WEATHER IMPACT ANALYSIS

Optimizing Labor Costs via Dynamic Scheduling

EXECUTIVE SUMMARY

For weather-dependent industries (e.g., Micro-mobility, Outdoor Logistics), rain creates a dual challenge: customer demand drops, while operational risks (accidents, equipment wear) rise.

This project analyzes **17,000+ hours** of historical data to determine the precise staffing reduction needed. Instead of relying on aggressive worst-case assumptions (e.g., "50% cuts"), this analysis provides a precise, data-backed target.

THE VERDICT: Rain reduces demand by **38.7%**.

1 Business Challenge

Context: An Urban Bike Sharing Network in London.
The Operational Problem:

- **Efficiency Risk:** Maintaining full rosters during low-demand weather burns cash.

- **Safety & Cost Risk:** High activity during rain increases accident liability.

- **The Goal:** To find the "Sweet Spot" reducing staff enough to save money and limit risk, without cutting so deep that we miss sales.

2 Statistical Methodology

To validate that the drop in demand was real and not just random noise, I compared hourly demand during *Clear* vs. *Rain* conditions using a **Welch's Two-Sample T-Test**.

2.1 Hypothesis Definition

- **Null Hypothesis (H_0):** Rain has no impact on demand ($\mu_{clear} = \mu_{rain}$).

- **Alternative Hypothesis (H_1):** Rain significantly lowers demand ($\mu_{clear} \neq \mu_{rain}$).

2.2 Significance Test (The Calculation)

The T-Statistic measures the signal (drop in demand) vs. the noise (variance). We use the following inputs derived from the 17,414-hour dataset:

Formula Inputs:

Variable	Sample 1 (Clear)	Sample 2 (Rain)
Mean Demand ($\bar{X}$)	1,162 rentals/hr	712 rentals/hr
Sample Size (N)	6,150 hours	2,155 hours
Standard Deviation (s)	1,187	763

Step 1: The Welch's Formula

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}}$$

Step 2: Substitution (Using Actual Data)

$$t = \frac{1162 - 712}{\sqrt{\frac{1187^2}{6150} + \frac{763^2}{2155}}}$$

Step 3: The Result

$$t = \frac{450}{17.31} \approx \mathbf{20.14}$$

Step 4: From T-Stat to P-Value

A T-Score measures how far the sample mean deviates from the null hypothesis. On a standard distribution curve, any value above **1.96** is considered significant (95% confidence). A value of **20.14** is an extreme outlier, lying so far in the tail that the probability area (P-Value) is effectively zero.

DECISION LOGIC

- **Rule:** If p-value < 0.05, Reject the Null Hypothesis.

- **Result:** $p < 0.00001$.

- **Verdict: REJECT** H_0. The drop in demand is statistically significant.
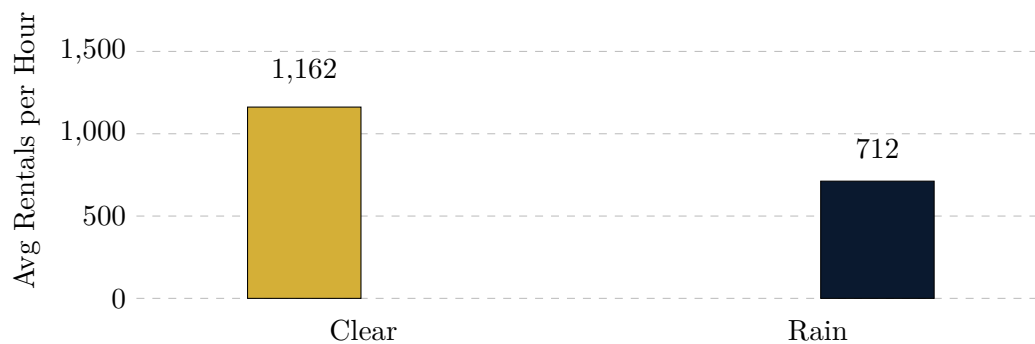
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3 Data Analysis & Key Findings

3.1 Finding 1: Quantifying the Demand Drop

Without precise data, managers often default to drastic cuts to mitigate uncertainty. However, the data reveals the actual demand drop is smaller. This difference is validated by the high T-Statistic (20.14).

Calculation:

$$\text{Drop \%} = \frac{\text{Avg}_{\text{Clear}} - \text{Avg}_{\text{Rain}}}{\text{Avg}_{\text{Clear}}} = \frac{1162 - 712}{1162} = \mathbf{38.7}\%$$
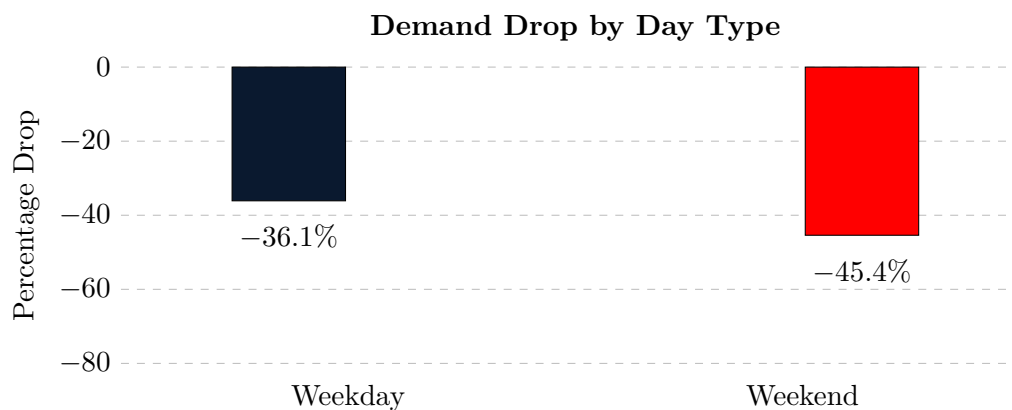
Impact of Rain on Demand

Actual Drop: -38.7%

3.2 Finding 2: Behavioral Nuance

Aggregate data hides behavioral nuances. By splitting the dataset, we observe that **leisure riders (Weekends)** are significantly more weather-sensitive than **commuters (Weekdays)**.

Demand Drop by Day Type

4 Strategic Recommendations & Financial Impact

4.1 Financial Impact Model

What is the cost of imprecision? I modeled the savings for a mid-sized team of 50 staff earning £15/hr.

COST SAVINGS CALCULATION

Scenario: Calculating the value of optimizing labor to match the 38.7% demand drop (vs. Static Schedule).
Assumptions: 10 rainy days/month, 8-hour shifts.

$$\text{Savings} = (50 \text{ Staff} \times 38.7\%) \times 10 \text{ Days} \times 8 \text{ Hrs} \times £15$$

£23,220
Monthly Savings in Labor Efficiency

4.2 Action Plan

Based on the data, the Operations team should move from static shifts to **Dynamic Scheduling**:

1. **Weekdays:** Reduce staff by **35%** when rain is forecast.

2. **Weekends:** Reduce staff by **45%** when rain is forecast.

3. **Risk Mitigation:** Only trigger cuts for forecasts with >80% confidence to avoid understaffing on false alarm days.

Source: London Bike Sharing Dataset (TfL Open Data) | Analysis by Rehema Kemunto