DD Case Study Datasets

Import lib & files

In [29]:

```
import pandas as pd
import numpy as np

import matplotlib.pyplot as plt
import seaborn as sns

df = pd.read_csv('Analytics_Sample_Data_rsc.csv')
```

In [30]:

```
df.columns
```

Out[30]:

```
Index(['Customer_placed_order_datetime',
       'Placed_order_with_restaurant_datetime',
       'Driver_at_restaurant_datetime', 'Delivered_to_consumer_datetime',
       'Driver_ID', 'Restaurant_ID', 'Consumer_ID', 'Is_New',
       'Delivery_Region', 'Is_ASAP', 'Order_total', 'Amount_of_discount',
       'Amount_of_tip', 'Refunded_amount'],
      dtype='object')
```

Data Cleaning

missing value check

In [31]:

```
for col in df.columns:
    print(col, df[col].isna().sum(), "missing")
```

```
Customer_placed_order_datetime 0 missing
Placed_order_with_restaurant_datetime 40 missing
Driver_at_restaurant_datetime 4531 missing
Delivered_to_consumer_datetime 0 missing
Driver_ID 0 missing
Restaurant_ID 0 missing
Consumer_ID 0 missing
Is_New 0 missing
Delivery_Region 26 missing
Is_ASAP 0 missing
Order_total 0 missing
Amount_of_discount 0 missing
Amount_of_tip 0 missing
Refunded_amount 0 missing
```

remove duplicate rows

In [32]:

```
print("original records #: ", len(df))
df = df.drop_duplicates()
print("after deleting records: ", len(df))
```

```
original records #:  18078
after deleting records:  18078
```

time format conversion

In [33]:

```
def hms_to_sec(val):
    """transfer HH:MM:SS into seconds"""
    if pd.isna(val):
        return np.nan
    time_str = str(val).split()[-1]
    h, m, s = map(int, time_str.split(":"))
    return h*3600 + m*60 + s

def time_diff(t1, t2):
    """compute time difference in seconds, consider the case across midnight"""
    if pd.isna(t1) or pd.isna(t2):
        return np.nan
    return t2 - t1 if t2 >= t1 else t2 + 86400 - t1


df['order_to_rest'] = df.apply(
    lambda r: time_diff(hms_to_sec(r['Customer_placed_order_datetime']),
                        hms_to_sec(r['Placed_order_with_restaurant_datetime'])),
    axis=1
)

df['rest_to_csmer'] = df.apply(
    lambda r: time_diff(hms_to_sec(r['Driver_at_restaurant_datetime']),
                        hms_to_sec(r['Delivered_to_consumer_datetime'])),
    axis=1
)

df['total_delivery_time'] = df.apply(
    lambda r: time_diff(hms_to_sec(r['Customer_placed_order_datetime']),
                        hms_to_sec(r['Delivered_to_consumer_datetime'])),
    axis=1
)

df['dasher_waiting_time'] = df.apply(
    lambda r: time_diff(hms_to_sec(r['Placed_order_with_restaurant_datetime']),
                        hms_to_sec(r['Driver_at_restaurant_datetime'])),
    axis=1
)

df['dasher_delivery_time'] = df.apply(
    lambda r: time_diff(hms_to_sec(r['Driver_at_restaurant_datetime']),
                        hms_to_sec(r['Delivered_to_consumer_datetime'])),
    axis=1
)

# Time logic check
viol1 = (df['total_delivery_time'] < df['rest_to_csmer'])  #
viol2 = (df['total_delivery_time'] < df['order_to_rest'])  #
viol3 = (df['total_delivery_time'] < df['dasher_waiting_time'])
viol4 = (df['total_delivery_time'] < df['dasher_delivery_time'])
# delete the violations
print('before delete: ',len(df))
df = df[~(viol1 | viol2 | viol3 | viol4)]
df = df[
    (df['total_delivery_time'] <= 8*3600) & # total delivery time not possible exceed 8h
    (df['order_to_rest'] <= 2*3600)  # order to restaurant time not possible exceed 2h
]
print('after delete: len(df)', len(df))
print(df[['order_to_rest','rest_to_csmer','total_delivery_time']].describe())
```

```
before delete:  18078
after delete: len(df) 17335
       order_to_rest  rest_to_csmer  total_delivery_time
count   17335.000000   12990.000000         17335.000000
mean      725.477819    1445.020939          3241.897375
std      1115.404946     630.176513          1566.323436
min         6.000000      39.000000           593.000000
25%        89.000000    1015.000000          2216.000000
50%       249.000000    1336.000000          2846.000000
75%       929.000000    1753.750000          3787.000000
max      7188.000000   10091.000000         21747.000000
```

Add new columns

In [34]:

```
df['original_order_total'] = df['Order_total'] + df['Amount_of_discount']
df["Has_Discount"] = (df["Amount_of_discount"] > 0).astype(int)
df['Refund?'] = (df['Refunded_amount'] > 0).astype(int)
df["order_day"] = df["Customer_placed_order_datetime"].str.split().str[0].astype(int)
```

Customer indicators

In [35]:

```
# adoption Rate
adoption_rate = (df['Amount_of_discount'] > 0).sum() / len(df) * 100
print(f"❤️Adoption Rate: {adoption_rate:.2f}%")
# Customer-paid Order Value (AOV)
aov_w_discount = df[df['Amount_of_discount'] > 0]['Order_total'].mean()
aov_w0_discount = df[df['Amount_of_discount'] == 0]['Order_total'].mean()
print(f"❤️Customer-paid: AOV with discount: {aov_w_discount:.2f}, AOV without discount: {aov_w0_discount:.2f}")
# Gross AOV
gaov_w_discount = df[df['Amount_of_discount'] > 0]['original_order_total'].mean()
gaov_w0_discount = df[df['Amount_of_discount'] == 0]['original_order_total'].mean()
print(f"❤️Gross AOV with discount: {gaov_w_discount:.2f}, Gross AOV without discount: {gaov_w0_discount:.2f}")
# Incremental lift
incremental_lift = (gaov_w_discount - gaov_w0_discount) / gaov_w0_discount * 100
print(f"❤️Incremental lift: {incremental_lift:.2f}%")
# refund rate
refund_rate_w_discount = (df[df['Amount_of_discount'] > 0]['Refunded_amount'] > 0).sum() / len(df[df['Amount_of_discount'] > 0]
refund_rate_w0_discount = (df[df['Amount_of_discount'] == 0]['Refunded_amount'] > 0).sum() / len(df[df['Amount_of_discount'] ==
print(f"❤️Refund rate with discount: {refund_rate_w_discount:.2f}%, Refund rate without discount: {refund_rate_w0_discount:.2f}
# new customer rate
return_customer_rate_w_discount = (df[df['Amount_of_discount'] > 0]['Is_New'] == 0).sum() / len(df) * 100
```

```
return_customer_rate_w0_discount = (df[df['Amount_of_discount'] == 0]['Is_New'] == 0).sum() / len(df) * 100
print(f"❤️return customer rate with discount: {return_customer_rate_w_discount:.2f}%, return customer rate without discount: {r
# total delivery time
total_delivery_time_w_discount = df[df['Amount_of_discount'] > 0]['total_delivery_time'].mean()
total_delivery_time_w0_discount = df[df['Amount_of_discount'] == 0]['total_delivery_time'].mean()
print(f"❤️Total delivery time with discount: {total_delivery_time_w_discount:.2f} seconds, Total delivery time without discount
```

```
❤️Adoption Rate: 15.28%
❤️Customer-paid: AOV with discount: 45.75, AOV without discount: 49.53
❤️Gross AOV with discount: 54.59, Gross AOV without discount: 49.53
❤️Incremental lift: 10.20%
❤️Refund rate with discount: 2.53%, Refund rate without discount: 2.66%
❤️return customer rate with discount: 11.56%, return customer rate without discount: 69.07%
❤️Total delivery time with discount: 3158.94 seconds, Total delivery time without discount: 3256.85) seconds
```

Dasher indicators

In [36]:

```
# Tip rate  = mean(Amount_of_tip / Order_total)
tip_rate_w_discount = df[df['Amount_of_discount'] > 0]['Amount_of_tip'].sum() / df[df['Amount_of_discount'] > 0]['original_orde
tip_rate_w_discount_discounted_order_total = df[df['Amount_of_discount'] > 0]['Amount_of_tip'].sum() / df[df['Amount_of_discoun
tip_rate_w0_discount = df[df['Amount_of_discount'] == 0]['Amount_of_tip'].sum() / df[df['Amount_of_discount'] == 0]['original_o
print(f"❤️Tip rate with discount: {tip_rate_w_discount:.5f}, Tip rate with dict (dicounted order):{tip_rate_w_discount_discount
# mean tip amount
mean_tip_w_discount = df[df['Amount_of_discount'] > 0]['Amount_of_tip'].mean()
mean_tip_w0_discount = df[df['Amount_of_discount'] == 0]['Amount_of_tip'].mean()
print(f"❤️Mean tip amount with discount: {mean_tip_w_discount:.2f}, Mean tip amount without discount: {mean_tip_w0_discount:.2f
# average dasher waiting time
avg_dasher_waiting_time_w_discount = df[df['Amount_of_discount'] > 0]['dasher_waiting_time'].mean()
avg_dasher_waiting_time_w0_discount = df[df['Amount_of_discount'] == 0]['dasher_waiting_time'].mean()
print(f"❤️Average dasher waiting time with discount: {avg_dasher_waiting_time_w_discount:.2f} seconds, Average dasher waiting t
# average dasher delivery time
avg_dasher_delivery_time_w_discount = df[df['Amount_of_discount'] > 0]['dasher_delivery_time'].mean()
avg_dasher_delivery_time_w0_discount = df[df['Amount_of_discount'] == 0]['dasher_delivery_time'].mean()
print(f"❤️Average dasher delivery time with discount: {avg_dasher_delivery_time_w_discount:.2f} seconds, Average dasher deliver
```

```
❤️Tip rate with discount: 5.79528, Tip rate with dict (dicounted order):6.91532,Tip rate without discount: 6.91679
❤️Mean tip amount with discount: 3.16, Mean tip amount without discount: 3.43
❤️Average dasher waiting time with discount: 999.56 seconds, Average dasher waiting time without discount: 1086.68 seconds
❤️Average dasher delivery time with discount: 1453.83 seconds, Average dasher delivery time without discount: 1443.43 seconds
```

Platform indicators

In [37]:

```
df["Net_Revenue_Proxy"] = df["original_order_total"] - df["Amount_of_discount"] - df["Refunded_amount"]

summary = df.groupby("Has_Discount").agg(
    GOV=("original_order_total", "mean"),
    GMV=("Order_total", "mean"),
    Net_Revenue=("Net_Revenue_Proxy", "mean")
).reset_index()
print("numerical summary: ")
print(summary)

# --- 1. numerical values ---
platform_summary = df.groupby("Has_Discount").agg(
    GOV=("original_order_total", "sum"),
    GMV=("Order_total", "sum"),
    Discount_Spend=("Amount_of_discount", "sum"),
    Refund_Amount=("Refunded_amount", "sum"),
    Net_Revenue=("Net_Revenue_Proxy", "sum")
).reset_index()

# --- 2. ratios ---
platform_summary["Refund_Rate"] = platform_summary["Refund_Amount"] / platform_summary["GOV"]
platform_summary["Discount_Spend_%"] = platform_summary["Discount_Spend"] / platform_summary["GOV"]
platform_summary["Net_Revenue_Margin"] = platform_summary["Net_Revenue"] / platform_summary["GOV"]

print("ratio summary: ")
print(platform_summary[["Has_Discount", "Refund_Rate", "Discount_Spend_%", "Net_Revenue_Margin"]])
```

```
numerical summary: 
   Has_Discount        GOV        GMV  Net_Revenue
0             0  49.532375  49.532375    48.934204
1             1  54.586639  45.745525    45.333693
ratio summary: 
   Has_Discount  Refund_Rate  Discount_Spend_%  Net_Revenue_Margin
0             0     0.012076          0.000000            0.987924
1             1     0.007545          0.161965            0.830491
```

EDA

In [38]:

```
print(df.columns)
```

```
Index(['Customer_placed_order_datetime',
       'Placed_order_with_restaurant_datetime',
       'Driver_at_restaurant_datetime', 'Delivered_to_consumer_datetime',
       'Driver_ID', 'Restaurant_ID', 'Consumer_ID', 'Is_New',
       'Delivery_Region', 'Is_ASAP', 'Order_total', 'Amount_of_discount',
       'Amount_of_tip', 'Refunded_amount', 'order_to_rest', 'rest_to_csmer',
       'total_delivery_time', 'dasher_waiting_time', 'dasher_delivery_time',
       'original_order_total', 'Has_Discount', 'Refund?', 'order_day',
       'Net_Revenue_Proxy'],
      dtype='object')
```

