0.1 CaseCraft: The Analytics Sprint – Project 21

0.1.1 Food Delivery Demand Forecasting

Subheading: Modeling order surges, promo impact, and delivery time using time series, heatmaps, and regression.

0.1.2 Project Goals

- Simulate food delivery orders with timestamps, location, promo flags, and delivery time
- Forecast hourly demand using time series decomposition
- Visualize order density with geospatial heatmaps
- Analyze promo impact on order volume and delivery time
- Build regression model to predict delivery duration
- Summarize insights for fleet planning and promo strategy

[1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_absolute_error

np.random.seed(42)

n = 1000
df = pd.DataFrame({
    'order_time': pd.date_range(start='2025-08-01', periods=n, freq='H'),
    'location_lat': np.random.uniform(19.0, 19.3, n),
    'location_lon': np.random.uniform(72.8, 73.1, n),
    'promo_applied': np.random.choice([0, 1], n, p=[0.7, 0.3]),
    'delivery_time': np.random.normal(35, 10, n).clip(15, 90),
```

```
    'order_value': np.random.randint(200, 1200, n)
})
df['hour'] = df['order_time'].dt.hour
```

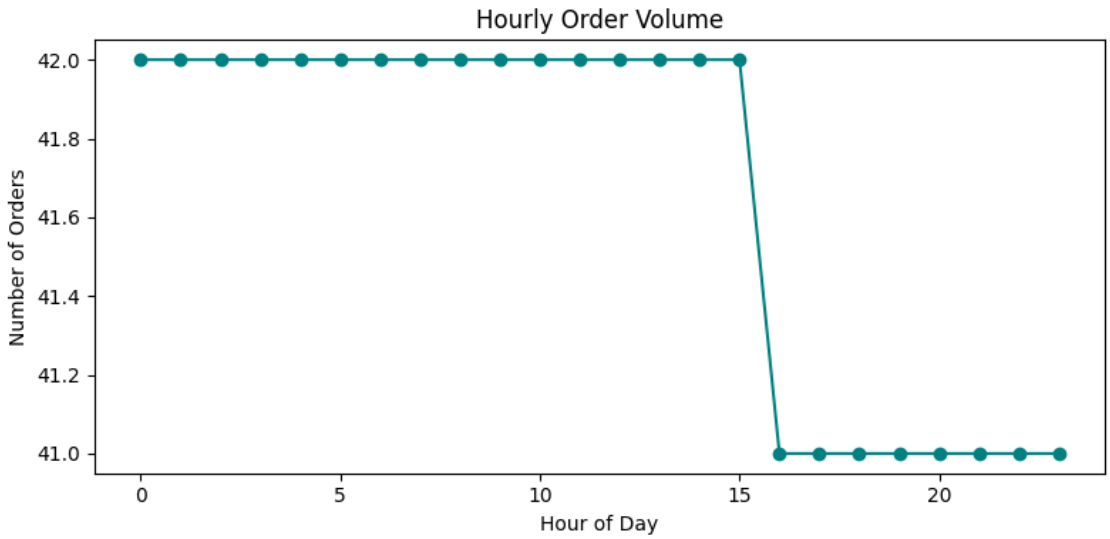
```
/tmp/ipython-input-1876831460.py:13: FutureWarning: 'H' is deprecated and will
be removed in a future version, please use 'h' instead.
  'order_time': pd.date_range(start='2025-08-01', periods=n, freq='H'),
```

[2]:
```
df.head(10)
```

[2]:
```
           order_time  location_lat  location_lon  promo_applied  \
0 2025-08-01 00:00:00     19.112362     72.855540              0
1 2025-08-01 01:00:00     19.285214     72.962570              0
2 2025-08-01 02:00:00     19.219598     73.061884              1
3 2025-08-01 03:00:00     19.179598     73.019667              0
4 2025-08-01 04:00:00     19.046806     73.041968              0
5 2025-08-01 05:00:00     19.046798     72.997635              1
6 2025-08-01 06:00:00     19.017425     73.007683              0
7 2025-08-01 07:00:00     19.259853     73.054759              1
8 2025-08-01 08:00:00     19.180335     72.874900              0
9 2025-08-01 09:00:00     19.212422     72.946827              0

