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Instacart Market Basket Analysis

Springboard Capstone Project # 2

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SPRINGBOARD

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Background

Instacart operates an online grocery delivery and pick-up service. Orders are fulfilled and delivered by an Instacart personal shopper, who picks, packs, and delivers the order within the customer's designated time frame

Currently they use transactional data to develop models that predict which products a user will buy again, try for the first time, or add to their cart next during a session

Through a competition, Instacart is challenging the Kaggle community to use this anonymized data on customer orders over time to predict which previously purchased products will be in a user's next order.

Problem Statement & Objective

Problem statement: Which products will an Instacart consumer purchase again?

The overall objective is to predict products that a user will buy again, try for the first time or add to cart next during a session

- Instacart currently uses XGBoost, word2vec and Annoy in production on similar data to sort items for users to "buy again"
- This data, and the algorithms trained upon it, are enabling Instacart to revolutionize how consumers discover and purchase groceries
- This helps Instacart make the right product recommendations to the customer, thereby, making the shopping experience more convenient for consumer

Data

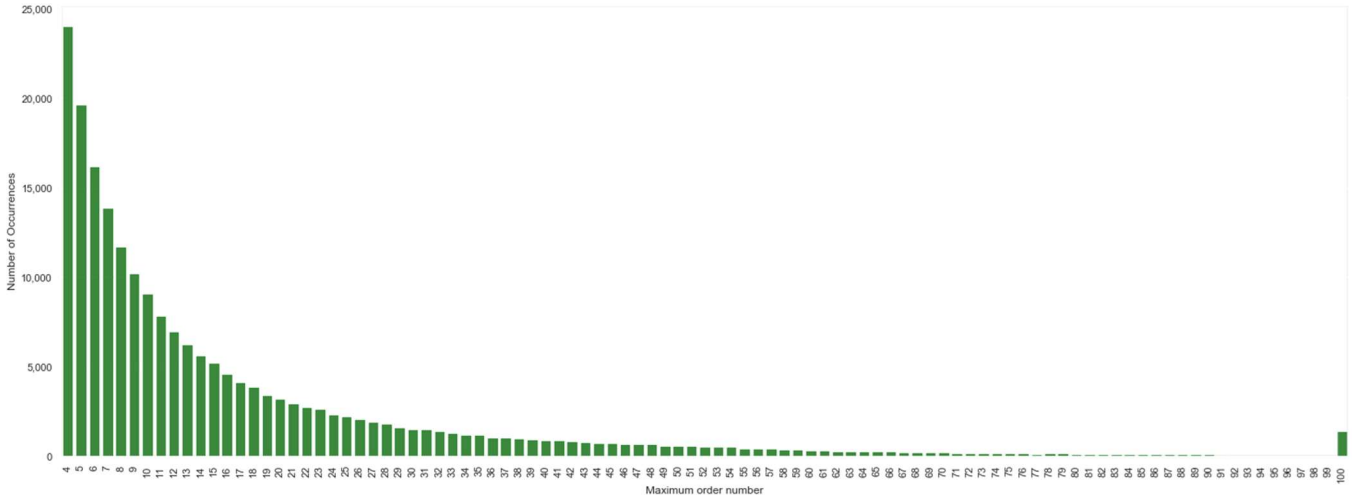
The dataset for this competition is a relational set of files describing customers' orders over time. The dataset is anonymized and contains a sample of over 3 million grocery orders from more than 200,000 Instacart users. The datasets are:

1. aisles.csv: contains the aisle_id and aisle_name of a product
2. departments.csv: contains the department_id and department_name of a product
3. order_products__prior.csv: contains previous order contents for all customers. 'reordered' indicates that the customer has a previous order that contains the product
4. order_products__train.csv:
5. orders.csv: Contains information about which set (prior, train, test) an order belongs. Need to predict reordered items only for the test set orders. 'order_dow' is the day of week
6. products.csv: contains mapping between product, aisle and department

