Methodology

```
from google.colab import drive
drive.mount('/content/drive')
```

```
from google.colab import auth
auth.authenticate_user()
```

```
from google.cloud import storage

project_id = "sharp-matter-449521-u2"
!gcloud config set project {project_id}
```

```
Updated property [core/project].
```

```
!wget -P /usr/lib/spark/jars/ https://storage.googleapis.com/hadoop-lib/gcs/gcs-connector-hadoop3-latest.jar
```

```
--2025-04-09 22:20:49--  https://storage.googleapis.com/hadoop-lib/gcs/gcs-connector-hadoop3-latest.jar
Resolving storage.googleapis.com (storage.googleapis.com)... 172.253.117.207, 142.250.99.207, 142.250.107.207, ...
Connecting to storage.googleapis.com (storage.googleapis.com)|172.253.117.207|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 40713341 (39M) [application/java-archive]
Saving to: ‘/usr/lib/spark/jars/gcs-connector-hadoop3-latest.jar’

gcs-connector-hadoo 100%[===================>]  38.83M   207MB/s    in 0.2s

2025-04-09 22:20:49 (207 MB/s) - ‘/usr/lib/spark/jars/gcs-connector-hadoop3-latest.jar’ saved [40713341/40713341]
```

```
import warnings
warnings.filterwarnings('ignore')
```

```
from pyspark.sql import SparkSession
```

```
spark = SparkSession.builder \
    .appName("BigDataProcessing") \
    .config("spark.jars", "/usr/lib/spark/jars/gcs-connector-hadoop3-latest.jar") \
    .config("spark.hadoop.fs.gs.impl", "com.google.cloud.hadoop.fs.gcs.GoogleHadoopFileSystem") \
    .config("spark.hadoop.fs.gs.auth.service.account.enable", "true") \
    .getOrCreate()
```

```
spark
```

SparkSession - in-memory

SparkContext

Spark UI

Version
    v3.5.5
Master
    local[*]
AppName
    BigDataProcessing

```
df_reviews = spark.read.parquet('gs://final_dataset_dat490/dat490_final_dataset_cleaned.parquet', headers=True, inferSchema=True)
```

```
df_reviews.columns
```

```
['gmap_id',
 'customer_name',
 'rating',
 'reviews',
 'time',
 'avg_rating',
 'category',
 'latitude',
 'longitude',
 'business_name',
 'num_of_reviews',
 'state',
 'standard_category',
 'Monday',
 'Tuesday',
 'Wednesday',
 'Thursday',
 'Friday',
 'Saturday',
 'Sunday',
 'timestamp',
 'week',
 'month',
 'year',
 'time_seconds']
```

VADER

```
from pyspark.sql.functions import udf
from pyspark.sql.types import FloatType
from nltk.sentiment.vader import SentimentIntensityAnalyzer
import nltk
nltk.download("vader_lexicon")

# Initializing VADER
sia = SentimentIntensityAnalyzer()

def vader_sentiment(text):
    if text:
        return float(sia.polarity_scores(text)["compound"])
    else:
        return 0.0

vader_udf = udf(vader_sentiment, FloatType())

df_sentiment = df_reviews.withColumn("sentiment_score", vader_udf("reviews"))
```

```
[nltk_data] Downloading package vader_lexicon to /root/nltk_data...
```

```
from pyspark.sql.functions import when

df_sentiment = df_sentiment.withColumn(
    "sentiment_label",
    when(df_sentiment["sentiment_score"] > 0.2, "Positive")
    .when(df_sentiment["sentiment_score"] < -0.2, "Negative")
    .otherwise("Neutral")
)
```

```
from pyspark.sql.functions import approx_count_distinct

df_sentiment.groupBy("sentiment_label").agg(approx_count_distinct("gmap_id").alias("approx_count")).show()
```

```
+---------------+------------+
|sentiment_label|approx_count|
+---------------+------------+
|       Positive|     2598785|
|        Neutral|      149531|
|       Negative|      197929|
+---------------+------------+
```

```
from pyspark.sql.functions import when

df_sentiment = df_sentiment.withColumn(
    "sentiment_label",
    when(df_sentiment["sentiment_score"] > 0.05, "Positive")
    .when(df_sentiment["sentiment_score"] < -0.05, "Negative")
    .otherwise("Neutral")
)
```

```
df_sentiment.select("reviews", "sentiment_score", "sentiment_label").show(10)
```

```
+--------------------+---------------+---------------+
|             reviews|sentiment_score|sentiment_label|
+--------------------+---------------+---------------+
|The pizza, steak ...|         0.6114|       Positive|
|Great way to get ...|         0.6249|       Positive|
|Went there for a ...|         0.7392|       Positive|
|Friendly and know...|         0.4939|       Positive|
|My personal choic...|         0.8308|       Positive|
|This store has be...|        -0.6324|       Negative|
|I am disappointed...|          0.975|       Positive|
|AUAF oversee a va...|         0.9042|       Positive|
|Great neighborhoo...|         0.6249|       Positive|
|This is place is ...|         0.8807|       Positive|
+--------------------+---------------+---------------+
only showing top 10 rows
```

```
from pyspark.sql.functions import approx_count_distinct

df_sentiment_counts = df_sentiment.groupBy("sentiment_label").agg(approx_count_distinct("gmap_id").alias("approx_count"))
```

```
from pyspark.sql.functions import approx_count_distinct

df_sentiment.groupBy("sentiment_label").agg(approx_count_distinct("gmap_id").alias("approx_count")).show()
```

```
+---------------+------------+
|sentiment_label|approx_count|
+---------------+------------+
|       Positive|     2647752|
|        Neutral|       91804|
|       Negative|      227790|
+---------------+------------+
```

```
from pyspark.sql.functions import col, round

df_percentages = df_sentiment_counts.withColumn(
    "percentage", round((col("approx_count") / 2884722) * 100, 2)
)
```

