Optimizing Delivery Logistics for E-Commerce Warehouses

Rahul Dipak Talreja

Topic selection

Our topic is optimizing delivery logistics for e-commerce warehouses in the United States. We aim to reduce delivery costs while ensuring timely shipments, focusing on improving operational efficiency and customer satisfaction.

Importance:

- Enhance operational profitability
- Improve customer satisfaction

Objective of the problem

- Minimize total delivery costs while ensuring that shipments reach customers on time.
- Identify the factors contributing to delayed deliveries and improve delivery prediction accuracy.
- Develop recommendations for optimal shipment modes and logistics planning to enhance customer satisfaction.

Practical Implications of solving the problem

- **Cost Reduction:** Through optimized shipment mode and warehouse selection.
- **Improved Timeliness:** Higher customer satisfaction rates
- **Operational Efficiency:** Streamlined processes to handle higher order volumes.
- **Sustainability:** Reduced carbon footprint via route optimization.

Known and unknown variables

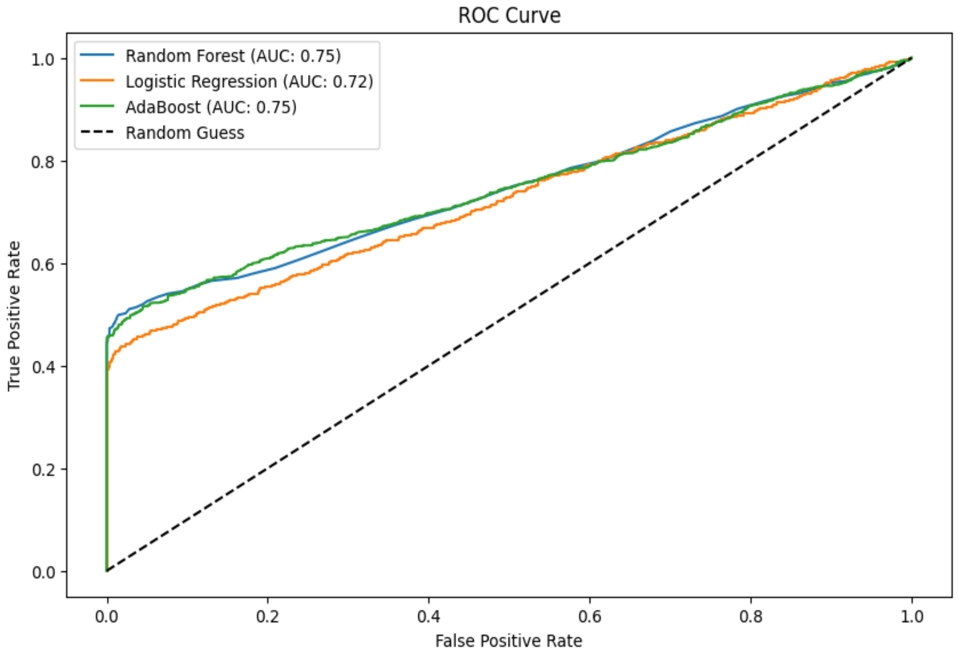
Known Variables:

- Warehouse block
- Mode of shipment
- Customer care calls
- Product importance
- Gender
- Discount offered
- Weight in grams
- Prior purchases
- Product importance

Unknown variables:

- Future delays in shipment
- Ideal shipment mode and warehouse allocation for cost reduction
- Factors leading to variability in customer satisfaction.

