Fast Food Marketing Campaign A/B Test

Goal of the A/B Test

The goal of the A/B test is to determine which of the three marketing campaigns has the greatest effect on the sales of a new menu item introduced by a fast-food chain. The new item was introduced at various store locations across different markets, each using one of the three distinct promotional strategies. By analysing the sales data collected over a four-week period, we aim to identify the most effective promotion that maximises sales performance. This will help the fast-food chain make an informed decision on which marketing campaign to roll out on a larger scale.

Context

The dataset provided consists of sales data aggregated by LocationID, PromotionID, and week. Each location was subjected to one of the three promotions, and the sales figures were recorded for four consecutive weeks. The dataset includes information on the market size, age of the store, and sales figures in thousands for each combination of location, promotion, and week. The markets are categorised into small, medium, and large based on their sales potential, which could influence the effectiveness of the promotions.

Target Metric

The primary target metric for this A/B test will be the average sales per week (SalesInThousands) for each promotion. This metric provides a clear indication of how effective each marketing campaign is in driving sales of the new menu item. By comparing the average weekly sales across the three promotions, we can determine which campaign yields the highest sales performance.

Sample Ratio Mismatch Test

Chi-Square Statistic:

$\chi^2 = \sum \frac{(O_{ij}-E_{ij})^2}{E_{ij}}$ where O_{ij} are observed values and E_{ij} are the expected values.

Observed Counts:

- Promotion 1: 43 locations
- Promotion 2: 47 locations
- Promotion 3: 47 locations

Expected Counts:

Assuming an equal distribution, each promotion should ideally have:

$Expected\ Count = \frac{43+47+47}{3} = 45.67\ locations$

Chi-Square Test Results:

- **Chi-Square Statistic:** 0.234
- **P-Value:** 0.890

The p-value of 0.890 is significantly higher than the common significance levels (0.01, 0.05, 0.10). This indicates that there is no significant difference between the observed and expected counts, suggesting that the sample distribution across the three promotions is approximately equal.

T-Test Calculations

The formula for the t-test is:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

where $\bar{X}_1$ and $\bar{X}_2$ are the sample means, s_1^2 and s_2^2 are the sample variances, n_1 and n_2 are the sample sizes.

The degrees of freedom (df) for the test is calculated using the following formula:

$$df = \frac{(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2})^2}{\frac{\left(\frac{s_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{s_2^2}{n_2}\right)^2}{n_2 - 1}}$$

Means and Sample Sizes:

$$\bar{X}_1 = \frac{\sum X_1}{n_1}, \qquad \bar{X}_2 = \frac{\sum X_2}{n_2}$$

Variances:

$$s_1^2 = \frac{\sum (X_1 - \bar{X}_1)^2}{n_1 - 1}, \qquad s_2^2 = \frac{\sum (X_2 - \bar{X}_2)^2}{n_2 - 1}$$

Two-tailed p-value: $p = 2 \times (1 - CDF\ of\ t\text{-}distribution\ at\ |t|)$

H_0: "There is no statistically significant difference between the two populations."
H_1: "There is a statistically significant difference between the two populations."

In the context of this A/B test analysis, we are using a 99% confidence level. This means we are testing our hypotheses at a 1% significance level ($\alpha = 0.01$). If the p-value obtained from our statistical tests is less than 0.01, we will reject the null hypothesis and conclude that there is a statistically significant difference in the mean sales between the promotions.

comparison	$\bar{X}_1$	$\bar{X}_2$	s_1^2	s_2^2	n_1	n_2
promo 1 vs promo 2	58.1	47.3	256.9	210.2	43	47
promo 1 vs promo 3	58.1	55.4	256.9	268.4	43	47
promo 2 vs promo 3	47.3	55.4	210.2	268.4	47	47

comparison	t-statistic	p-value	degrees of freedom
promo 1 vs promo 2	3.332	0.0013	85
promo 1 vs promo 3	0.7997	0.426	88
promo 2 vs promo 3	-2.518	0.0136	91

Conclusion from the T-Tests

1. **Promotion 1 vs Promotion 2:**
    - **T-Statistic:** 3.332 (positive)
    - **P-Value:** 0.0013 (reject the H_0)
    - **Interpretation:** Promotion 1 has significantly higher average sales compared to Promotion 2. The p-value is significantly lower than 0.01, indicating a statistically significant difference at the 99% confidence level.

