**Promotion Analysis for the Google Merchandise Store**

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**Objective**

**Increase purchase revenue for our eCommerce store!**

First, we must ask ourselves…

* Did promotions (homepage carousels) help the business grow?
* If yes, how could we apply promotions to improve our business in the future?

To answer questions above, we break down our analysis into 5 phases:

**#0** Get the data, dive deeper into the data, and structure our analysis

**#1** Answer the first question: “Did promotions help our business grow?”

**#2** Discover successful characteristics and popular item categories for future promotions

**#3** Identify product preference among customers using cluster analysis

**#4** Create promotional strategies to improve our business

**#5** Design an A/B test plan for launching new promotion

Let’s walk through each phase and find out the answers!

**Dataset**

[The data](https://developers.google.com/analytics/bigquery/web-ecommerce-demo-dataset) provides an obfuscated Google Analytics 4-property dataset for BigQuery, which contains business/eCommerce data from [Google Merchandise Store](https://www.googlemerchandisestore.com/), an online store that sells Google-branded merchandise.

The dataset includes the following kinds of information:

* **Traffic source data**: information about where website visitors originate. This includes data about organic traffic, paid search traffic, display traffic, etc.
* **Content data**: information about the behavior of users on the site. This includes the URLs of pages that visitors look at, how they interact with content, etc.
* **Transactional data**: information about the transactions that occur on the Google Merchandise Store website.
* **Time Period**: 2020-11-01 to 2021-01-31

Limitation of this dataset:

* Data for some fields have been obfuscated such as **fullVisitorId**, or removed such as **clientId**, **adWordsClickInfo**, and **geoNetwork**.
* Data may include strings such as “Not available in demo dataset” and “null” when querying the fields that contain no data.

**Data Analysis & Solution Approach**

**Phase #0** Get the data, dive deeper into the data, and structure our analysis

First, we must get the dataset through the BigQuery Public Datasets program on the Google BigQuery UI or by downloading it to our local computer. After querying the table on the Cloud Console interface, the result shows there's a total of 3,980,420 rows complete dataset, which is too huge to download through the interface.

Therefore, we utilize the latter way, downloading query results for the dataset to DataFrame.

Step 1: Advance preparation

* [Create service accounts and service account keys](https://cloud.google.com/iam/docs/creating-managing-service-accounts).
* [Create credentials with scopes](https://cloud.google.com/bigquery/docs/samples/bigquery-auth-drive-scope).

Step 2: Download query results for **ga4\_obfuscated\_sample\_ecommerce** dataset as a Pandas DataFrame

* Read documents/articles about GA4 and write a SQL query.
* [Download query results as a DataFrame](https://cloud.google.com/bigquery/docs/samples/bigquery-query-results-dataframe) for further analysis.

Step 3: Dig into the data and structure the customer journey funnel

* Study articles such as [Introduction to Google Analytics 4 (GA4) and advanced topics](https://developers.google.com/analytics/devguides/collection/ga4/ecommerce) about implementing GA4 in an eCommerce business.
* Know more about [GA4 events](https://developers.google.com/analytics/devguides/collection/ga4/reference/events).

There're 8 events in this dataset, based on the eCommerce customer journey, we order those events by mapping with the customer journey map:

1. **view\_promotion, select\_promotion**: customers can see a carousel on the website’s homepage, which are the internal promotions in this case
2. **view\_item\_list, select\_item, view\_item**: search/select items or click specific item to its product page
3. **add\_to\_cart**: add items to a cart before checking out
4. **begin\_checkout, purchase**: complete purchasing one or more items

We can generate different metrics by calculating event counts and applying aggregations. For further analysis, we then build up a funnel with two ways/journeys based on whether the customer responds to/engage with promotions or not:

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According to the funnel, we can identify whether customers respond to promotions in each session. Moreover, we can uncover how many customers bounce/churn in each stage, which enables us to measure the effectiveness and evaluate the profits for sessions with each promotion or with no promotion.