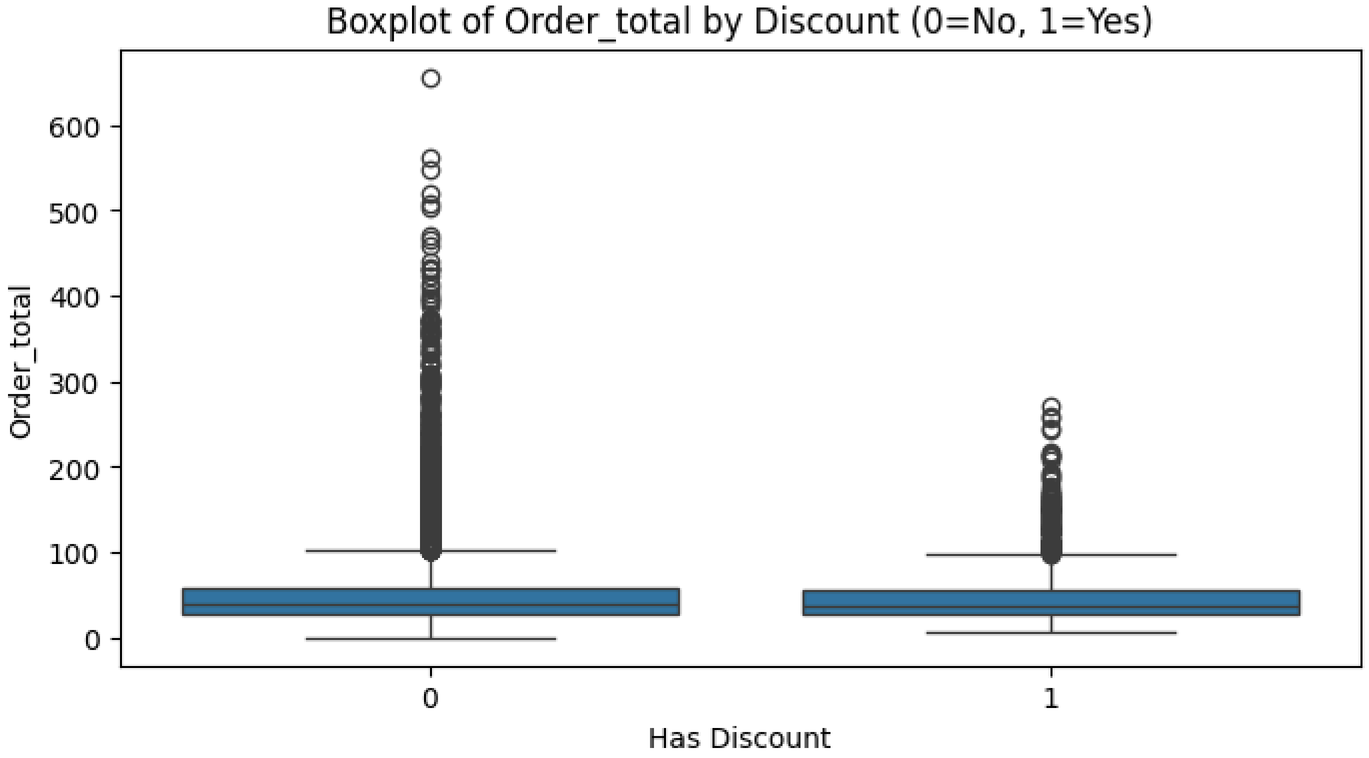
In [39]:

```python
ignore_columns = ['Customer_placed_order_datetime',
       'Placed_order_with_restaurant_datetime',
       'Driver_at_restaurant_datetime', 'Delivered_to_consumer_datetime',
       'Driver_ID', 'Restaurant_ID', 'Consumer_ID']

# ignore the columns not related to analysis
df_viz = df.drop(columns=ignore_columns, errors='ignore')

df_viz['Has_Discount'] = (df_viz['Amount_of_discount'] > 0).astype(int)
df_viz['Refund?'] = (df_viz['Refunded_amount'] > 0).astype(int)
```

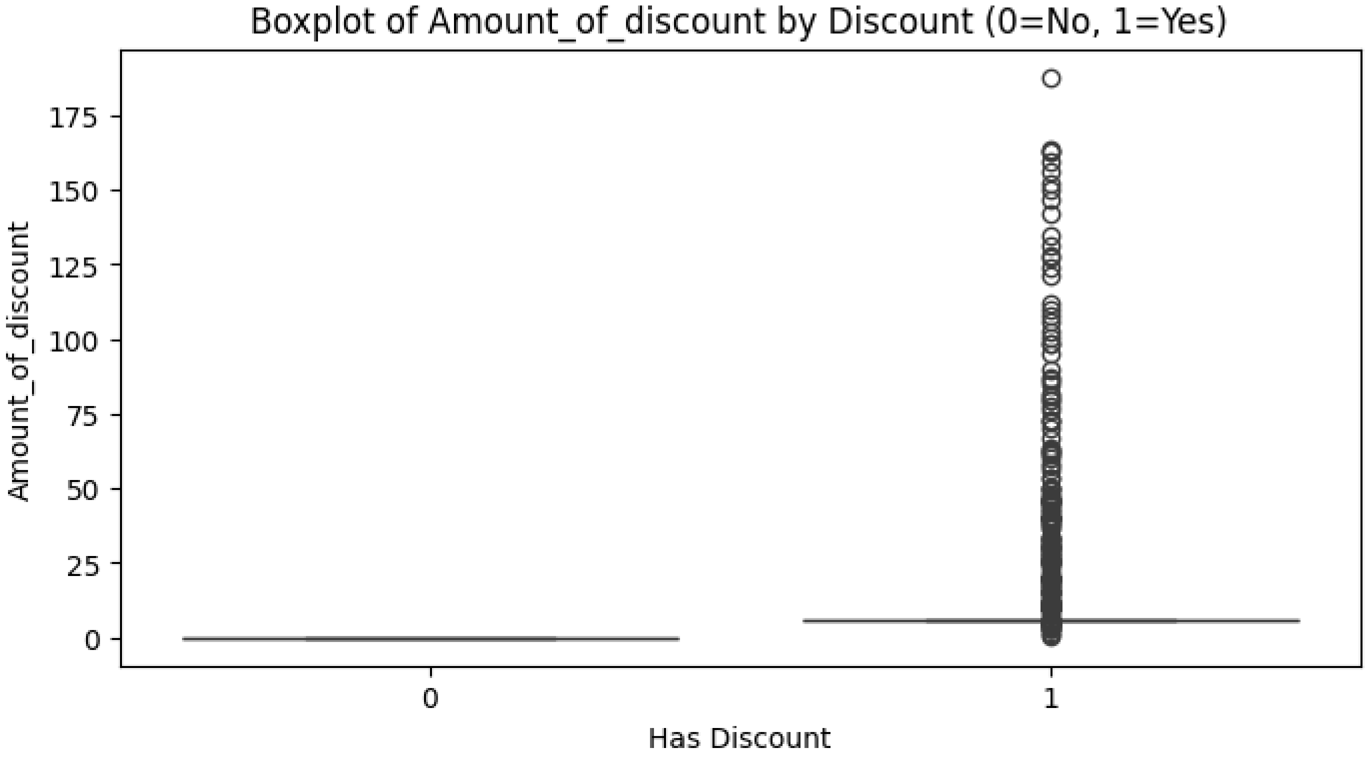
Numerical Values

In [40]:

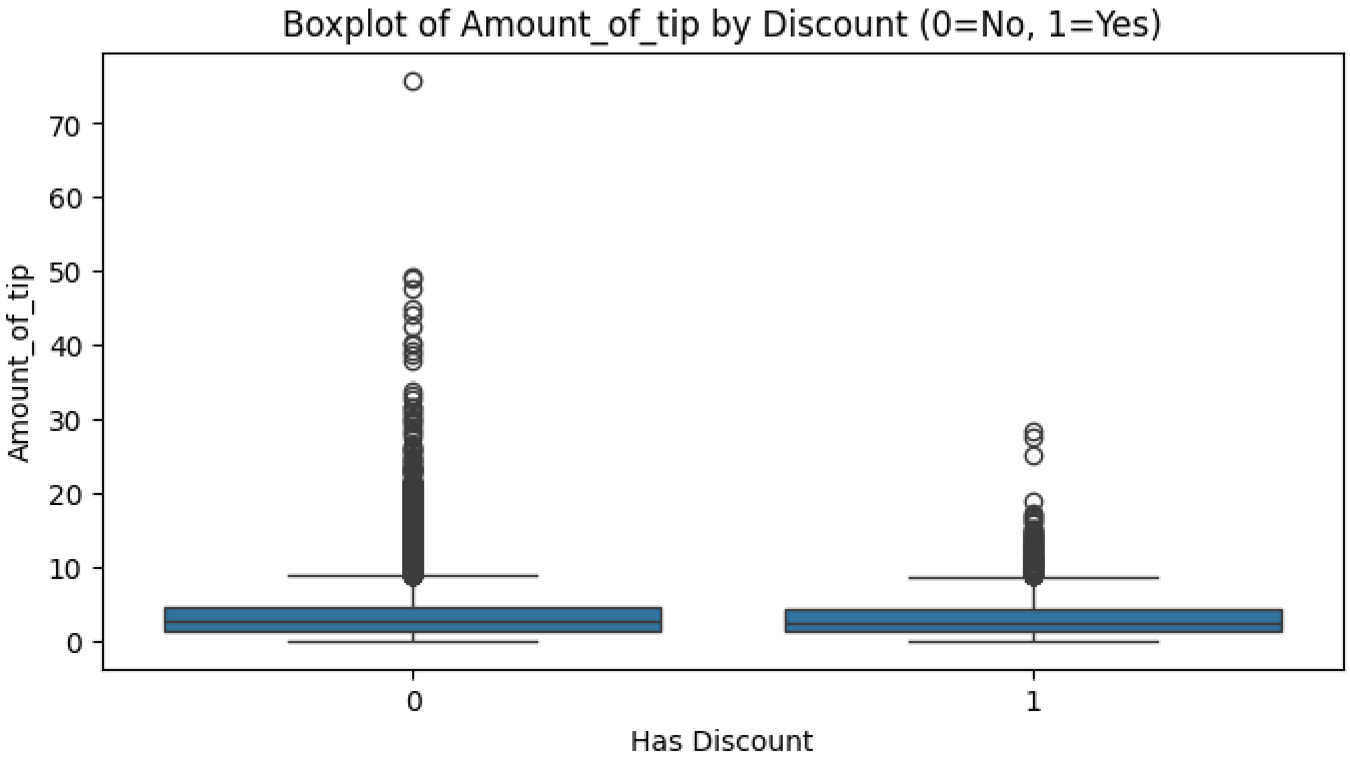
```python
# Boxplots for numerical columns
numeric_cols = df_viz.select_dtypes(include=['int64', 'float64']).columns

for col in numeric_cols:
    if col not in ignore_columns:
        plt.figure(figsize=(8,4))
        sns.boxplot(x="Has_Discount", y=col, data=df_viz)
        plt.title(f"Boxplot of {col} by Discount (0=No, 1=Yes)")
        plt.xlabel("Has Discount")
        plt.ylabel(col)
        plt.show()
```



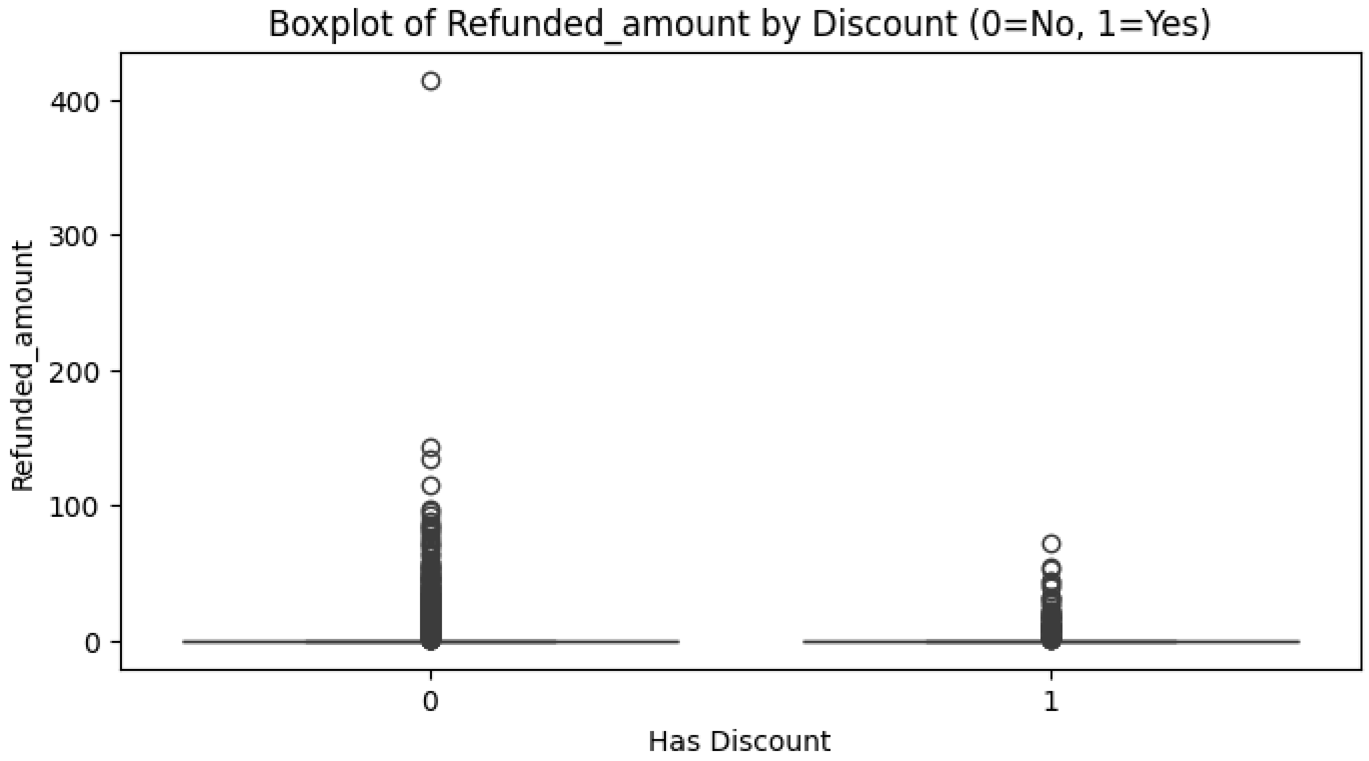
Boxplot of Order_total by Discount (0=No, 1=Yes)



