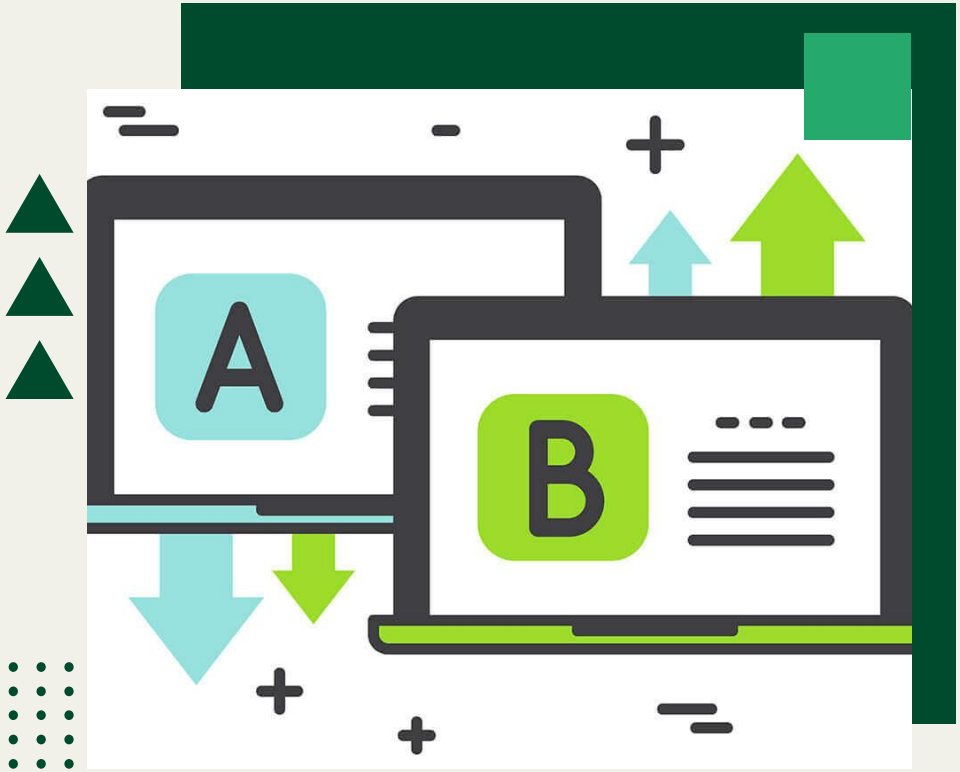
A/B Testing Implementation:

New Product Marketing Strategy Research



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Contents

Business Understanding

BACKGROUND

A fast-food chain plans to add a new item to its menu. However, they are still undecided between three possible marketing campaigns for promoting the new product. In order to determine which promotion has the greatest effect on sales, the new item is introduced at locations in several randomly selected markets. A different promotion is used at each location, and the weekly sales of the new item are recorded for the first four weeks.

- Promotion type 1: Flash sale discount
- Promotion type 2: Special cashback point
- Promotion type 3: Bundling deals

BUSINESS QUESTION

Is there a difference in sales performance among the three marketing strategies?

GOALS

Evaluate A/B testing results and decide which marketing strategy works the best.

Data Overview

MarketID	MarketSize	LocationID	AgeOfStore	Promotion	week	SalesInThousands
1	Medium	1	4	3	1	33.73
1	Medium	1	4	3	2	35.67
1	Medium	1	4	3	3	29.03
1	Medium	1	4	3	4	39.25
1	Medium	2	5	2	1	27.81

Variable	Total Unique Value
MarketID	10
MarketSize	3
LocationID	548
AgeOfStore	25
Promotion	3
SalesInThousands	137
548 rows, 6 columns	

- MarketID : unique identifier for market
- MarketSize : size of market area by sales (Large, Medium, Small)
- LocationID : unique identifier for store location
- AgeOfStore : age of store in years
- Promotion : one of three promotions that were tested (1, 2, 3)
- Week : one of four weeks when the promotions were run (1, 2, 3, 4)
- SalesInThousands : sales amount for a specific LocationID, Promotion, and week

Method & Workflow

Research Design **Analysis Method** **Workflow**

- This analysis was conducted in several stores at multiple locations. Each location will implement a different type of marketing strategy. Sales results will be measured weekly for four consecutive weeks at each store.
- The statistical methods used are the tests for differences in means for more than two groups (parametric: ANOVA Test or non-parametric: Kruskal-Wallis Test).

Step 1	Step 2	Step 3	Step 4	Step 5
Preprocessing Data: - Change column names - Handling missing value or invalid value - Remove duplicate data - Reformatting data type (as required)	Data Understanding & EDA	Assumption Test: - Normality test - Homogeneity test Additional Test: Bimodality Coefficient & Silverman's Test	Difference Test: - ANOVA test (if the assumptions are met) - Kruskal Wallis test (if the assumptions aren't met)	Post-hoc Test: - ANOVA: Tukey's HSD test - Kruskal Wallis: Dunn test with bonferroni correction

Step 1: Data Preprocessing

Change column names:

- MarketID ➜ Market ID
- MarketSize ➜ Market Size
- LocationID ➜ Location ID
- AgeOfStore ➜ Age of Store
- Week ➜ Week
- SalesInThousands ➜ Sales (Thousands)

Market ID	Market Size	Location ID	Age of Store	Promotion	Week	Sales (Thousands)
1	Medium	1	4	3	1	33.73
1	Medium	1	4	3	2	35.67
1	Medium	1	4	3	3	29.03
1	Medium	1	4	3	4	39.25
1	Medium	2	5	2	1	27.81

Step 1: Data Preprocessing

- In this case, we need to do data cleaning to overcome inconsistencies between data and handling missing values. But, no invalid data or missing values were identified.
- Additionally, we need to change the data type of several columns, including MarketID, LocationID, Promotion, and week from integer to string because these columns represent categorical data (even though they are in numeric form).