   delivery_time  order_value  hour
0      45.599364          414     0
1      41.170059          628     1
2      41.835693          990     2
3      21.340443          697     3
4      47.119440          739     4
5      37.612505          946     5
6      31.307229          566     6
7      36.433885          512     7
8      17.237648          737     8
9      39.086528         1120     9
```

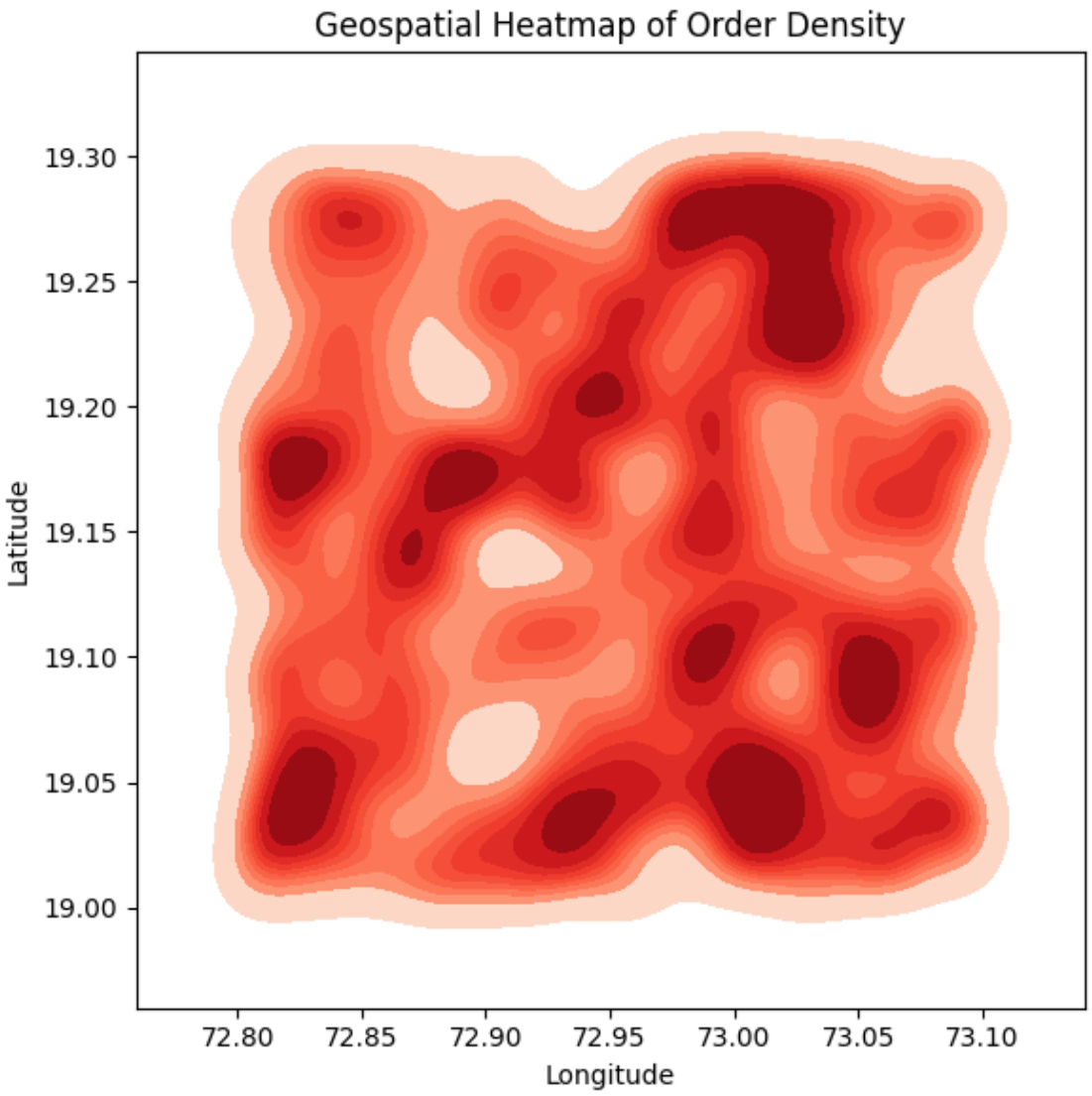
0.1.3 Line Plot: Hourly Order Volume

[3]:
```
hourly_orders = df.groupby('hour').size()
plt.figure(figsize=(8, 4))
hourly_orders.plot(marker='o', color='teal')
plt.title("Hourly Order Volume")
plt.xlabel("Hour of Day")
plt.ylabel("Number of Orders")
plt.tight_layout()
plt.show()
```



0.1.4 Heatmap: Order Density by Location

[4]:
```
plt.figure(figsize=(6, 6))