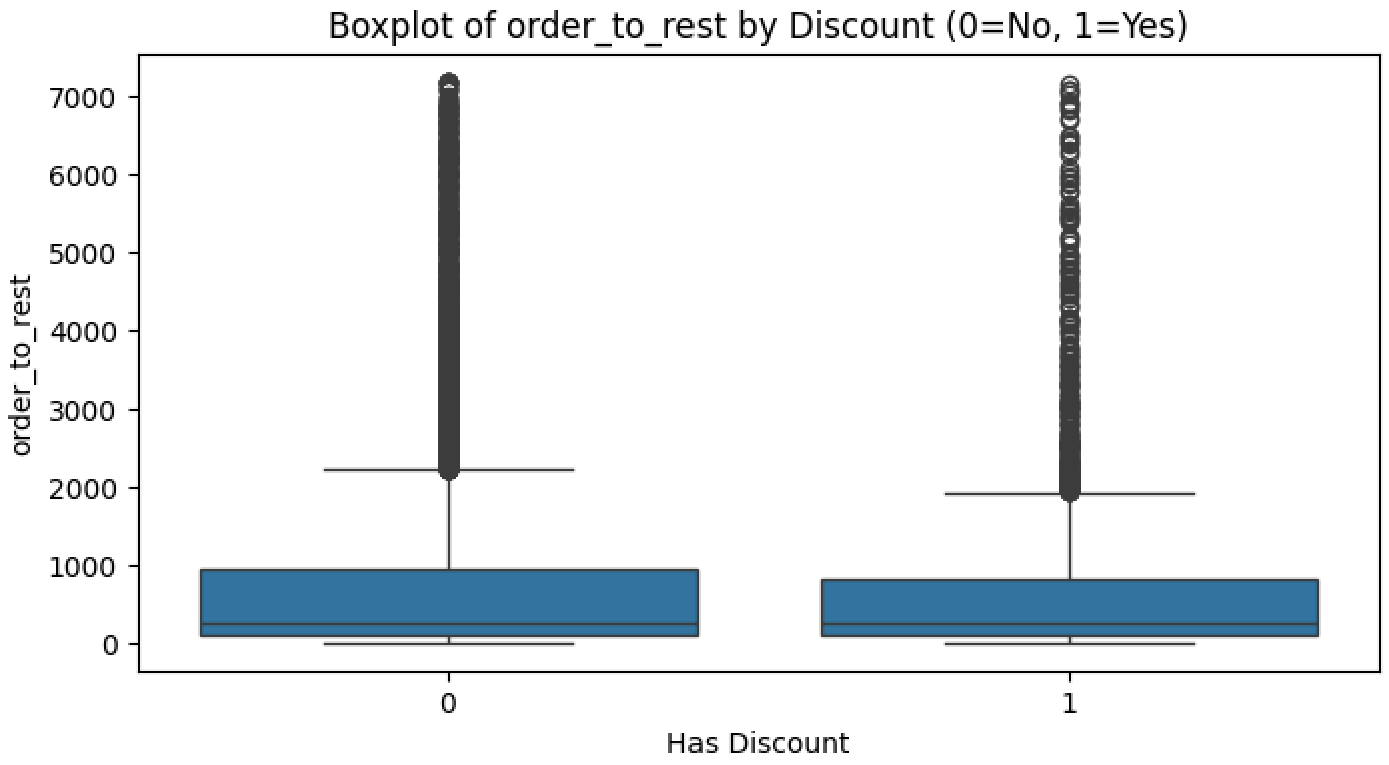
Boxplot of Amount_of_discount by Discount (0=No, 1=Yes)

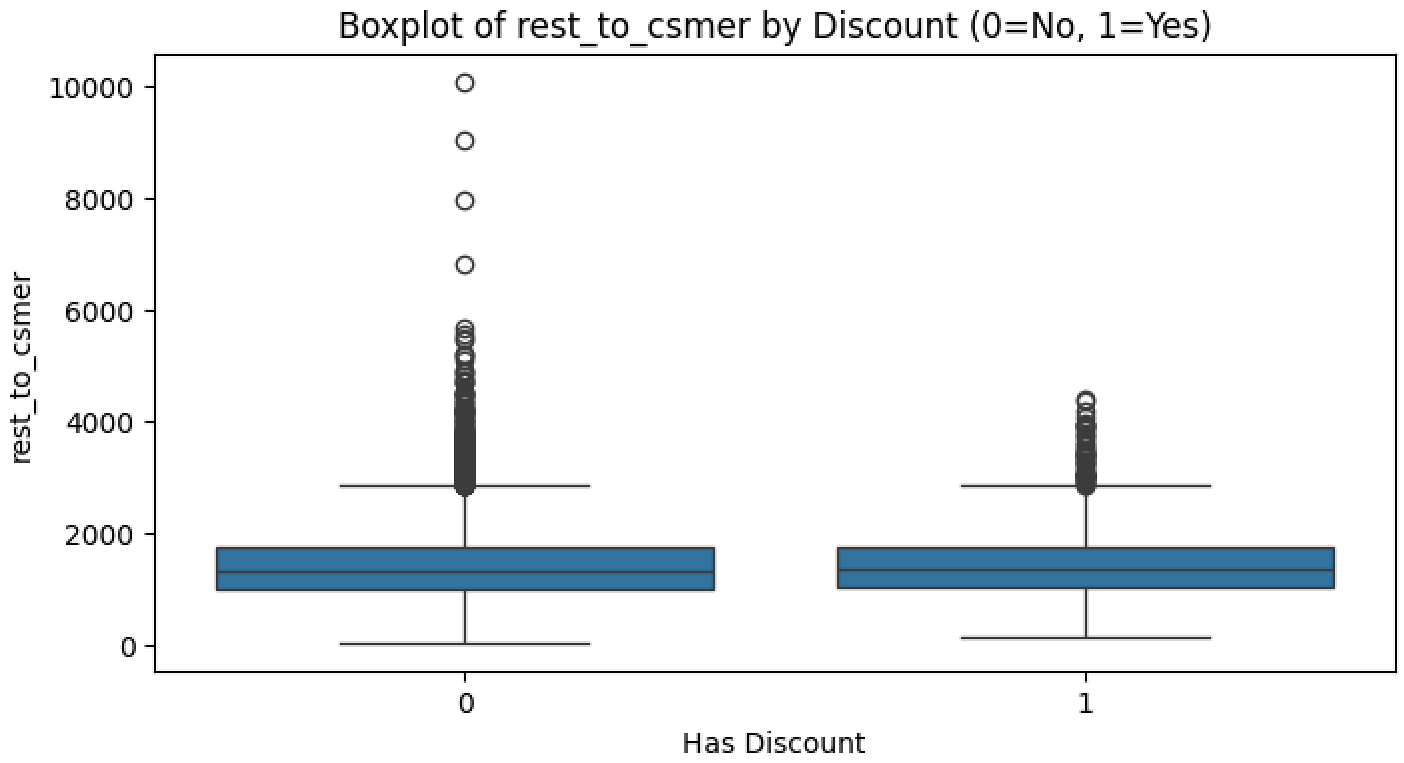


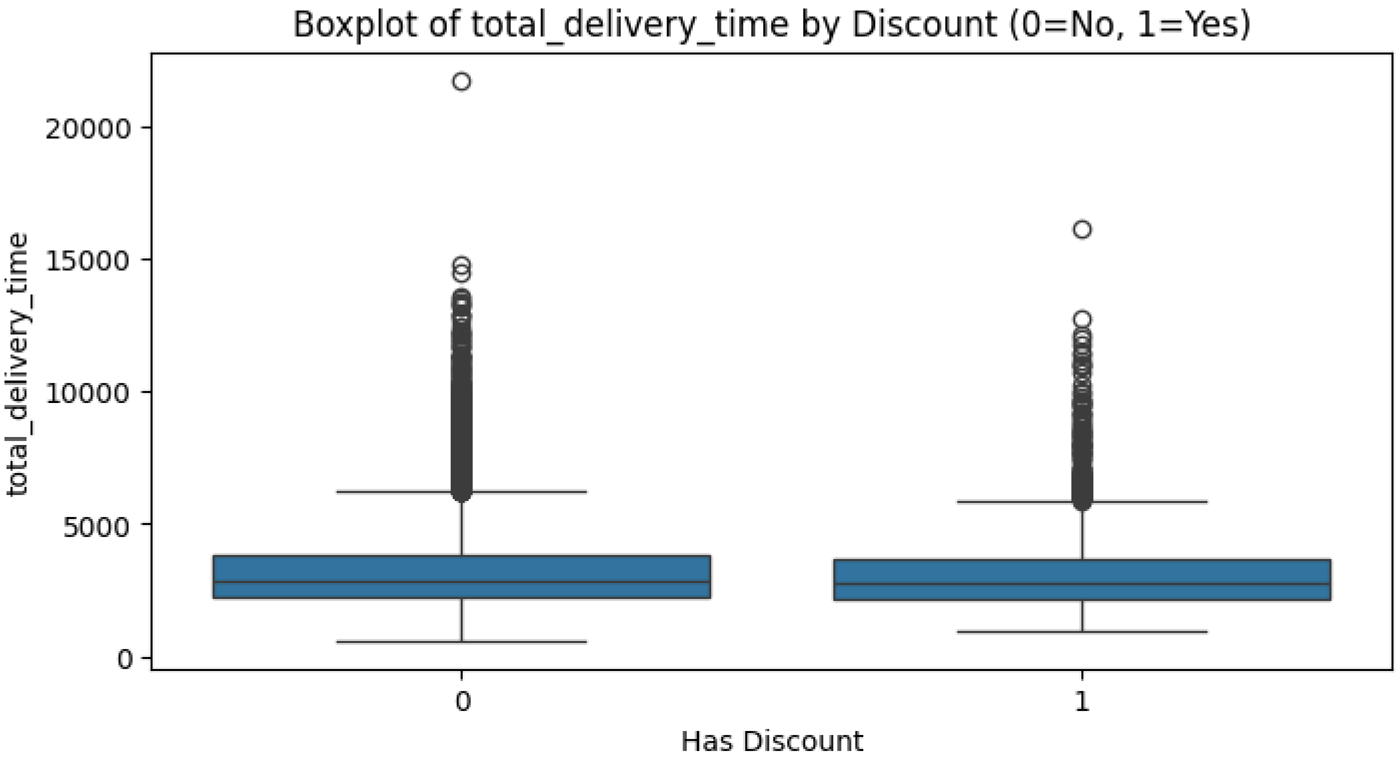
Boxplot of Amount_of_tip by Discount (0=No, 1=Yes)