Total NaN value for each variable	
Market ID	0
Market Size	0
Location ID	0
Age of Store	0
Promotion	0
Week	0
Sales (Thousands)	0

There are no duplicate data.

Column	Before	After
Market ID	object	object
Market Size	int64	object
Location ID	int64	object
Age of Store	int64	int64
Promotion	int64	object
Week	int64	object
Sales (Thousands)	float64	float64

Step 1: Data Preprocessing

- Before conducting further analysis, it is necessary to create a data summary that depicts the total sales over 4 weeks (not in the format of weekly sales amounts).
- Additionally, the 'Week' column will be removed.

Market ID	Market Size	Location ID	Age of Store	Promotion	Week	Sales (Thousands)
1	Medium	1	4	3	1	33.73
1	Medium	1	4	3	2	35.67
1	Medium	1	4	3	3	29.03
1	Medium	1	4	3	4	39.25
1	Medium	2	5	2	1	27.81

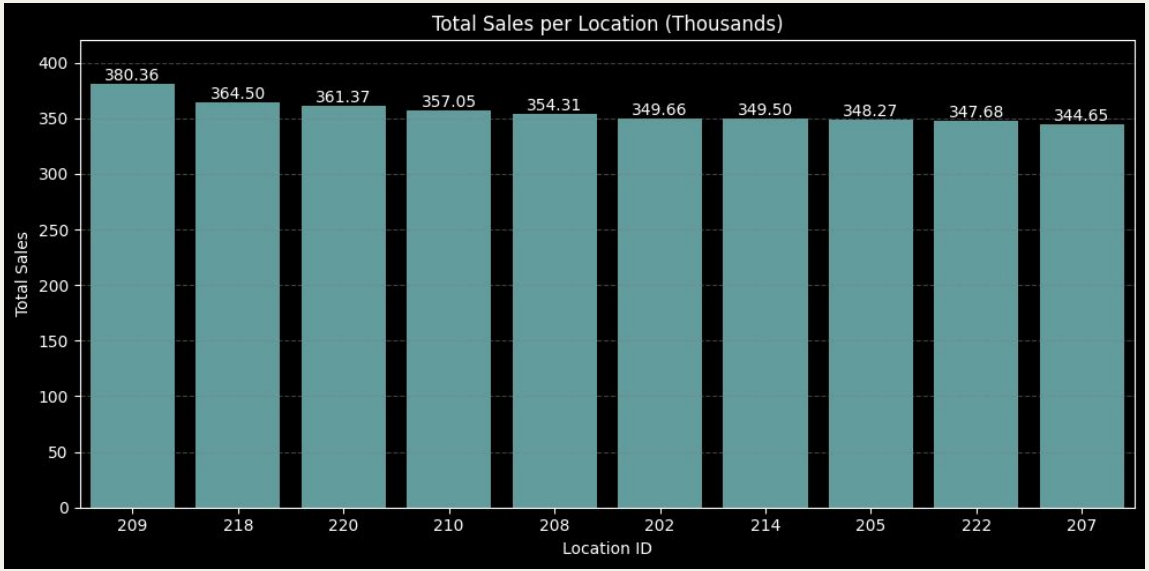
548 rows, 6 columns

Market ID	Market Size	Location ID	Age of Store	Promotion	Sales (Thousands)
1	Medium	1	4	3	137.68
1	Medium	1	4	3	122.66
1	Medium	1	4	3	145.45
1	Medium	1	4	3	151.14
1	Medium	2	5	2	169.49

137 rows, 6 columns

Step 2: Data Understanding & EDA

EDA QUESTION 1: What is the average sales over the last 4 weeks at each location?



The chart alongside depicts the top 10 locations with the highest total sales of new products over the 4-week research period (initial product launch).

Location with ID 209 ranked the highest with total sales amounting to 380.36 thousand. This figure has a significant gap with the rank below it (compared to the differences in sequential ranks).

The second to tenth ranks have sales ranging from 344 to 365 thousand, with the sales differences not being too significant.

Step 2: Data Understanding & EDA

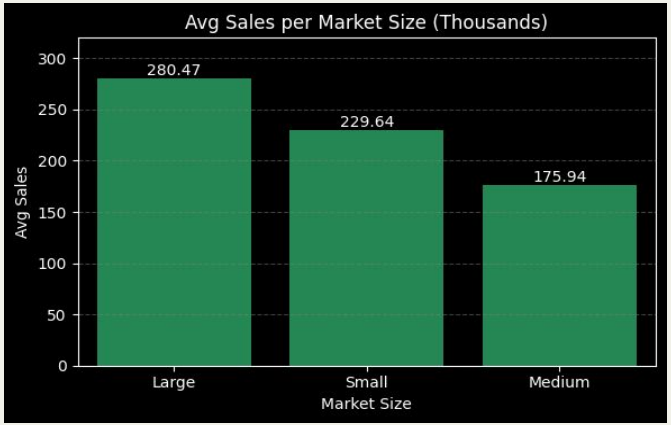
EDA QUESTION 2: How are the sales performances for each market size? Is market size positively correlated with sales performance?