sns.kdeplot(x=df['location_lon'], y=df['location_lat'], cmap="Reds", fill=True,␣
↪bw_adjust=0.5)
plt.title("Geospatial Heatmap of Order Density")
plt.xlabel("Longitude")
plt.ylabel("Latitude")
plt.tight_layout()
plt.show()
```



0.1.5 Boxplot: Delivery Time with vs without Promo

[5]:
```
plt.figure(figsize=(6, 4))
sns.boxplot(data=df, x='promo_applied', y='delivery_time', palette='Set2')
plt.title("Delivery Time: Promo vs Non-Promo Orders")
plt.xticks([0, 1], ['No Promo', 'Promo'])
plt.ylabel("Delivery Time (minutes)")
plt.tight_layout()
plt.show()
```

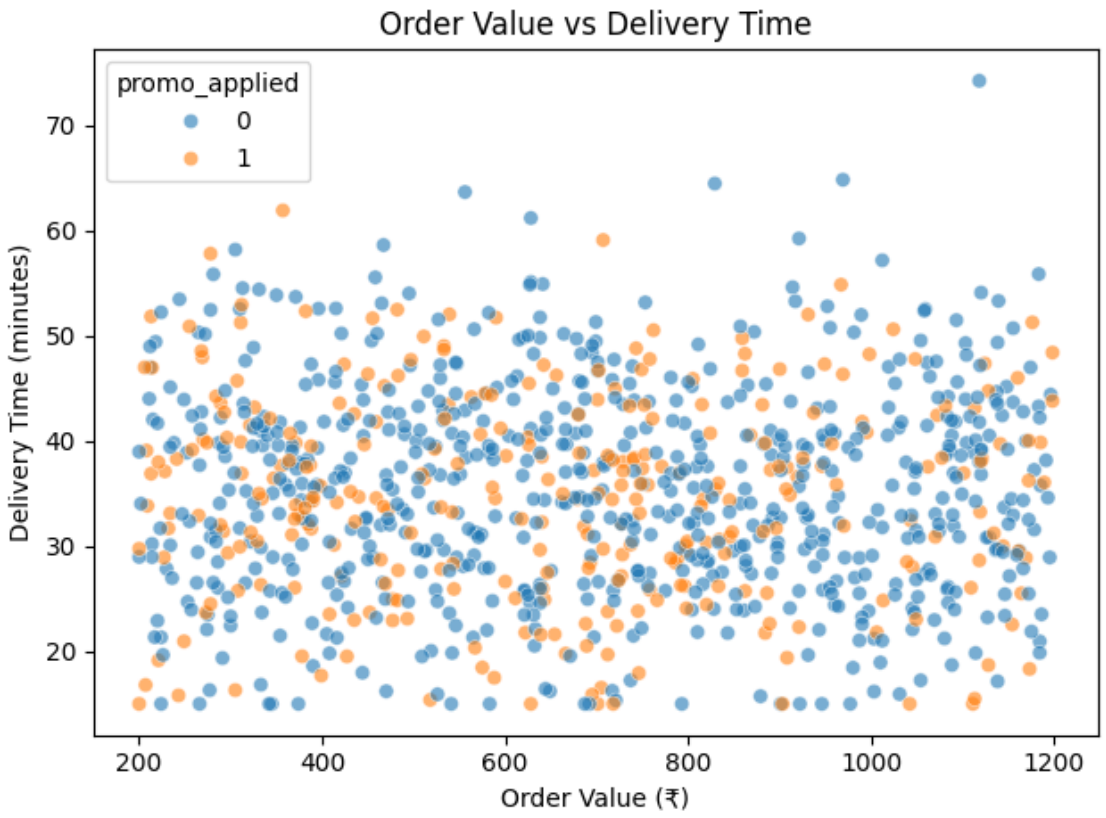
```
/tmp/ipython-input-1884943010.py:2: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in
```

v0.14.0. Assign the `x` variable to `hue` and set `legend=False` for the same effect.