Exploratory Data Analysis

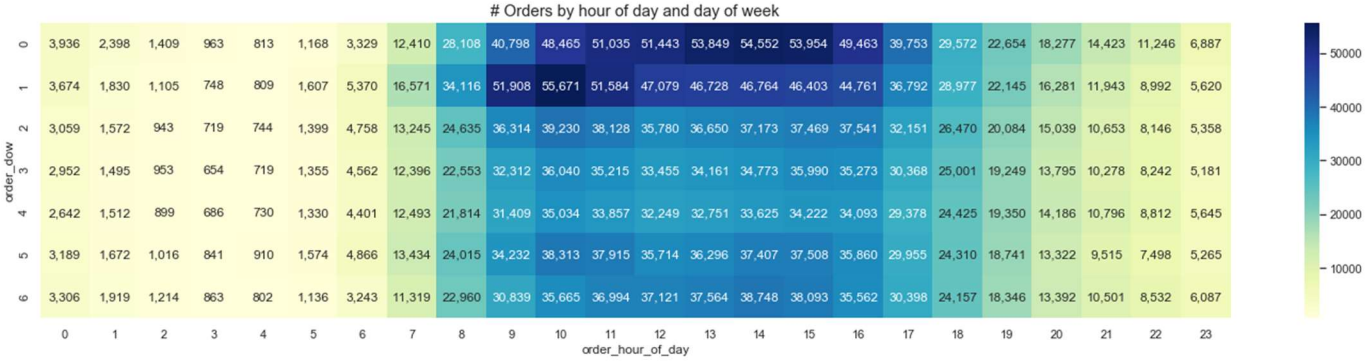
1. Orders by Order Number

- All users have at least 4 orders and at most 100 orders



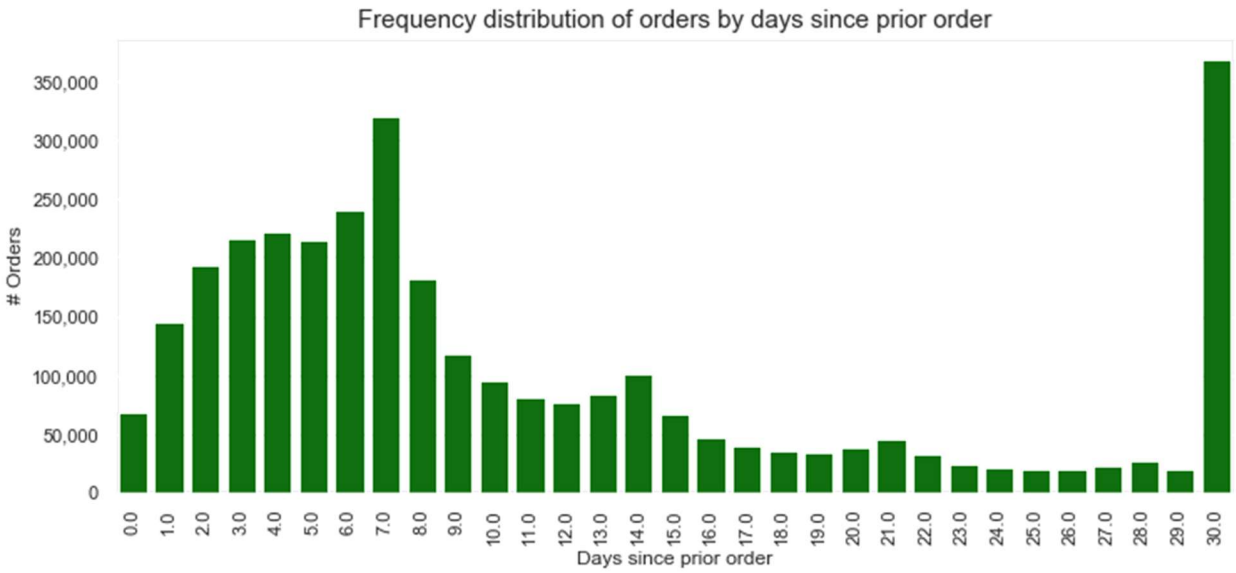
2. Order Frequency

- Saturday afternoon and Sunday mornings/afternoons have high order frequencies



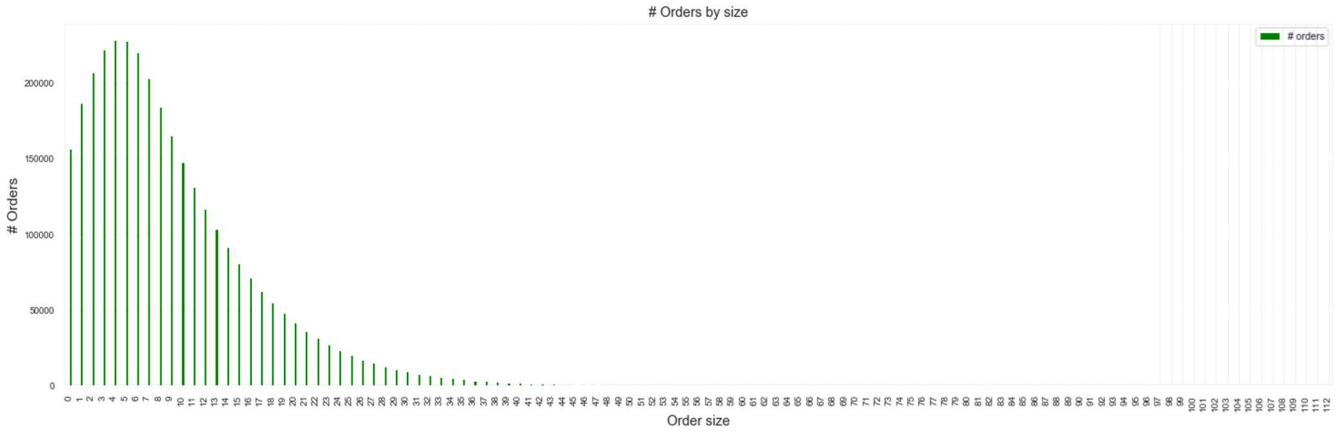
3. Order Distribution by Days Since Prior Order