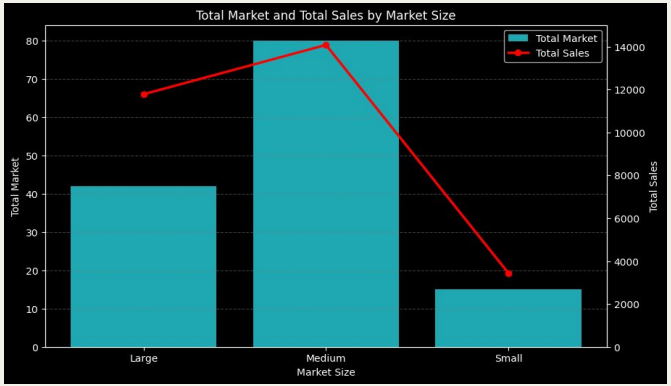
Large Market is the type of market with the highest average sales compared to other types of markets, amounting to 280.47 thousand.

The anomaly here is that the Small Market actually has a higher average sales than Medium Market, with a significant difference where the Small Market has an average sales of 229.64 thousand, while the Medium Market has an average sales of 175.94 thousand.

The graph shows that market size does not always correlate with sales performance.

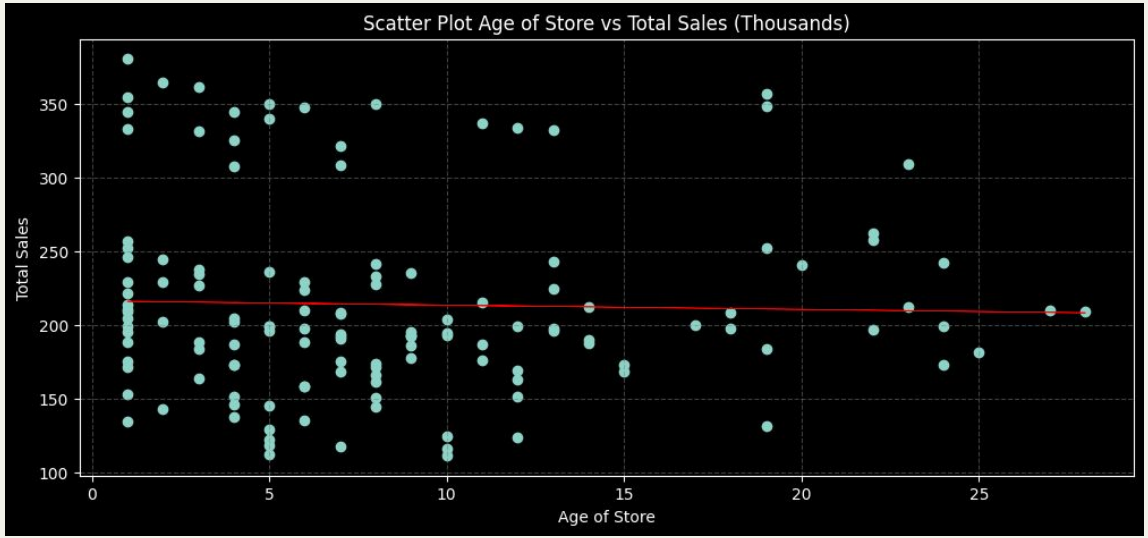
Upon further investigation, although the Medium Market has the highest total sales, this figure is also supported by the large number of stores in that category. This indicates that there may be some stores with low sales achievements.





Step 2: Data Understanding & EDA

EDA QUESTION 3: What is the relationship between store age and sales performance? Is store age positively correlated with sales performance?



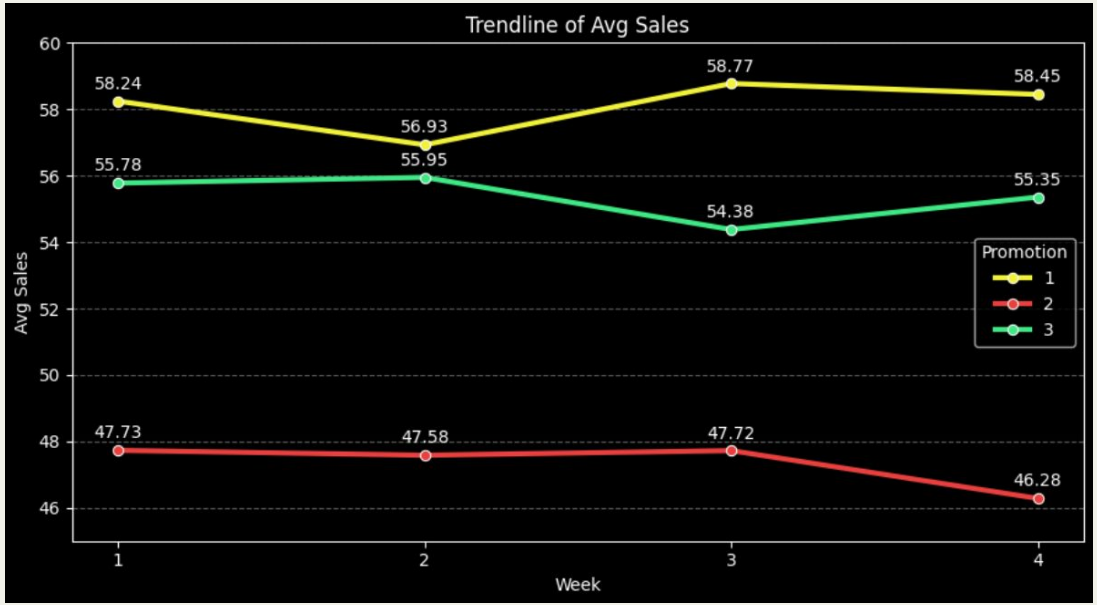
The Total sales and the age of a store don't have a specific relationship pattern.