**Phase #1** Answer the first question: “Did promotions help our business grow?”

Step 1: Data preparation and processing for performing exploratory data analysis to have a better understanding of this eCommerce business

* Create customer & session-level data, and item-level data  
  - **Customer & Session data**: unique ID, geographic data, and device/web related information of customer/session; information for each session, including origin, number of unique pages, total time duration, total quantity of items, total revenue of all transactions, etc.  
  - **Item data**: number of unique customers/sessions viewed this item, added this item to a cart, and purchased this item

Step 2: Visualize the data and find insights

* **﻿**Customer distribution by country/device/brand/browser  
  - **Insight #1**: Some customer profiles like most of our customers are in Northern America and Southern Asia, which accounts for around 62% of total customers.
* **﻿**Customers & revenue timing trend  
  - **Insight #2**: Comparing sessions with promotions with those without promotions, we can find that both daily customer count and total purchase revenue of sessions with promotions are mostly higher during these three months. See [Figure 1](#Figure_1).
* ﻿Bounce & Abandonment of each item category

- **Insight #3**: Comparing total view sessions, add-to-cart rate \*, session conversion rate (CVR) \*, and total item revenue among all item categories between sessions with promotions and those without promotions, the average of all metrics of sessions with promotions are higher than that of sessions without promotions. See [Figure 2](#Figure_2).

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**Figure 1.** Sessions and Total Purchase Revenue Timing Trend byPromotion or Not

**Table

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**Figure 2.** Metrics (Total View Sessions, Add-to-Cart Rate, Session CVR, and Total Item Revenue) of Each Item Category byPromotion or Not

From the analysis above, we can conclude and answer the question: **“Yes, promotions on the website did help our business grow!”** However, how to improve business using promotions? To answer this question, we have to discover the most effective promotions and corresponding target markets, which will not only improve our promotional effectiveness but increase our business performance.

**Phase #2** Discover successful characteristics and popular item categories for future promotions

Step 1: Create promotion-level data with metrics such as promotion click-through rate (CTR) and session CVR to measure promotion effectiveness

* **For sessions with promotions:**

* **For sessions without promotions:**

Step 2: Calculate the percentage of unique items by item category among all unique items viewed by customers, which helps us identify the most popular categories (mostly viewed by customers) for each promotion

* For instance, there’s a total of 608 unique items viewed in the "Act Responsible" promotion, and among those unique items, 3 unique items are in the "Accessories" category, which accounted for 0.5% of the total unique items viewed (3/608) in this promotion.

Step 3: Visualize the data and find insights

* Comparison of metrics and performance among all promotions and without promotions (See [Figure 3](#Figure_3))  
  - **Insight #1**: Add-to-cart rate and CVR among sessions without promotions are lower than most sessions with promotions. Among all promotions, “Reach New Heights” has the lowest performance.  
  - **Insight #2**: “Act Responsible” and “Complete Your Collection” have relatively higher promotion CTRs, however, “Google Mural Collection” has the highest add-to-cart rate (41.9%) and CVR (15.9%).  
  - **Insight #3**: From average item quantity and purchase revenue per transaction, we can find that profits among promotions and without promotions are similar, therefore, stimulating engagement (CTR, add-to-cart rate, or CVR) of specific promotions to improve overall revenue won’t cause extremely different level of revenue growth.
* Go into the percentage of viewed unique items by item category for each promotion (See [Figure 4](#Figure_4))  
  - **Insight #4**: “Apparel” and “Lifestyle” are popular categories among all customers.

- **Insight #5**: “Sale” is popular among customers purchasing with promotions; on the other hand, “Shop by Brand” is relatively more popular among customers purchasing without promotions.

- **Insight #6**: We find that the number of unique items viewed in sessions without promotions (1,129 unique items) is extremely higher than that of sessions with promotions (around 600 unique items), which indicates that customers who don’t respond to/engage with promotions tend to browse around the website, but those who engage with promotions are directed to the categories/products while purchasing.

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**Figure 3.** Metrics (Promotion CTR, Add-to-Cart Rate, Session CVR, and Average Item Quantity and Purchase Revenue Per Transaction) of Each Promotion

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**Figure 4.** ﻿Percentage of Viewed Unique Products by Item Category for Each Promotion