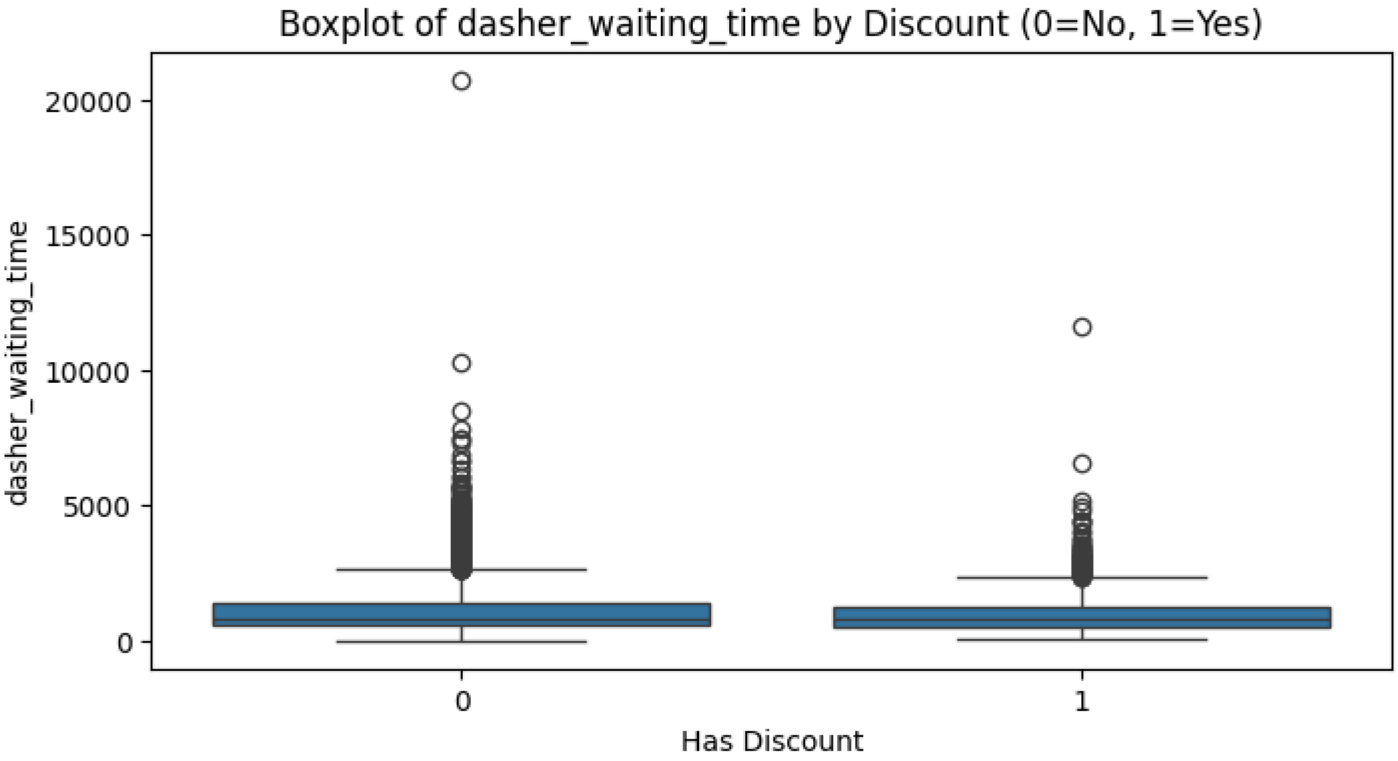


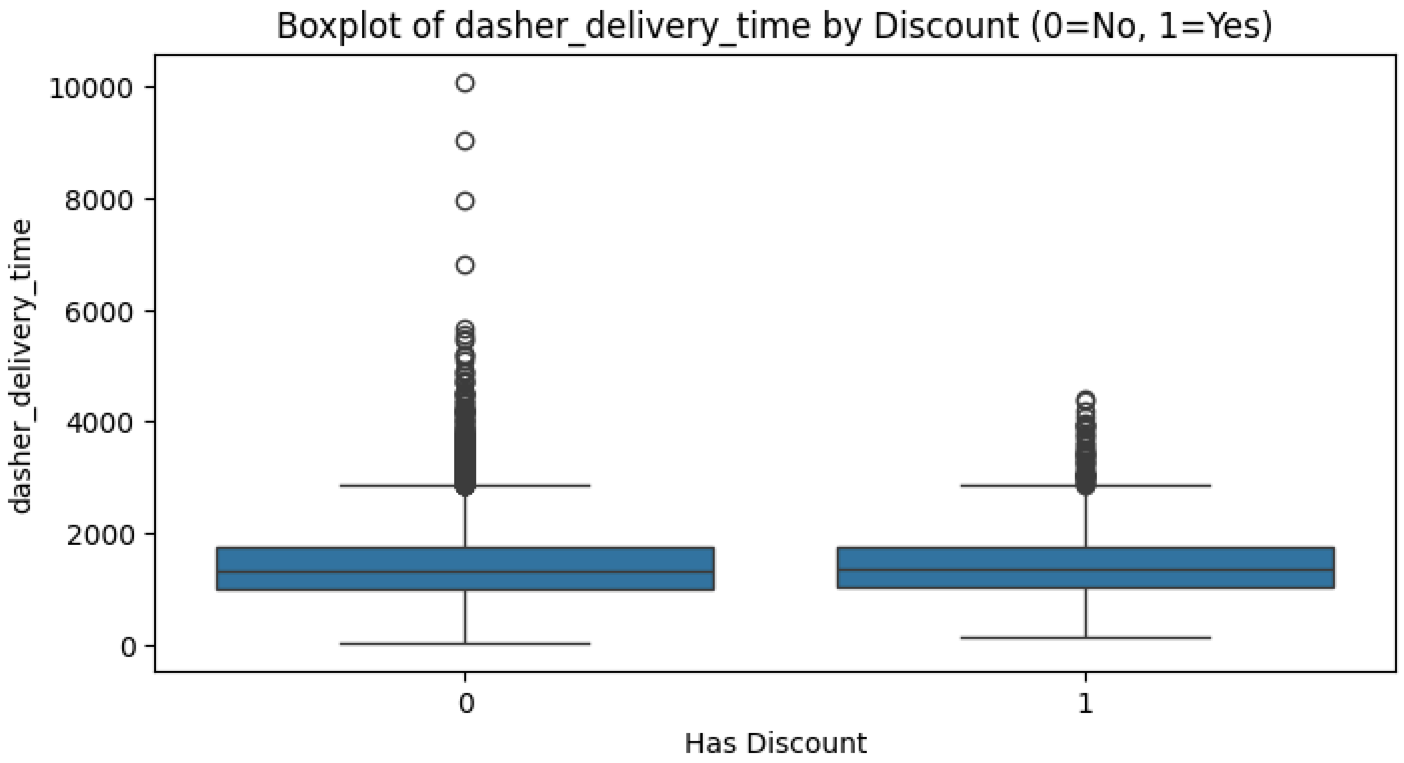
Boxplot of Refunded_amount by Discount (0=No, 1=Yes)

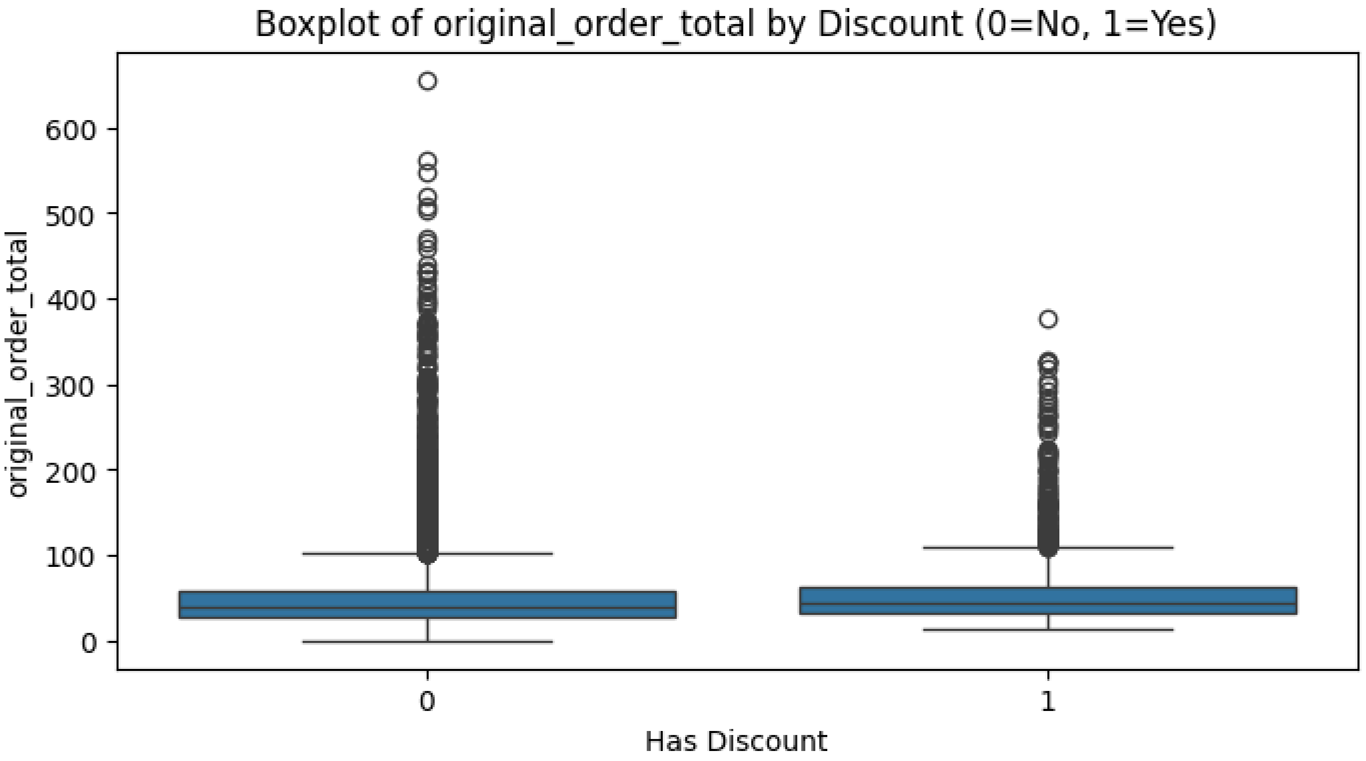

Boxplot of order_to_rest by Discount (0=No, 1=Yes)
order_to_rest
7000
6000
5000
4000
3000
2000
1000
0
0
1
Has Discount

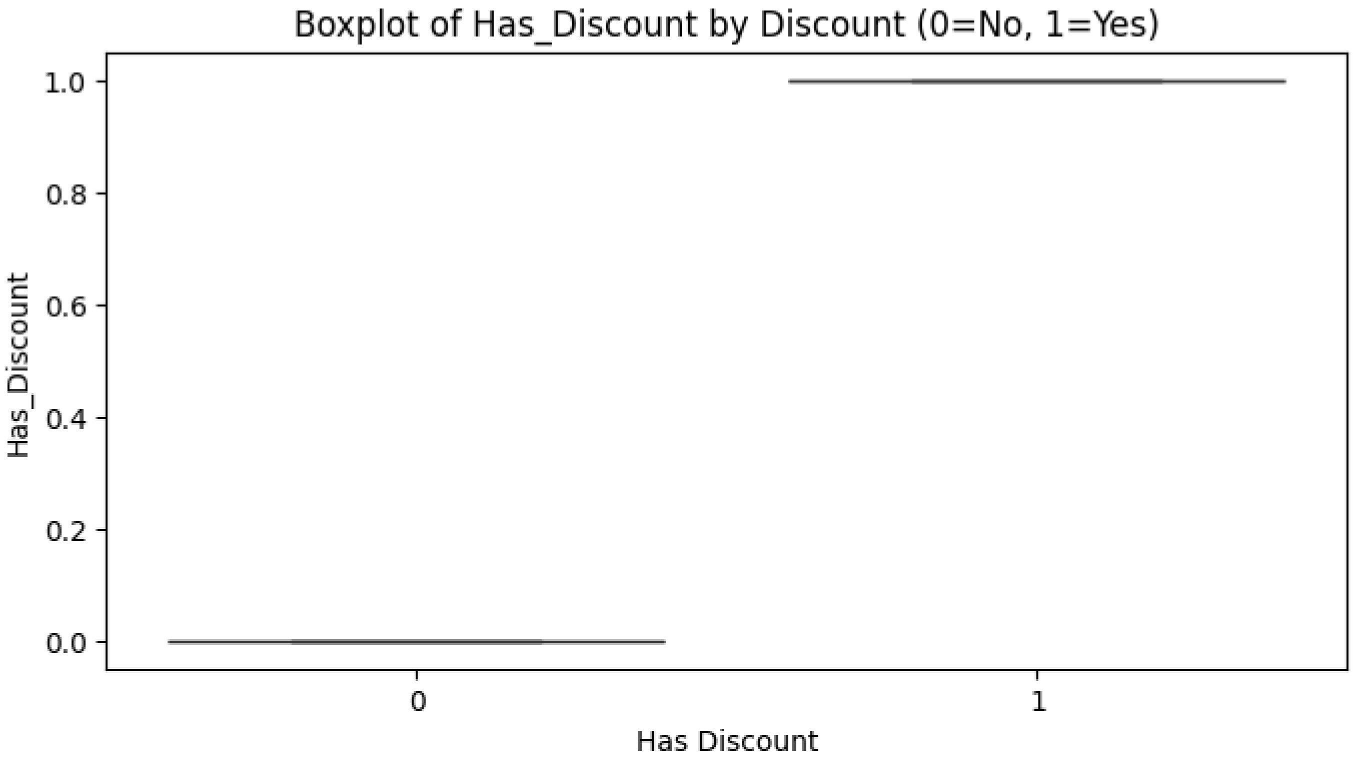

Boxplot of rest_to_csmer by Discount (0=No, 1=Yes)
rest_to_csmer
10000
8000
6000
4000
2000
0
0
1
Has Discount

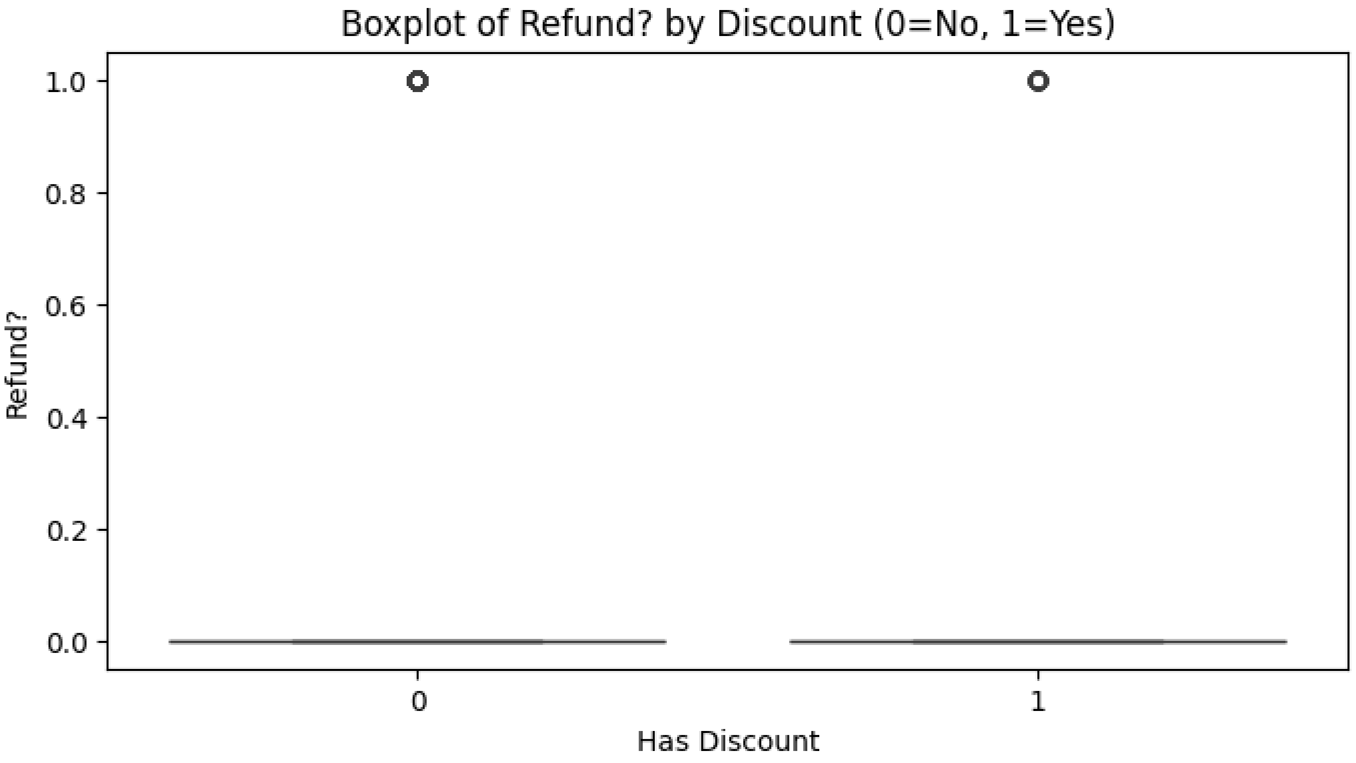

Boxplot of total_delivery_time by Discount (0=No, 1=Yes)
total_delivery_time
0
5000
10000
15000
20000
0
1
Has Discount