If a trend line is drawn, it generally appears that the increase in the age of a store is not accompanied by an increase in total sales. This means that new stores do not always have consistently low/high sales, and vice versa.

It appears that the majority of stores with high sales are relatively new (for example, above 300 thousand).

Step 2: Data Understanding & EDA

EDA QUESTION 4: What are the sales trends for each type of promotion?



Overall, the first type of promotion dominates weekly sales.

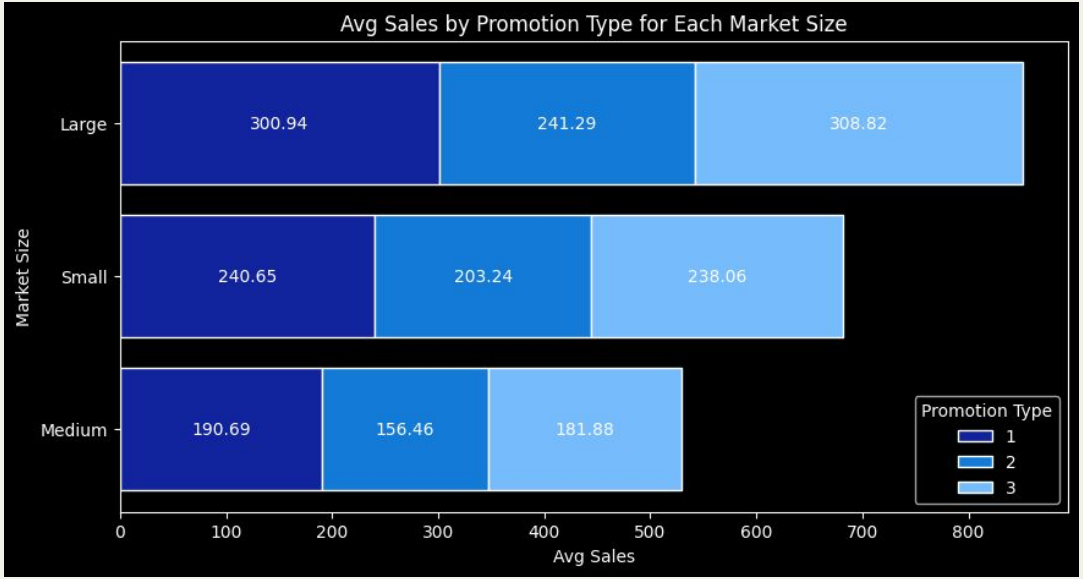
All three types of promotions experienced fluctuating sales trends over the 4-week period.

Each type of promotion achieved its highest sales in different weeks.

- The first type of promotion achieved its highest sales in the 3rd week with a total of 58.77 thousand,
- the second type in the 1st week with a total of 47.73 thousand, and
- the third type in the 2nd week with a total of 55.95 thousand.

Step 2: Data Understanding & EDA

EDA QUESTION 5: Which type of promotion achieved the highest sales figures? Compare also in each market size.



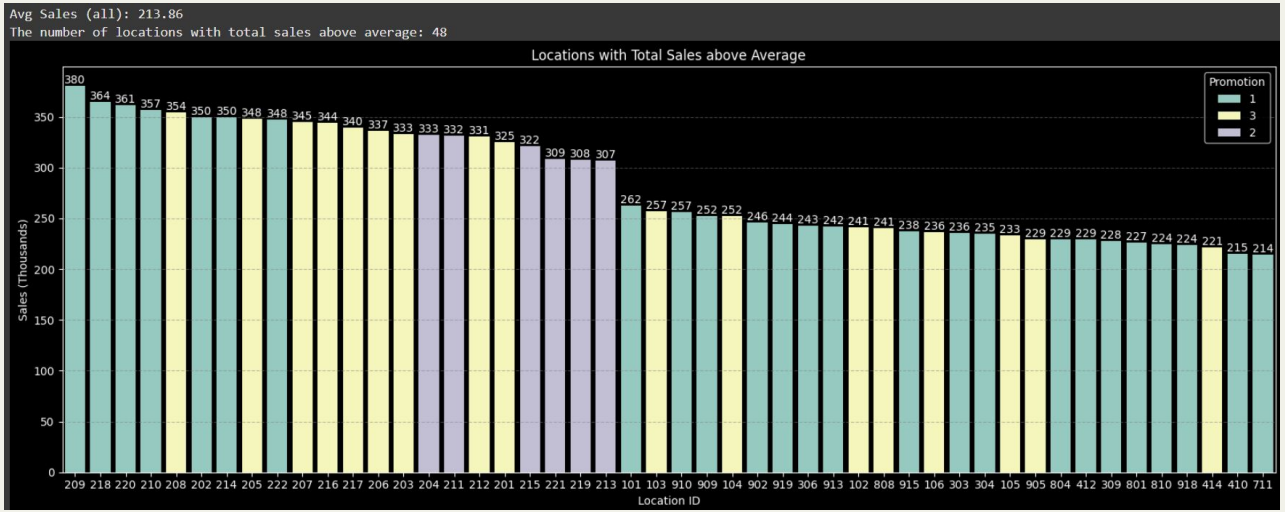
As explained in EDA Question 4, the first type of promotion dominates overall (even on a weekly basis).