2. **Promotion 1 vs Promotion 3:**
    - **T-Statistic:** 0.800 (positive)
    - **P-Value:** 0.426 (fail to reject the H_0)
    - **Interpretation:** There is no statistically significant difference in average sales between Promotion 1 and Promotion 3.
3. **Promotion 2 vs Promotion 3:**
    - **T-Statistic:** -2.518 (negative)
    - **P-Value:** 0.0136 (fail to reject the H_0)
    - **Interpretation:** Promotion 3 has significantly higher average sales compared to Promotion 2. The p-value is higher than 0.01 but lower than 0.05, the difference is statistically significant at the 95% confidence level but not at the 99% confidence level.

Summary of Rankings:

1. **Best Promotion:**
    - **Promotion 1** is the best, as it has significantly higher average sales compared to Promotion 2, and there is no statistically significant difference between Promotion 1 and Promotion 3.
2. **Second Best Promotion:**
    - **Promotion 3** is very close to Promotion 1 in terms of performance since there is no statistically significant difference between them.
3. **Worst Promotion:**
    - **Promotion 2** is the worst, as it is significantly worse than Promotion 1 and also worse than Promotion 3 at the 95% confidence level.

Decision

Based on these findings, it is recommended to choose **Promotion 1** for the marketing campaign, as it demonstrates the highest average sales and performs significantly better than **Promotion 2**. **Promotion 3** can be considered a good alternative, especially if there are other non-quantitative factors that might make it preferable. **Promotion 2** should be avoided due to its significantly lower performance.

Figure 1 illustrates the average sales per week for each promotion, with Promotion 1 showing the highest average sales, followed by Promotion 3, and Promotion 2 having the lowest average sales. The error bars represent the 95% confidence intervals, providing a measure of the precision of these estimates. This visualization supports the recommendation by highlighting the superior performance of Promotion 1 and the substantial underperformance of Promotion 2.

Figure 2 presents the sales distribution for each promotion using box plots. The box plots display the median, interquartile range, and potential outliers. Promotion 1 and Promotion 3 both exhibit higher median sales compared to Promotion 2. Moreover, Promotion 1 shows less variability in the central 50% of the data, indicating more consistent performance. This figure also complements the statistical analysis by visually confirming that Promotion 1 and Promotion 3 are more effective than Promotion 2.

