A/B Testing on Marketing Campaigns

***Abstract*— In the ever-evolving landscape of the marketing industry, organizations seek data-driven insights to enhance campaign performance, improve customer engagement, and maximize return on investment. This project aims to evaluate and analyze the effectiveness of marketing strategies through A/B testing.**

I. Introduction

In a digital ecosystem where data-driven decision-making is paramount, A/B Testing is one of the strategies organizations utilize to evaluate and optimize marketing efforts and achieve sustainable growth. This approach enables businesses to refine their marketing strategies, reduce costs, and boost revenue. By utilizing A/B Testing, organizations can adapt to evolving consumer behaviors, maximize their return on investment, and maintain a competitive edge.

This project employs a systematic approach to conducting AB tests, where variations of marketing campaigns (test campaign and control campaign) are tested on separate cohorts of users. Key performance indicators (KPIs) such as Click-Through Rate (CTR), Conversion Rate, Cost Per Click (CPC), and Customer Acquisition Cost (CAC) are calculated and analyzed each day. By comparing the results from the control campaign and the test campaign, we can determine the impact of specific campaign elements. Our project leverages statistical analysis and hypothesis testing to identify conclusions about the performance differences between the two groups. It involves calculating essential KPIs, detecting outliers, and performing data cleansing to ensure the validity of results. The outcomes of this project empower organizations to make informed decisions regarding marketing budget allocation, content optimization, and audience targeting. Through the insights gained, businesses can fine-tune their marketing strategies, and reduce acquisition costs.

II. Data Processing and Feature Creation

A. *The Dataset*

The dataset was found on Kaggle.com and is called A/B Testing dataset. There are two .csv files: test and control. Each file has the following ten features: Campaign Name, Date, Spend, # of Impressions, Reach, # of Website Clicks, #of Searches, # of View Content, # of Add to Cart, # of Purchase.

B. *Data Processing*

Several data preprocessing for performed on both the control and test dataset. First, null values were checked, however there were none present in both datasets. After removing null values, duplicate rows were then checked and deleted. Outliers were then identified and removed, and the 'Date' feature was converted to a datetime format. Finally, the index was reset – to ensure clean index structure.

C. *Feature Creation*

Several key performance indicators (KPI's) relevant to the dataset were calculated and added to both datasets. These KPIs include Cost Per Click (CPC), Cost Per Acquisition (CPA), Average Order Value (AOV), Click-Through Rate (CTR), and Conversion Rate. The resulting calculated metrics will be useful for finding insights into various aspects of campaign performance, such as advertising efficiency, customer acquisition cost, user engagement, and revenue generation.

III. Data Visualization

A. *Frequency Distribution*

In the analysis, we delved into various visualizations, with an initial focus on the frequency distribution of all numeric features, including key performance indicator (KPI) features. This exploration provided a foundational understanding of the inherent patterns and variations within the data.

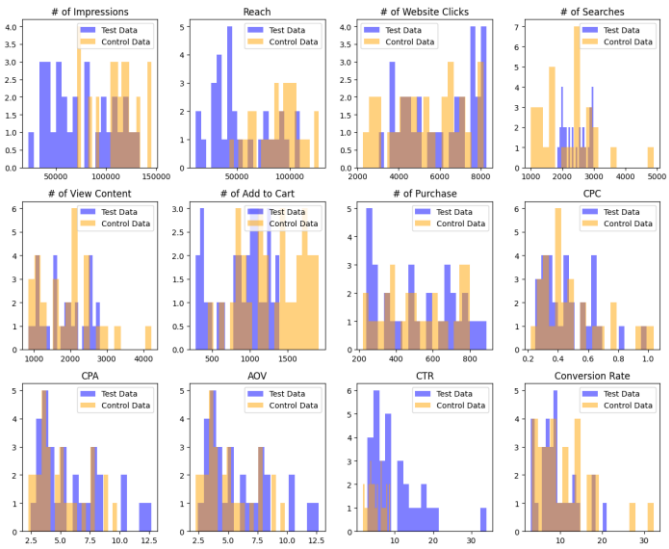

Fig. 1. Numeric Feature Distribution

The examination of frequency distribution results across various features - as shown in Figure 1 - provides valuable insights into the performance of the two campaigns. In terms of impressions, the test campaign exhibits a greater spread, indicating heightened variability compared to the control campaign. Similarly, the reach in the test campaign is skewed right, suggesting a few instances with a higher reach, while the control data adheres to a more normal distribution. Notably, the test campaign demonstrates a left skew in the number of website clicks, indicating a scarcity of instances with high click numbers, in contrast to the control data, which showcases a broader spread, implying increased variability in clicks.

Moreover, the data highlights differences in user interactions, where the control campaign exhibits larger spreads in the number of searches and views, indicating a wider range of values, while the test campaign demonstrates smaller spreads, indicating fewer variations. Interestingly, the test campaign records lower frequency in users adding products to the cart, suggesting reduced engagement compared to the control campaign. Furthermore, the test campaign presents a significantly right-skewed distribution in the number of purchases, signifying instances with markedly higher purchase numbers. Additionally, both campaigns display rightward-skewed distributions in cost-related metrics (CPC and CPA) and performance indicators (AOV, CTR, and Conversion Rate), indicating the presence of instances with higher values in both test and control campaigns.