When broken down by market size, in terms of average sales, only the Large Market is not dominated by the first type of promotion, but rather by the third type.

For the Small Market and Medium Market, the highest sales are achieved by the first type of promotion.

Step 2: Data Understanding & EDA

EDA QUESTION 6: Which locations have total sales above the average? Which type of promotion has the greatest impact on boosting sales at these locations?



The average sales across all locations are recorded at 213.86 thousand.

The number of locations with total sales above the average is recorded at 48 locations.

The top 4 locations with the highest sales use the first type of promotion. Overall, the majority of locations with above-average sales also use the first type of promotion.

Only few locations with above average sales use the second type of promotion.

Step 3: Assumption Test

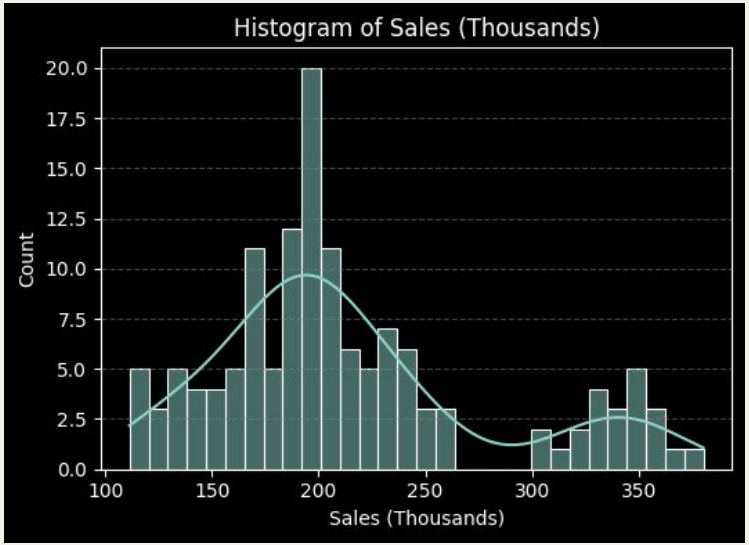
NORMALITY TEST

Hypothesis
H_0: The data follows a normal distribution.
H_1: The data does not follow a normal distribution.

Significant level (alpha)
5% (0.05)

Shapiro-Wilk Test
Shapiro-wilk test for group 1: p-value = 0.000157
Shapiro-wilk test for group 2: p-value = 0.000024
Shapiro-wilk test for group 3: p-value = 0.000135

Result
Reject the null hypothesis because p-value < alpha (0.05).
The data doesn't follow a normal distribution.



Identification
Based on the histogram shown ('Histogram of Sales (Thousands)'), there is a suspicion that the data comes from two different groups/populations (bimodal distribution), hence a test is needed to determine whether the data is identified as having a bimodal distribution or is just a collection of outlier values (positive skewness).

Step 3: Assumption Test

BIMODAL DISTRIBUTION TEST

Testing using Bimodality Coefficient

- If the Bimodality Coefficient is greater than 0.555 → bimodal distribution.
- The analysis results show that Bimodality Coefficient (BC): 0.571633. So the distribution can be categorized as bimodal.

Testing using Silverman's Test (KDE + Mode Detection)