- Customers order once in every week (peak at 7 days) or once in a month (peak at 30 days)
- Also observed smaller peaks at 14, 21 and 28 days (weekly intervals)



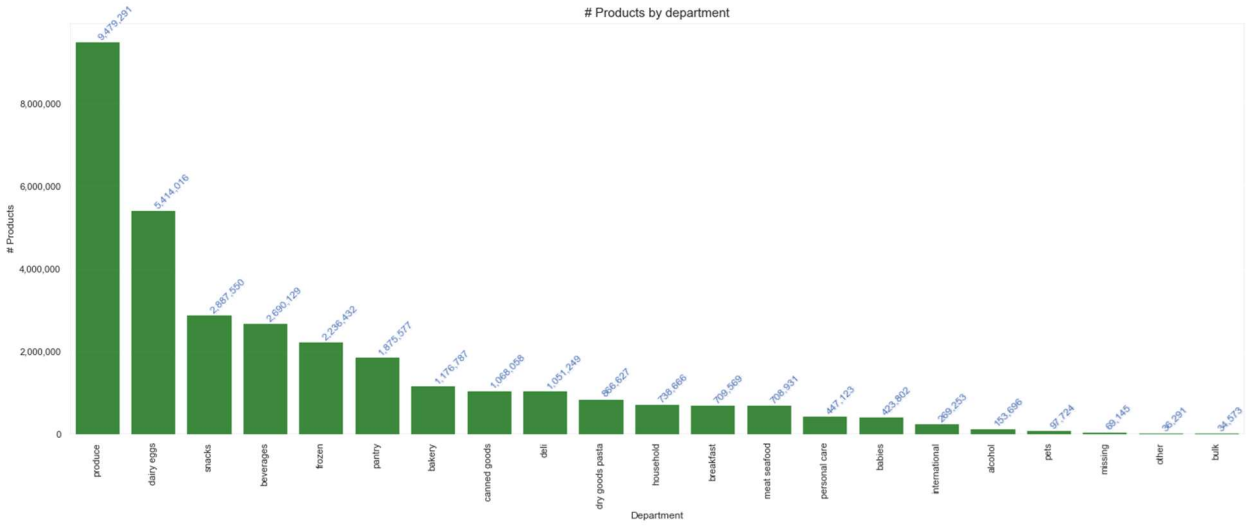
4. Order Distribution by Order Size

- Maximum order size is 5, with most orders with 3-7 products



5. Products by Department

- Most products are ordered from the Produce department (Fruits and vegetables)