Step 4: Summarize key traits of those successful promotions

* From **Insights #1**, we wonder the causes of the poor performance of “Reach New Heights”  
  - There’s no further information for this promotion, also, from the percentage of viewed unique items by item category for this promotion, we cannot find any significant difference between this promotion and other promotions.  
  - As we dig into the events, we suggest this promotion is the first slide of our homepage carousel! Thus, there’s a chance that the content on it may not be attractive to our customers so they choose to skip it and scroll to the latter pages.  
  - The Google Merchandise Store can try to identify the causes of low performance for this promotion, and avoid them when designing/launching new promotions in the future.
* Based upon **Insight #2**, we dive deeper into the promotion with the best performance, “Google Mural Collection” (Take a look at some items in this collection in [Figure 5](#Figure_5).)  
  - We discover that this collection was conceived by a team of Googlers and a San Francisco based artist Monica Garwood to illustrate Google’s unique and amazing culture. In addition, a 27’ mural in the Google Merchandise Store in Mountain View, and thousands of visitors stop by each week to take pictures with it! You can check out [Monica’s post](https://www.facebook.com/MonicaGarwoodIllustration/posts/3066493026724121/) and enjoy one of the most “Googley” landmarks around Google’s main campus!  
  - The Google Merchandise Store can add some designs and elements similar to this illustration on their future carousels/promotions, or even invite talented artists or designers of their special collections to create artworks for advertising products.
* According to **Insight #4** and **Insight #5**  
  - We can promote more items in “Apparel” and “Lifestyle” on our homepage carousel or in future promotions because those items are most of our customers’ fav!  
  - For those customers who don’t respond to promotions, we can create a new promotional strategy specifically for “Shop by Brand” to attract customers to our promotion as well as guide them to the item category efficiently, which can improve customer experience.

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**Figure 5.** Some Adorable Items in Google Mural Collection

We believe when customers enter the Google Merchandise Store and see the carousel/promotions showing popular categories/items they might want to buy, we can convert potential customers and boost our sales effectively. Also, transforming products and designs into practical illustrations or artworks is a great way to promote our collections and brand as well.

**Phase #3** Identify product preference among customers using cluster analysis

In this part, we focus on our two main markets, Northern America and Southern/Eastern Asia:

* **Northern America**

- Countries including the United States and Canada  
- Customer count: 52,466 (51.5% of total customers)   
- Session count: 66,429 (16.9% of total sessions)

* **Southern & Eastern Asia**- Countries including India, China, Taiwan, Japan, etc.- Customer count: 17,172 (51.6% of total sessions)   
  - Session count: 21,712 (16.9% of total sessions)

In our opinion, customer preference and behavior will be different across countries/regions.

Step 1: Data preparation for clustering

* Extract session/event data of customers in Northern America and Southern Asia separately, and calculate metrics for all items viewed, added to cart, or purchased by customers in these two regions.
* Metrics such as number of unique sessions viewed/added/purchased and total purchase revenue, implying the popularity of each item as well as how customers engage with each item.
* To get more precise results, we narrow down the scope of products and only focus on top items in each region. More specifically, if one of the metrics of an item is greater than at most 50% of all data points in the region, we regard this item as a top item in this region.

Step 2: Conduct Cluster Analysis

* Implement cluster analysis on items based on product popularity and customer behavior for Northern America and Southern/Eastern Asia individually.
* After comparing the clustering performance of K-means Clustering with that of Kohonen Clustering Network by looking into the distance between clusters and standard deviations of each cluster, we choose the analysis results from Kohonen Clustering Network, which performs better (standard deviations of most clusters are lower).
* Individually, we group those top items among customers in Northern America and customers in Southern/Eastern Asia into 4 clusters, determined by [the Elbow Method and the Silhouette Method](https://medium.com/analytics-vidhya/how-to-determine-the-optimal-k-for-k-means-708505d204eb). In [Figure 6.1](#Figure_6_1) and [Figure 6.2](#Figure_6_2), we can see that k=6 is the inflection point; however, the Silhouette score as k=6 is too low. Therefore, we choose k=4 for clustering.

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**Figure 6.1** The Elbow Plot for Finding Optimal Value of K in Clustering for Northern America

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**Figure 6.2** The Silhouette Plot for Finding Optimal Value of K in Clustering for Northern America