B. KPI Distribution over Time

After looking at frequency distribution, we then looked at the distribution of the daily KPI metrics – Figure 2 - to discern patterns, trends, and potential variations that enhance the understanding of how both campaigns performed overall.

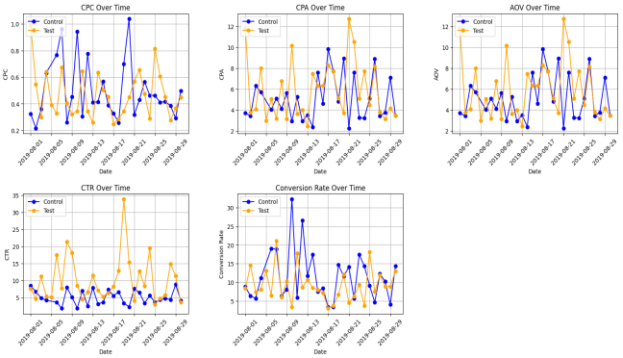

Fig. 2. KPI Distribution over time

Throughout the campaign analysis, distinct trends emerged across key performance indicators (KPIs). In terms of Cost Per Click (CPC), the control campaign witnessed a sustained increase in CPC over time while maintaining relative consistency, whereas the test campaign strategically implemented a gradual decrease in CPC indicating the test campaign's ability to optimize its cost per click, presenting a noteworthy departure from the control's more stable but ascending CPC trajectory. Similarly, the Cost Per Acquisition (CPA) exhibited divergent patterns, with the test campaign showcasing a progressive decrease over the campaign duration, punctuated by a few days of elevated CPA. In contrast, the control campaign experienced an overall increase in CPA, suggesting that the test campaign actively worked to enhance efficiency and cost-effectiveness in its acquisition strategies, potentially yielding superior outcomes compared to the control. Analysis of Average Order Value (AOV) revealed parallel trends in peaks and lows for both campaigns, yet the test campaign consistently maintained higher AOV values compared to the control which implies that, on average, the test campaign generated greater revenue per order, hinting at potentially more lucrative or substantial transactions compared to its control counterpart. In terms of Click-Through Rate (CTR), the test campaign consistently outperformed the control, maintaining a higher percentage of clicks in relation to impressions for the majority of the campaign. Although the control briefly caught up on a few occasions, this suggests that the test campaign fostered more effective audience engagement. Lastly, both the test and control campaigns demonstrated an overall positive trend in Conversion Rate, indicating improved effectiveness in converting interactions into desired outcomes. The parallel improvement in conversion rates for both campaigns suggest that both had an overall increased user engagement.

IV. Hypothesis Testing

In the hypothesis testing, we examined six key performance indicators (KPIs) to ascertain the significance of differences between the test and control campaigns. The null hypothesis indicates that there is no significant difference in the KPI metric between the campaigns, while the alternate hypothesis suggested a significant difference, signifying that one campaign outperforms the other for the respective metric.

TABLE I. Hypothesis Testing Results

Metric	***P – value Results***	***Results***
CPC	.83	Do Not Reject Null
CPA	.27	Do Not Reject Null
AOC	0.27	Do Not Reject Null
CTR	.3061	Reject Null
Conversion Rate	.003	Do Not Reject Null

The resulting P-values, presented in Table I, shed light on the statistical significance of these hypotheses. Notably, the P-value for Click-Through Rate (CTR) was 0.3061, leading to rejecting the null hypothesis, indicating a significant difference between the test and control campaigns in terms of CTR. This rejection suggests that the test campaign excelled in attracting clicks compared to the control. While other metrics did not exhibit statistically significant differences, the nuanced insights gained from this hypothesis testing contribute to a comprehensive understanding of the distinct performance dynamics observed in the A/B testing of the marketing campaigns.

V. Conclusion

The exploration of frequency distribution unveiled distinctive patterns between the test and control campaigns, providing valuable insights into user interactions and highlighting differences in campaign performance. The examination of KPI distribution over time uncovered distinct trends, with the test campaign strategically managing a decrease in CPC and CPA, leading to potential improvements in efficiency and cost-effectiveness. Hypothesis testing results provided statistical validation of our findings, indicating significant differences in CTR, suggesting the test campaign's superiority in attracting clicks. While other metrics did not exhibit statistically significant differences, the trends observed throughout the study empower organizations to make informed

decisions regarding marketing budget allocation, content optimization, and audience targeting.

In conclusion, this project demonstrates how to utilize A/B testing to evaluate and compare the performance of different marketing campaigns to determine which one yields the most favorable and statistically significant results. Overall, the test campaign exhibited strengths in specific KPIs, such as CTR, highlighting areas of success, while the control campaign demonstrated resilience in other metrics. By analyzing and understanding these findings, organizations can fine-tune their marketing strategies, reduce acquisition costs, and ultimately achieve a more impactful and efficient campaign performance.