6. Top 20 Products by # Orders

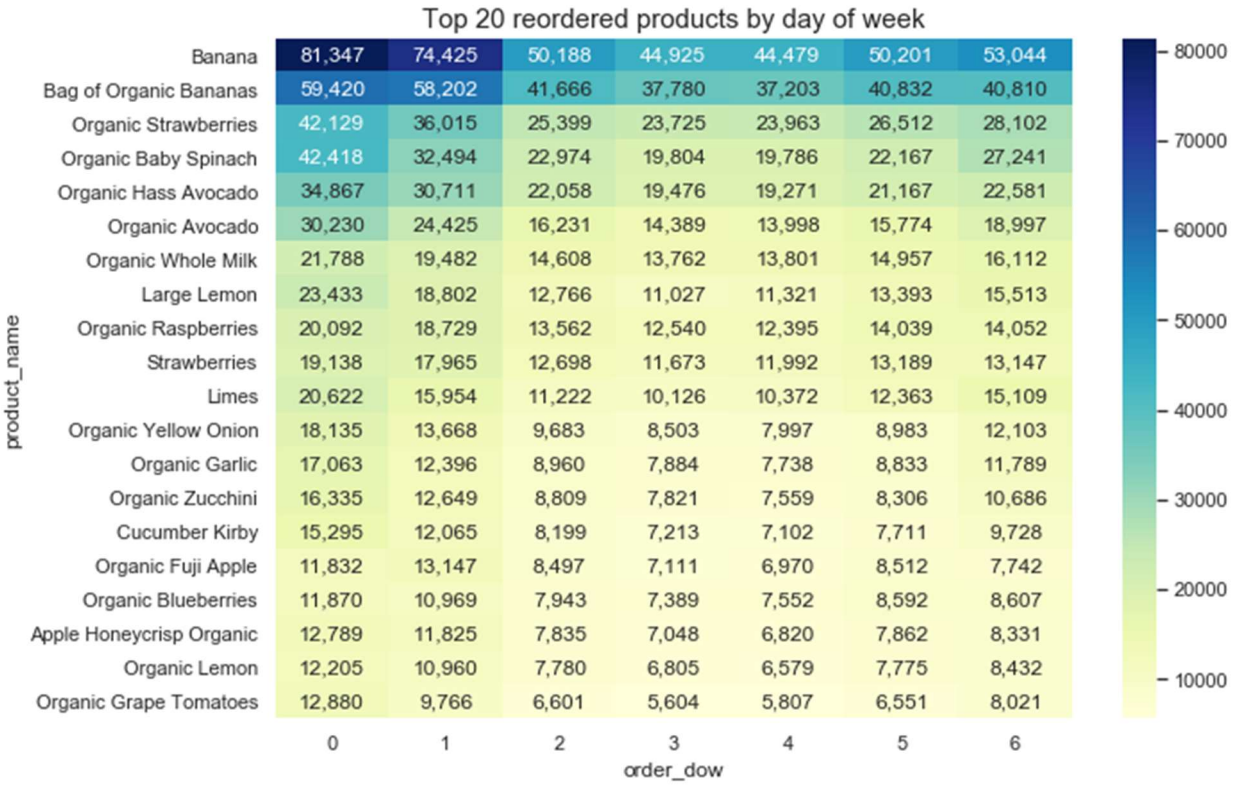
- Most of the top 20 ordered products are either fruits and vegetables

#	Aisle	Department	Product	# Orders	Reorder Ratio
1	fresh fruits	produce	Banana	472,565	84.4%
2	fresh fruits	produce	Bag of Organic Bananas	379,450	83.3%
3	fresh fruits	produce	Organic Strawberries	264,683	77.8%
4	packaged vegetables fruits	produce	Organic Baby Spinach	241,921	77.3%
5	fresh fruits	produce	Organic Hass Avocado	213,584	79.7%
6	fresh fruits	produce	Organic Avocado	176,815	75.8%
7	fresh fruits	produce	Large Lemon	152,657	69.6%
8	fresh fruits	produce	Strawberries	142,951	69.8%
9	fresh fruits	produce	Limes	140,627	68.1%
10	milk	dairy eggs	Organic Whole Milk	137,905	83.0%
11	packaged vegetables fruits	produce	Organic Raspberries	137,057	76.9%
12	fresh vegetables	produce	Organic Yellow Onion	113,426	69.7%
13	fresh vegetables	produce	Organic Garlic	109,778	68.0%
14	fresh vegetables	produce	Organic Zucchini	104,823	68.8%

15	packaged vegetables fruits	produce	Organic Blueberries	100,060	62.9%
16	fresh vegetables	produce	Cucumber Kirby	97,315	69.2%
17	fresh fruits	produce	Organic Fuji Apple	89,632	71.2%
18	fresh fruits	produce	Organic Lemon	87,746	69.0%
19	fresh fruits	produce	Apple Honeycrisp Organic	85,020	73.5%
20	packaged vegetables fruits	produce	Organic Grape Tomatoes	84,255	65.6%