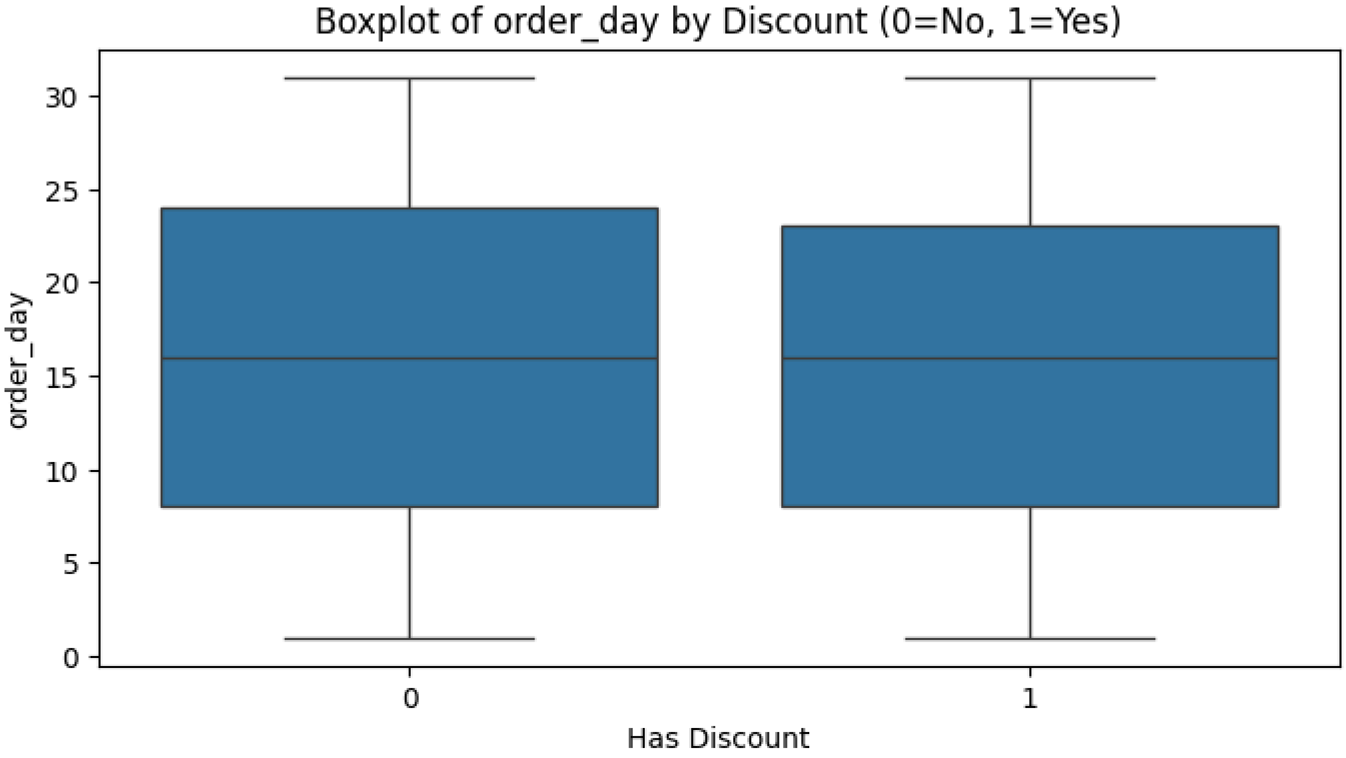

Boxplot of dasher_waiting_time by Discount (0=No, 1=Yes)
dasher_waiting_time
0
5000
10000
15000
20000
0
1
Has Discount


Boxplot of dasher_delivery_time by Discount (0=No, 1=Yes)
dasher_delivery_time
10000
8000
6000
4000
2000
0
0
1
Has Discount

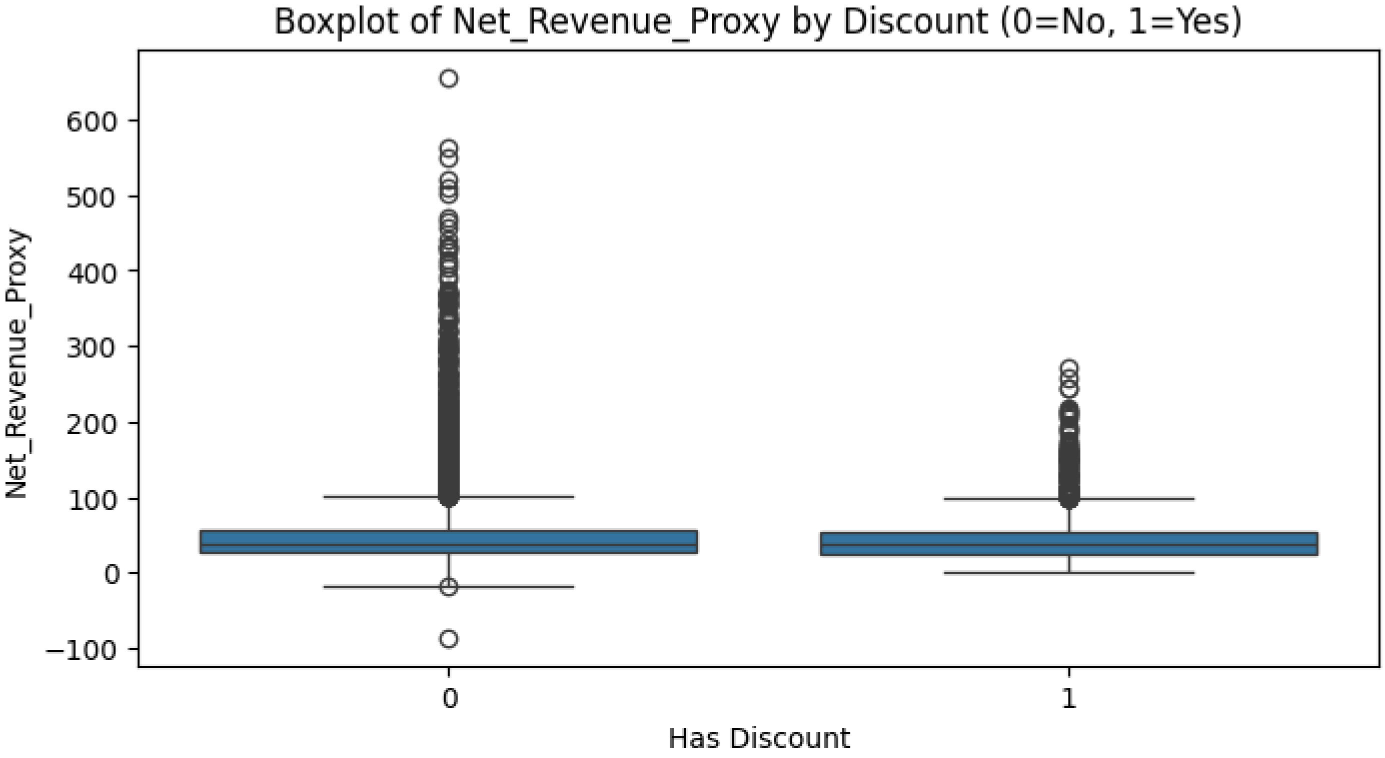

Boxplot of original_order_total by Discount (0=No, 1=Yes)
original_order_total
600
500
400
300
200
100
0
0
1
Has Discount


Boxplot of Has_Discount by Discount (0=No, 1=Yes)


Boxplot of Refund? by Discount (0=No, 1=Yes)



Boxplot of order_day by Discount (0=No, 1=Yes)



Boxplot of Net_Revenue_Proxy by Discount (0=No, 1=Yes)

Outlier Check

In [41]:

```
def summarize_by_discount(df, numeric_cols, discount_col="Amount_of_discount"):
    results = []

    for col in numeric_cols:
        if col not in ignore_columns:
            for has_disc, group in df.groupby(df[discount_col] > 0):
                # statistics
                mean_val = group[col].mean()
                median_val = group[col].median()
                q1 = group[col].quantile(0.25)
                q3 = group[col].quantile(0.75)
                iqr = q3 - q1

                # outlier check (1.5 * IQR)
                lower_bound = q1 - 1.5 * iqr
                upper_bound = q3 + 1.5 * iqr
                outlier_ratio = ((group[col] < lower_bound) | (group[col] > upper_bound)).mean()* 100

                results.append({
                    "Column": col,
                    "Has_Discount": int(has_disc),
                    "Mean": mean_val,
                    "Median": median_val,
                    "IQR": iqr,
                    "Outlier_Ratio": f"{outlier_ratio:.2f}%"
                })

    return pd.DataFrame(results)


summary_table = summarize_by_discount(df_viz, numeric_cols)
summary_table
```

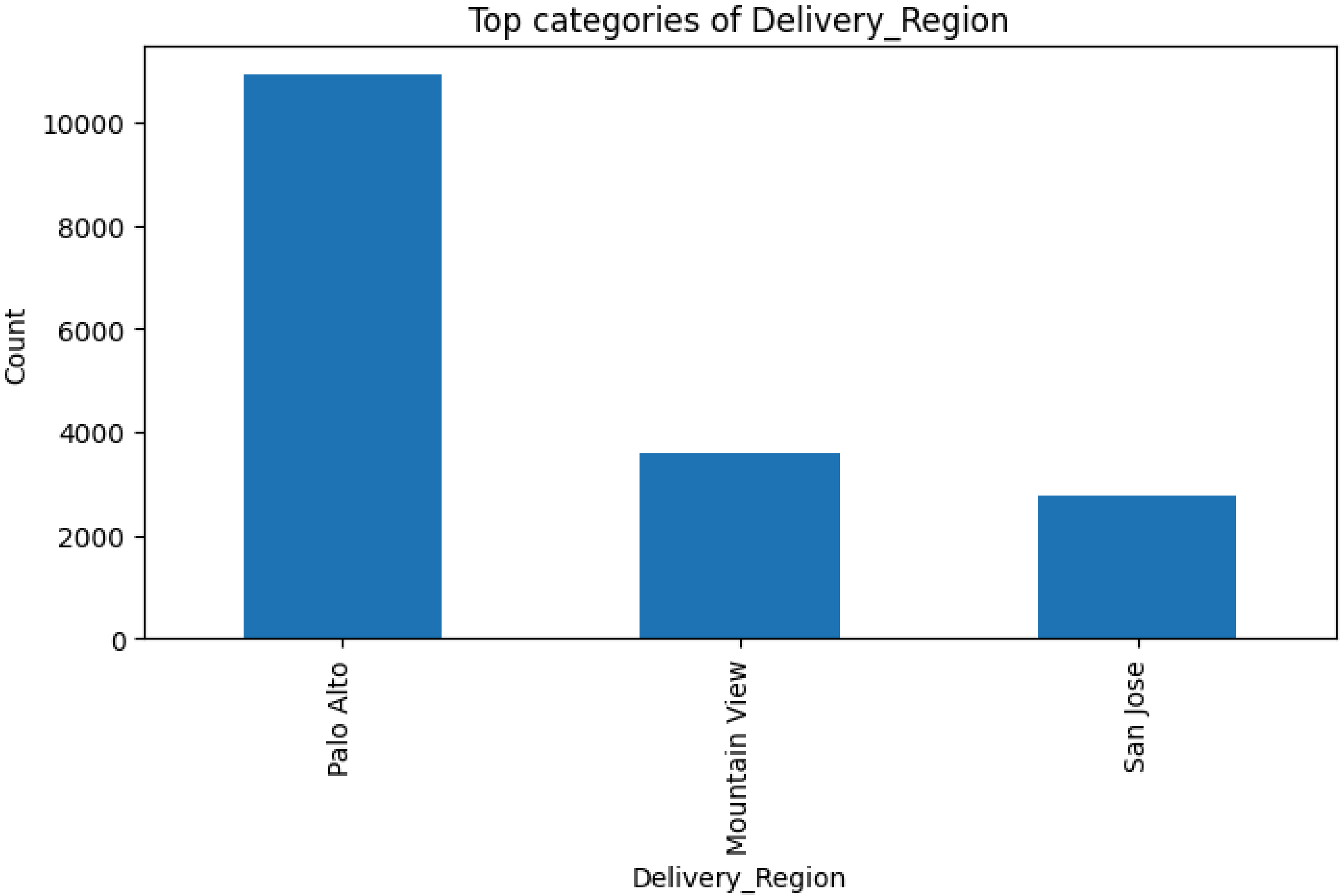
Out[41]:

	Column	Has_Discount	Mean	Median	IQR	Outlier_Ratio
0	Order_total	0	49.532375	38.46	30.2900	6.53%
1	Order_total	1	45.745525	38.03	28.9175	5.40%
2	Amount_of_discount	0	0.000000	0.00	0.0000	0.00%
3	Amount_of_discount	1	8.841114	6.00	0.0000	10.88%
4	Amount_of_tip	0	3.426052	2.53	2.9900	5.39%
5	Amount_of_tip	1	3.163448	2.45	2.9600	4.65%
6	Refunded_amount	0	0.598171	0.00	0.0000	2.66%
7	Refunded_amount	1	0.411832	0.00	0.0000	2.53%
8	order_to_rest	0	732.272894	250.00	854.5000	8.65%
9	order_to_rest	1	687.789275	243.50	738.0000	9.71%
10	rest_to_csmer	0	1443.434451	1336.00	734.5000	2.16%
11	rest_to_csmer	1	1453.827030	1345.00	742.5000	1.93%
12	total_delivery_time	0	3256.854838	2857.00	1599.5000	5.52%
13	total_delivery_time	1	3158.936556	2794.50	1460.0000	5.40%
14	dasher_waiting_time	0	1086.680839	831.00	839.0000	4.24%
15	dasher_waiting_time	1	999.557741	803.00	726.0000	3.78%
16	dasher_delivery_time	0	1443.434451	1336.00	734.5000	2.16%
17	dasher_delivery_time	1	1453.827030	1345.00	742.5000	1.93%
18	original_order_total	0	49.532375	38.46	30.2900	6.53%
19	original_order_total	1	54.586639	44.70	30.8950	5.97%
20	Has_Discount	0	0.000000	0.00	0.0000	0.00%
21	Has_Discount	1	1.000000	1.00	0.0000	0.00%
22	Refund?	0	0.026554	0.00	0.0000	2.66%
23	Refund?	1	0.025302	0.00	0.0000	2.53%
24	order_day	0	15.811806	16.00	16.0000	0.00%
25	order_day	1	15.571752	16.00	15.0000	0.00%

