Johnson
Cornell
SC Johnson College of Business

JD.COM

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JD.com Capstone

Masters of Science in Business Analytics

Presented by:
Lauren Darienzo, Rohini Iyengar, Tiffany Pham, Uzair Siddiq, Barbara Talagan

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Meet the Team

MSBA SC Johnson School of Business Class of 2023

Lauren Darienzo

Business Development

Uzair Siddiq

Business Strategist

Tiffany Pham

Project Manager

Rohini Iyengar

Data Scientist

Barbara Talagan

Data Engineer

Jonathan Yee

EY Capstone Coach

JD.com is one of China's Leading E-Commerce Platforms

305 M
Customers

Founded in 2004 in Beijing, China

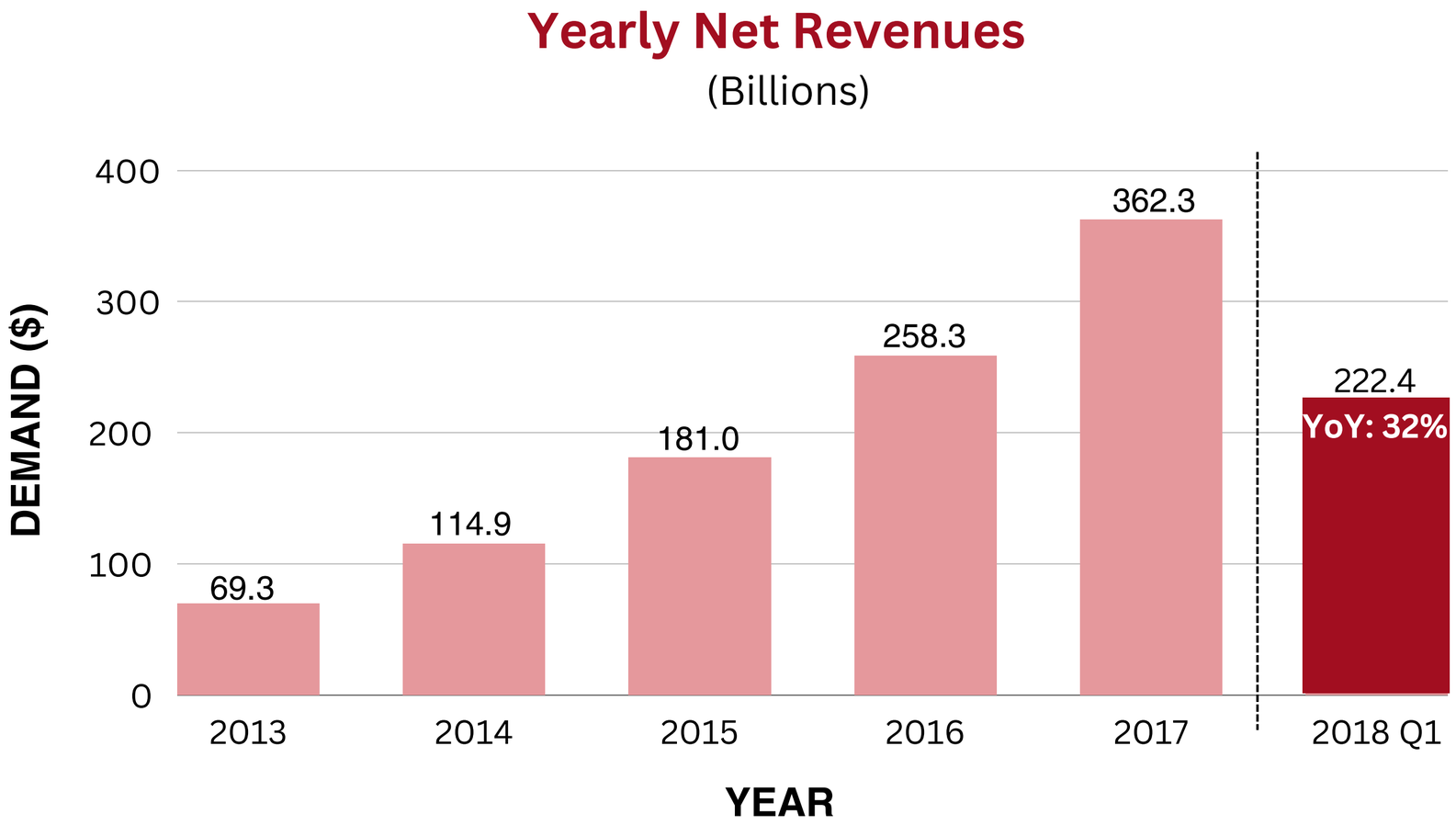
$67.2 B
Revenue

China’s largest retailer and biggest internet company by revenue

400+
Warehouses

Prioritizes speed of order fulfillment and delivery

JD.com's Net Revenue has Consistently Grown Over the Past 5 Years

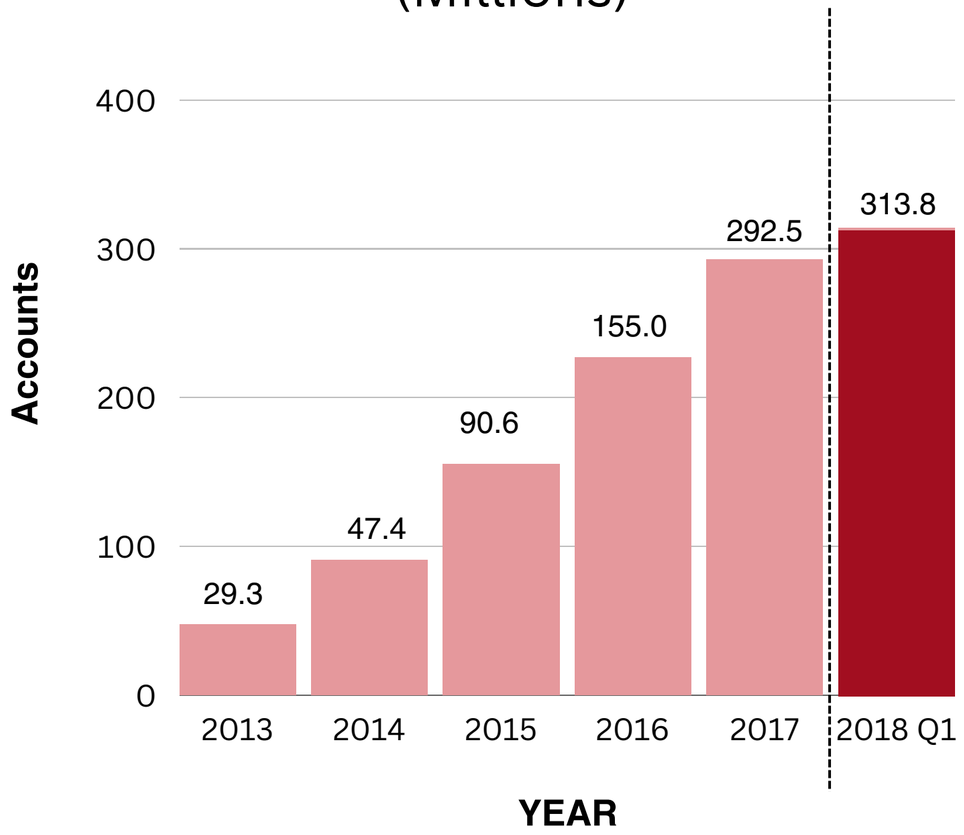


Source: JD.com 2Q 2018 Report, as reported in JD.com: Incredible, Overlooked, Underappreciated, Seeking Alpha, September 19, 2018, https://seekingalpha.com/article/4207186-jd-com-incredible-overlooked-underappreciated

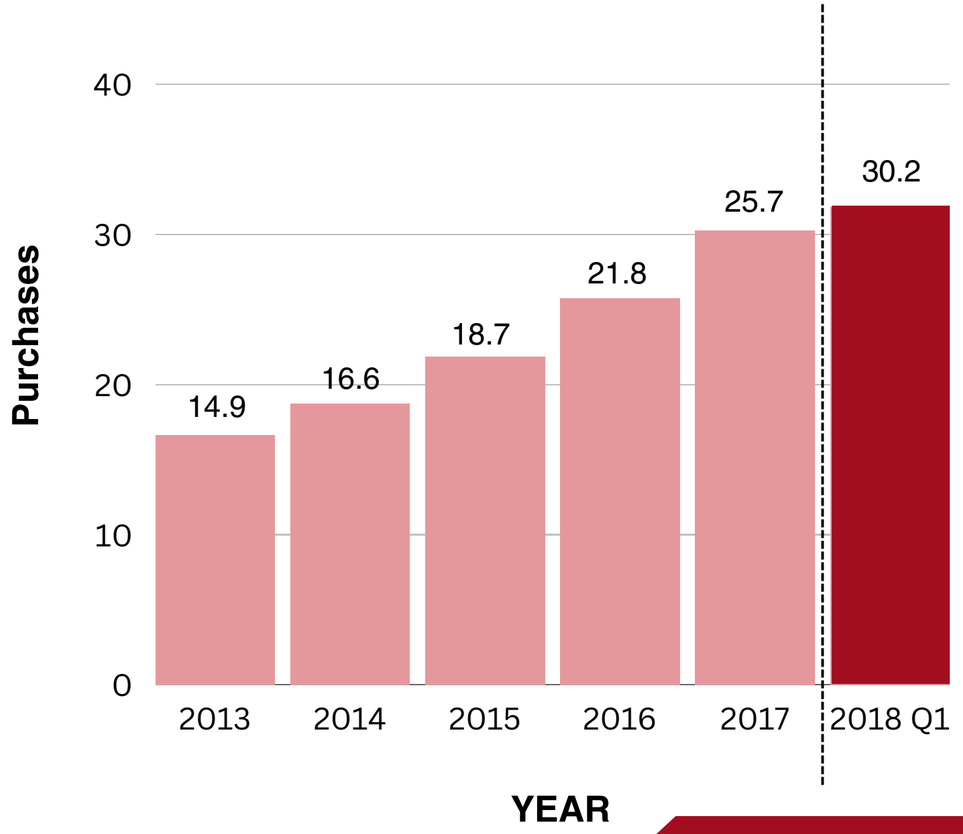
Number of Customer Accounts and the Average Purchases per Customer have Increased Steadily Over the Past 5 Years

Active Customer Accounts

(Millions)