- If the number of modes is more than one, the distribution can be considered bimodal. If only one, then the distribution is unimodal.
- The analysis results show mode = 2, thus the data can be categorized as a bimodal distribution.
- Based on the graph, the mode values appear at two points (196 and 343).

```
Bimodality Coefficient: 0.571633185838776
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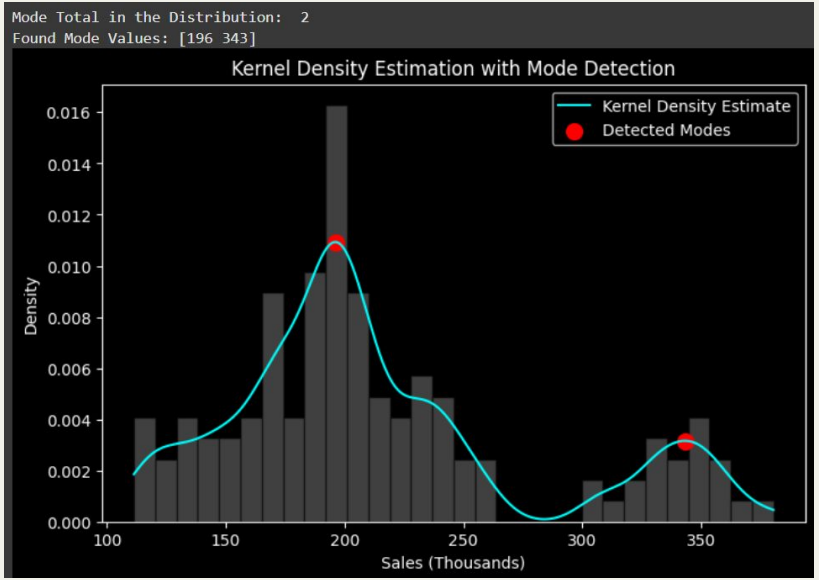
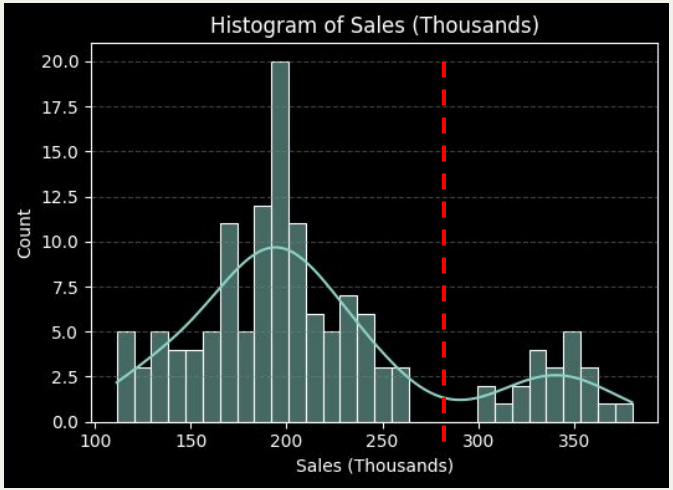


Step 3: Assumption Test

SEPARATING DATA

- We will use the histogram to estimate the threshold between two groups of data. Based on the histogram, the threshold of the two groups is at 275.
- Two datasets were formed (df_1 and df_2), each containing 115 rows and 22 rows, respectively.



Data (df_1) shape: (115, 6)	
Promotion	Total
1	36
2	41
3	38

Data (df_2) shape: (22, 6)	
Promotion	Total
1	7
2	6
3	9

Step 3: Assumption Test

NORMALITY TEST FOR EACH DATASET

- **First Dataset (df_1)**
  Shapiro-wilk test for df_1 **group 1: p-value = 0.049387**
  Shapiro-wilk test for df_1 **group 2: p-value = 0.000631**
  Shapiro-wilk test for df_1 **group 3: p-value = 0.397674**
  With a significance level (alpha) of 0.05, reject H_0 because the p-value is smaller than alpha (for group 1 and group 2), indicating that the data does not follow a normal distribution.

- **Second Dataset (df_2)**
  Shapiro-wilk test for df_2 **group 1: p-value = 0.233013**
  Shapiro-wilk test for df_2 **group 2: p-value = 0.075242**
  Shapiro-wilk test for df_2 **group 3: p-value = 0.996028**
  With a significance level (alpha) of 0.05, fail to reject H_0 because the p-value is greater than alpha (for all groups), indicating that the data follows a normal distribution.

HOMOGENEITY TEST

Hypothesis
H_0: The data are homogeneous.
H_1: The data aren't homogeneous.

Significant level (alpha)
5% (0.05)

Levene Test
Levene Test df_1 **(1st dataset): p-value = 0.799583**
Levene Test df_2 **(2nd dataset): p-value = 0.611496**

Result
Failed to reject H_0 because the p-value is greater than alpha (for all dataset), indicating that the data are homogeneous.

Step 4: Difference Test

FIRST DATASET: KRUSKAL WALLIS TEST

Hypothesis
H_0: There is no difference in sales median/distribution for each promotion type.
H_1: At least one type of promotion has a different sales median/distribution.

Significant level (alpha)
5% (0.05)

Kruskal-Wallis Test
Kruskal-Wallis Test: statistic = 20.838426, p-value = 0.0000299

Result
Reject the null hypothesis (H_0) because p-value < alpha (0.05).
So at least one type of promotion has a different sales median/distribution.

SECOND DATASET: ANOVA TEST

Hypothesis
H_0: There is no difference in average sales for each promotion type.
H_1: At least one type of promotion has a different average sales.

Significant level (alpha)
5% (0.05)

Kruskal-Wallis Test
ANOVA Test: statistic = 22.788589, p-value = 0.000009

Result
Reject the null hypothesis (H_0) because p-value < alpha (0.05).
So at least one type of promotion has a different average sales.

Step 5: Post-Hoc Test

FIRST DATASET: DUNN TEST

	1	2	3
1	1	0.000021	0.297623
2	0.000021	1	0.013036
3	0.297623	0.013036	1

Based on the table output above, it can be concluded that:

