Demand Forecasting

Meal kit delivery service

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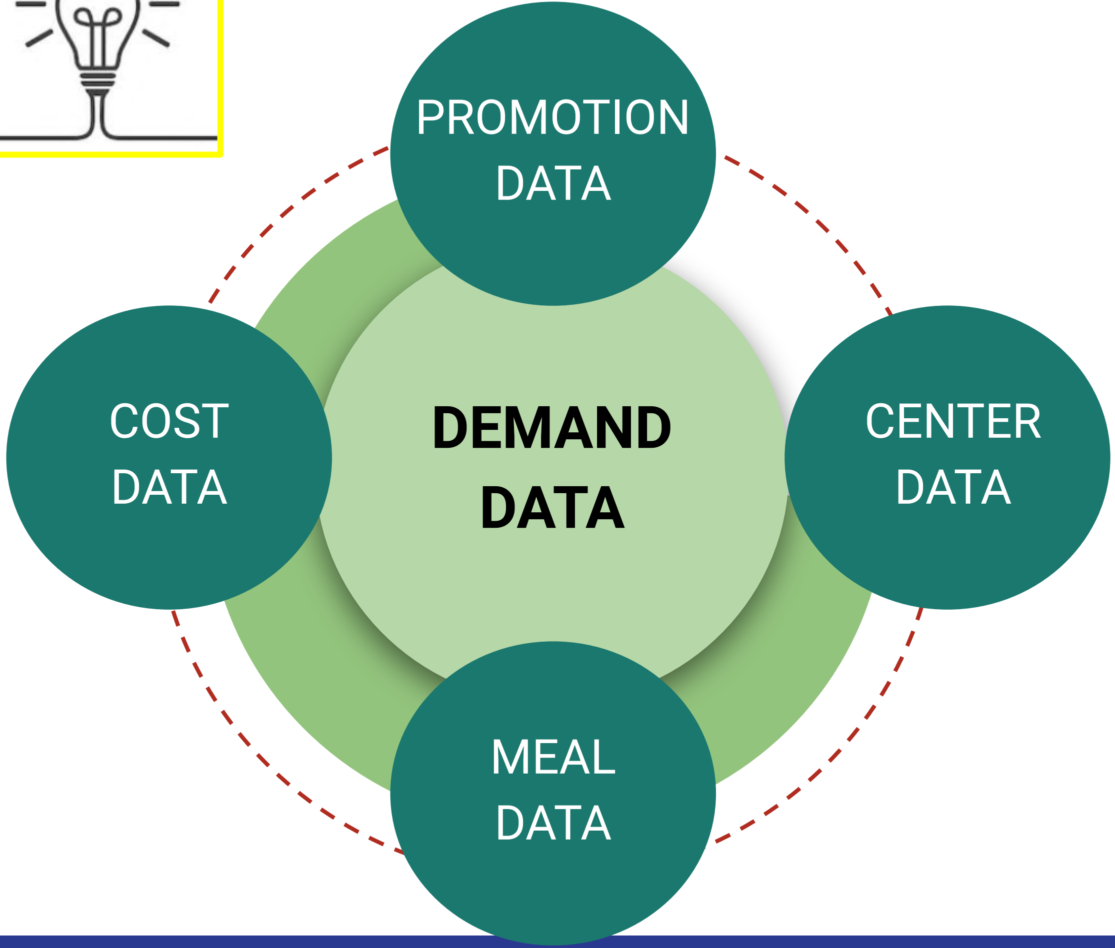
PROBLEM STATEMENT



Predict the demand for next week for all meal categories in each fulfilment center.