Average Number of Purchases made by Active Customer Accounts



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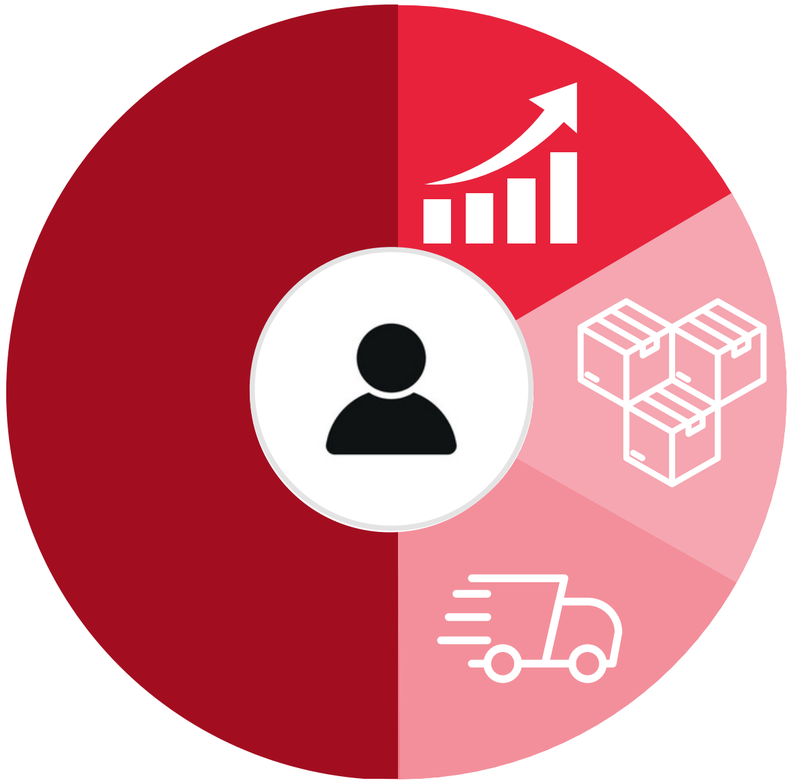
See Appendix

In 2018, Alibaba's Net Profit is More Than Double that of JD.com

	JD.com (JD)	Alibaba (BABA)	Amazon (AMZN)
Total Revenue	$67.2B	$39.9B	$232.9B
Net Profit	$9.6B	$22.8B	$10.1B
# of Customers	305.3M	636M	112.1M
Market Share	24% (in China)	69% (in China)	41% (in US)
Business Model	Mostly 1P (First-Party)	Mostly 3P (Third-Party)	Mostly 3P (Third-Party)

JD.com's Challenges Cause Customer Attrition



SCALING

Increasing the scale of operations was not the optimal solution, but the company was not sure how to adapt its fulfillment and inventory allocation strategies to meet customers' needs efficiently and effectively

INVENTORY

Inventory shortages delay the delivery of products, which leads customers to stop purchasing from JD.com and makes it difficult to attract new customers.

DELIVERY

The inability to provide timely and accurate fulfillment services to customers negatively impacts customers' shopping experiences

Key Questions

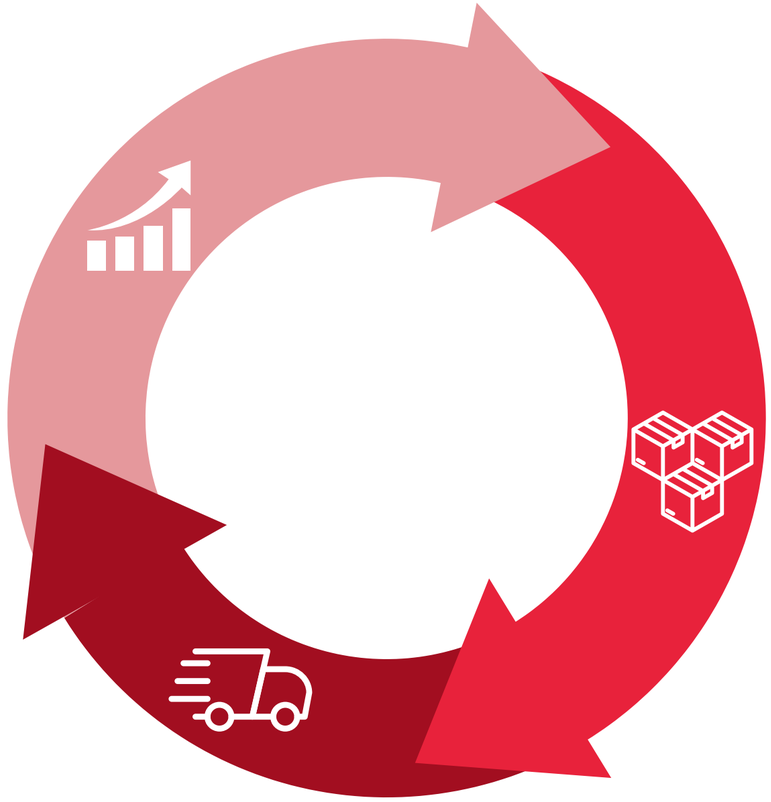
How can JD.com increase sales by improving its fulfillment efficiency and inventory allocation strategies?

1. How can JD.com forecast short-term demand?

2. How can JD.com improve its on-time delivery rate?

3. How should warehouses optimally stock up for certain products?

Solving JD.com's Challenges Using Demand Prediction and Inventory Optimization



Accurate Demand Prediction

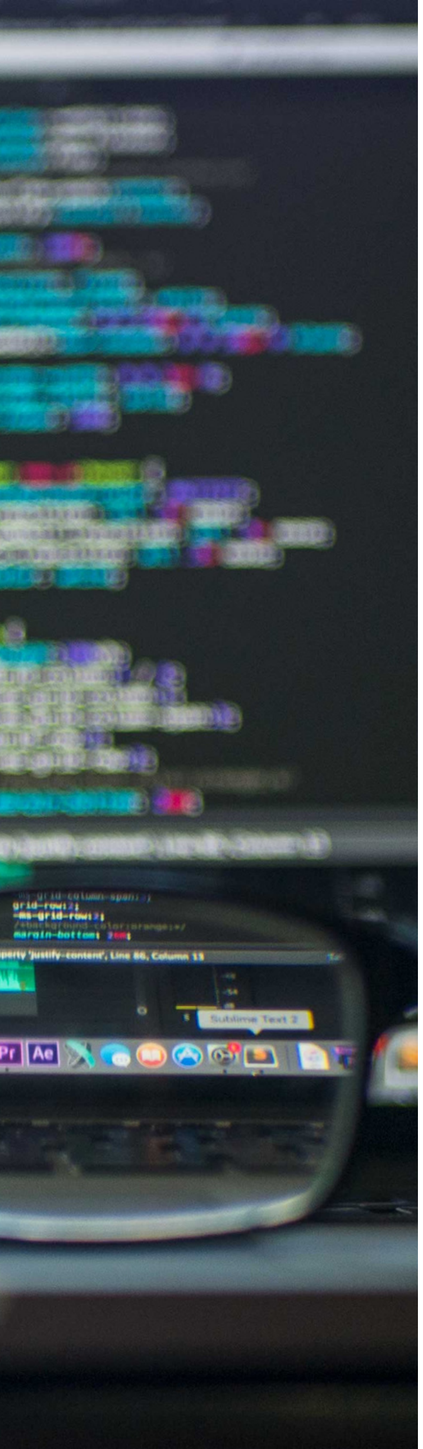
Ensure customer demands are met while reducing unnecessary costs

Optimize Inventory Placement

Optimize inventory levels, minimize stock-outs, and improve overall operational efficiency.

On-Time Delivery

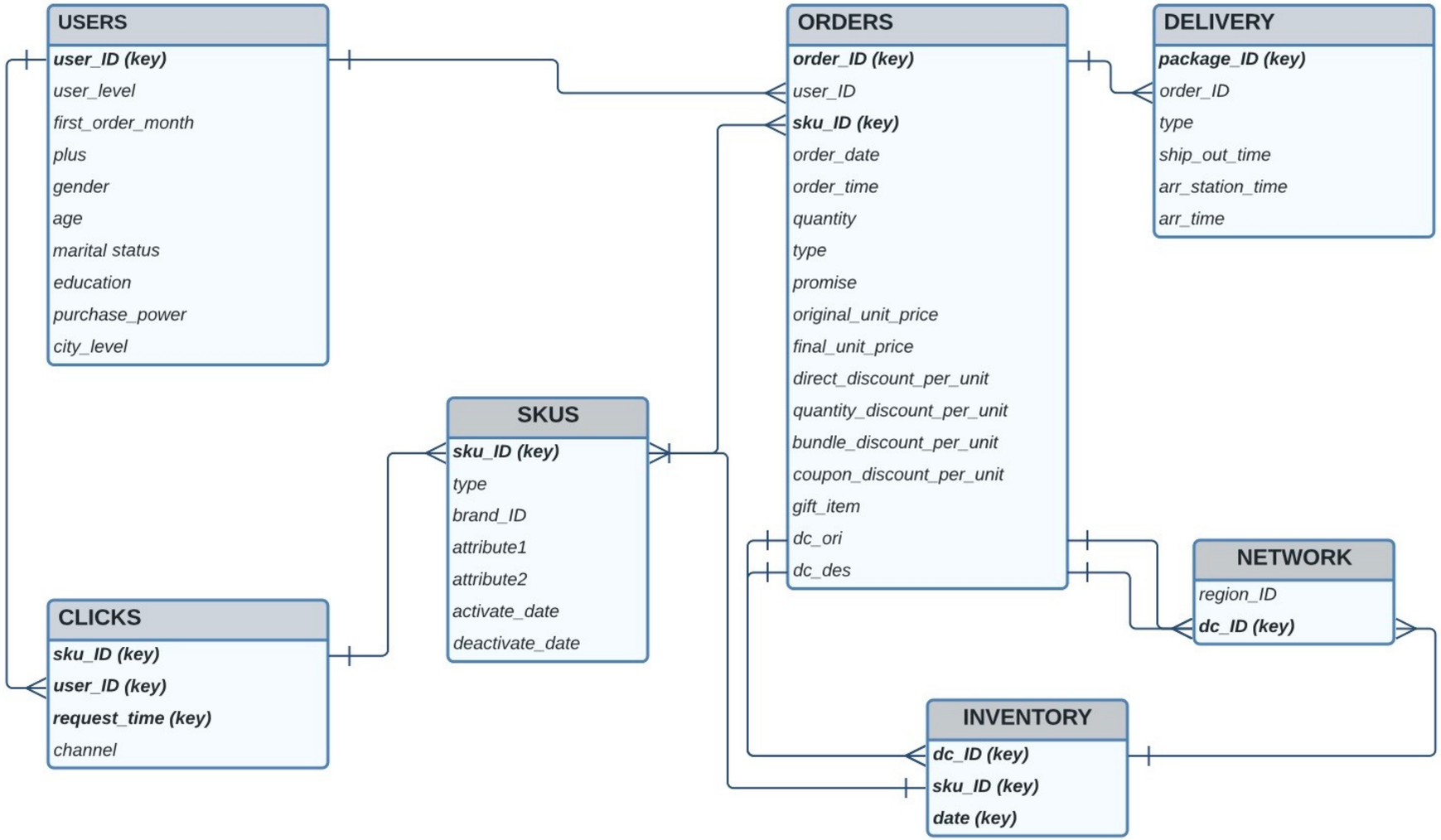
Improve the delivery promise and enhance customer satisfaction and competitive advantage



Dataset

Database Relationships

Data Type: Time Series



Selected Data for Delivery Descriptive Statistics

	Orders Table	Delivery Table
Dataset:	**Orders Table**	**Delivery Table**
Description:	Use customer order data to determine the destination warehouse and promise delivery time for packages	Use delivery data to access package delivery time
Key Variables:	Order ID Type of Order DC Destination Delivery Promise	Order ID Type of Order Order Shipping Time Order Arrival Time

Selected Data for Inventory Optimization Model

Dataset: Orders Table

Description: Use customer order data to forecast demand at the SKU and warehouse level to optimize inventory for each warehouse and product

Key Variables:

Order ID
Type of Order
Original Unit Price
Final Unit Price
DC Destination

Significant Data Limitations

Only one month of daily time series data

No inventory-related costs (holding costs, transportation costs), inventory re-order lead times, warehouse capacities, or quantities of starting inventory

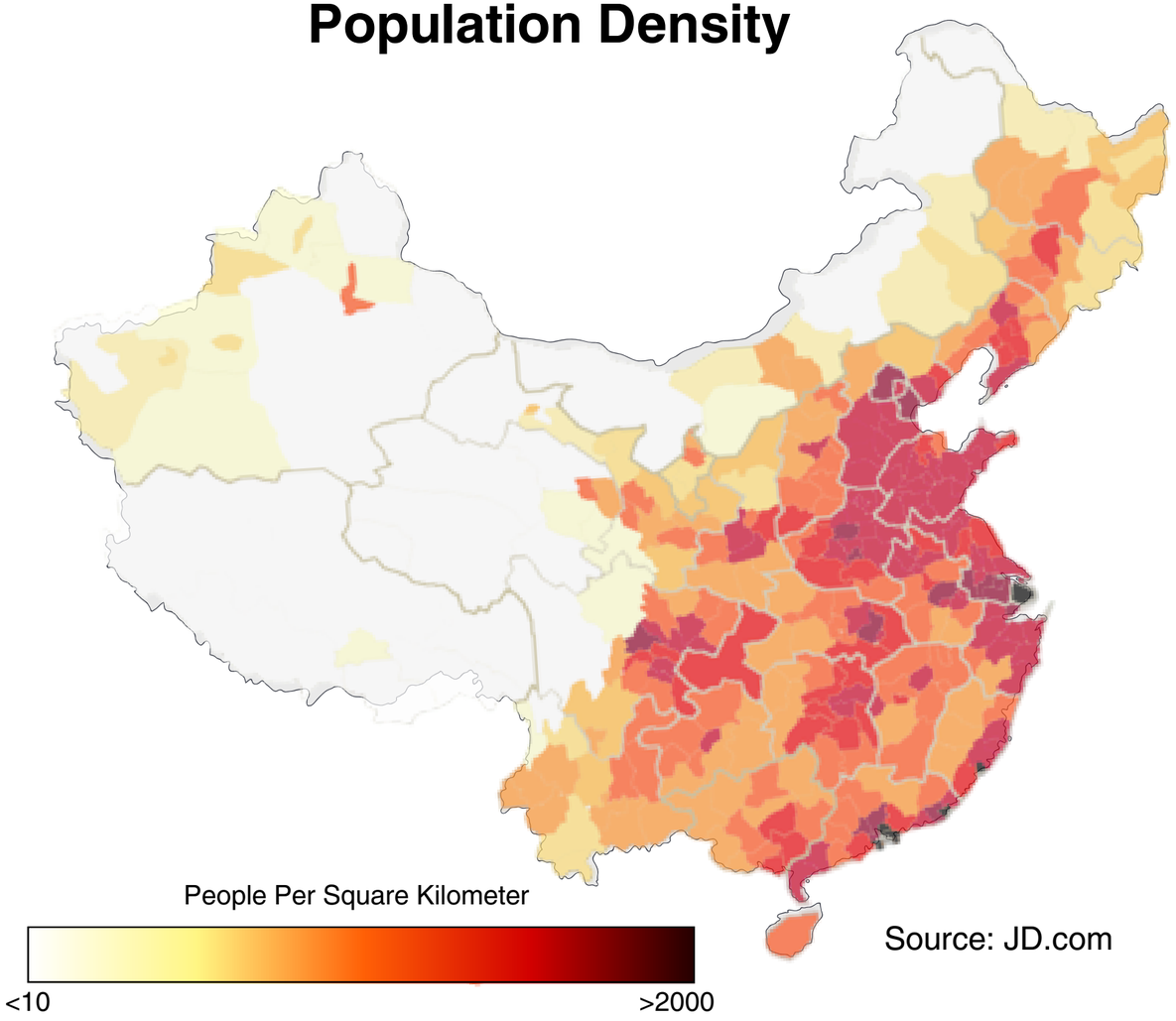
No customer addresses, location of warehouses, or distances between warehouses and customers

Incomplete information on most 3P (Third-Party) products

Descriptive Statistics

JD.com's Delivery Network Reaches 99% of China's 1.4 Billion Population

Population Density



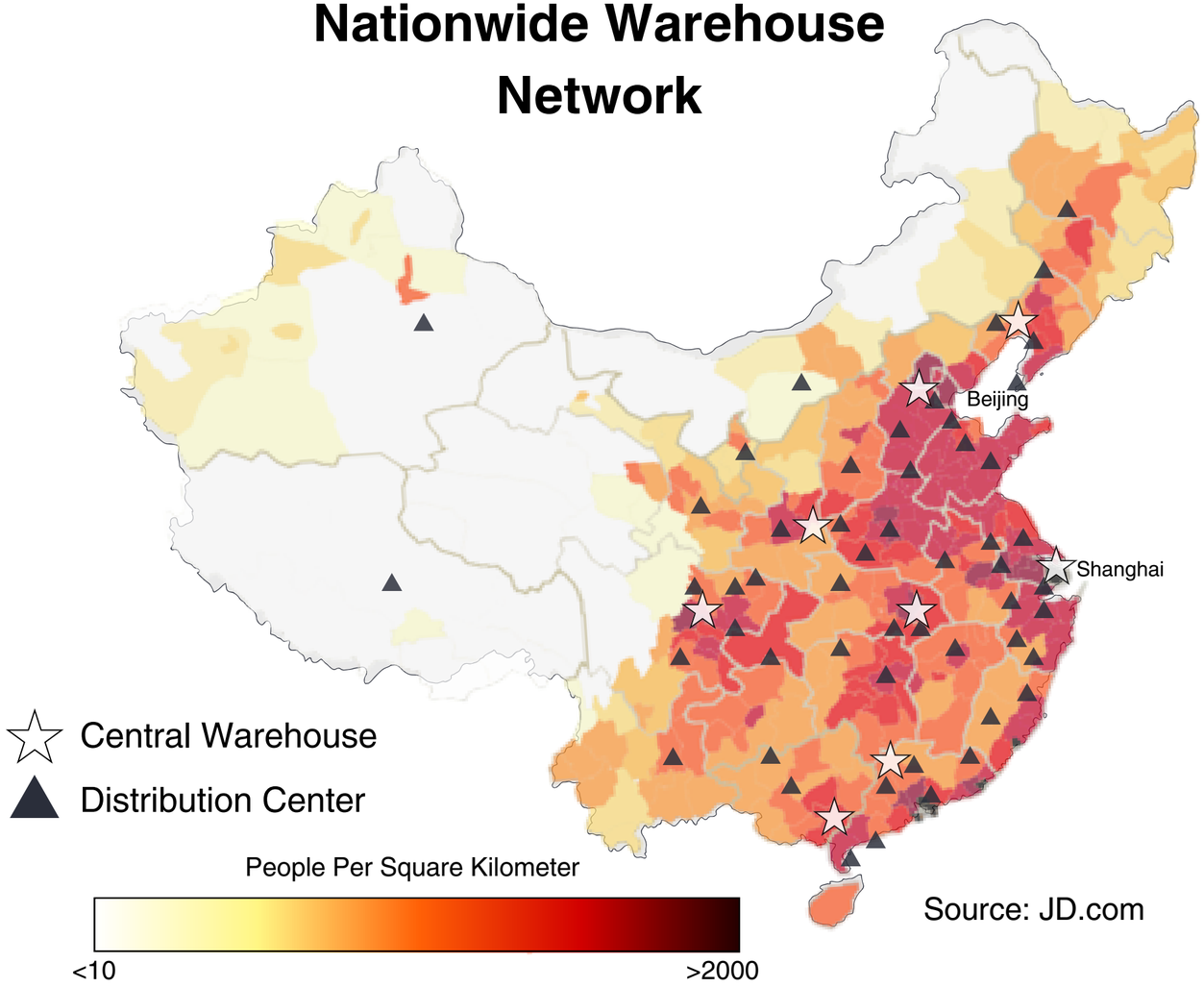
Source: JD.com

Fulfillment Capabilities

Central Warehouse	8 Cities
Distribution Centers	27 Cities
# of Orders	Approx. 486,000
Delivery Personnel	Approx. 200,000
Geographical Coverage	Almost all counties and districts in China

JD.com's Delivery Network Reaches 99% of China's 1.4 Billion Population

Nationwide Warehouse Network



Source: JD.com

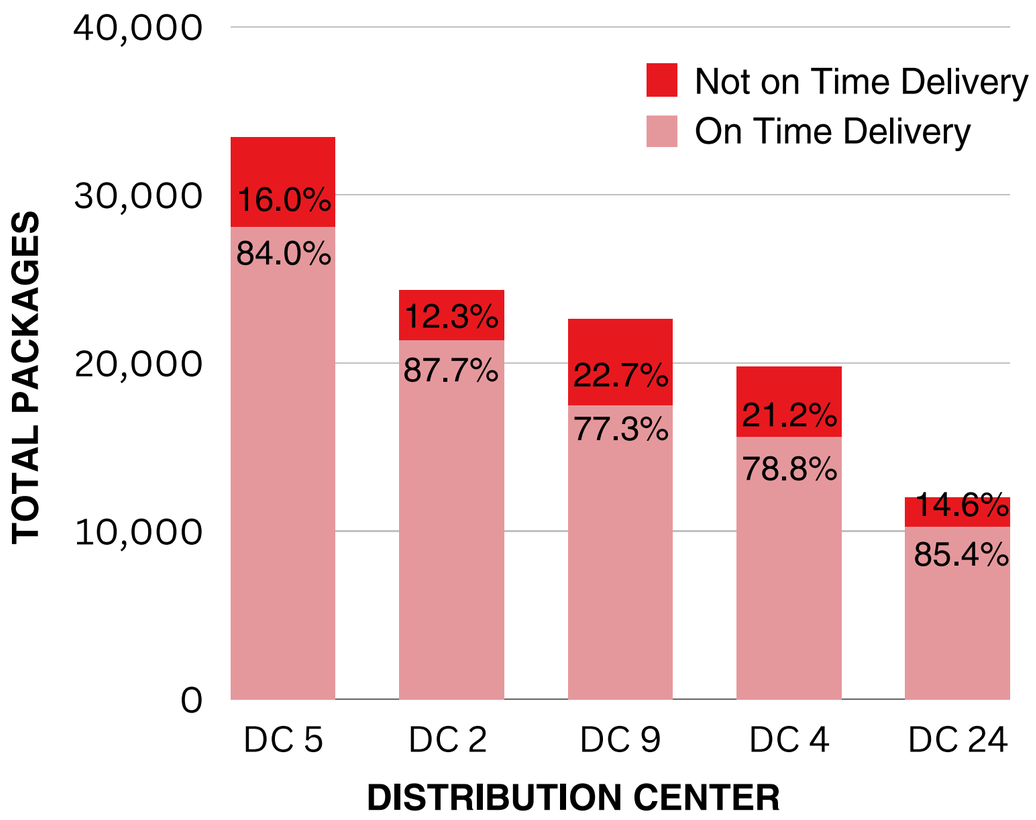
Fulfillment Capabilities

Central Warehouse	8 Cities
Distribution Centers	27 Cities
# of Orders	Approx. 486,000
Delivery Personnel	Approx. 200,000
Geographical Coverage	Almost all counties and districts in China