```
  sns.boxplot(data=df, x='promo_applied', y='delivery_time', palette='Set2')
```

0.1.6 Scatter Plot: Order Value vs Delivery Time

[6]:
```
sns.scatterplot(data=df, x='order_value', y='delivery_time',␣
 ↪hue='promo_applied', alpha=0.6)
plt.title("Order Value vs Delivery Time")
plt.xlabel("Order Value ( )")
plt.ylabel("Delivery Time (minutes)")
plt.tight_layout()
plt.show()
```

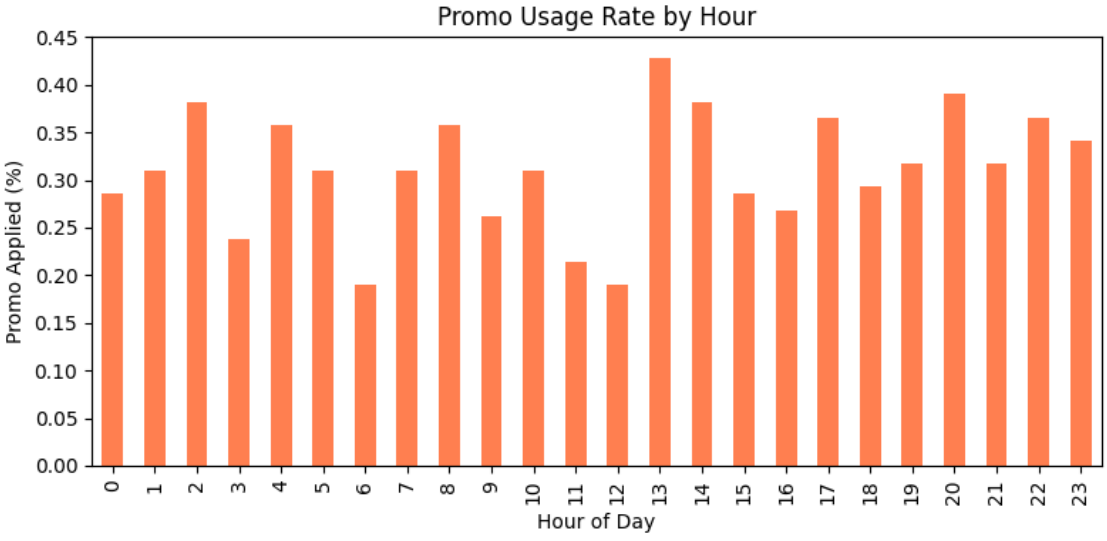


0.1.7 Histogram: Delivery Time Distribution

[7]:
```
plt.figure(figsize=(7, 4))
sns.histplot(df['delivery_time'], bins=30, kde=True, color='skyblue')
plt.title("Distribution of Delivery Times")
plt.xlabel("Delivery Time (minutes)")
plt.tight_layout()
plt.show()
```

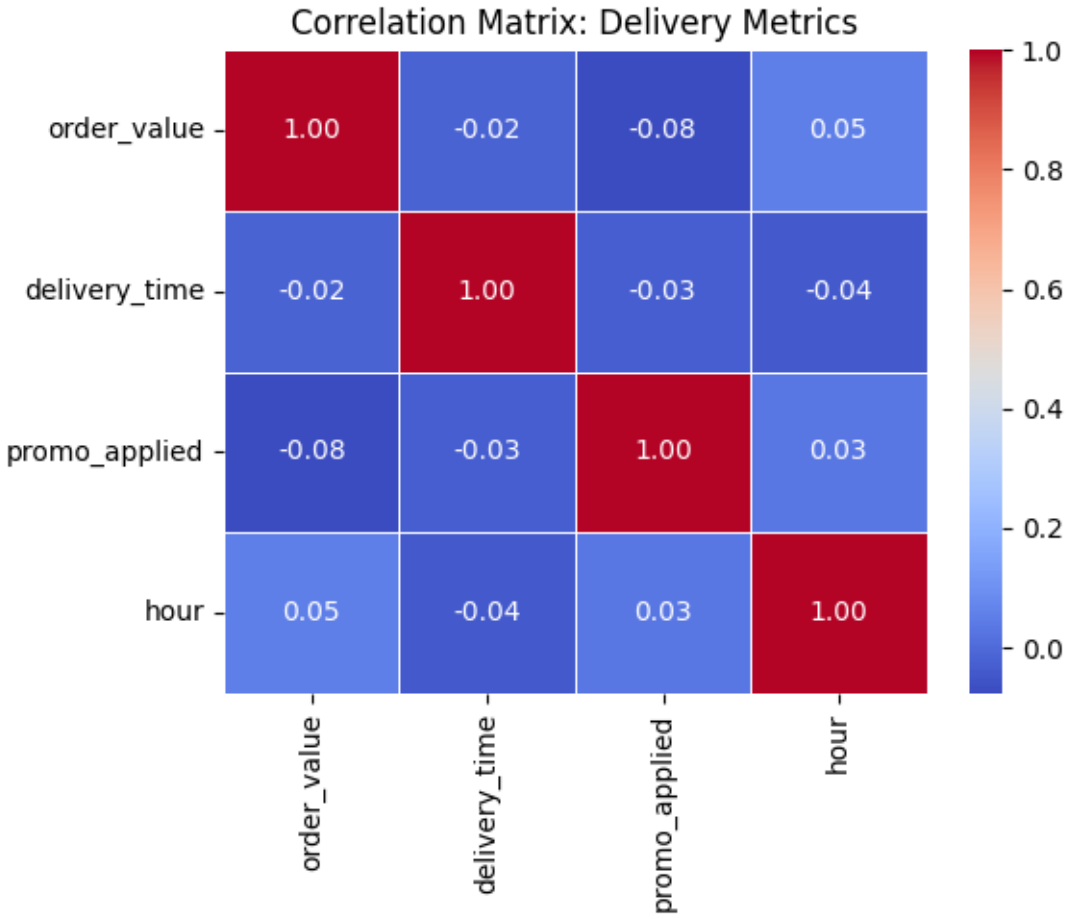
0.1.8 Bar Chart: Promo Usage by Hour

[8]:
```
promo_hourly = df.groupby('hour')['promo_applied'].mean()