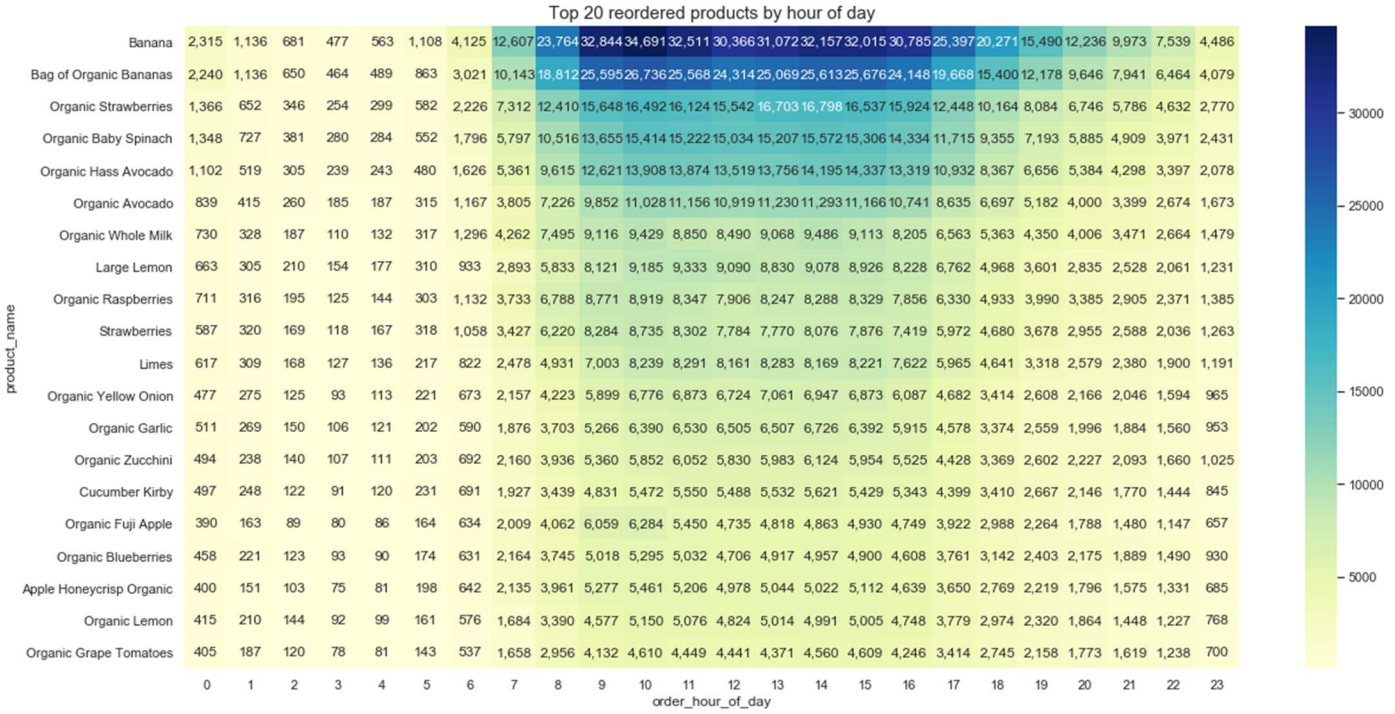
7. Product by Order Day of Week

- Banana is the most ordered and reordered product and mostly ordered on Saturday and Sunday