Highest Volume Warehouses Provide Opportunities for Improvement

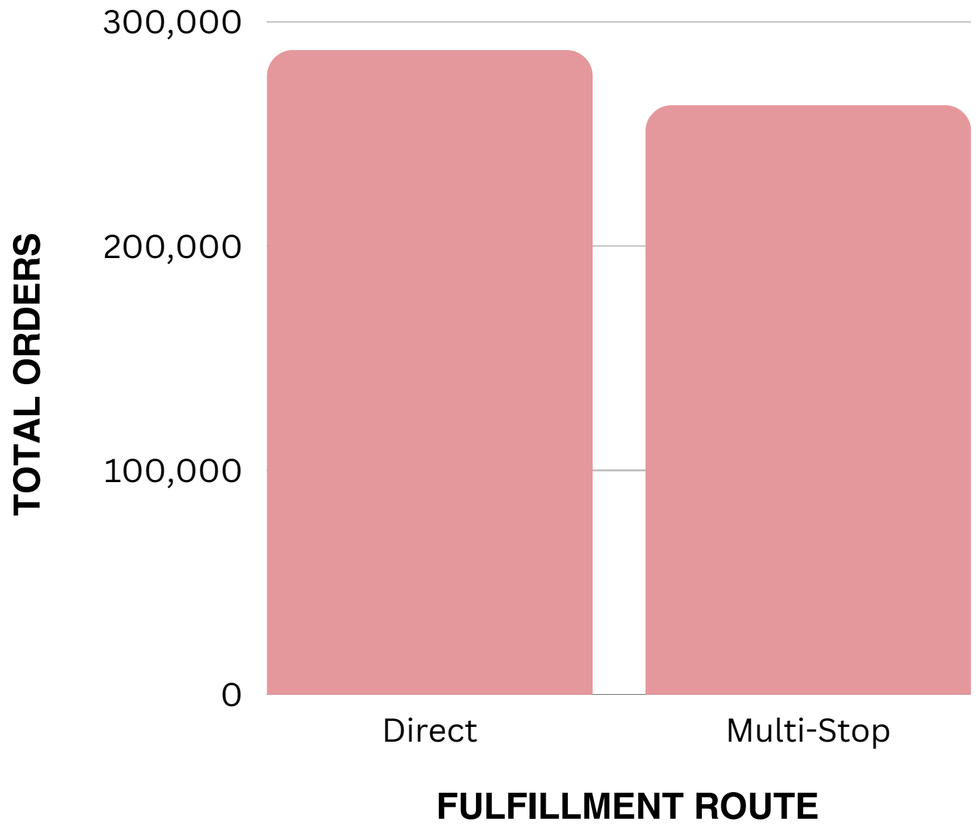
Highest Volume Warehouses

(Based on Total Packages Shipped)



Customer Shipments

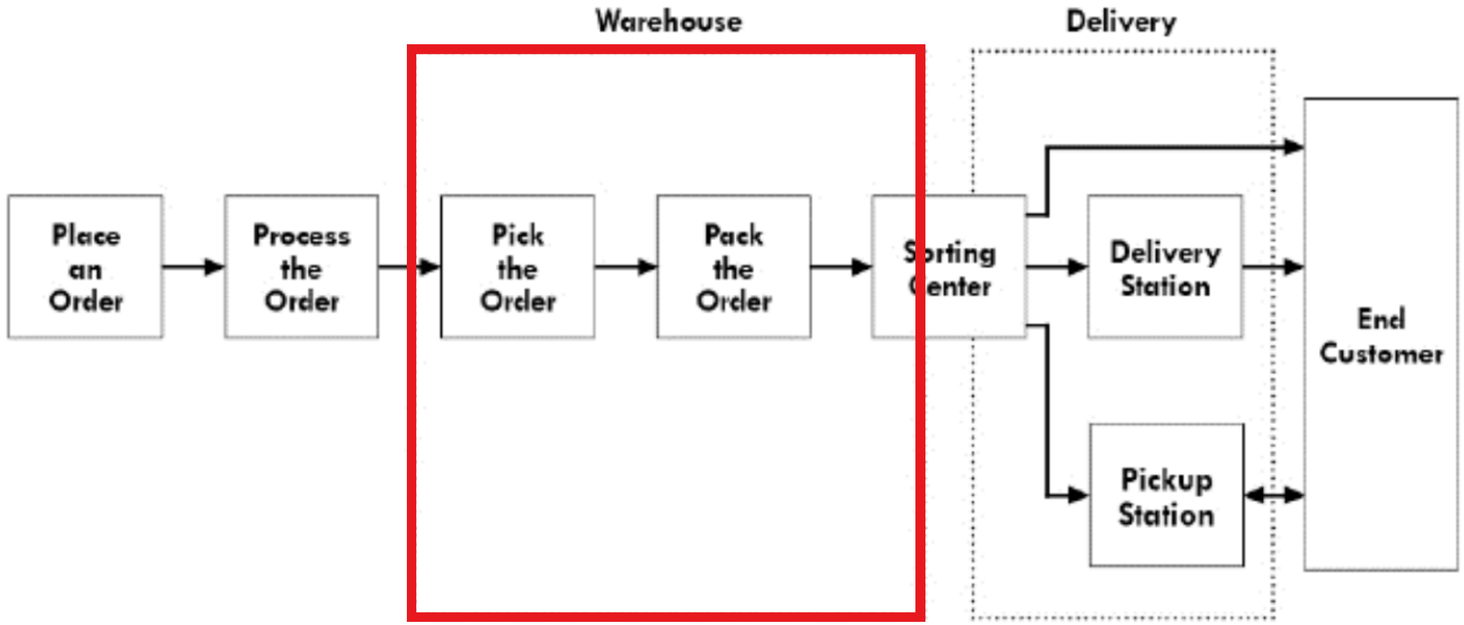
(Based on Total Orders Shipped)



See Appendix

Optimization Model

Inventory Model Optimized for 67 Individual Warehouses and 328 Products



Average Daily Demand

32,152 units

Daily Safety Stock

63,534 units

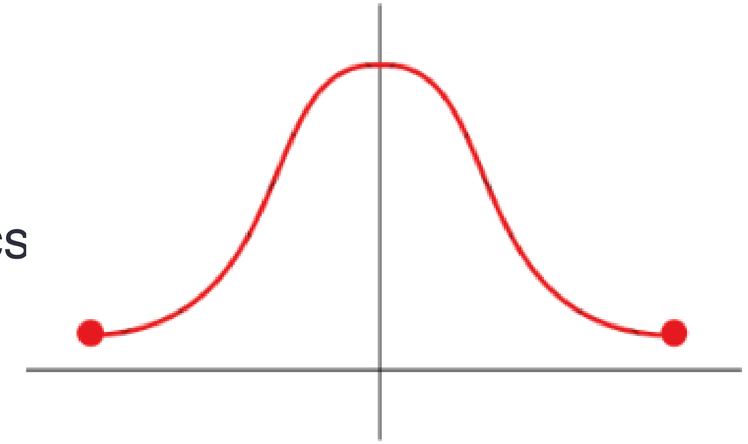
Total Daily Inventory Cost

$1,001,393

Source (Fulfillment Diagram): JD.com SEC Form 20-f, filed April 15, 2019, https://ir.jd.com/node/8141/html

We Assumed a Normal Distribution of Demand to Model the Daily Demand

We adopted a normal distribution approach for predicting daily demand to find the following essential inventory metrics for optimization since faced the issue of working with a single-month time series dataset:



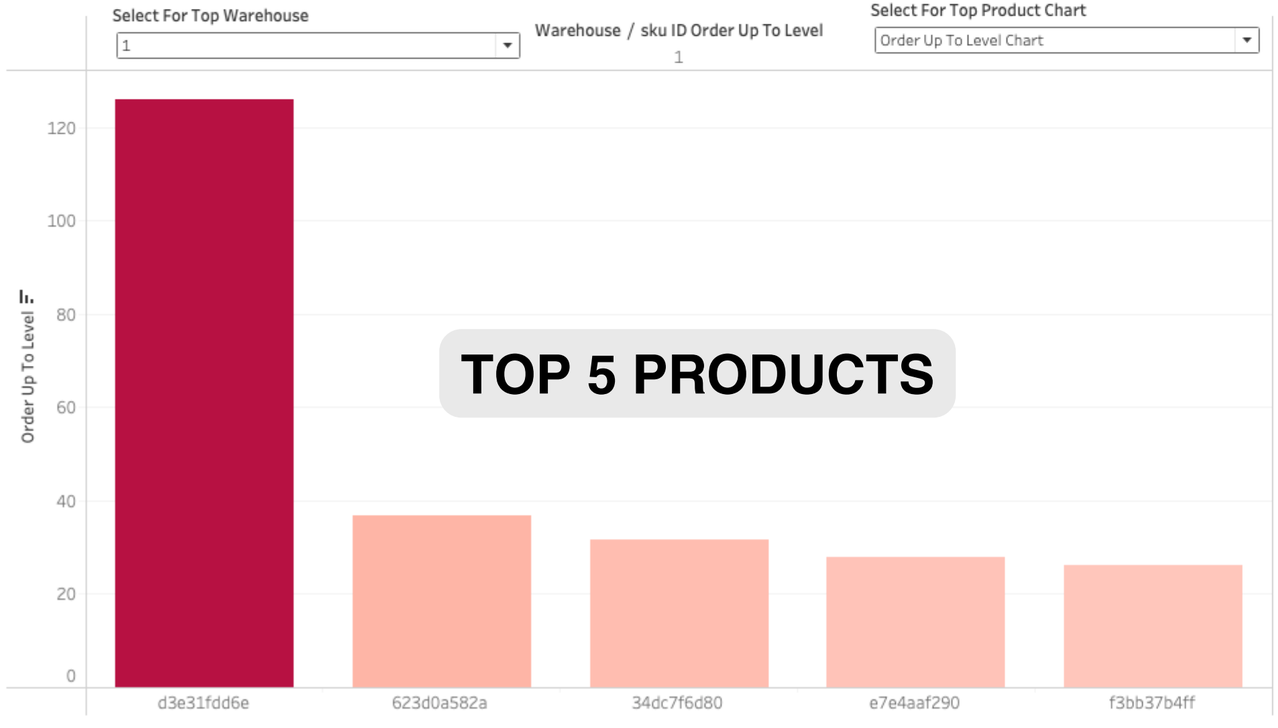
Safety Stock	Order-Up-To-Level	Cost of Excess Inventory
Expected Lost Sales	Mean Lead Time Demand	Cost of Lost Sales
Expected Sales	Expected Excess Inventory	Total Costs

To Tackle Data Limitations and Ensure the Model's Success, We Made the Following Assumptions:

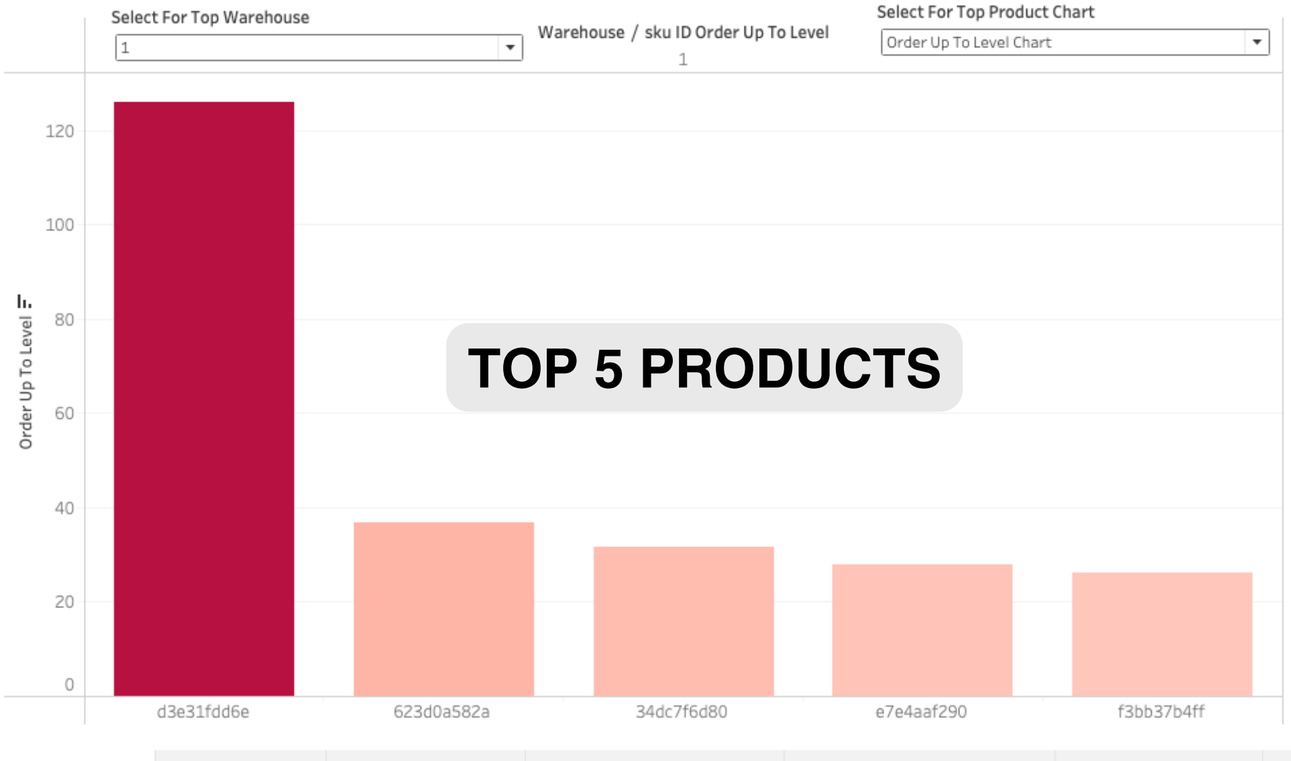
- **Service Rate:** Set at 95% to reflect JD's commitment to sufficient stock
- **Inventory Reorder Lead Time:** set to 7 days
- **Standard Deviation of Lead Time:** 0 days as an industry leader with steady reorder lead times
- **Profit Margin:** Set at 13% on goods sold (macrotrends).
- **Inventory Holding Costs:** Set at 30% of product cost
- **Goodwill (Penalty) Costs:** Inventory shortage cost is assumed to be 50% of product cost

Dashboards will allow managers to leverage the output of the model to aid in decisions on a daily level

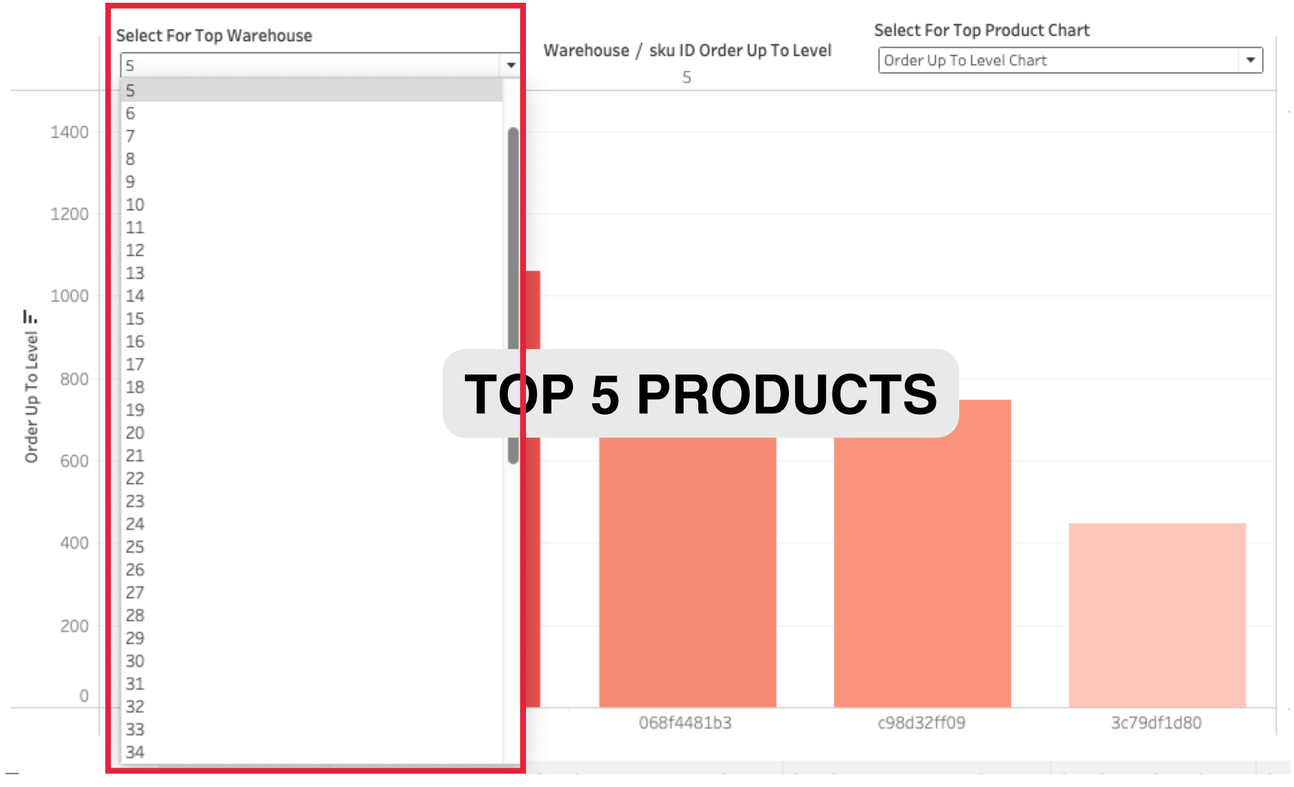

Warehouse Order Up To Level
Show Top 5 Warehouses For
Top Order Up To Level
Top Order Up To Level
18K
16K
14K
12K
10K
8K
6K
4K
2K
0K
5
2
4
9
27
TOP 5 WAREHOUSES


Select For Top Warehouse
1
Warehouse / sku ID Order Up To Level
1
Select For Top Product Chart
Order Up To Level Chart
Order Up To Level
120
100
80
60
40
20
0
d3e31fdd6e
623d0a582a
34dc7f6d80
e7e4aaf290
f3bb37b4ff
TOP 5 PRODUCTS

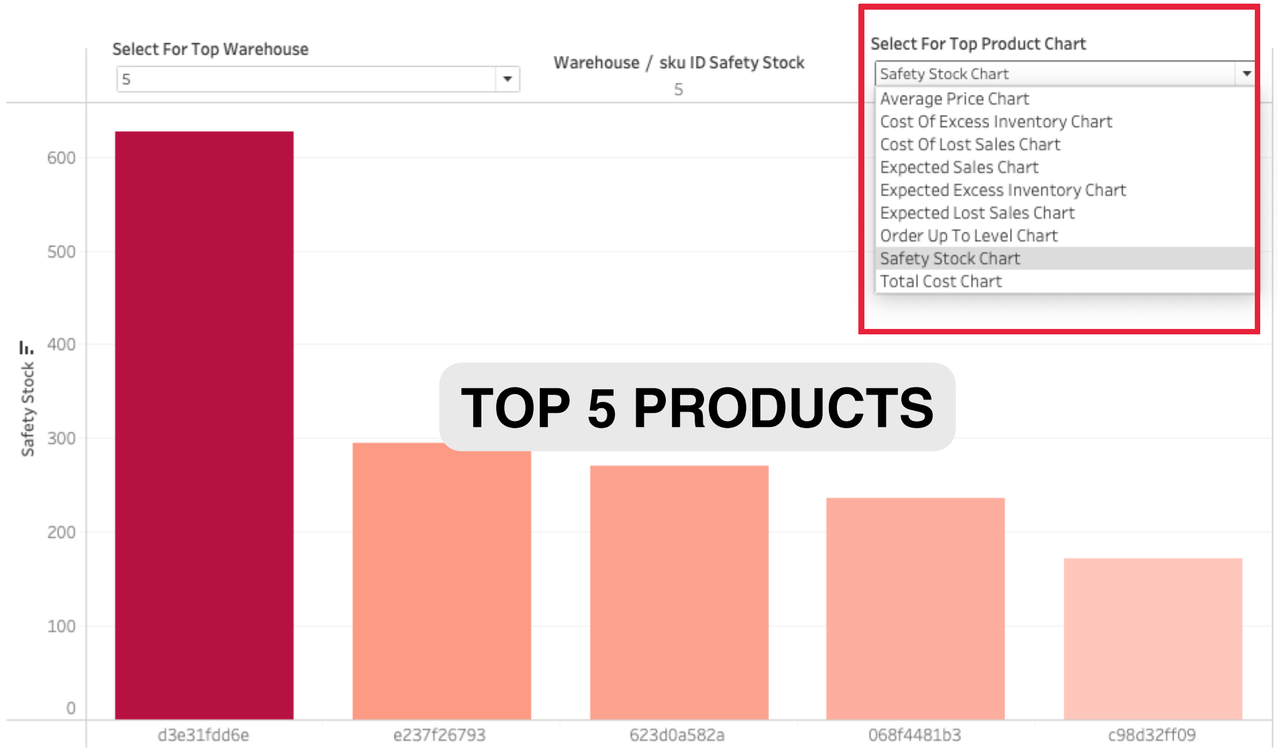

Warehouse Safety Stock
Show Top 5 Warehouses For
Top Safety Stock
Top Average Price
Top Cost Of Excess Inventory
Top Cost Of Lost Sales
Top Demand Sum
Top Expected Excess Inventory
Top Expected Lost Sales
Top Expected Sales
Top Mean Lead Time Demand
Top Order Up To Level
Top Safety Stock
Top Total Cost
TOP 5 WAREHOUSES
Top Safety Stock
6K
5K
4K
3K
2K
1K
0K
5
4
2
9
27


Select For Top Warehouse
1
Warehouse / sku ID Order Up To Level
1
Select For Top Product Chart
Order Up To Level Chart
TOP 5 PRODUCTS
Order Up To Level
120
100
80
60
40
20
0
d3e31fdd6e
623d0a582a
34dc7f6d80
e7e4aaf290
f3bb37b4ff