	Column	Has_Discount	Mean	Median	IQR	Outlier_Ratio
26	Net_Revenue_Proxy	0	48.934204	37.97	29.9600	6.56%
27	Net_Revenue_Proxy	1	45.333693	37.76	29.0050	5.36%

In [42]:

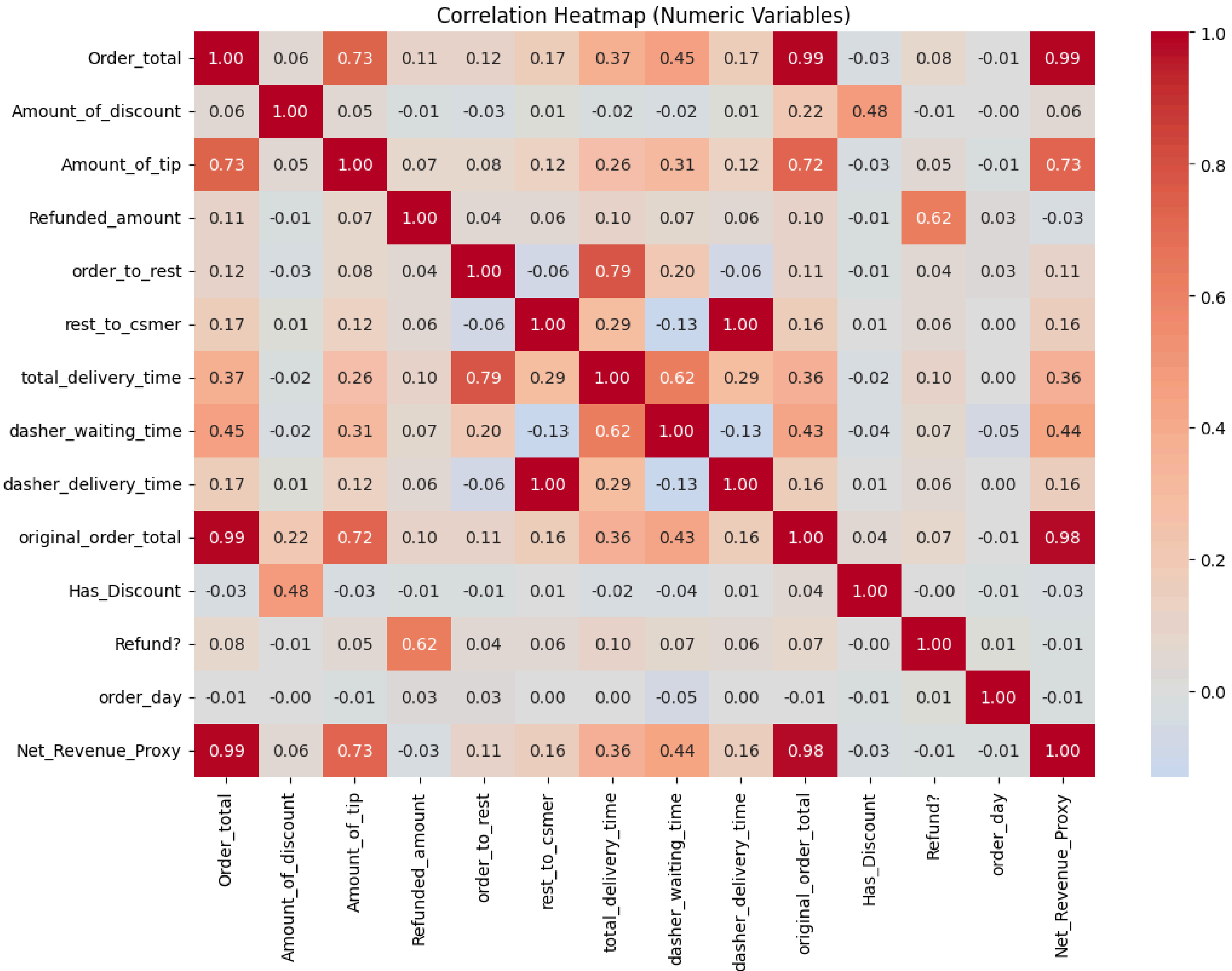
```python
# 2. Categorical Values
cat_cols = df_viz.select_dtypes(include=['object', 'category']).columns
for col in cat_cols:
    plt.figure(figsize=(8,4))
    df_viz[col].value_counts().head(20).plot(kind='bar')
    plt.title(f"Top categories of {col}")
    plt.xlabel(col)
    plt.ylabel("Count")
    plt.show()

# df.to_excel('dd_sample.xlsx', index=False)
```



Correlation

In [43]:

```
numeric_cols = [c for c in df_viz.select_dtypes(include=['int64', 'float64']).columns
                if c not in ignore_columns]

plt.figure(figsize=(12,8))
corr = df_viz[numeric_cols].corr()

sns.heatmap(corr, annot=True, fmt=".2f", cmap="coolwarm", center=0)
plt.title("Correlation Heatmap (Numeric Variables)")
plt.show()
```



	Order_total	Amount_of_discount	Amount_of_tip	Refunded_amount	order_to_rest	rest_to_csmer	total_delivery_time	dasher_waiting_time	dasher_delivery_time	original_order_total	Has_Discount	Refund?	order_day	Net_Revenue_Proxy
Order_total	1.00	0.06	0.73	0.11	0.12	0.17	0.37	0.45	0.17	0.99	-0.03	0.08	-0.01	0.99
Amount_of_discount	0.06	1.00	0.05	-0.01	-0.03	0.01	-0.02	-0.02	0.01	0.22	0.48	-0.01	-0.00	0.06
Amount_of_tip	0.73	0.05	1.00	0.07	0.08	0.12	0.26	0.31	0.12	0.72	-0.03	0.05	-0.01	0.73
Refunded_amount	0.11	-0.01	0.07	1.00	0.04	0.06	0.10	0.07	0.06	0.10	-0.01	0.62	0.03	-0.03
order_to_rest	0.12	-0.03	0.08	0.04	1.00	-0.06	0.79	0.20	-0.06	0.11	-0.01	0.04	0.03	0.11
rest_to_csmer	0.17	0.01	0.12	0.06	-0.06	1.00	0.29	-0.13	1.00	0.16	0.01	0.06	0.00	0.16
total_delivery_time	0.37	-0.02	0.26	0.10	0.79	0.29	1.00	0.62	0.29	0.36	-0.02	0.10	0.00	0.36
dasher_waiting_time	0.45	-0.02	0.31	0.07	0.20	-0.13	0.62	1.00	-0.13	0.43	-0.04	0.07	-0.05	0.44
dasher_delivery_time	0.17	0.01	0.12	0.06	-0.06	1.00	0.29	-0.13	1.00	0.16	0.01	0.06	0.00	0.16
original_order_total	0.99	0.22	0.72	0.10	0.11	0.16	0.36	0.43	0.16	1.00	0.04	0.07	-0.01	0.98
Has_Discount	-0.03	0.48	-0.03	-0.01	-0.01	0.01	-0.02	-0.04	0.01	0.04	1.00	-0.00	-0.01	-0.03
Refund?	0.08	-0.01	0.05	0.62	0.04	0.06	0.10	0.07	0.06	0.07	-0.00	1.00	0.01	-0.01
order_day	-0.01	-0.00	-0.01	0.03	0.03	0.00	0.00	-0.05	0.00	-0.01	-0.01	0.01	1.00	-0.01
Net_Revenue_Proxy	0.99	0.06	0.73	-0.03	0.11	0.16	0.36	0.44	0.16	0.98	-0.03	-0.01	-0.01	1.00

Significance Test

In [44]:

```
from scipy.stats import ttest_ind, mannwhitneyu, chi2_contingency

stat_results = []

discount_group = df[df['Amount_of_discount'] > 0]
no_discount_group = df[df['Amount_of_discount'] == 0]

# ---------- 1. numerical ----------
numeric_metrics = {
    "Order_total": "Customer-paid AOV",
    "original_order_total": "Gross AOV",
    "total_delivery_time": "Total Delivery Time",
    "dasher_waiting_time": "Dasher Waiting Time",
    "dasher_delivery_time": "Dasher Delivery Time",
    "Amount_of_tip": "Tip Amount"
}

for col, metric_name in numeric_metrics.items():
    x = discount_group[col].dropna()
    y = no_discount_group[col].dropna()

    # t-test
    t_stat, t_p = ttest_ind(x, y, equal_var=False)

    # non-parametric
    u_stat, u_p = mannwhitneyu(x, y, alternative="two-sided")

    stat_results.append({
        "Metric": metric_name,
        "Test": "t-test",
        "p_value": t_p,
        "Significant?": "Yes" if t_p < 0.05 else "No"
    })

    stat_results.append({
        "Metric": metric_name,
        "Test": "Mann-Whitney U",
        "p_value": u_p,
        "Significant?": "Yes" if u_p < 0.05 else "No"
    })
```

```python
# ---------- 2. Ratios (Chi-square)  ----------
# Refund Rate
contingency_refund = pd.crosstab(df['Amount_of_discount'] > 0, df['Refunded_amount'] > 0)
chi2, p_refund, _, _ = chi2_contingency(contingency_refund)
stat_results.append({
    "Metric": "Refund Rate",
    "Test": "Chi-square",
    "p_value": p_refund,
    "Significant?": "Yes" if p_refund < 0.05 else "No"
})

# New Customer Rate
contingency_new = pd.crosstab(df['Amount_of_discount'] > 0, df['Is_New'] == 1)
chi2, p_new, _, _ = chi2_contingency(contingency_new)
stat_results.append({
    "Metric": "New Customer Rate",
    "Test": "Chi-square",
    "p_value": p_new,
    "Significant?": "Yes" if p_new < 0.05 else "No"
})


# ---------- 3. Per-order (t-test)  ----------

df['Net_Revenue_Proxy'] = df['original_order_total'] - df['Amount_of_discount'] - df['Refunded_amount']

discount_group    = df[df['Amount_of_discount'] > 0]
no_discount_group = df[df['Amount_of_discount'] == 0]

# t-test
x = discount_group['Net_Revenue_Proxy'].dropna()
y = no_discount_group['Net_Revenue_Proxy'].dropna()

t_stat, t_p = ttest_ind(x, y, equal_var=False)

stat_results.append({
    "Metric": "Net Revenue Proxy per Order",
    "Test": "t-test",
    "p_value": t_p,
    "Significant?": "Yes" if t_p < 0.05 else "No"
})


results_df = pd.DataFrame(stat_results)
print(results_df)
```

```
                         Metric            Test       p_value Significant?
0             Customer-paid AOV          t-test  2.374336e-08          Yes
1             Customer-paid AOV  Mann-Whitney U  3.707388e-02          Yes
2                     Gross AOV          t-test  2.502287e-10          Yes
3                     Gross AOV  Mann-Whitney U  1.108261e-44          Yes
4           Total Delivery Time          t-test  2.123878e-03          Yes
5           Total Delivery Time  Mann-Whitney U  1.130832e-02          Yes
6           Dasher Waiting Time          t-test  1.883772e-06          Yes
7           Dasher Waiting Time  Mann-Whitney U  7.057865e-03          Yes
8          Dasher Delivery Time          t-test  4.856422e-01           No
9          Dasher Delivery Time  Mann-Whitney U  2.661761e-01           No
10                   Tip Amount          t-test  1.549851e-05          Yes
11                   Tip Amount  Mann-Whitney U  3.882294e-03          Yes
12                  Refund Rate      Chi-square  7.609362e-01           No
13            New Customer Rate      Chi-square  2.887587e-12          Yes
14  Net Revenue Proxy per Order          t-test  9.800080e-08          Yes
```