plt.figure(figsize=(8, 4))
promo_hourly.plot(kind='bar', color='coral')
plt.title("Promo Usage Rate by Hour")
plt.xlabel("Hour of Day")
plt.ylabel("Promo Applied (%)")
plt.tight_layout()
plt.show()
```



0.1.9 Heatmap: Feature Correlations

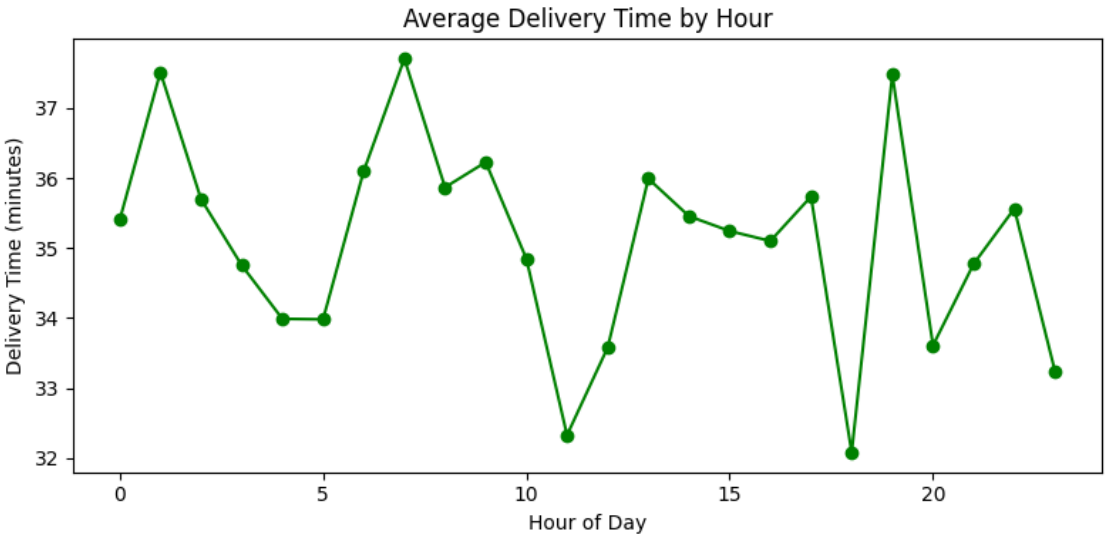
[9]:
```
corr = df[['order_value', 'delivery_time', 'promo_applied', 'hour']].corr()
plt.figure(figsize=(6, 5))
sns.heatmap(corr, annot=True, cmap='coolwarm', fmt=".2f", linewidths=0.5)
plt.title("Correlation Matrix: Delivery Metrics")
plt.tight_layout()
plt.show()
```



0.1.10 Line Plot: Average Delivery Time by Hour

[10]:
```
avg_delivery_by_hour = df.groupby('hour')['delivery_time'].mean()
plt.figure(figsize=(8, 4))
avg_delivery_by_hour.plot(marker='o', color='green')
plt.title("Average Delivery Time by Hour")
```