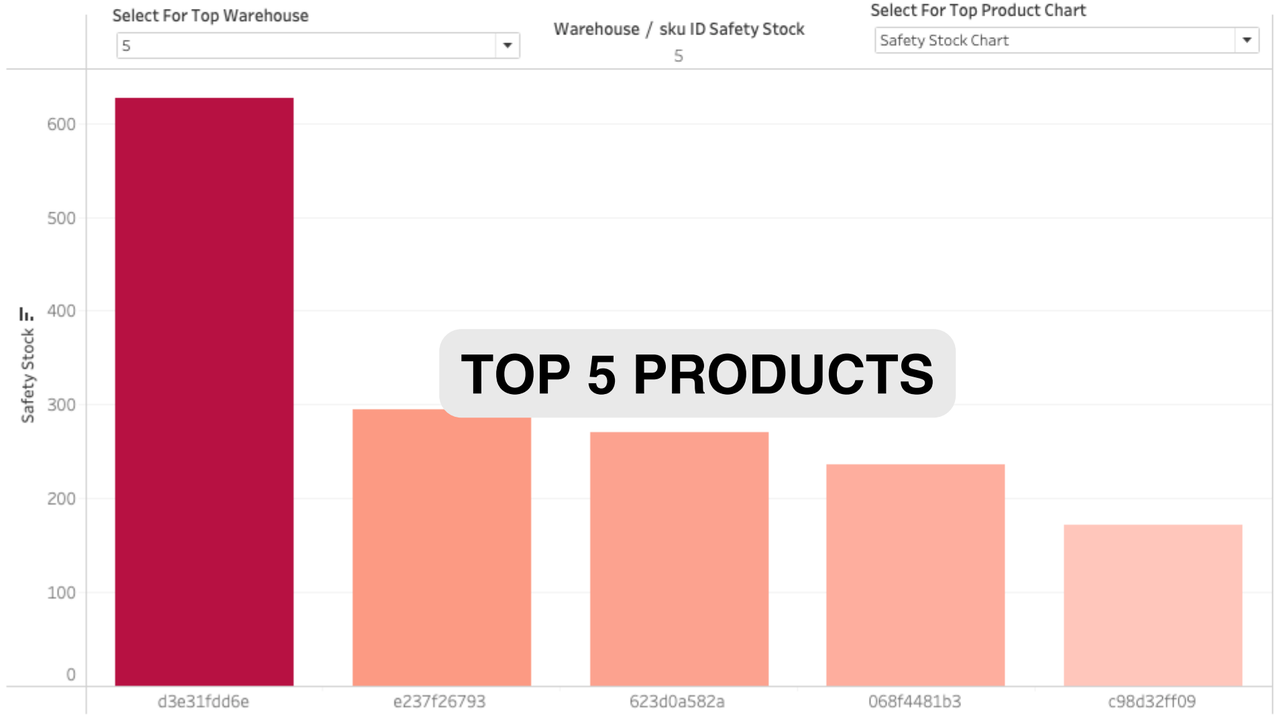

Warehouse Safety Stock
Show Top 5 Warehouses For
Top Safety Stock
6K
5K
4K
3K
2K
1K
0K
Top Safety Stock
5
4
2
9
27
TOP 5 WAREHOUSES


Select For Top Warehouse
5
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
Warehouse / sku ID Order Up To Level
5
Select For Top Product Chart
Order Up To Level Chart
1400
1200
1000
800
600
400
200
0
Order Up To Level
068f4481b3
c98d32ff09
3c79df1d80
TOP 5 PRODUCTS


Warehouse Safety Stock
Show Top 5 Warehouses For
Top Safety Stock
6K
5K
4K
3K
2K
1K
0K
Top Safety Stock
5
4
2
9
27
TOP 5 WAREHOUSES

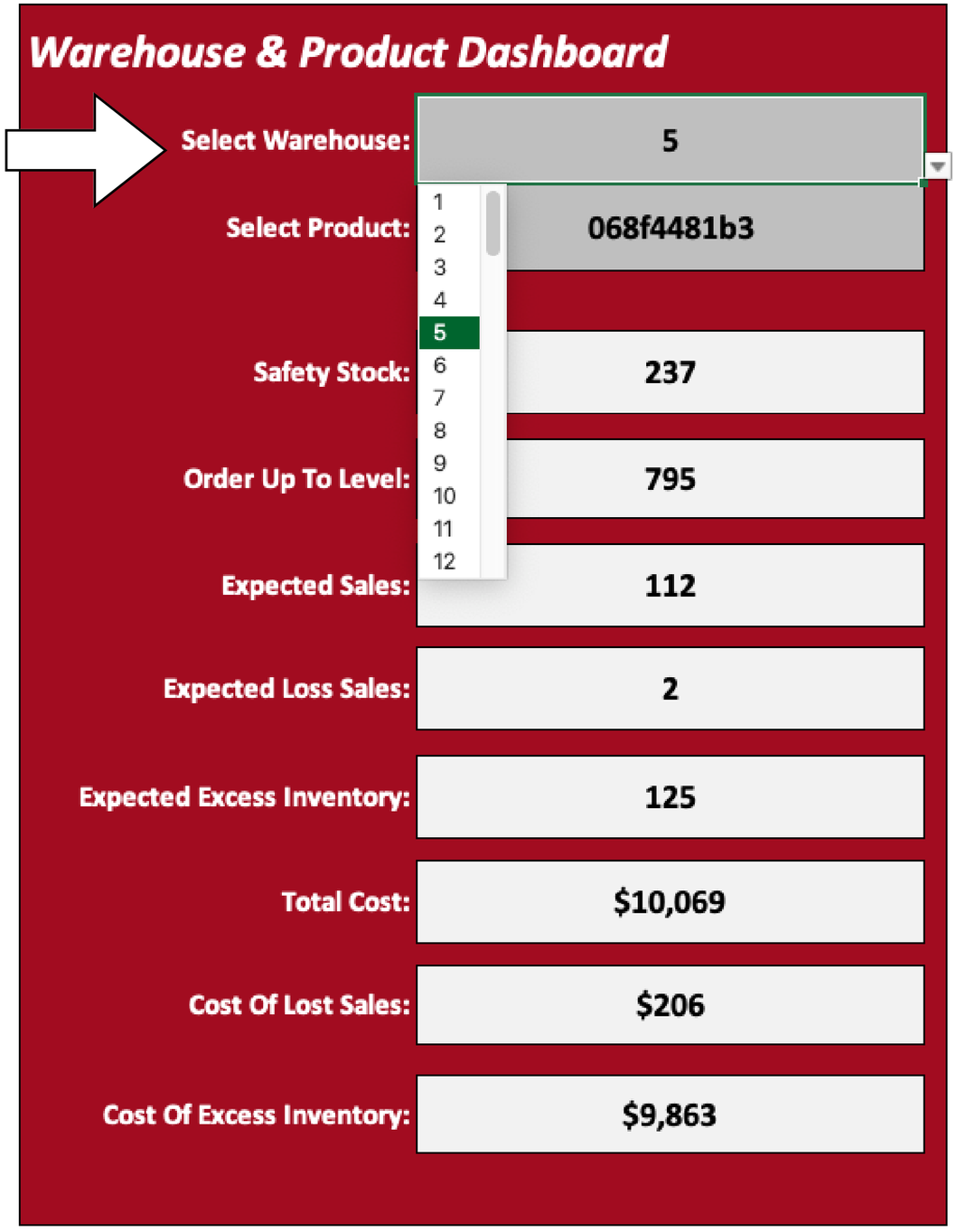

Select For Top Warehouse
5
Warehouse / sku ID Safety Stock
5
Select For Top Product Chart
Safety Stock Chart
Average Price Chart
Cost Of Excess Inventory Chart
Cost Of Lost Sales Chart
Expected Sales Chart
Expected Excess Inventory Chart
Expected Lost Sales Chart
Order Up To Level Chart
Safety Stock Chart
Total Cost Chart
600
500
400
300
200
100
0
Safety Stock
d3e31fdd6e
e237f26793
623d0a582a
068f4481b3
c98d32ff09
TOP 5 PRODUCTS

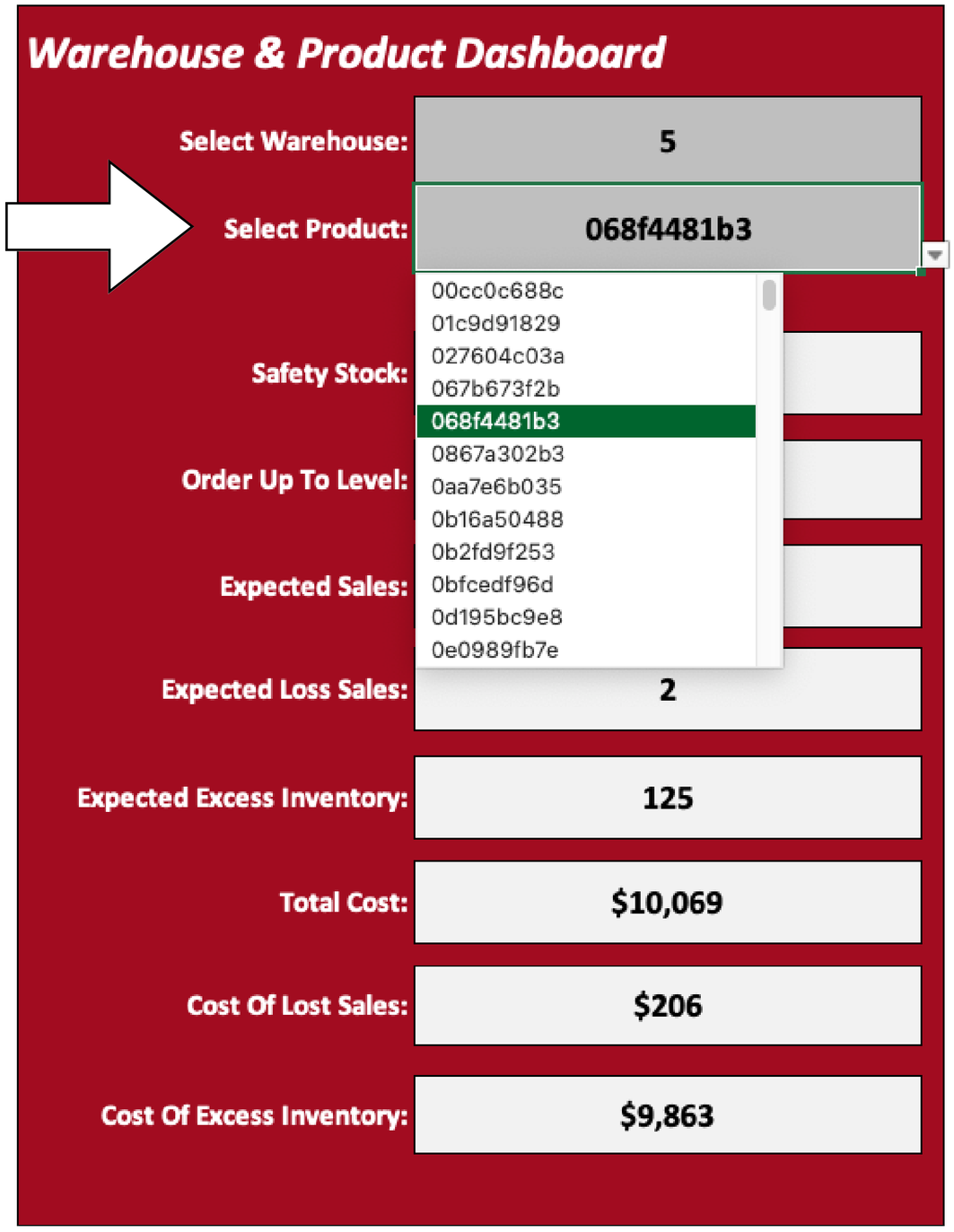

Warehouse Safety Stock
Show Top 5 Warehouses For
Top Safety Stock
Top Safety Stock
6K
5K
4K
3K
2K
1K
0K
5
4
2
9
27
TOP 5 WAREHOUSES