- Promotion types 1 and 2 have a significant difference in sales results with a p-value of 0.000021.
- Promotion types 1 and 3 don't show a significant difference in sales results, with a p-value of 0.297623.
- Promotion types 2 and 3 have a significant difference in sales results, with a p-value of 0.013036.

SECOND DATASET: TUKEY'S HSD TEST

Group 1	Group 2	Mean diff	p-value	Reject
1	2	-40.2202	0	TRUE
1	2	-18.9019	0.0064	TRUE
2	3	21.3183	0.0035	TRUE

Based on the table output above, it can be concluded that:

- Promotion types 1 and 2 have a significant difference in sales results, with a p-value of 0.0.
- Promotion types 1 and 3 have a significant difference in sales results, with a p-value of 0.0064.
- Promotion types 2 and 3 have a significant difference in sales results, with a p-value of 0.0035.

Step 5: Post-Hoc Test

Comparing Between Groups

The higher the mean rank, median, and average, the higher the sales performance. This indicates that the implemented promotional strategy was successful.

Both tables below show consistent results, namely that **promotion type 1 has the highest mean rank, median, and average** compared to the other promotion types, followed by promotion type 3 in second place, and promotion type 2 in third place.

FIRST DATASET

Promotion	Mean Rank	Median
1	74.416667	211.815
2	40.219512	183.89
3	61.631579	196.33

SECOND DATASET

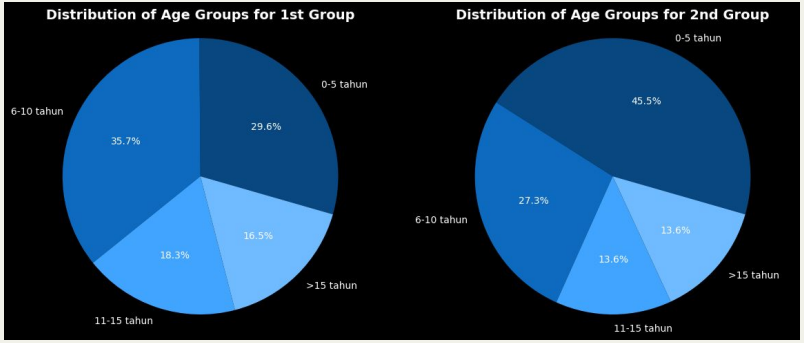
Promotion	Average Sales
1	232.396047
2	189.31766
3	221.457872

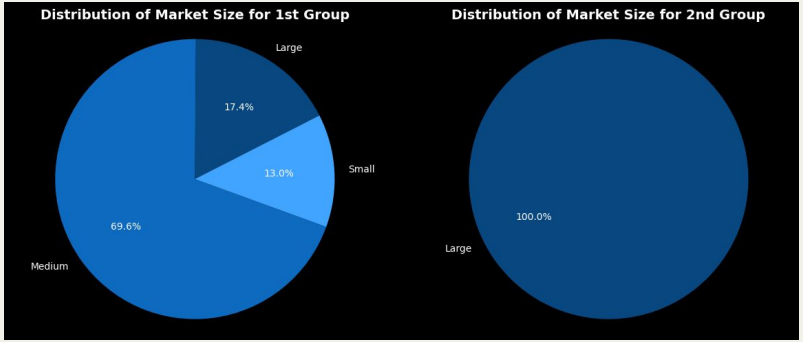
NEW INSIGHT: COMPARISON BETWEEN DATA GROUPS

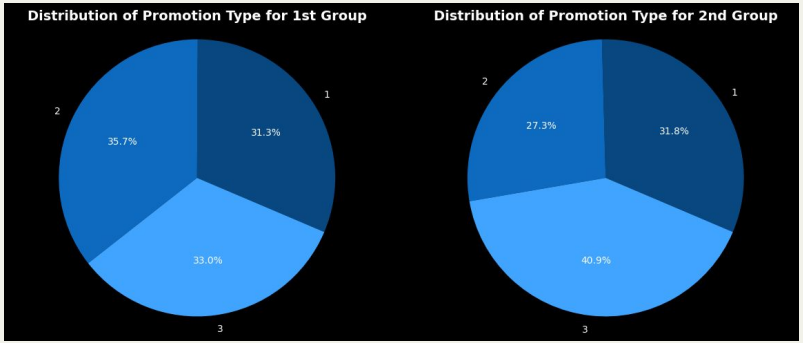
The analysis results identified two data groups. The chart beside illustrates the differences between the two groups based on the distribution of store age, store size, and the promotions implemented.

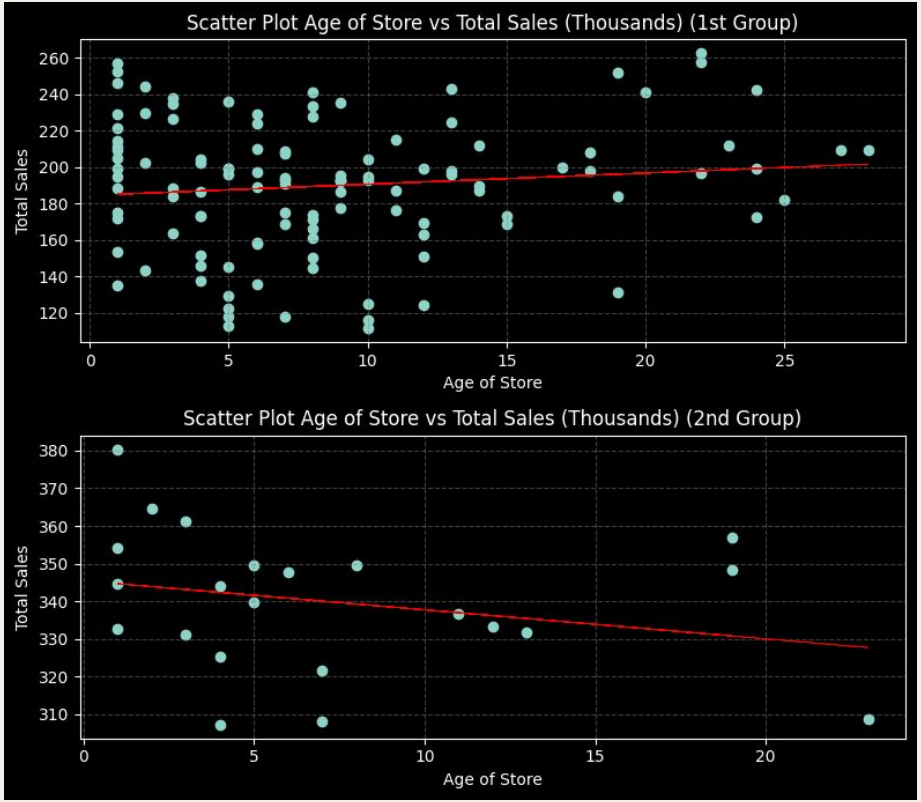
- Based on store age, the first group consists primarily of stores aged 6–10 years, while the second group is dominated by stores aged 0–5 years.
- Based on market size, the first group is dominated by medium markets, whereas the second group is entirely composed of large markets.
- Based on promotion type, the implementation of promotional strategies in the first group is relatively evenly distributed across all three types. However, in the second group, promotion type 3 is the most dominant.

In general, **the second group is characterized by new large markets that heavily implement promotion type 3**. However, **the first group shows more variety in store age and promotion type, with medium markets being the majority.**.









NEW INSIGHT: COMPARISON BETWEEN DATA GROUPS

When examining the relationship between store age and sales performance, the **majority of stores in both groups fall within the 0–10 year age** range, with only slight differences observed between the two groups.

1. The first group shows an upward trend, meaning that **the older the store, the higher the sales performance** of its new products.
2. In contrast, the second group exhibits a downward trend, indicating that **newer stores tend to have higher sales**. The younger the store, the greater the sales performance of its new products. An interesting finding in the second group is that the highest sales were generated by newer stores.