AGENDA

Introduction

Exploratory Data Analysis

Feature Engineering

Model Building, selection & tuning

Results

Business Value

INITIAL DATA DICTIONARY

WEEKLY DEMAND DATA

Variable	Definition
id	Unique ID
week	Week No
center_id	Unique ID for fulfillment center
meal_id	Unique ID for Meal
checkout_price	Final price including discount, taxes & delivery charges
base_price	Base price of the meal
emailer_for_promotion	Emailer sent for promotion of meal
homepage_featured	Meal featured at homepage
num_orders	(Target) Orders Count

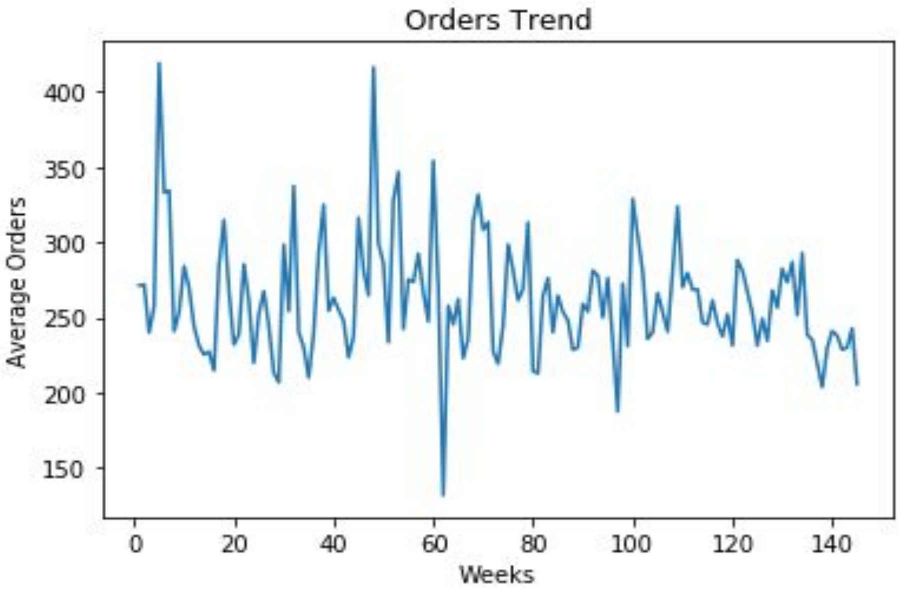
FULFILMENT CENTER INFO

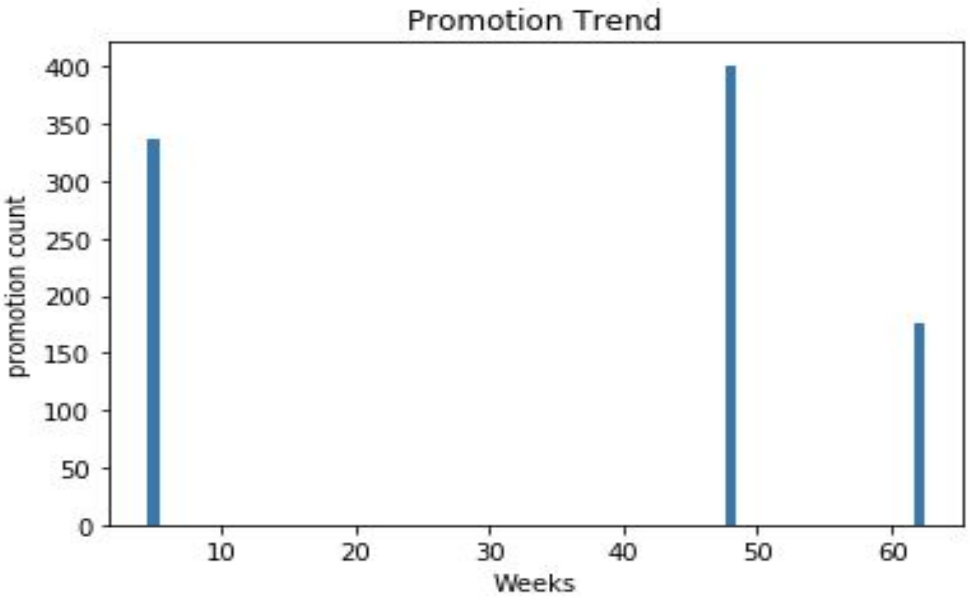
Variable	Definition
center_id	Unique ID for fulfillment center
city_code	Unique code for city
region_code	Unique code for region
center_type	Anonymized center typ
op_area	Area of operation (in km^2)

