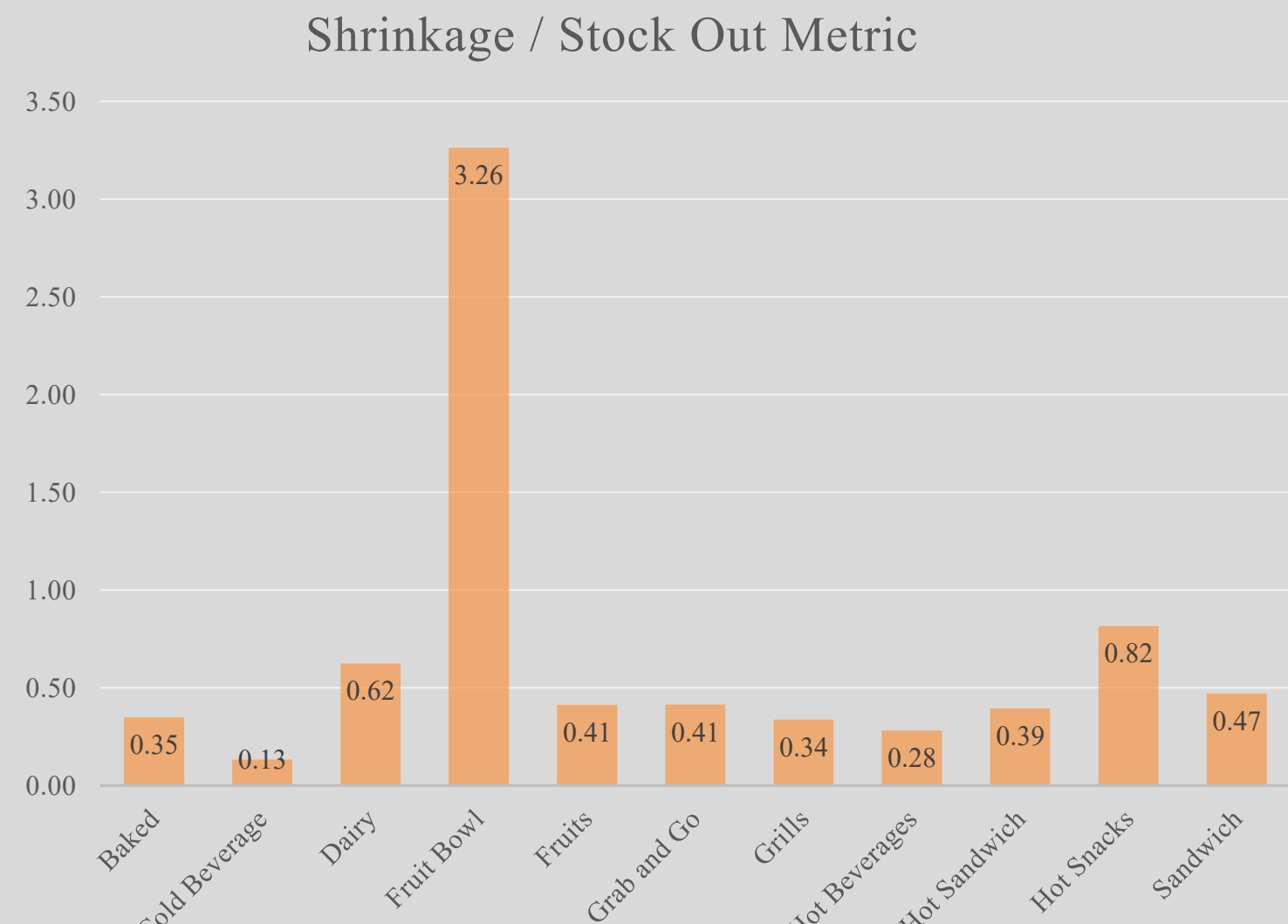
Improved productivity:
- Reduced time spent on planning order placement
- Increase in availability of time spent for non-inventory processes.

16 Hours: Current stock assessment (~4 hours) → Heuristic demand forecasting (~16 hours) → Order placement (~4 hours)

4 Hours: Current stock assessment (~4 hours) → Demand forecasting toolkit (~4 hours) → Order placement (~4 hours)

ACKNOWLEDGEMENTS