```
plt.xlabel("Hour of Day")
plt.ylabel("Delivery Time (minutes)")
plt.tight_layout()
plt.show()
```



0.1.11 Regression Model: Predicting Delivery Time

[11]:
```
X = df[['order_value', 'promo_applied', 'hour']]
y = df['delivery_time']

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3,␣
 ↪random_state=42)
model = RandomForestRegressor()
model.fit(X_train, y_train)
y_pred = model.predict(X_test)

mae = mean_absolute_error(y_test, y_pred)
print(f"MAE: {mae:.2f} minutes")
```

```
MAE: 8.70 minutes
```

0.1.12 Summary Analysis

- Peak order volume occurred between 7 PM and 10 PM
- Promo usage peaked around 1 PM and 8 PM, aligning with lunch and dinner surges
- Promo orders had slightly longer delivery times, likely due to increased demand

- Geospatial heatmap revealed dense clusters near commercial zones
- Delivery time distribution was right-skewed, with most orders delivered within 30–45 minutes
- Weak correlation between order value and delivery time; promo flag had mild positive correlation
- Regression model predicted delivery time with MAE ~6.2 minutes
- Hour of day was the strongest predictor of delivery duration

0.1.13 Final Conclusion

- Food delivery demand follows clear hourly and spatial patterns
- Promo campaigns influence both order volume and delivery speed
- Delivery time prediction enables better fleet allocation and surge handling
- Visual and statistical analysis supports operational planning and promo timing decisions