MEAL INFO

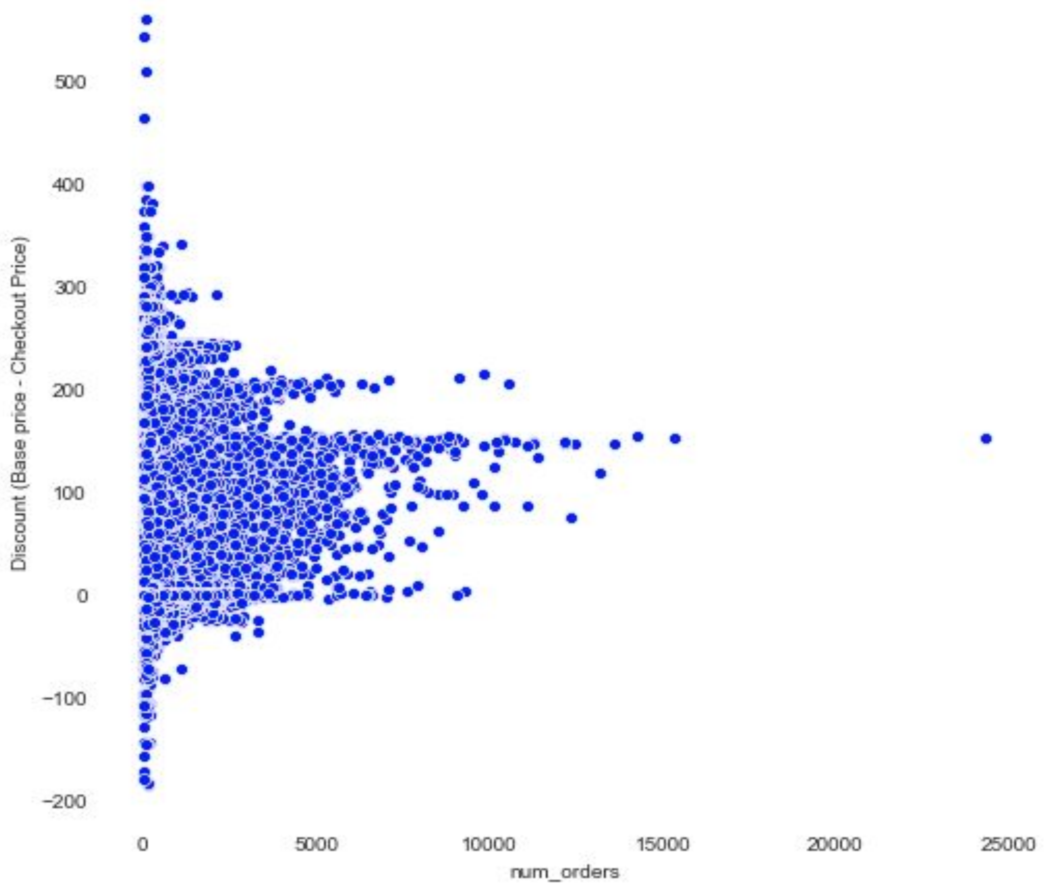
meal_id	Unique ID for the meal
category	Type of meal (soups/snacks...)
cuisine	Meal cuisine (Indian/Italian/…)