TextBlob

```
from pyspark.sql.functions import col, when, regexp_replace
from textblob import TextBlob
from pyspark.sql.functions import udf
from pyspark.sql.types import StructType, StructField, DoubleType, StringType

def get_textblob_sentiment(text):
    if text is not None and isinstance(text, str):
        blob = TextBlob(text)
        return float(blob.sentiment.polarity), float(blob.sentiment.subjectivity)
    else:
        return 0.0, 0.0

schema = StructType([
    StructField("polarity", DoubleType(), True),
    StructField("subjectivity", DoubleType(), True)
])

sentiment_udf = udf(get_textblob_sentiment, schema)

df_reviews = df_reviews.withColumn("sentiment", sentiment_udf("reviews"))
df_reviews = df_reviews.withColumn("polarity", col("sentiment.polarity"))
df_reviews = df_reviews.withColumn("subjectivity", col("sentiment.subjectivity"))
```

```
from pyspark.sql.functions import when

# Putting all the reviews into 3 categories based on their polarity
df_reviews = df_reviews.withColumn(
    "sentiment_label",
    when(col("polarity") <= -0.2, "Negative").
    when(col("polarity") <= 0.2, "Neutral").
    otherwise("Positive")
)
```

```
df_reviews.select('reviews', 'polarity', 'sentiment_label').show(10, truncate=False)
```

```
+------------------------------------------------------------------------------------------------------------------------------------
|reviews
+------------------------------------------------------------------------------------------------------------------------------------
|The pizza, steak street tacos and the portobello truffle fries and were all delicious!
|Great way to get around town, and very affordable.
|Went there for a volleyball tournament. The facilities are nice. They have a lot of bleacher  seating. They offered guest wifi but I di
|Friendly and knowledgeable. I was able to get a copy of my pets shots.
|My personal choice for somewhat upscale dining in Woodstock. The burgers are delicious, but my go to item is the Lobster Cobb Salad. Yo
|This store has been featured on the Instagram account of “overpriced bourbon”. Tells you all you need to know. Along with the miserable
|I am disappointed to see negative reviews for this establishment. I am very frequent here and always have a pleasant experience. The be
|AUAF oversee a variety  programs. I work as a Home Care Aide through them. As an employee of AUAF Home Care program I was treated with
|Great neighborhood bar
|This is place is solid. The prices are reasonable and the portions large. However the food is not stellar. Some things are pretty good,
+------------------------------------------------------------------------------------------------------------------------------------
only showing top 10 rows
```

```
sentiment_label_count = df_reviews.groupby('sentiment_label').count()
```

```
from pyspark.sql.functions import col, round
df_sentiment_all = df_reviews.withColumn("sentiment_score", vader_udf("reviews"))
df_sentiment_all = df_sentiment_all.withColumn("polarity", col("sentiment.polarity"))
df_sentiment_all.columns
```

```
['gmap_id',
 'customer_name',
 'rating',
 'reviews',
 'time',
 'avg_rating',
 'category',
 'latitude',
 'longitude',
 'business_name',
 'num_of_reviews',
 'state',
 'standard_category',
 'Monday',
 'Tuesday',
 'Wednesday',
 'Thursday',
 'Friday',
 'Saturday',
 'Sunday',
 'timestamp',
 'week',
 'month',
 'year',
 'time_seconds',
 'sentiment',
 'polarity',
 'subjectivity',
 'sentiment_label',
 'sentiment_score']
```

```
from pyspark.sql.functions import when, length, col
from pyspark.sql import functions as F

df_labeled = df_sentiment_all.withColumn(
    "vader_label",
    when(col("sentiment_score") >= 0.05, "Positive")
    .when(col("sentiment_score") <= -0.05, "Negative")
    .otherwise("Neutral")
)
df_labeled = df_labeled.withColumn(
    "textblob_label",
    when(col("polarity") >= 0.05, "Positive")
    .when(col("polarity") <= -0.05, "Negative")