Step 3: Find insights from our analysis results

* Top items we can focus on promoting in **Northern America**  
  - **Cluster #1**: Items like "Google Crewneck Sweatshirt Navy" and "Google Badge Heavyweight Pullover Black" are highly viewed and added to cart by customers, however, the CVR of those items are relatively lower than other groups of items. If customers actually purchase those items, it will bring us revenue due to the high item prices.  
  - **Cluster #4**: Items such as "Google Men's Puff Jacket Black" and "Google Heather Green Speckled Tee" have high add-to-cart rates and CVRs, which indicates that items in this group are pretty popular among customers.
* Top items we can focus on promoting in **Southern/Eastern Asia**  
  - **Cluster #3**: Items including "Google Men's Tech Fleece Grey" and " Google Badge Heavyweight Pullover Black" have high add-to-cart rates and CVRs, and those items bring us great revenue because of their high prices.   
  - **Cluster #4**: Items such as "Google Crewneck Sweatshirt Navy" and "Google Crewneck Sweatshirt Grey" are similar to items in Cluster #3 but with lower CVRs.
* Some interesting insights from **Cluster #3 in Northern America**  
  - Products in the "Stationery" and some of in the "Lifestyle" are slightly viewed by customers compared to items in other groups, but the add-to-cart rates of those products are relatively high. Profits from those items are low because most of them are inexpensive products.  
  - When we plan to improve clearance sales for those two categories but not focus on revenue growth, we can prioritize promotions for those products in the future.

**Phase #4** Create promotional strategies to improve our business

According to our analysis, we can run promotions on our eCommerce store as follows:

1. Promote popular items with high add-to-cart rates and CVRs on our homepage carousel such as Google Men's Tech Fleece Grey, Google Badge Heavyweight Pullover Black, and so on (we can get a detailed item list from the results of cluster analysis).   
   **→ Convert potential customers and increase purchase revenue!**
2. Create a new promotion specifically for “Shop by Brand” to attract customers to our promotion and guide them to this category efficiently.   
   **→ Improve engagement in promotions and customer experience!**
3. Invite artists or designers to create practical artworks like hand-painted advertising and photography for advertising our brand and products.   
   **→ Promote item collections and emphasize brand image!**

Besides, it's worth noting that:

1. Products in the "Stationery" and some of in the "Lifestyle", which are relatively inexpensive, are slightly viewed but are often added to a cart after being viewed by customers. In the future, when we focus on having clearance sales but not increasing profits, it will be suitable to promote items in those two categories in the sales.
2. Uncover hidden causes of the poor performance of “Reach New Heights”, and optimize the content on the first slide of our homepage carousel, which is a visitor’s very first experience of our site.

So far, we’ve learned a lot about our business/customers and uncovered various intriguing insights while analyzing the data. And those insights can all be transformed into actions to help our business grow.

Last but not least, in the final phase of our analysis, we are going to integrate insights we found with practice. Let’s create an A/B test plan to achieve the objective, increasing purchase revenue for our eCommerce store!

**Phase #5** Design an A/B test plan for launching new promotion

Step 1: Set Up the Experiment

* In the past, homepage carousels on the Google Merchandise Store website are merely promoting specific item categories or collections. Here, we plan to increase sales and improve our business in the Northern American region by displaying popular and high-value products among customers on a slide of our homepage carousel.
* For our experiment, we are creating a slide showing items with high add-to-cart rates and CVRs in Northern America based on our cluster analysis, and testing two different contents:

- The original slide which shows specific item category  
- The new slide promoting popular products

We would like to evaluate the impact (if any) on revenue. Our hypothesis is: “*Showing a homepage carousel with popular and high-value items will increase revenue.*”

Step 2: Define Goal/Success Metrics

* **Primary metric** that we hope to improve and achieve:- *Revenue Per Session*: Does our business grow because of the new promotion? We include all potentially affected users, but no unaffected users (users who never select the promotion) who distort our results.

* **Secondary metric** to monitor our goal:

- *Promotion CTR*: Does the content of the new promotion attract customers?

- *CVR*: Are customers actually buying more products?

Our refined hypothesis becomes “*Showing a homepage carousel with popular and high-value items will increase revenue per session for customers who click this promotion.*”

Step 3: Design the Experiment – How large (size) does our experiment need to be?

* A sample cannot represent the population if its size is not sufficiently large. Therefore, we should find out the optimal sample size for our experiment to get unbiased results and minimize the costs from negative metrics.
* We calculate sample size by the following formula:

: Confidence level, the probability of making *type I errors*)  
- We usually set as 5%, ≈ 1.96

: Power of statistical test, the probability of making *type II errors*)

- We usually set as 20%, ≈ 0.84

**Baseline metric**: Calculated from historical data in the past month  
- After calculating the number of sessions engaged with promotions and total purchase revenue in the past one month, we get the average revenue per session from 2021/1/1 to 2021/1/31 in Northern America, which is around $6.  
  
: Get the standard deviation based on the baseline metric   
- The standard deviation of revenue per session is around $5.3.