Average orders per week

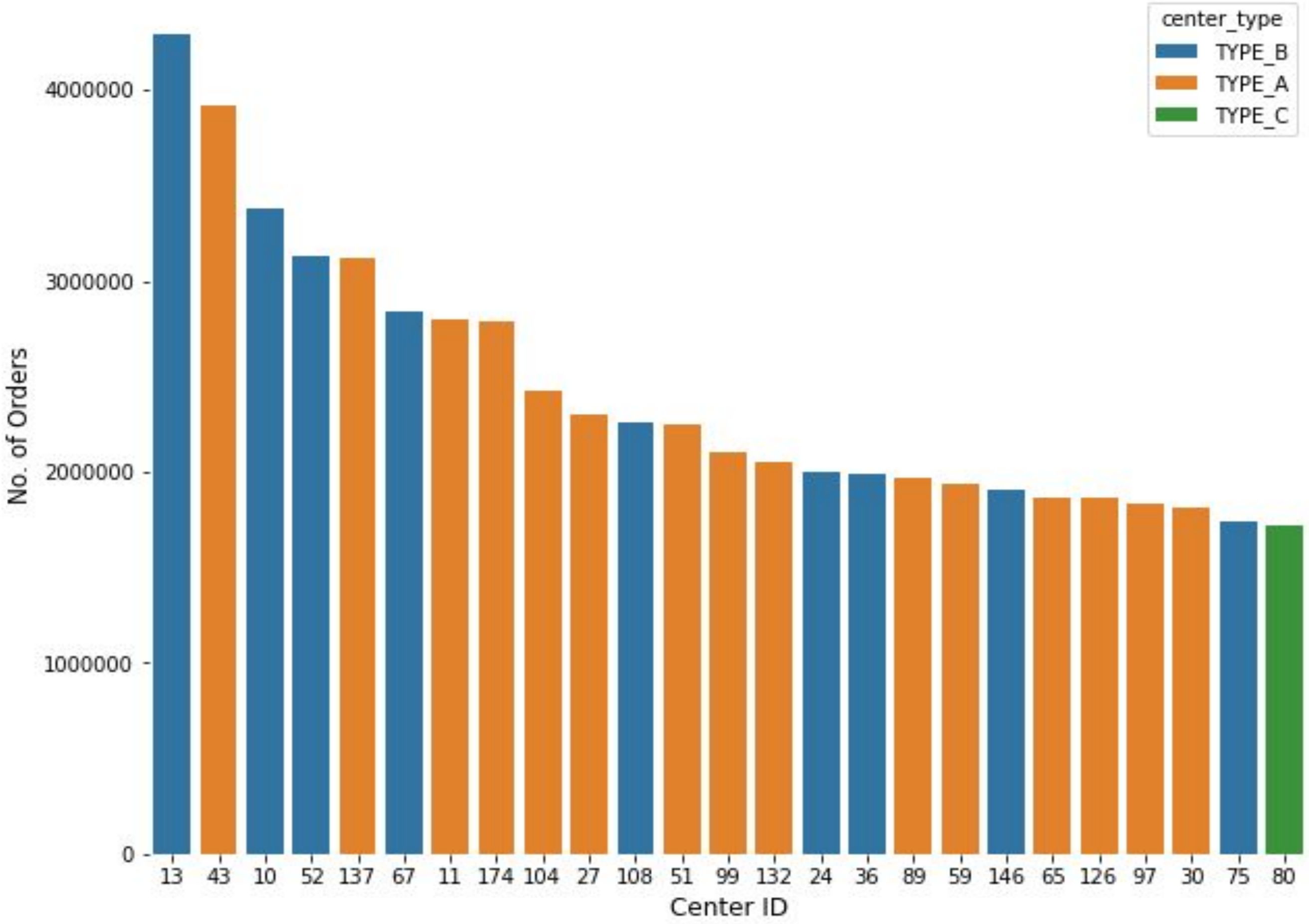




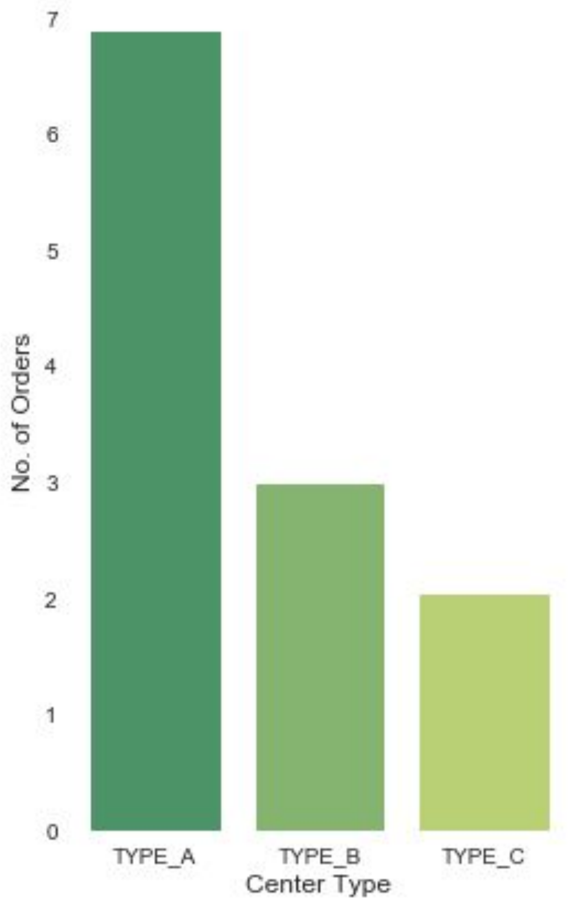
Discount v/s No. of Orders