Select For Top Warehouse
5
Warehouse / sku ID Safety Stock
5
Select For Top Product Chart
Safety Stock Chart
Safety Stock
600
500
400
300
200
100
0
d3e31fdd6e
e237f26793
623d0a582a
068f4481b3
c98d32ff09
TOP 5 PRODUCTS

Warehouse & Product Dashboard

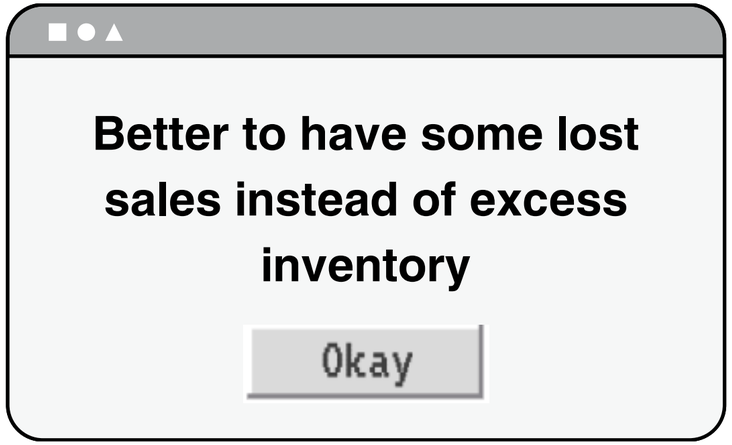
Select Warehouse:	1
Select Product:	068f4481b3
Safety Stock:	7
Order Up To Level:	22
Expected Sales:	3
Expected Loss Sales:	0
Expected Excess Inventory:	4
Total Cost:	$284
Cost Of Lost Sales:	$6
Cost Of Excess Inventory:	$279


Warehouse & Product Dashboard
Select Warehouse:
5
1
2
3
4
5
6
7
8
9
10
11
12
Select Product:
068f4481b3
Safety Stock:
237
Order Up To Level:
795
Expected Sales:
112
Expected Loss Sales:
2
Expected Excess Inventory:
125
Total Cost:
$10,069
Cost Of Lost Sales:
$206
Cost Of Excess Inventory:
$9,863


Warehouse & Product Dashboard
Select Warehouse:
5
Select Product:
068f4481b3
00cc0c688c
01c9d91829
027604c03a
067b673f2b
068f4481b3
0867a302b3
0aa7e6b035
0b16a50488
0b2fd9f253
0bfcedf96d
0d195bc9e8
0e0989fb7e
Safety Stock:
Order Up To Level:
Expected Sales:
Expected Loss Sales:
2
Expected Excess Inventory:
125
Total Cost:
$10,069
Cost Of Lost Sales:
$206
Cost Of Excess Inventory:
$9,863

Warehouse & Product Dashboard

Select Warehouse:	5
Select Product:	d3e31fdd6e
Safety Stock:	627
Order Up To Level:	1,429
Expected Sales:	199
Expected Loss Sales:	5
Expected Excess Inventory:	428
Total Cost:	$111
Cost Of Lost Sales:	$2
Cost Of Excess Inventory:	$108



Our Recommendations Will Improve Operational and Commercial Performance

- Better short-term planning
- Reduced backorders
- Faster delivery times
- Decrease operational costs
- Increased sales
- Handle unforeseen challenges

Over the next 6 years, JD.com can enhance inventory management, pricing, and logistics through AI, boosting efficiency and managing risks

2018

Utilize recommended models

2020

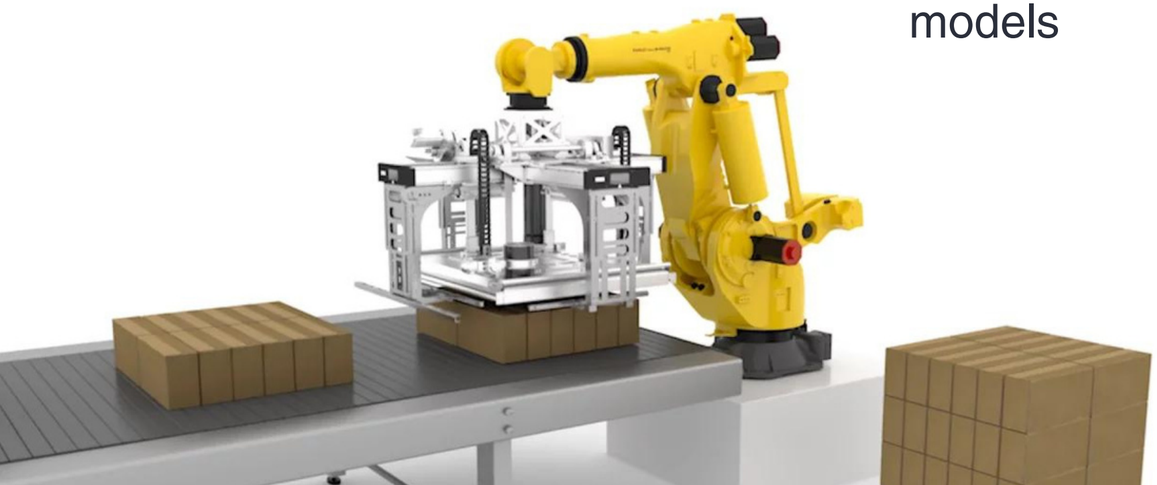
Introduce AI-powered demand forecasting models

2022

Invest in automation to streamline warehouse operations

2024

Utilize AI to achieve fully automated inventory replenishment and allocation



Next Steps: Additional Data Can Enhance Our Model's Performance for JD.com

1

Order & Inventory Data
Detailed order and inventory data

2

Geographic Data
Warehouse locations and customer addresses

3

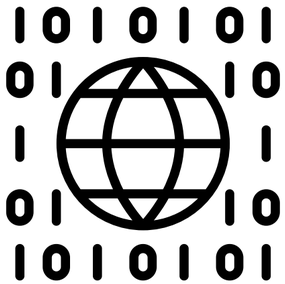
Cost Data
Logistics and warehouse operational expenses

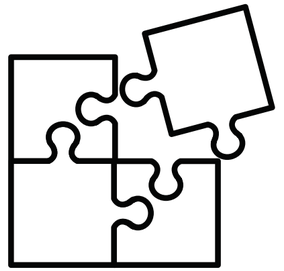
Relevance and Professional Impact

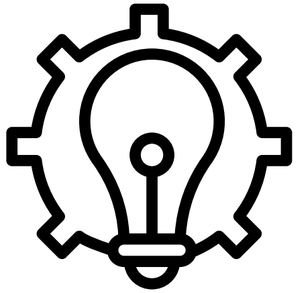
Bridging the gap between our capstone and our careers

Key Lessons Learned

- Working with incomplete datasets
- Utilizing team member skills
- Asking the right questions
- Project management skills
- Real-world operational problems







Thank You

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Appendix

Appendix:
Inventory Optimization Model

Appendix: General Information

The following series of calculations were used to fine-tune inventory levels and optimize the overall efficiency of the system.

- **Data Type:** Time Series
  - 31 days
  - March, 2018
- **Software used for analysis:** R-Studio
- **Group by** functions were performed to get individual warehouse and product optimization within the system.
- **Demand:** Assumed a normal distribution with the daily mean and standard deviation of quantity ordered
- **Z-Score:** qnorm() function on a 95% service rate

Appendix: Performance Metrics

The following series of calculations were used to fine-tune inventory levels and optimize the overall efficiency of the system.

- **Safety Stock:** Demand Mean + Stdev mean * Z score
- **Probabilty of Stock Out:** 1 - Service Rate
- **Expected Lost Sales:** Stdev mean * Standard loss function at the service rate
- **Expected Sales:** Demand Mean - Expected Lost Sales
- **Expected Excess Inventory:** Safety Stock - Expected Sales

Appendix: Lead Time & Cost Metrics

The following series of calculations were used to fine-tune inventory levels and optimize the overall efficiency of the system

- **Mean Lead Time Demand:** Demand Mean * Lead Time
- **Order-up-to-level:** Mean Lead Time Demand + Z Score * Stdev Lead Time Demand
- **Cost of Excess Inventory:** Holding Cost * Expected Excess Inventory
- **Cost of Lost Sales:** Goodwill Cost * Expected Lost Sales
- **Total Cost:** Cost of Excess Inventory + Cost of Lost Sales

Appendix:
R-Studio

Appendix: Finding Mean and Stdev Demand

Click the Github link for the full R-Script

```
# To find daily mean day 1 + day 2 + day 3 ... day 31 / 31

mean_std_outflow_day <- data %>%
  # Finding the total daily demand by warehouse and product
  group_by(order_date, dc_des, sku_ID) %>%
  summarize(sum_order_quantity = sum(quantity),
            avg_price = mean(original_unit_price)) %>%
  group_by(dc_des, sku_ID) %>%
  # Finding the average daily demand by warehouse and product
  summarize(demand_mean = mean(sum_order_quantity),
            stdev_mean = sd(sum_order_quantity),
            avg_price = mean(avg_price)) %>%
  rename(warehouse = dc_des)
## `summarise()` has grouped output by 'order_date', 'dc_des'.
You can override
## using the `.groups` argument.
## `summarise()` has grouped output by 'dc_des'. You can
override using the
## `.groups` argument.
```

Appendix: Optimization

Click the Github link for the full R-Script

```
# Change to your desired lead time
desired_lead_time = 7 #days

capacity_data <- mean_std_outflow_day %>%
        # Adding more scaling variables
  mutate(service_rate = 0.95,
         z_score = qnorm(service_rate),
         safety_stock = (demand_mean + stdev_mean * z_score),
         # Performance metrics
         probability_stockout = (1- service_rate),
         stand_loss_function = (-z_score*(1-pnorm(z_score)) + dnorm(z_score, 0, 1)),
         exp_lost_sales = (stdev_mean * stand_loss_function),
         exp_sales = (demand_mean - exp_lost_sales),
         exp_excess_inventory = (safety_stock - exp_sales),
         # Lead time metrics
         lead_time = desired_lead_time,
         stdev_lead_time = 0,
         mean_lead_time_demand = (demand_mean * lead_time),
         stdev_lead_time_demand = 0,
         order_up_to_level = (mean_lead_time_demand + z_score *
stdev_lead_time_demand),
         # Cost Optimization
         profit_margin = .13,
         cost = (avg_price / (1 + profit_margin)),
         holding_cost = (cost * .30),
         goodwill_cost = (cost * .50),
         cost_of_excess_inventory = (holding_cost * exp_excess_inventory),
         cost_of_lost_sales = (goodwill_cost * exp_lost_sales),
         total_cost = cost_of_excess_inventory + cost_of_lost_sales)
```