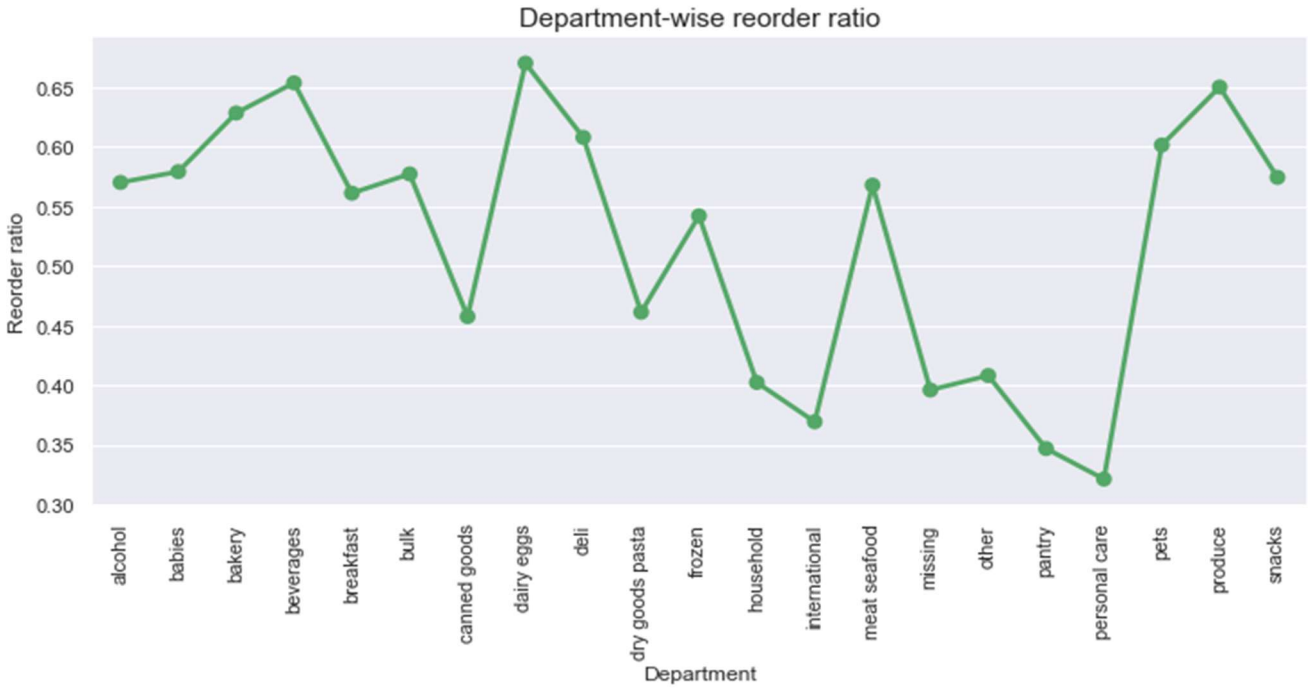
8. Product by Order Hour of Day

- Banana is the most ordered and reordered product and mostly ordered during afternoon hours



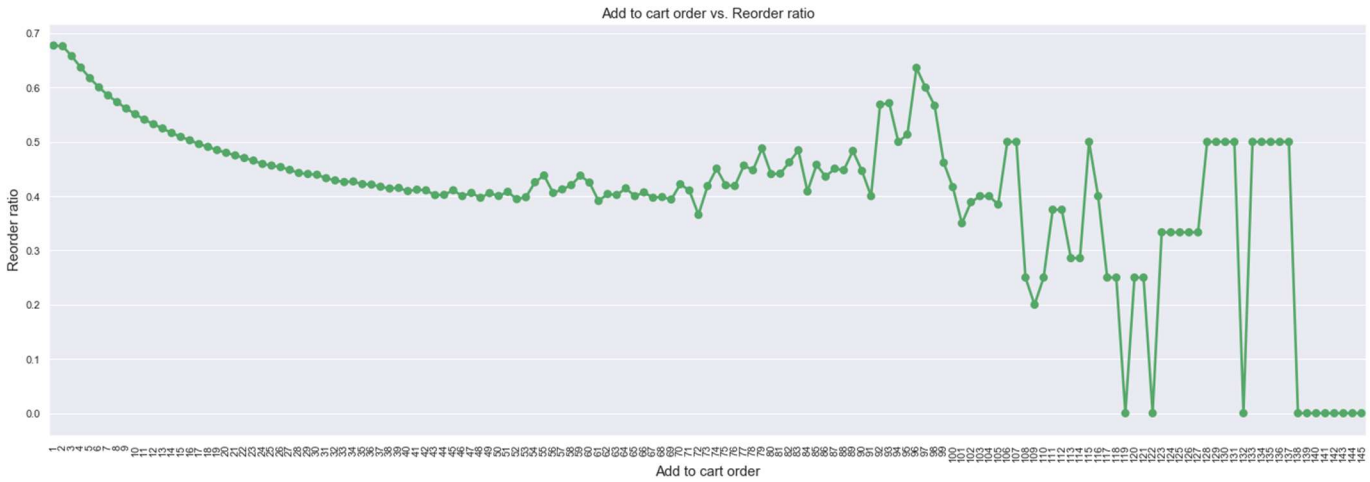
9. Product Reorder Ratio

- Dairy eggs department has highest reorder ratio and Personal care has the lowest