Top 25 Centers with Maximum Orders



Total No. of Orders for each Center type



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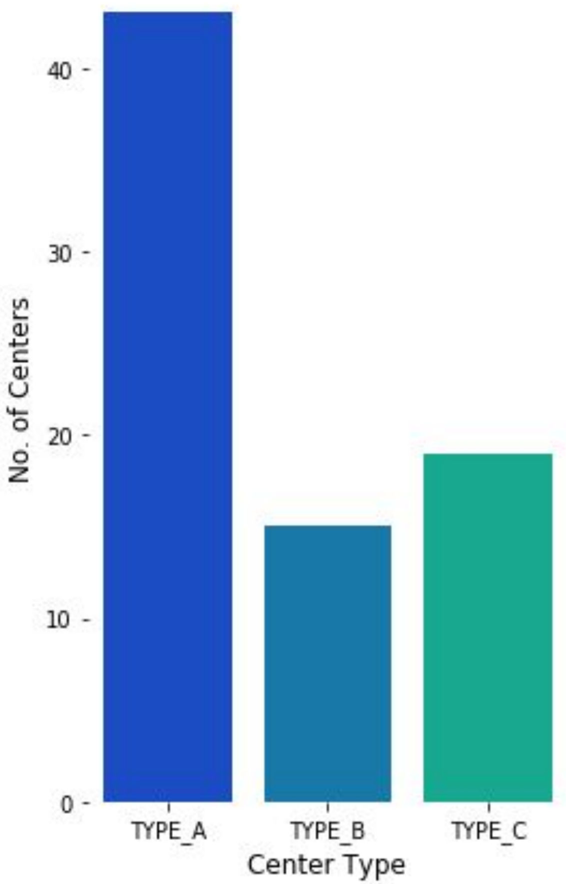
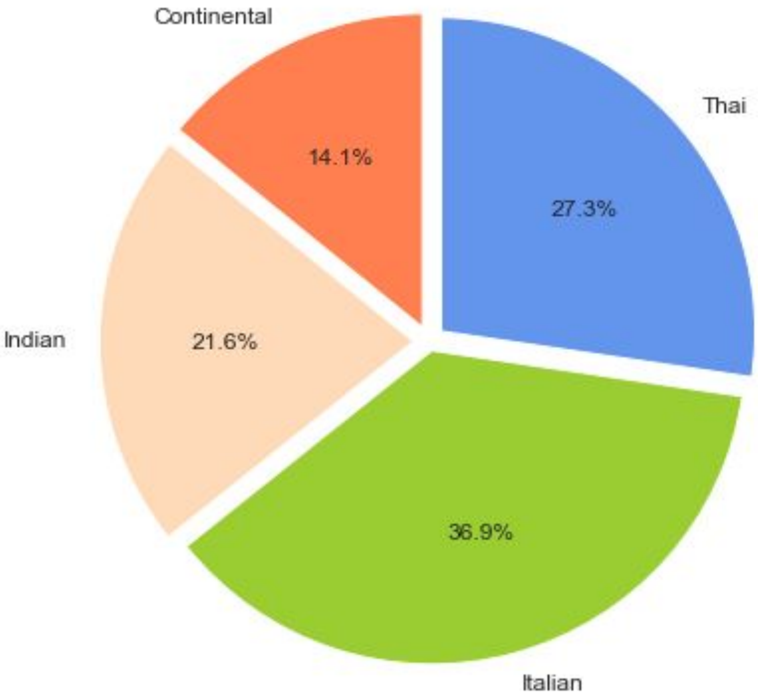
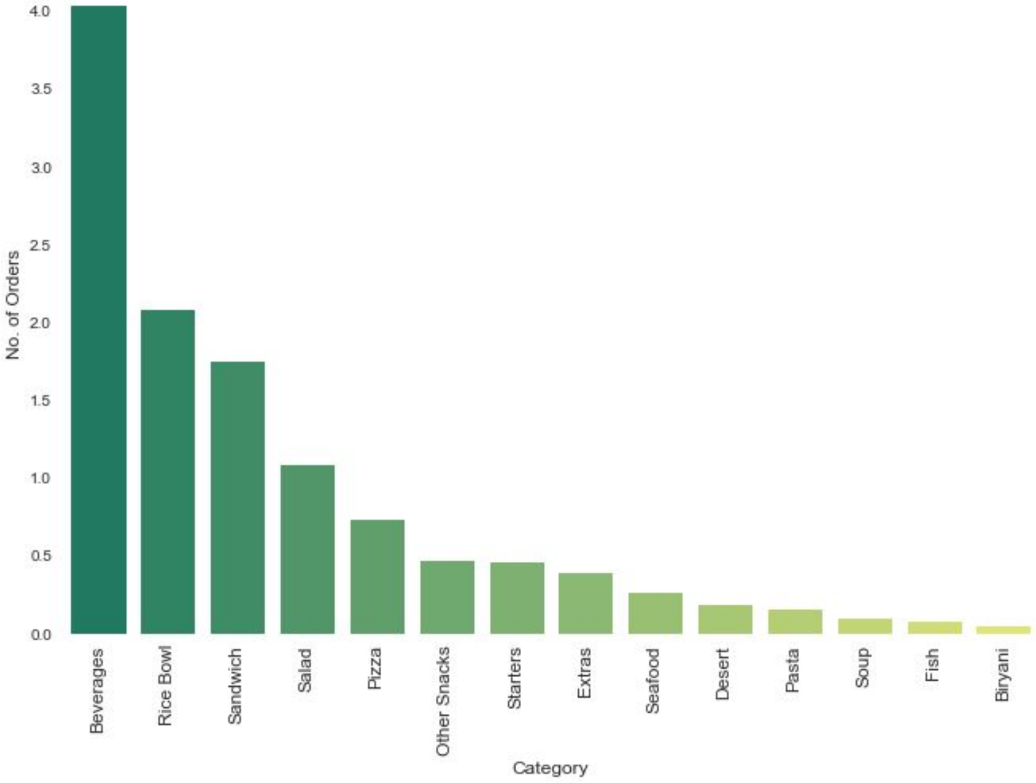