Link to Github

Appendix:
Data Constraints

Price Optimization: Regression Study

The following series of calculations were used to predict demand using an optimal price

- **Prepared Data for Regression:** Calculated the log of daily mean for quantity ordered, price, and discounts
- **Multivariate Regression: Y :** Log of Quantity Sold **X :** Log of Avg Original Unit Price, Log of Avg Total Discount

```
Call:
lm(formula = log_quantity_sold ~ log_avg_original_unit_price +
    log_avg_total_discount, data = regression_data)

Residuals:
   Min     1Q Median     3Q    Max
-3.437 -1.093  0.005  1.003  4.568

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                  6.01938    0.57884  10.399  < 2e-16 ***
log_avg_original_unit_price -0.62576    0.12254  -5.106 5.94e-07 ***
log_avg_total_discount       0.21883    0.07523   2.909   0.0039 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.418 on 291 degrees of freedom
  (8 observations deleted due to missingness)
Multiple R-squared:  0.1376,    Adjusted R-squared:  0.1316
F-statistic: 23.21 on 2 and 291 DF,  p-value: 4.448e-10
```

Price Optimization: Excel Solver

The following excel file was used to optimize price with the regression output and data using Excel Solver

Price Optimization for Multiplicative Demand Model

Step 1: Enter the sku_ID you wish to find the optimal price for

Product (sku_ID)	623d0a582a
final price	49.05521409

Step 2: Click on Cell D10, then go to Data > Solver > Solve

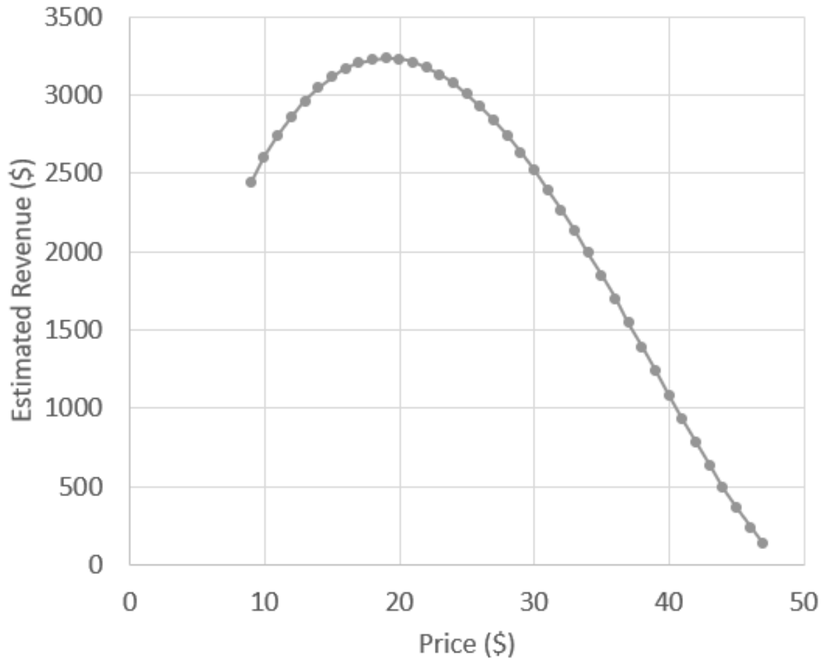
	Coefficients	Data Values	log(data values)
Intercept	6.02	1	1
Price	-0.05	19.021	2.945565165
Discount	1.50	0.612	-0.491

Step 3: Get Estimated Demand, Estimated Revenue, and a data table showing revenue as a function of price

Estimated Demand	170.063
Estimated Revenue	3234.833

Solver optimizes the price by maximizing revenue

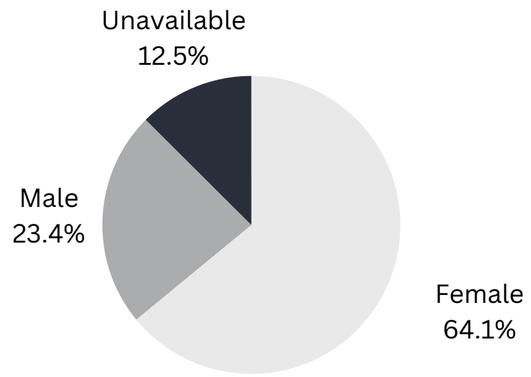
Data table showing revenue as a function of price		
Starting Price	9	
Step	1	
		3234.833
	9	2447.229647
	10	2604.19973



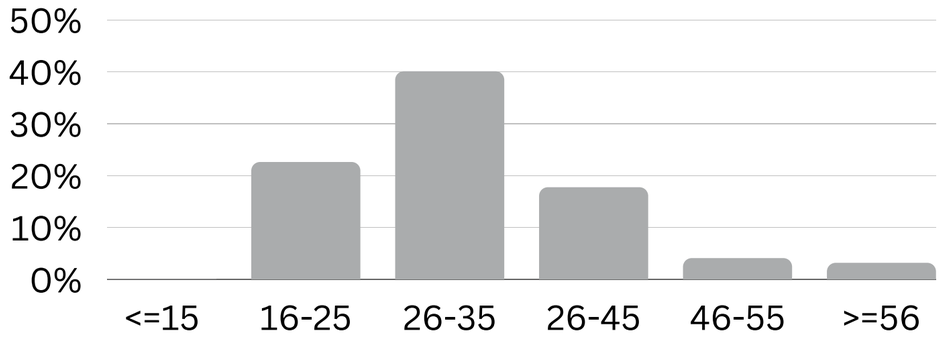
Appendix: Customer Demographics

The following series of information was used to understand and analyze customer behavior

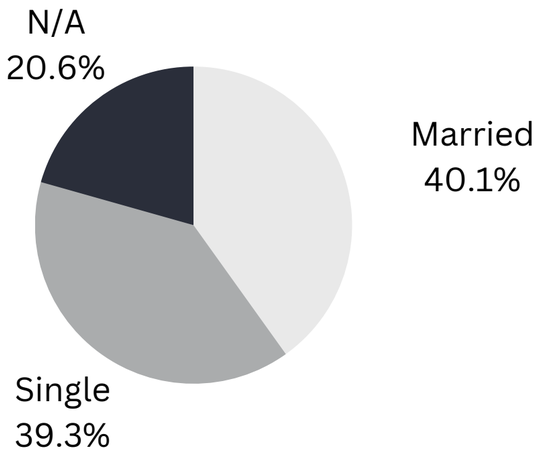
Gender



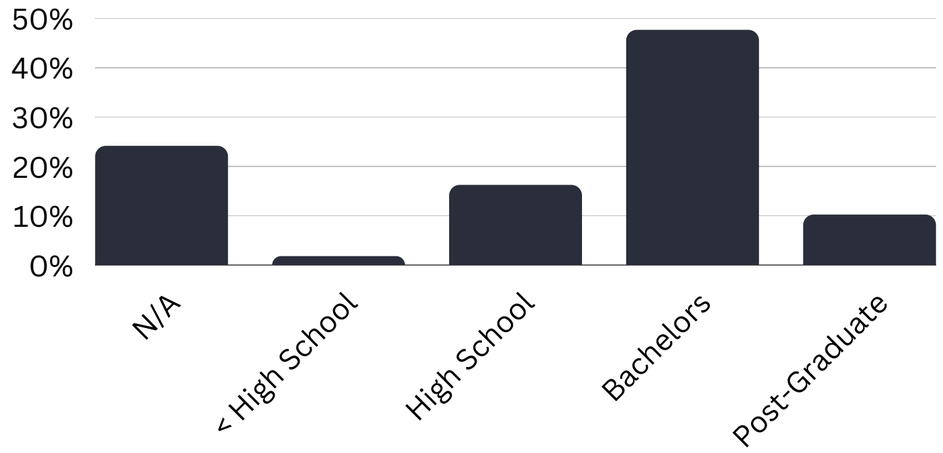
Age Range



Marital Status



Education



Appendix: Order Information

The following series of information was used to understand and analyze customer behavior for March 2018

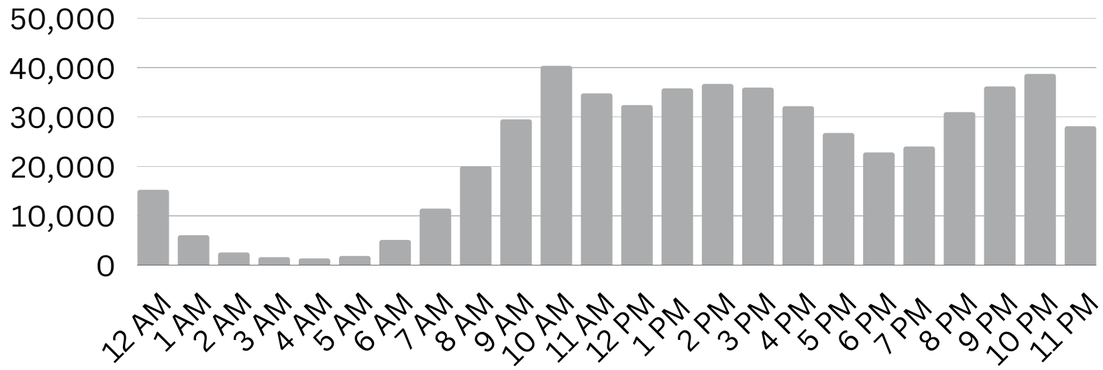
Average Order Value

$71.57

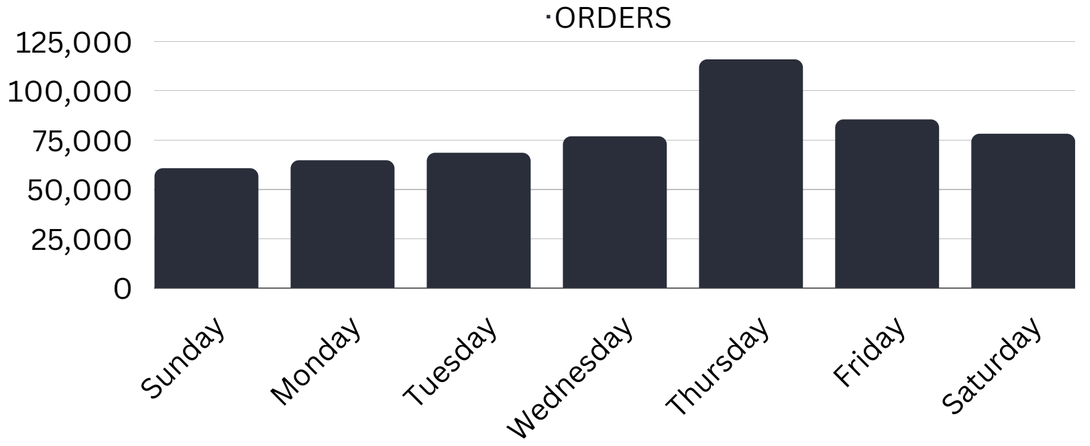
Units Per Transaction

1.22 Units

Peak Order Times



Orders for Days of Week



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