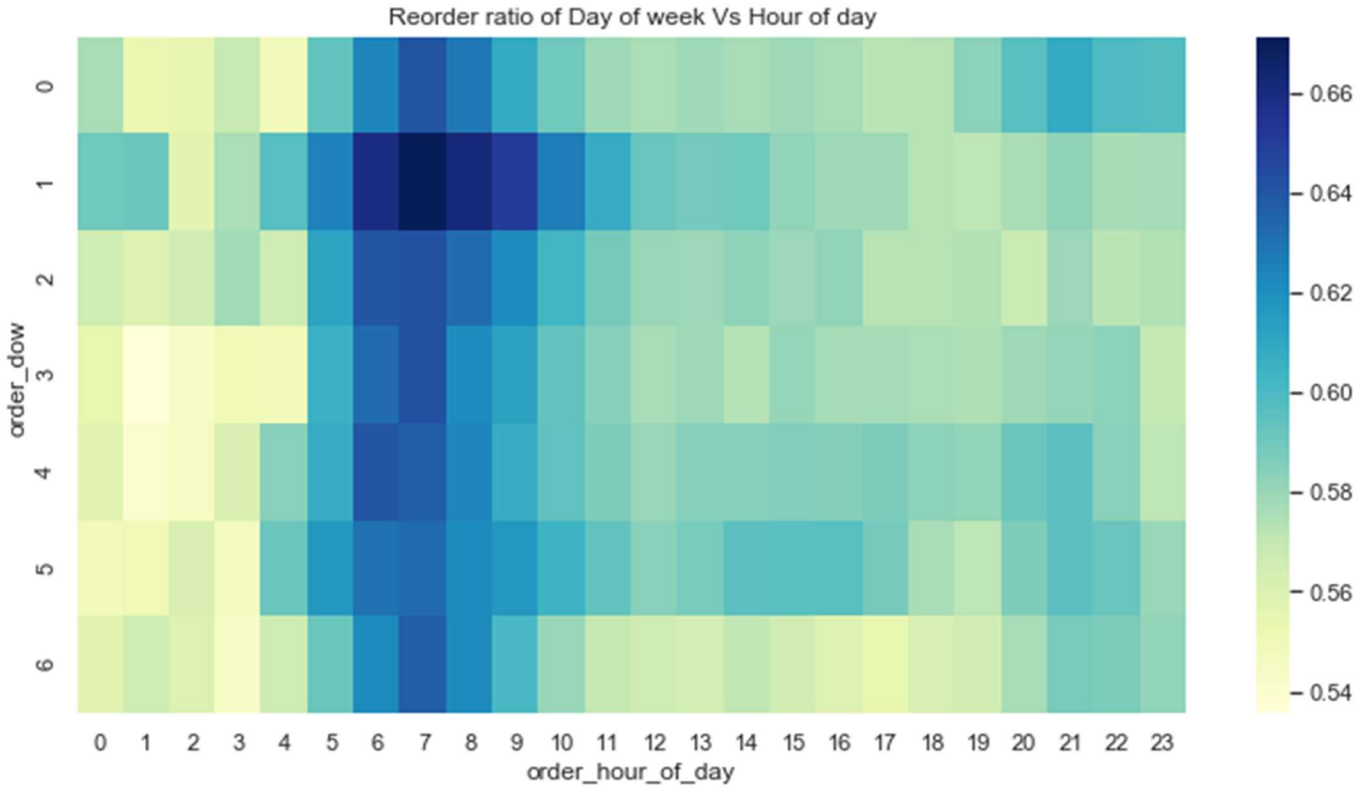
10. Reorder Ratio by Add to Cart Order

- The products that are added to the cart initially are more likely to be reordered again compared to the ones added later which makes sense as we tend to first order all the products we buy frequently and then search for new products



11. Reorder Ratio by Order Day of Week and Hour of Day

- Most of the reordered or frequently ordered products are ordered in the early morning hours