Direction + Impact

In [45]:

```python
from scipy.stats import ttest_ind

def effect_size_label(d):
    if abs(d) < 0.2:
        return "Negligible"
    elif abs(d) < 0.5:
        return "Small"
    elif abs(d) < 0.8:
        return "Medium"
    else:
        return "Large"

metrics = [
    ("Order_total", "Customer-paid AOV"),
    ("original_order_total", "Gross AOV"),
    ("total_delivery_time", "Total Delivery Time (sec)"),
    ("dasher_waiting_time", "Dasher Waiting Time (sec)"),
    ("dasher_delivery_time", "Dasher Delivery Time (sec)"),
    ("Amount_of_tip", "Tip Amount ($)"),
    ("Net_Revenue_Proxy", "Net Revenue Proxy per Order ($)"),
]
g1 = df[df['Amount_of_discount'] > 0]
g0 = df[df['Amount_of_discount'] == 0]

def cohens_d_welch(x, y):
    x = np.asarray(x, float); y = np.asarray(y, float)
    nx, ny = len(x), len(y)
    if nx < 2 or ny < 2: return np.nan
    vx, vy = x.var(ddof=1), y.var(ddof=1)

    s = np.sqrt(((nx-1)*vx + (ny-1)*vy) / (nx+ny-2)) if (nx+ny-2)>0 else np.nan
    if s == 0 or np.isnan(s): return np.nan
    return (x.mean() - y.mean()) / s

rows = []
for col, name in metrics:
    x = g1[col].dropna()
    y = g0[col].dropna()

    # t-test
    t_stat, p_val = ttest_ind(x, y, equal_var=False)

    # Cohen's d
    d = cohens_d_welch(x, y)

    rows.append({
        "Metric": name,
        "Mean_YesDisc": x.mean(),
        "Mean_NoDisc": y.mean(),
        "Mean_Diff(Yes-No)": x.mean() - y.mean(),
        "p<0.05?": "Yes" if p_val < 0.05 else "No",
        "Higher Group": "YesDisc" if x.mean() > y.mean() else "NoDisc",
        "Cohen's d": round(d, 3),
        "Effect Size": effect_size_label(d)
    })

prop_results = []

# Refund Rate
refund_rate_yes = (discount_group['Refunded_amount'] > 0).mean()
refund_rate_no  = (no_discount_group['Refunded_amount'] > 0).mean()
prop_results.append({
    "Metric": "Refund Rate",
    "Mean_YesDisc": refund_rate_yes,
    "Mean_NoDisc": refund_rate_no,
    "Mean_Diff(Yes-No)": refund_rate_yes - refund_rate_no,
    "p<0.05?": "Yes" if p_refund < 0.05 else "No",
    "Higher Group": "YesDisc" if refund_rate_yes > refund_rate_no else "NoDisc",
    "Cohen's d": "N/A",
    "Effect Size": "Proportion"
})
```

```
# New Customer Rate
new_rate_yes = (discount_group['Is_New'] == 1).mean()
new_rate_no  = (no_discount_group['Is_New'] == 1).mean()
prop_results.append({
    "Metric": "New Customer Rate",
    "Mean_YesDisc": new_rate_yes,
    "Mean_NoDisc": new_rate_no,
    "Mean_Diff(Yes-No)": new_rate_yes - new_rate_no,
    "p<0.05?": "Yes" if p_new < 0.05 else "No",
    "Higher Group": "YesDisc" if new_rate_yes > new_rate_no else "NoDisc",
    "Cohen's d": "N/A",
    "Effect Size": "Proportion"
})

summary_table = pd.DataFrame(rows)

final_results = pd.concat([summary_table, pd.DataFrame(prop_results)], ignore_index=True)

final_results
```

Out[45]:

	Metric	Mean_YesDisc	Mean_NoDisc	Mean_Diff(Yes-No)	p<0.05?	Higher Group	Cohen's d	Effect Size
0	Customer-paid AOV	45.745525	49.532375	-3.786850	Yes	NoDisc	-0.095	Negligible
1	Gross AOV	54.586639	49.532375	5.054264	Yes	YesDisc	0.124	Negligible
2	Total Delivery Time (sec)	3158.936556	3256.854838	-97.918282	Yes	NoDisc	-0.063	Negligible
3	Dasher Waiting Time (sec)	999.557741	1086.680839	-87.123099	Yes	NoDisc	-0.104	Negligible
4	Dasher Delivery Time (sec)	1453.827030	1443.434451	10.392579	No	YesDisc	0.016	Negligible
5	Tip Amount ($)	3.163448	3.426052	-0.262604	Yes	NoDisc	-0.08	Negligible
6	Net Revenue Proxy per Order ($)	45.333693	48.934204	-3.600510	Yes	NoDisc	-0.09	Negligible
7	Refund Rate	0.025302	0.026554	-0.001252	No	NoDisc	N/A	Proportion
8	New Customer Rate	0.243202	0.184721	0.058481	Yes	YesDisc	N/A	Proportion

correlation between tip rate & campaign

In [46]:

```
from scipy.stats import ttest_ind, mannwhitneyu

# 1. define tip rate
df["tip_rate_original"] = df["Amount_of_tip"] / df["original_order_total"]
```

```
df["tip_rate_paid"] = df["Amount_of_tip"] / df["Order_total"]

# 2. discount vs no discount
discount_group = df[df["Has_Discount"] == 1]
no_discount_group = df[df["Has_Discount"] == 0]

results_tiprate = []

# ---------- tip_rate vs origional price ----------
x = discount_group["tip_rate_original"].dropna()
y = no_discount_group["tip_rate_original"].dropna()

t_stat, t_p = ttest_ind(x, y, equal_var=False)
mw_stat, mw_p = mannwhitneyu(x, y, alternative="two-sided")

results_tiprate.append({
    "Metric": "Tip Rate vs Original Price",
    "t-test p_value": t_p,
    "Mann-Whitney p_value": mw_p,
    "Significant?": "Yes" if t_p < 0.05 or mw_p < 0.05 else "No"
})

# ---------- tip_rate vs paid amount ----------
x = discount_group["tip_rate_paid"].dropna()
y = no_discount_group["tip_rate_paid"].dropna()

t_stat, t_p = ttest_ind(x, y, equal_var=False)
mw_stat, mw_p = mannwhitneyu(x, y, alternative="two-sided")

results_tiprate.append({
    "Metric": "Tip Rate vs Paid Amount",
    "t-test p_value": t_p,
    "Mann-Whitney p_value": mw_p,
    "Significant?": "Yes" if t_p < 0.05 or mw_p < 0.05 else "No"
})

import pandas as pd
results_df = pd.DataFrame(results_tiprate)
print(results_df)
```

```
                      Metric  t-test p_value  Mann-Whitney p_value  \
0  Tip Rate vs Original Price    2.851397e-55          1.078181e-65
1     Tip Rate vs Paid Amount    4.520850e-01          2.483377e-01

  Significant?
0          Yes
1           No
```

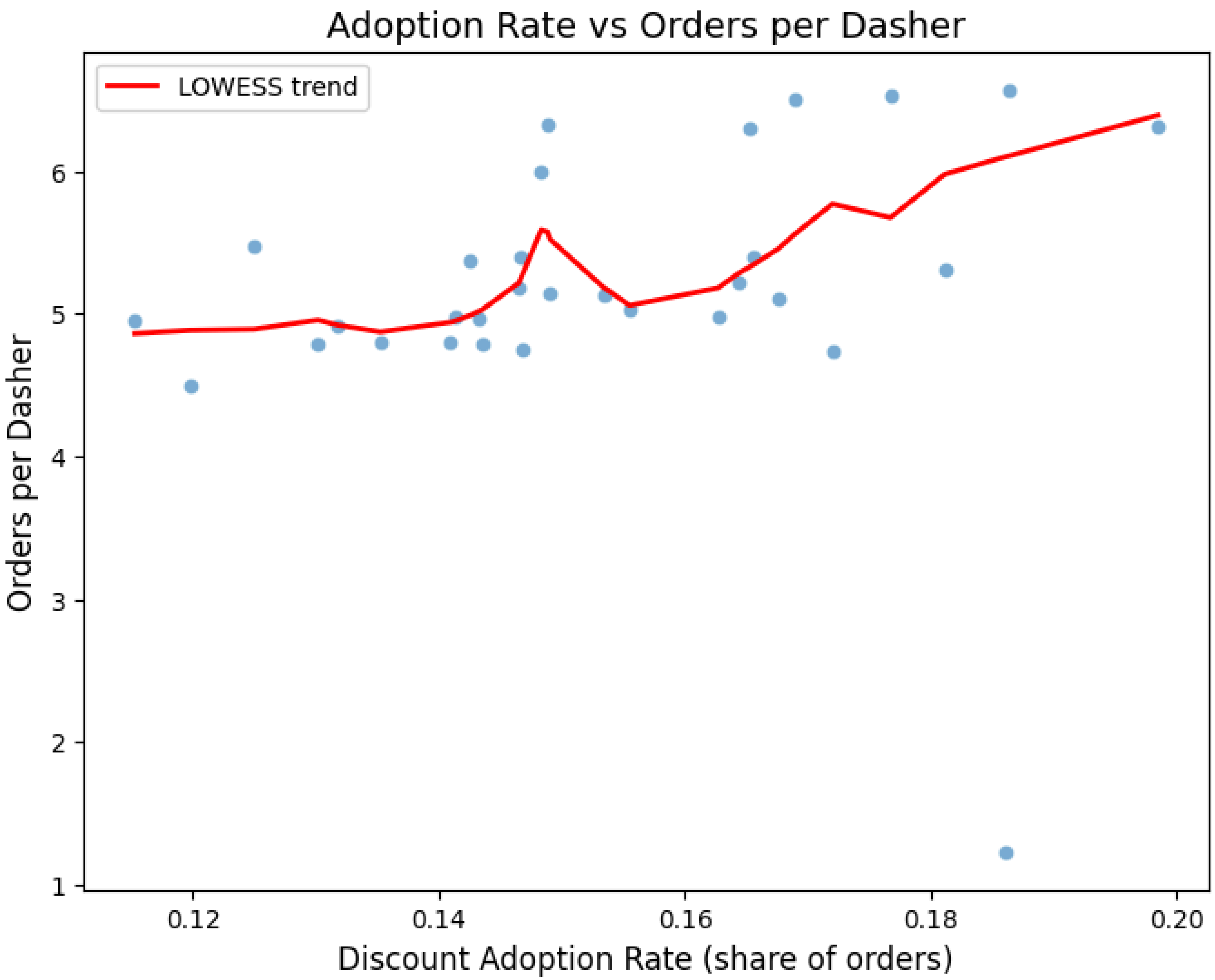
In [47]:

```python
daily = df.groupby("order_day").agg(
    total_orders=("Customer_placed_order_datetime", "count"),
    total_dashers=("Driver_ID", "nunique"),
    discount_orders=("Has_Discount", "sum")
).reset_index()

daily["adoption_rate"] = daily["discount_orders"] / daily["total_orders"]
daily["orders_per_dasher"] = daily["total_orders"] / daily["total_dashers"]

# correlation analysis
from scipy.stats import pearsonr, spearmanr
corr, pval = pearsonr(daily["adoption_rate"], daily["orders_per_dasher"])
print("Pearson correlation:", corr, "p:", pval)

spearman_corr, spearman_p = spearmanr(daily["adoption_rate"], daily["orders_per_dasher"])
print("Spearman correlation:", spearman_corr, "p:", spearman_p)
```

```
Pearson correlation: 0.1303549327111997 p: 0.4845825304917199
Spearman correlation: 0.42661290322580653 p: 0.01669687826038512
```

In [48]:

```python
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm


plt.figure(figsize=(8,6))

# Scatter plot
sns.scatterplot(
    data=daily,
    x="adoption_rate",
    y="orders_per_dasher",
    alpha=0.6
)

# LOWESS smoothing
lowess = sm.nonparametric.lowess
z = lowess(daily["orders_per_dasher"], daily["adoption_rate"], frac=0.3)
plt.plot(z[:,0], z[:,1], color="red", linewidth=2, label="LOWESS trend")
plt.title("Adoption Rate vs Orders per Dasher", fontsize=14)
plt.xlabel("Discount Adoption Rate (share of orders)", fontsize=12)
plt.ylabel("Orders per Dasher", fontsize=12)
plt.legend()
plt.show()
```

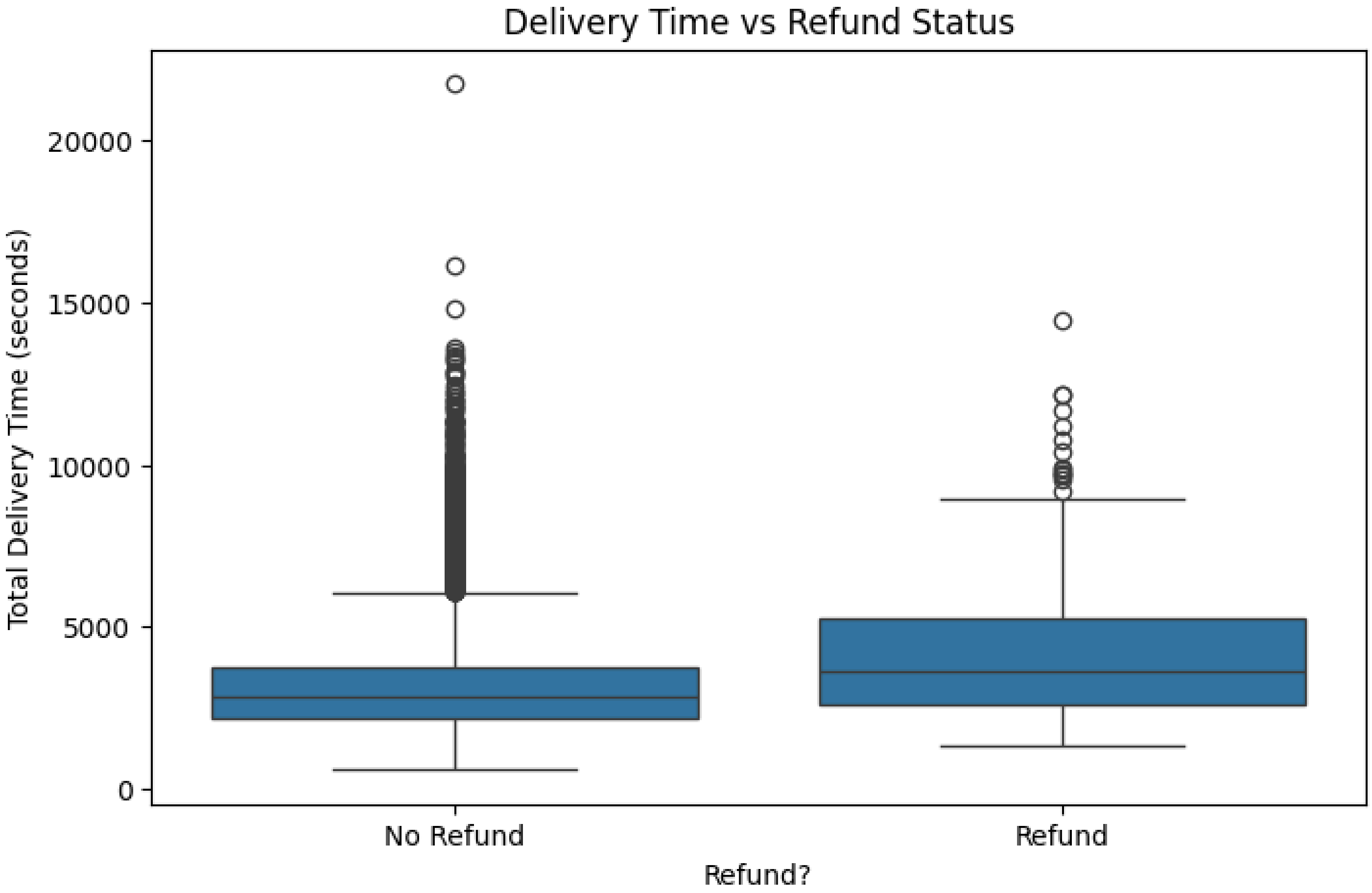


refund & delivery time

In [49]:

```
plt.figure(figsize=(8,5))
sns.boxplot(x="Refund?", y="total_delivery_time", data=df)
```

```
plt.xticks([0,1], ["No Refund", "Refund"])
plt.title("Delivery Time vs Refund Status")
plt.ylabel("Total Delivery Time (seconds)")
plt.show()


refund_group = df[df["Refund?"]==1]["total_delivery_time"].dropna()
no_refund_group = df[df["Refund?"]==0]["total_delivery_time"].dropna()

t_stat, t_p = ttest_ind(refund_group, no_refund_group, equal_var=False)
u_stat, u_p = mannwhitneyu(refund_group, no_refund_group, alternative="two-sided")

print("T-test p-value:", t_p)
print("Mann-Whitney U p-value:", u_p)
print("avg delivery time (No Refund) :", no_refund_group.mean())
print("avg delivery time (Refund) :", refund_group.mean())
```