: Minimum detectable effect (MDE), the desired lift/growth in the metric

- We first set our desired growth on revenue per session as 10%, so the expected revenue per session after launching our new promotion will be 5.92 \* (1+10%) = 6.512, and the MDE will be 6.512 – 6 = 0.512.

After getting all parameters in the formula, finally, we evaluate the sample size for each group

That is, we should collect a total of 1,680 \* 2 = 3,360 subjects for the experiment. We can also utilize [online sources](https://www.evanmiller.org/ab-testing/sample-size.html) which automatically compute the sample size for us after filling up the parameters if the metric is a ratio, e.g., add-to-cart rate, CVR, etc.

Step 4: Design the Experiment – How long do we run the experiment?

* Because groups of active users might be different every day (referring to [day-of-the-week effects on consumer behavior](https://richrelevance.com/2012/08/27/monday-matters-how-day-of-week-affects-online-shopping-for-four-major-retailers/)), it’s necessary to run the experiment for at least a full week or run for a usage cycle such as multiples of 7 days.
* According to some articles, experts recommend running an A/B test for a minimum of one to two weeks. By doing so, we could cover all the different days which visitors interact with our website.
* We can also determine the test duration based on dividing sample size by daily active users (DAU). In this case, we can divide 1680 by daily sessions with promotions on our website.

In conclusion, our experiment design is as follows:

1. For our experiment, we are creating a slide showing items with high add-to-cart rates and CVRs in Northern America based on our cluster analysis.
2. The hypothesis of our experiment is “Showing a homepage carousel with popular and high-value items will increase revenue per session for customers who click this promotion.”
3. We will target sessions among customers in Northern America and analyze those who click through our promotions.
4. We will run our experiment for 7 to 14 days, and potentially prolong it depending on whether the subjects reach 3,360.

After running the experiment, we can interpret the results by statistical inference and find out whether our new promotions increase revenue or not. If yes, we will make tradeoffs between different metrics and make the final decisions like “are we going to launch our new carousel to all customers in the Northern American region?”, and “is it suitable to expand this promotion to other countries such as Asia?”

From data to insights, we discover opportunities and build up strategies. And from results to decisions, we make positive and profitable impacts on our company.

**Reference**

**[Google Cloud]**

Create and Manage service accounts and service account keys

<https://cloud.google.com/iam/docs/creating-managing-service-accounts>

Create credentials with scopes

<https://cloud.google.com/bigquery/docs/samples/bigquery-auth-drive-scope>

Download query results to DataFrame

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**[GA4]**

BigQuery Export integration

<https://support.google.com/analytics/topic/9359001?hl=en&ref_topic=9306488>

Dimensions and metrics

<https://support.google.com/analytics/answer/9143382>

Introduction to Google Analytics 4: Ecommerce

<https://developers.google.com/analytics/devguides/collection/ga4/ecommerce>

Google Analytics 4 Events

<https://developers.google.com/analytics/devguides/collection/ga4/reference/events>

**[Dataset]**

BigQuery sample dataset for Google Analytics 4 ecommerce web implementation

<https://developers.google.com/analytics/bigquery/web-ecommerce-demo-dataset>

Google Analytics Demo Account

<https://support.google.com/analytics/answer/6367342#access&zippy=%2Cin-this-article>

Google Merchandise Store

<https://www.googlemerchandisestore.com/>

**[Insights]**

Google Mural Collection designed by Monica Garwood

<https://www.facebook.com/MonicaGarwoodIllustration/posts/3066493026724121/>

**[Cluster Analysis]**

How to Determine the Optimal K for K-Means?

<https://medium.com/analytics-vidhya/how-to-determine-the-optimal-k-for-k-means-708505d204eb>

**[A/B Test]**

從案例實戰看AB Test系統設計及其原理

# <https://www.163.com/dy/article/G1OPUU060511805E.html>

A/B Testing by Google - Online Experiment Design and Analysis

<https://www.udacity.com/course/ab-testing--ud257>

## Trustworthy Online Controlled Experiments: A Practical Guide to A/B Testing

## *Book by Diane Tang, Ron Kohavi, and Ya Xu*

Monday Matters: How Day of Week Affects Online Shopping for Four Major Retailers

<https://richrelevance.com/2012/08/27/monday-matters-how-day-of-week-affects-online-shopping-for-four-major-retailers/>