Conclusions

- Based on the EDA analysis, it is evident that the **Large Market generates the highest average sales** compared to other market sizes.
- Regarding promotional performance:
  - The **first type of promotion has effectively captured customer interest**, resulting in the highest average sales over the past four weeks. This performance is only slightly different from the third type of promotion.
  - In contrast, the **second type of promotion shows much lower sales** figures than the other two types of promotion.
- Insights derived from the correlation between age of store and sales performance are as follows:
  - There is a group of relatively **new stores (especially new Large Market) that have successfully recorded high sales**. **Further analysis is needed** to determine the factors behind this achievement, such as:
    a) ‘Effective marketing strategies’: A type of promotion that successfully introduces and popularizes the new product in that specific location.
    b) ‘Successful product innovation’: A new product that aligns with the interests of customers in that location.
    c) ‘Favorable external factors’: External factors that cause anomalies (such as unusually high sales performance). Examples include strategic store locations, the impact of local events, specific moment (long holiday), etc.
  - There are **several older stores that still contribute significantly to sales** and should therefore be maintained.

Next Steps

Research Area

Conducting research while **considering external factors** that may potentially influence the results, such as differences in location that lead to variations in geographic and demographic conditions, differing sample sizes between groups that can impact the validity of the analysis, and avoiding other external factors such as time (e.g., specific commemorative days, local events, and so on).

Business Area

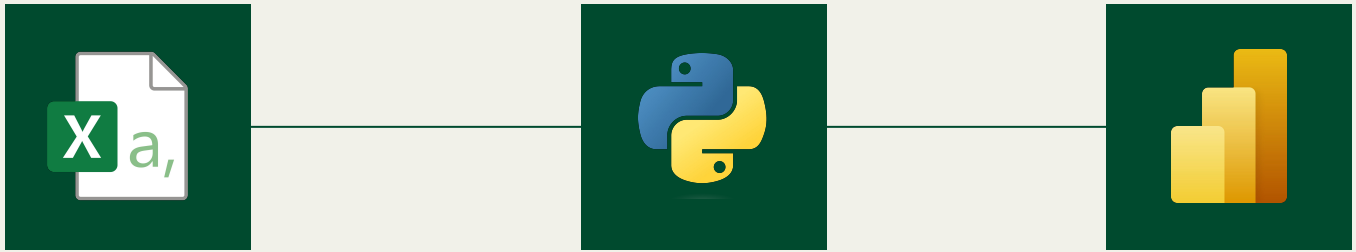
- **Implementing similar promotional strategies** that have proven successful in this study for the promotion of new products in the future (while taking into account changes in trends).
- **Reevaluating the sales of new products in stores with low sales performance**, as the products might not be in demand. Conducting research on new product development tailored to the trends of the local area.
- Continuing to **monitor the sales of new products in newly opened stores with high sales performance** to determine whether the success is due to external factors or if the products are genuinely popular among customers.
  a) ‘Successful product innovation’: Continuously introducing new or unique products to maintain customer interest and draw in a wider customer base.
  b) ‘Favorable external factors’: Examples include strategic store locations, the impact of local events, or other advantageous circumstances. These should be leveraged to amplify product awareness, perhaps by collaborating with influencers to produce engaging content, or by organizing product-related competitions to enhance visibility.

THANK YOU

Every byte of data holds a story. Dive deep to discover, analyze, and create with confidence.

Novia Anggita Aprilianti, Data Enthusiast

Attachment



Dataset | Python File | Dashboard