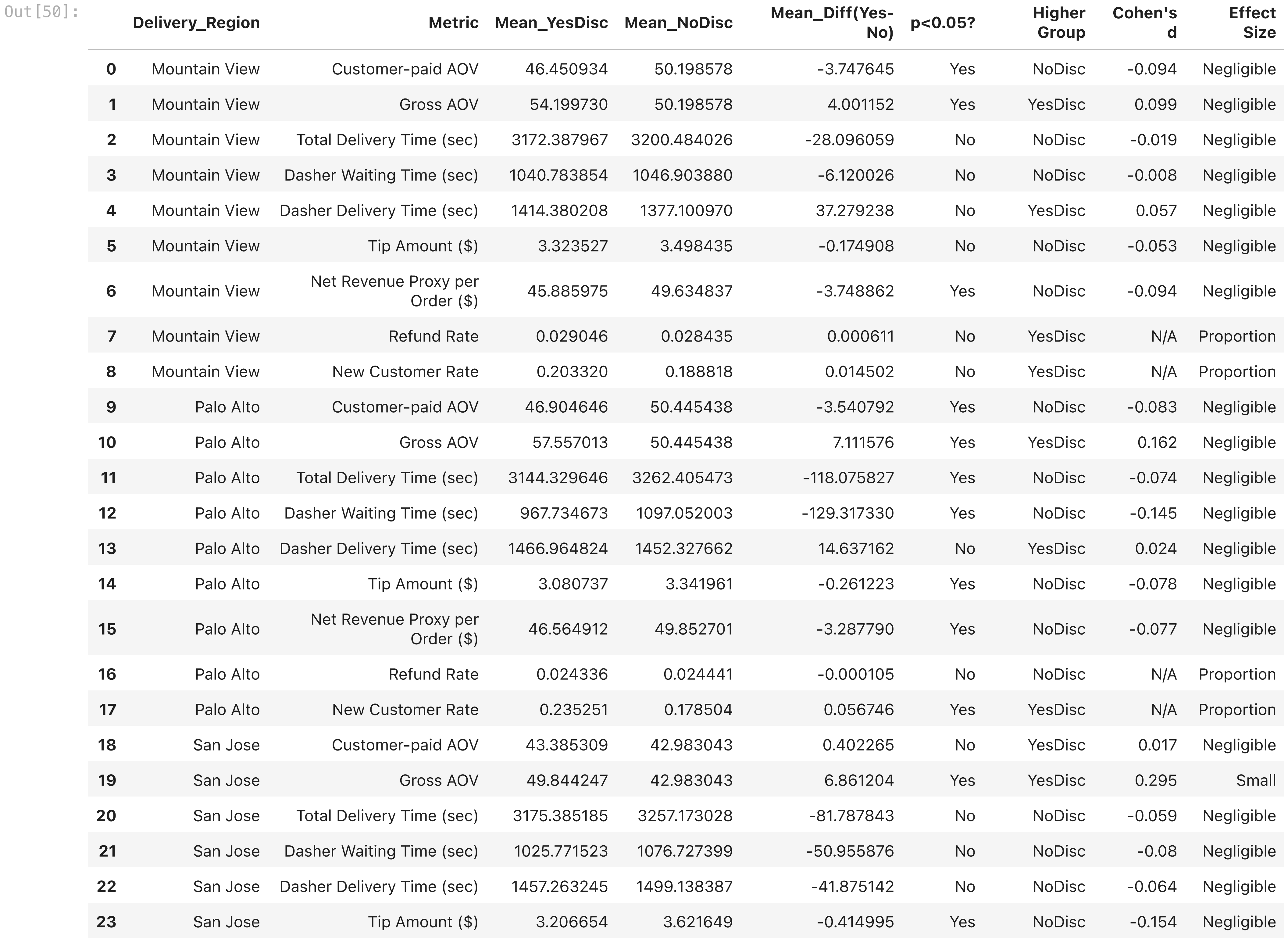


```
T-test p-value: 5.899646168653051e-21
Mann-Whitney U p-value: 4.1907883387433606e-29
avg delivery time (No Refund) : 3216.668325630999
avg delivery time (Refund) : 4173.6608315098465
```

Effectiveness by regions

In [50]:

```python
from scipy.stats import ttest_ind, mannwhitneyu, chi2_contingency


region_results = []

for region, region_df in df.groupby("Delivery_Region"):
    disc   = region_df[region_df['Amount_of_discount'] > 0]
    nodisc = region_df[region_df['Amount_of_discount'] == 0]

    # -------- numerical --------
    numeric_metrics = {
        "Order_total": "Customer-paid AOV",
        "original_order_total": "Gross AOV",
        "total_delivery_time": "Total Delivery Time (sec)",
        "dasher_waiting_time": "Dasher Waiting Time (sec)",
        "dasher_delivery_time": "Dasher Delivery Time (sec)",
        "Amount_of_tip": "Tip Amount ($)",
        "Net_Revenue_Proxy": "Net Revenue Proxy per Order ($)"
    }

    def cohen_d(a, b):
        nx, ny = len(a), len(b)
        s = np.sqrt(((nx-1)*a.var(ddof=1) + (ny-1)*b.var(ddof=1)) / (nx+ny-2))
        return (a.mean() - b.mean()) / s if s > 0 else np.nan

    for col, metric_name in numeric_metrics.items():
        x, y = disc[col].dropna(), nodisc[col].dropna()
        if len(x) == 0 or len(y) == 0:
            continue

        mean_disc, mean_nodisc = x.mean(), y.mean()
        diff = mean_disc - mean_nodisc

        # Welch's t-test
        t_stat, t_p = ttest_ind(x, y, equal_var=False)
        d_val = cohen_d(x, y)
        region_results.append({
            "Delivery_Region": region,
            "Metric": metric_name,
            "Mean_YesDisc": mean_disc,
            "Mean_NoDisc": mean_nodisc,
            "Mean_Diff(Yes-No)": diff,
            "p<0.05?": "Yes" if t_p < 0.05 else "No",
            "Higher Group": "YesDisc" if mean_disc > mean_nodisc else "NoDisc",
            "Cohen's d": round(d_val, 3) if pd.notna(d_val) else "N/A",
            "Effect Size": (
                "Negligible" if abs(d_val) < 0.2
                else "Small" if abs(d_val)<0.5
                else "Medium" if abs(d_val)<0.8
                else "Large"
            )
        })

    # --------- ratios ---------
    # Refund Rate
    contingency_refund = pd.crosstab(region_df['Amount_of_discount'] > 0, region_df['Refunded_amount'] > 0)
    if contingency_refund.shape == (2, 2):
        chi2, p_refund, _, _ = chi2_contingency(contingency_refund)
        refund_rate_yes = (disc['Refunded_amount'] > 0).mean()
        refund_rate_no  = (nodisc['Refunded_amount'] > 0).mean()
        region_results.append({
            "Delivery_Region": region,
            "Metric": "Refund Rate",
            "Mean_YesDisc": refund_rate_yes,
            "Mean_NoDisc": refund_rate_no,
            "Mean_Diff(Yes-No)": refund_rate_yes - refund_rate_no,
            "p<0.05?": "Yes" if p_refund < 0.05 else "No",
            "Higher Group": "YesDisc" if refund_rate_yes > refund_rate_no else "NoDisc",
            "Cohen's d": "N/A",
            "Effect Size": "Proportion"
        })

    # New Customer Rate
    contingency_new = pd.crosstab(region_df['Amount_of_discount'] > 0, region_df['Is_New'] == 1)
    if contingency_new.shape == (2, 2):
        chi2, p_new, _, _ = chi2_contingency(contingency_new)
        new_rate_yes = (disc['Is_New'] == 1).mean()
        new_rate_no  = (nodisc['Is_New'] == 1).mean()
        region_results.append({
            "Delivery_Region": region,
            "Metric": "New Customer Rate",
            "Mean_YesDisc": new_rate_yes,
            "Mean_NoDisc": new_rate_no,
            "Mean_Diff(Yes-No)": new_rate_yes - new_rate_no,
            "p<0.05?": "Yes" if p_new < 0.05 else "No",
            "Higher Group": "YesDisc" if new_rate_yes > new_rate_no else "NoDisc",
            "Cohen's d": "N/A",
            "Effect Size": "Proportion"
        })


region_results_df = pd.DataFrame(region_results)
region_results_df
```



Out[50]:

	Delivery_Region	Metric	Mean_YesDisc	Mean_NoDisc	Mean_Diff(Yes-No)	p<0.05?	Higher Group	Cohen's d	Effect Size
0	Mountain View	Customer-paid AOV	46.450934	50.198578	-3.747645	Yes	NoDisc	-0.094	Negligible
1	Mountain View	Gross AOV	54.199730	50.198578	4.001152	Yes	YesDisc	0.099	Negligible
2	Mountain View	Total Delivery Time (sec)	3172.387967	3200.484026	-28.096059	No	NoDisc	-0.019	Negligible
3	Mountain View	Dasher Waiting Time (sec)	1040.783854	1046.903880	-6.120026	No	NoDisc	-0.008	Negligible
4	Mountain View	Dasher Delivery Time (sec)	1414.380208	1377.100970	37.279238	No	YesDisc	0.057	Negligible
5	Mountain View	Tip Amount ($)	3.323527	3.498435	-0.174908	No	NoDisc	-0.053	Negligible
6	Mountain View	Net Revenue Proxy per Order ($)	45.885975	49.634837	-3.748862	Yes	NoDisc	-0.094	Negligible
7	Mountain View	Refund Rate	0.029046	0.028435	0.000611	No	YesDisc	N/A	Proportion
8	Mountain View	New Customer Rate	0.203320	0.188818	0.014502	No	YesDisc	N/A	Proportion
9	Palo Alto	Customer-paid AOV	46.904646	50.445438	-3.540792	Yes	NoDisc	-0.083	Negligible
10	Palo Alto	Gross AOV	57.557013	50.445438	7.111576	Yes	YesDisc	0.162	Negligible
11	Palo Alto	Total Delivery Time (sec)	3144.329646	3262.405473	-118.075827	Yes	NoDisc	-0.074	Negligible
12	Palo Alto	Dasher Waiting Time (sec)	967.734673	1097.052003	-129.317330	Yes	NoDisc	-0.145	Negligible
13	Palo Alto	Dasher Delivery Time (sec)	1466.964824	1452.327662	14.637162	No	YesDisc	0.024	Negligible
14	Palo Alto	Tip Amount ($)	3.080737	3.341961	-0.261223	Yes	NoDisc	-0.078	Negligible
15	Palo Alto	Net Revenue Proxy per Order ($)	46.564912	49.852701	-3.287790	Yes	NoDisc	-0.077	Negligible
16	Palo Alto	Refund Rate	0.024336	0.024441	-0.000105	No	NoDisc	N/A	Proportion
17	Palo Alto	New Customer Rate	0.235251	0.178504	0.056746	Yes	YesDisc	N/A	Proportion
18	San Jose	Customer-paid AOV	43.385309	42.983043	0.402265	No	YesDisc	0.017	Negligible
19	San Jose	Gross AOV	49.844247	42.983043	6.861204	Yes	YesDisc	0.295	Small
20	San Jose	Total Delivery Time (sec)	3175.385185	3257.173028	-81.787843	No	NoDisc	-0.059	Negligible
21	San Jose	Dasher Waiting Time (sec)	1025.771523	1076.727399	-50.955876	No	NoDisc	-0.08	Negligible
22	San Jose	Dasher Delivery Time (sec)	1457.263245	1499.138387	-41.875142	No	NoDisc	-0.064	Negligible
23	San Jose	Tip Amount ($)	3.206654	3.621649	-0.414995	Yes	NoDisc	-0.154	Negligible

	Delivery_Region	Metric	Mean_YesDisc	Mean_NoDisc	Mean_Diff(Yes-No)	p<0.05?	Higher Group	Cohen's d	Effect Size
24	San Jose	Net Revenue Proxy per Order ($)	42.943901	42.335623	0.608278	No	YesDisc	0.026	Negligible
25	San Jose	Refund Rate	0.024691	0.032570	-0.007879	No	NoDisc	N/A	Proportion
26	San Jose	New Customer Rate	0.280247	0.210178	0.070069	Yes	YesDisc	N/A	Proportion

```
In [ ]:
```