Predictive Models

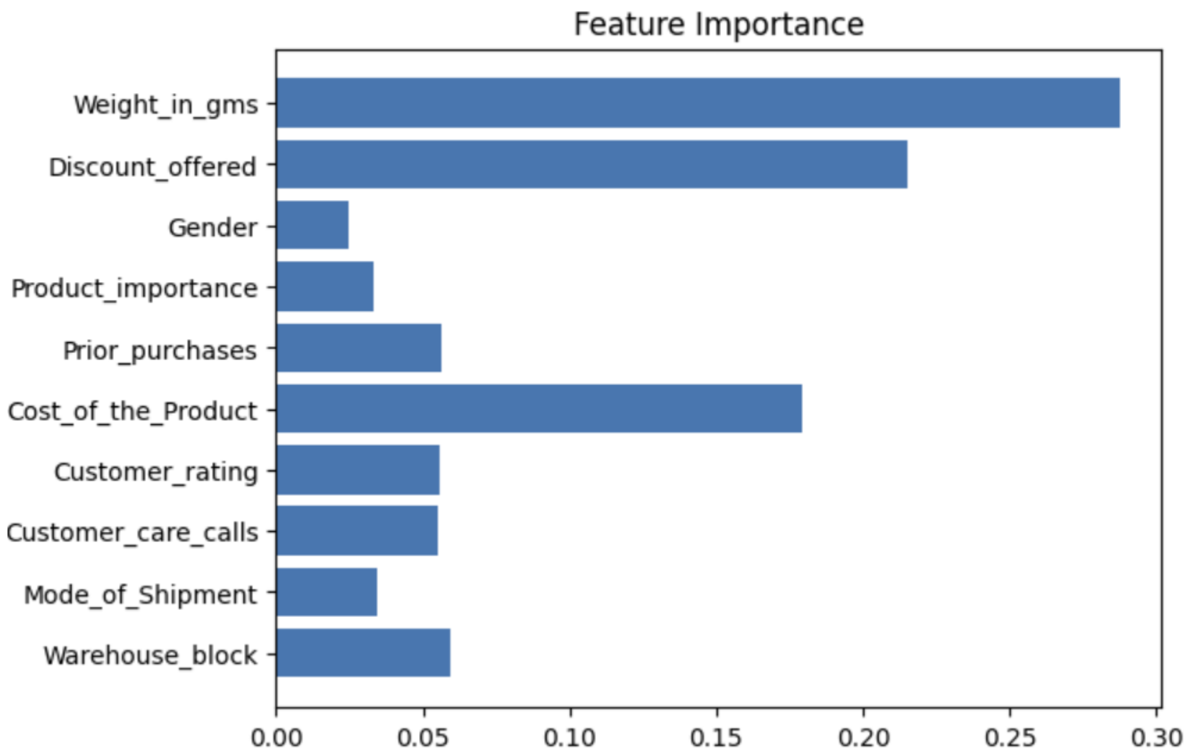



```
=== Random Forest Evaluation ===
Accuracy: 0.6659090909090909
AUC: 0.7464992829469808
              precision    recall  f1-score   support

           0       0.57      0.70      0.63       895
           1       0.76      0.64      0.69      1305

    accuracy                           0.67      2200
   macro avg       0.67      0.67      0.66      2200
weighted avg       0.68      0.67      0.67      2200
```

```
=== AdaBoost Evaluation ===
Accuracy: 0.6859090909090909
AUC: 0.7469355080374152
              precision    recall  f1-score   support

           0       0.59      0.78      0.67       895
           1       0.81      0.62      0.70      1305

    accuracy                           0.69      2200
   macro avg       0.70      0.70      0.69      2200
weighted avg       0.72      0.69      0.69      2200
```

```
=== Logistic Regression Evaluation ===
Accuracy: 0.6372727272727273
AUC: 0.7248605492412081
              precision    recall  f1-score   support

           0       0.56      0.54      0.55       895
           1       0.69      0.70      0.70      1305

    accuracy                           0.64      2200
   macro avg       0.62      0.62      0.62      2200
weighted avg       0.64      0.64      0.64      2200
```

Feature Importance (Random Forest)



Prescriptive Analytics

Formulating LP model

- **Decision Variables:**

Air units shipped : X_1=C2

Ship Units Shipped: X_2=C3

Road Units Shipped: X_3=C4

Objective Function: Min**:** $10X_1+5X_2+2X_3$

Total Demand:

$X_1+x_2+x_3 = 700$

Capacity Constraints:

Air: $x_1 \leq 100$

Ship: $x_2 \leq 300$

Road: $x_3 \leq 500$

Non-negativity Constraint: $X_1+x_2+x >= 0$

Optimal Solution

Air Units Shipped: 0
Ship Units Shipped: 200
Road Units Shipped: 500

The optimal solution indicates that to minimize shipping costs while satisfying the constraints, it is best to ship:

- All **200 units** by ship, due to its lower cost per unit compared to air.
- All **500 units** by road, which also has a lower cost and meets capacity requirements.
- No units should be shipped by air as it does not provide a cost advantage in this scenario.

Sensitivity Analysis

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
C2	Air Units shipped	0	5	10	1E+30	5
C3	Ship Units shipped	200	0	5	5	3
C4	Road Units shipped	500	-3	2	3	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
G3	Ship Total units shipped	700	5	700	100	200

- **Air Mode:** Too expensive unless its cost per unit decreases to $5.
- **Ship Mode:** Currently cost-effective but could lose priority if its cost increases above $10.
- **Road Mode:** Most cost-effective; can tolerate up to a $5 per unit cost before being replaced by ship or air.
- **Demand Constraint:** Increasing demand raises costs by $5 per additional unit.

Trade-off Analysis and Recommendations

Trade-Off Analysis

- **Cost vs. Shipment Capacity:**
  Using road maximizes cost-efficiency, but relaxing the capacity constraints of ship or air could alter the solution.

- **Flexibility vs. Cost:**
  Increasing the allowable capacity of ship might allow for lower total costs if road costs rise.

Recommendations

- **Dynamic Costs:** Explore seasonal changes in shipment costs.

- **Environmental Impact:** Introduce carbon emissions as a factor to evaluate sustainability trade-offs.

- **Multi-Period Demand:** Extend the model for multiple time periods to capture demand fluctuations.

Thank you