Independent Variables

#	Variable name	Description	Type
1	user_tot_orders	Number of total orders for a user (user level)	Numeric
2	user_tot_prods	Total number of items a user bought (user level)	Numeric
3	user_tot_dist_prods	Number of distinct products a user bought (user level)	Numeric
4	user_avg_days_bet_orders	Average number of days between orders for a user (user level)	Numeric
5	user_avg_order_size	Average number of items in a user's order (user level)	Numeric
6	order_hour_of_day	Hour of the day for the order for which we need to predict products (order level)	Numeric
7	days_since_prior_order	# of days since the prior order for the order for which we need to predict products (order level)	Numeric
8	days_since_ratio	days_since_prior_order/user_avg_days_bet_orders (order level)	Numeric
9	Department	Department name of the product (order level)	Categorical
10	prod_ordered	# of times the product has been ordered (product level)	Numeric
11	prod_reordered	# of times the product has been reordered (product level)	Numeric
12	prod_reorder_rate	prod_reordered / prod_ordered	Numeric
13	uxp_tot_orders	Total number of orders at user X product level	Numeric
14	uxp_order_rate	uxp_tot_orders / user_tot_orders	Numeric
15	uxp_avg_pos_in_cart	Average position in cart at user X product level	Numeric

16	uxp_reorder_rate	uxp_reordered/user_reorderd_prods	Numeric
17	uxp_orders_since_last_order	# orders since the user ordered this product (Total # of orders for a user – order number of the product when it was ordered by the user)	Numeric
18	uxp_delta_hour_vs_last	order_hour_of_day -	Numeric

Comparison Between Prediction Models

	XGBoost	Light GBM	Random Forest
Dependent variable	Predicts whether a product will be ordered in the user's next ordered	Predicts whether a product will be ordered in the user's next ordered	Predicts whether a product will be ordered in the user's next ordered
Hyperparameter Tuning Method	Randomized Search	Randomized Search	Grid Search
Optimal Hyperparameters	objective: 'binary:logistic' n_estimators: 50 max_depth: 5 learning_rate: 0.2	boosting_type: 'gbdt' objective: 'binary' metric: {'binary_logloss'} num_leaves: 96 max_depth: 10 feature_fraction: 0.9 bagging_fraction: 0.95 bagging_freq: 5	max_dept: 7 n_estimators: 70 max_features: 'auto'
Accuracy (Train set)	90.1%	-	90.7%
Accuracy (Hold out set on Kaggle)	37.4%	37.8%	17.4%

Variable Importance

- uxp_order_rate and uxp_orders_since_last_order are the top two predictors

#	Variable name	Importance	Description
1	uxp_order_rate	44.7%	uxp_tot_orders / user_tot_orders
2	uxp_orders_since_last_order	17.9%	# orders since the user ordered this product (Total # of orders for a user – order number of the product when it was ordered by the user)
3	uxp_reorder_rate	9.9%	uxp_reordered/user_reorderd_prods
4	uxp_tot_orders	7.3%	Total number of orders at user X product level
5	prod_reorder_rate	4.9%	prod_reordered / prod_ordered
6	department	3.8%	Department name of the product (order level)
7	days_since_prior_order	2.6%	# of days since the prior order for the order for which we need to predict products (order level)
8	days_since_ratio	1.4%	days_since_prior_order/user_avg_days_bet_orders (order level)
9	prod_reordered	1.3%	# of times the product has been reordered (product level)
10	uxp_delta_hour_vs_last	1.2%	order_hour_of_day -
11	user_tot_prods	0.8%	Total number of items a user bought (user level)
12	user_avg_days_bet_orders	0.7%	Average number of days between orders for a user (user level)
13	user_avg_order_size	0.7%	Average number of items in a user's order (user level)
14	user_tot_dist_prods	0.7%	Number of distinct products a user bought (user level)
15	user_tot_orders	0.7%	Number of total orders for a user (user level)

16	prod_ordered	0.6%	# of times the product has been ordered (product level)
17	uxp_avg_pos_in_cart	0.6%	Average position in cart at user X product level
18	order_hour_of_day	0.2%	Hour of the day for the order for which we need to predict products (order level)

Insights

- Out of the three classification models used, XGBoost, Light GBM and Random Forest, Light GBM classification model gives the best accuracy at 37.8% on the Kaggle hold out set
- Light GBM hyperparameters were determined using Randomized Search and the best hyperparameters are:
    - Boosting_type: 'gbdt'
    - Objective: 'binary'
    - Metric: {'binary_logloss'}
    - Num_leaves: 96
    - Max_depth: 10
    - Feature_fraction: 0.9
    - Bagging_fraction: 0.95
    - Bagging_freq: 5
- The top 5 variables as per the variable importance are:
    1. uxp_order_rate (44.7%)
    2. uxp_orders_since_last_order (17.9%)
    3. uxp_reorder_rate (9.9%)
    4. uxp_tot_orders (7.3%)
    5. prod_reorder_rate (4.9%)