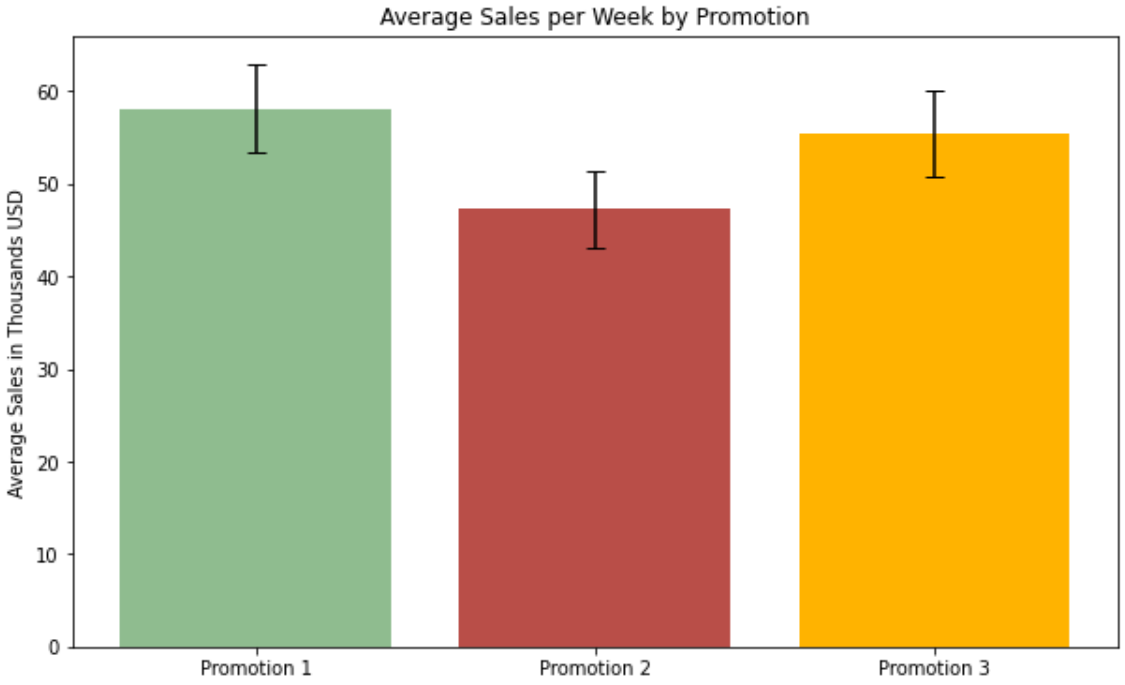

Figure 1: Comparison of Average Weekly Sales Across Promotions

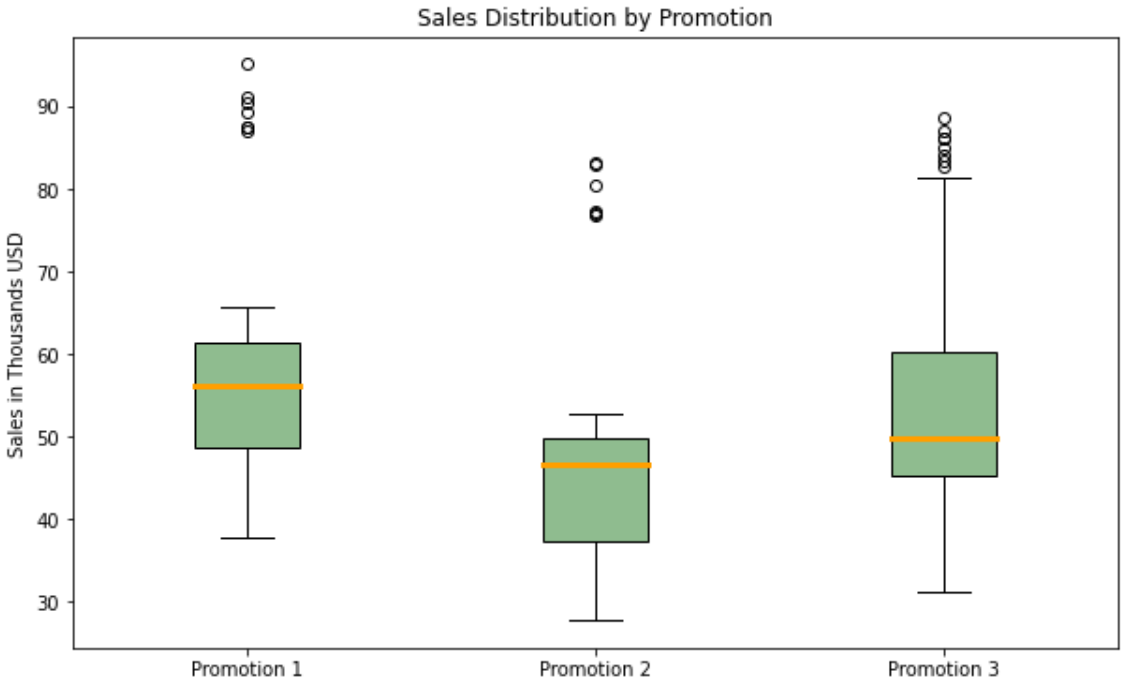

Figure 2: Distribution of Weekly Sales by Promotion

Further steps could include conducting additional tests to verify the robustness of the results, exploring different segmentation of the data (e.g., by market size or store age), and running follow-up experiments to optimise the promotions based on the initial findings. Additionally, incorporating customer feedback and qualitative data could provide deeper insights into the effectiveness of each promotion, leading to more targeted and refined marketing strategies.