Meal wise Order Trend

Total No. of Orders for each Cuisine Category



Total No. of Orders for each Meal Category



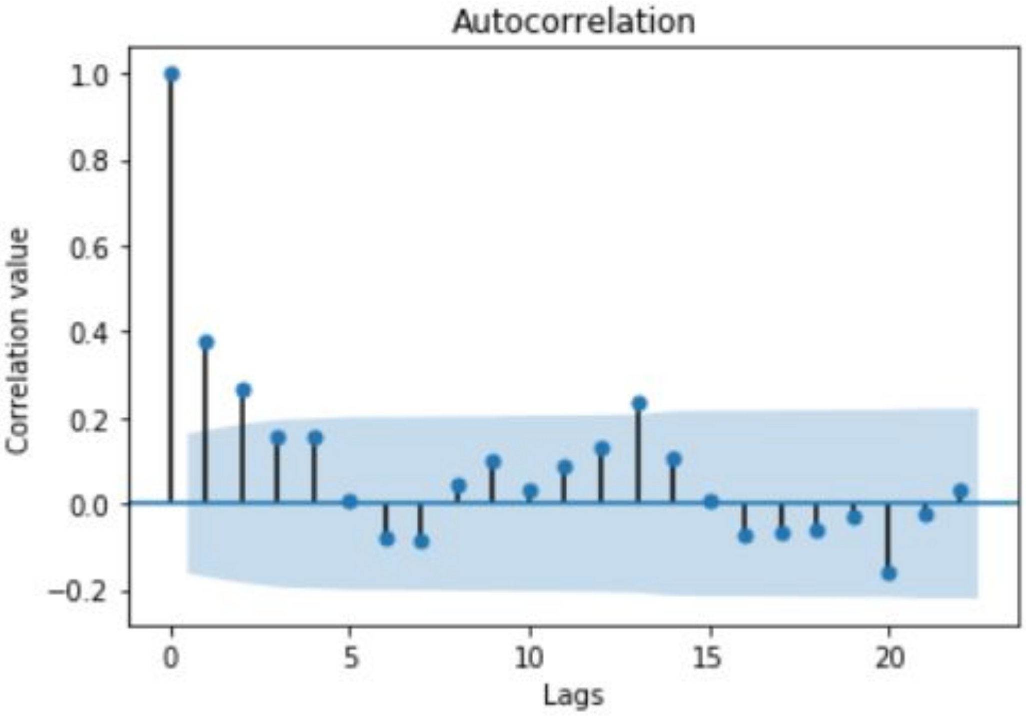
Feature Engineering 1

The table captures the weekly trend of price and demand across different categorical variables

week	meal_id	center_id	category	checkout_price	num_orders	price/avg_price_week_category	Avg_orders_cat_week
1	1062	10	Beverages	5.206147	6.763885	0.977655	5.147244
2	1062	10	Beverages	5.216890	6.663133	1.005516	5.431697
3	1062	10	Beverages	5.222300	6.747587	1.006351	5.240581
4	1062	10	Beverages	5.211451	7.092574	0.999393	5.264703
5	1062	10	Beverages	5.217053	6.865891	0.994085	4.962804

Picking the Number of Lags

Below we see the autocorrelation plot for demand



Feature Engineering 2

The tables below show the features which capture the previous week trend to predict next week's demand

week	meal_id	center_id	num_orders	expanding_mean	weighted_average_2w	weighted_average_3w
1	1062	10	6.763885	6.763885	NaN	NaN
2	1062	10	6.663133	6.713509	6.696717	NaN
3	1062	10	6.747587	6.724868	6.719435	6.722152
4	1062	10	7.092574	6.816794	6.977578	6.906004
5	1062	10	6.865891	6.826614	6.941452	6.921735

week	meal_id	center_id	perc_diff	num_orders_lag_1	perc_diff_lead1	target_lead
1	1062	10	0.000000	NaN	0.104365	6.663133
2	1062	10	0.104365	6.763885	0.208166	6.747587
3	1062	10	0.208166	6.663133	-0.104256	7.092574
4	1062	10	-0.104256	6.747587	0.209480	6.865891
5	1062	10	0.209480	7.092574	-2.357580	6.998510

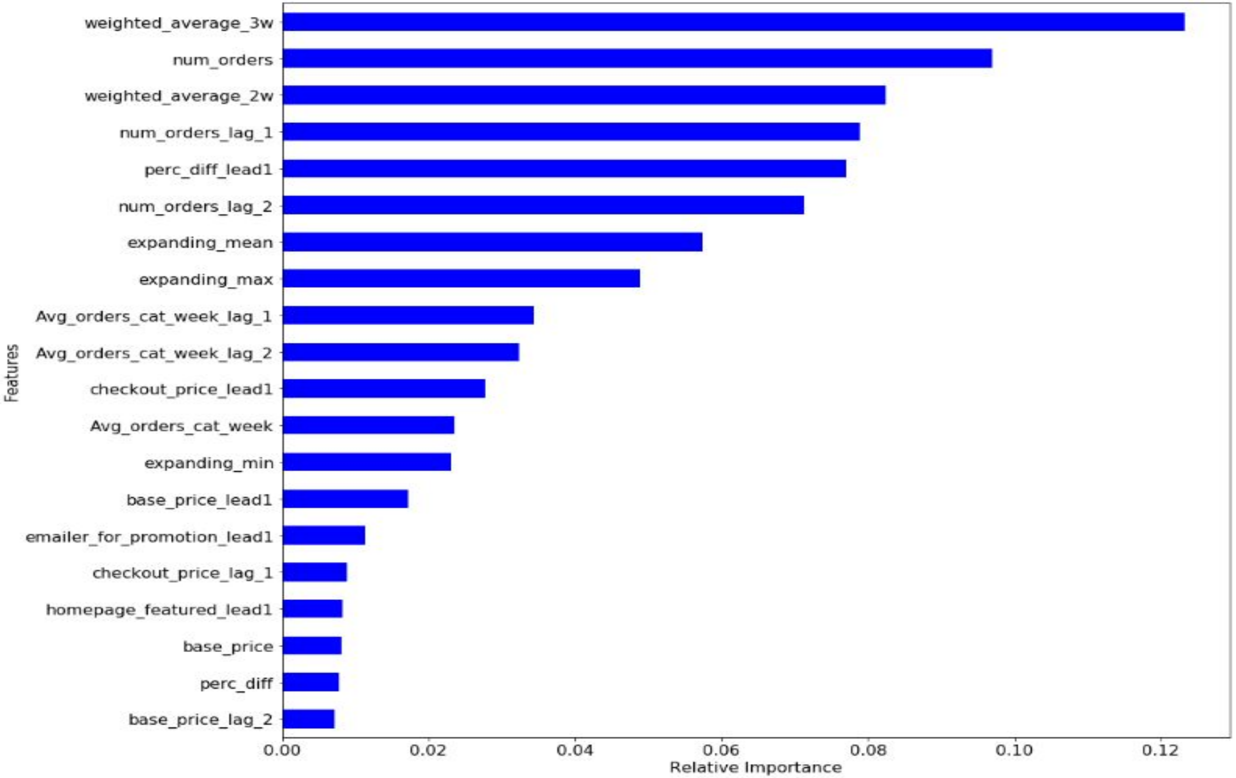
Model Selection

Split data into train, validation and test set.

Model/ Metrics	MSE	Training R-squared	Validation R-squared
Linear Regression	0.20	0.77	0.74
Lasso	0.79	0.0	-0.01
Random Forest	0.24	0.99	0.92
Gradient Boosting	0.37	0.89	0.87

Model Results

Test Set MSE: 0.31
Test Set R-Squared: 0.89



Let’s get to Business!

- The cost of each order = inventory cost + overhead cost + profit

  (60%) + (30%) + (10%)

- Inventory cost = Loss incurred during overprediction (Inventory loss)

  Profit = Loss incurred due to underprediction (Order loss)

Convention Adopted

Model Prediction	Actual demand	Prediction - sales	Type of Loss
5	6	-1 (Under Prediction)	Order loss
5	4	+1 (Over Prediction)	Inventory loss

A Quantitative measure

Baseline model (Avg sales/meal_id/center_id)	Actual Sales	Forecasted sales	Baseline Loss	Forecasted loss
4	7	8	- 3 = 3x order loss	+1 = 1x inventory loss

Where:
Order loss = profit per meal = 10% of checkout price of that meal.
Inventory loss = cost of perishables = 60% of checkout price of the meal.

The Losses

- Monetary loss Baseline prediction

  $386,015

- Monetary loss Model Prediction

  $279,384

- $ Amount we save if we use the model :

$106,631

Additional Use Case

What if we decide to increase the cost of each meal by 25%?

The overall demand decreases by : 39087 orders

What if we launch a 50% promotion?

The demand increases by : 40524 orders

Thank you!

We're open to questions!