    .otherwise("Neutral")
)
df_labeled = df_labeled.withColumn("review_length", length(col("reviews")))

df_labeled = df_labeled.withColumn(
    "length_bucket",
    when(col("review_length") < 100, "Short")
    .when(col("review_length") <= 300, "Medium")
```

```
        .otherwise("Long")
    )

    top_categories = [row['standard_category'] for row in df_labeled.groupBy("standard_category")
                      .count().orderBy(F.desc("count")).limit(5).collect()]

    df_filtered = df_labeled.filter(col("standard_category").isin(top_categories))

    samples = []
    for category in top_categories:
        for label in ["Positive", "Negative", "Neutral"]:
            for length_group in ["Short", "Medium", "Long"]:
                subset = (
                    df_filtered.filter(
                        (col("standard_category") == category) &
                        (col("vader_label") == label) &
                        (col("length_bucket") == length_group)
                    ).orderBy(F.rand()).limit(1)
                )
                samples.append(subset)

    df_sample_30 = samples[0]
    for i in range(1, len(samples)):
        df_sample_30 = df_sample_30.union(samples[i])

    df_final = df_sample_30.select(
        "reviews", "standard_category", "review_length",
        "vader_label", "sentiment", "textblob_label", "polarity"
    )

    df_final.show(30, truncate=False)



    df_final_30 = df_final.limit(30)


    from transformers import pipeline

    # Load zero-shot classification model
    zero_shot_classifier = pipeline("zero-shot-classification", model="facebook/bart-large-mnli")


    from pyspark.sql.functions import when, length, col

    df_bucketed = df_reviews.withColumn("review_length", length(col("reviews")))

    df_bucketed = df_bucketed.withColumn(
        "length_bucket",
        when(col("review_length") < 100, "Short")
        .when(col("review_length") <= 300, "Medium")
        .otherwise("Long")
    )


    from pyspark.sql import functions as F

    # Group count
    group_counts = df_bucketed.groupBy("standard_category", "length_bucket").count()

    # Total rows
    total_count = df_bucketed.count()

    # Target sample size
    sample_target = 10000

    # Compute fraction per group
    group_fractions = group_counts.withColumn(
        "fraction", (F.col("count") / total_count) * sample_target
    ).withColumn(
        "sample_size", F.round("fraction").cast("int")
    )



    sampled_dfs = []

    for row in group_fractions.collect():
        cat = row['standard_category']
    bucket = row['length_bucket']
    n = row['sample_size']

    if n > 0:
        subset = (
            df_bucketed.filter(
                (col("standard_category") == cat) &
                (col("length_bucket") == bucket)
            )
            .orderBy(F.rand())
            .limit(n)
        )
        sampled_dfs.append(subset)



df_sample_10k = sampled_dfs[0]
for sdf in sampled_dfs[1:]:
    df_sample_10k = df_sample_10k.union(sdf)



output_path = "gs://final_dataset_dat490/sample_reviews_stratified_10k.parquet"


df_sample_10k.write.mode("overwrite").parquet(output_path)


import pandas as pd
df_sample_pandas = pd.read_parquet(output_path)
df_sample_pandas = df_sample_pandas.sort_values(["gmap_id", "timestamp"]).reset_index(drop=True)
df_sample_pandas.columns
```

```
Index(['gmap_id', 'customer_name', 'rating', 'reviews', 'time', 'avg_rating',
       'category', 'latitude', 'longitude', 'business_name', 'num_of_reviews',
       'state', 'standard_category', 'Monday', 'Tuesday', 'Wednesday',
       'Thursday', 'Friday', 'Saturday', 'Sunday', 'timestamp', 'week',
       'month', 'year', 'time_seconds', 'review_length', 'length_bucket'],
      dtype='object')
```

```
df_sample_pandas[['reviews']]
```

```
                                        reviews
    0      Nice clean place and very friendly staff. Only...
    1    This company helped us buy our land 15 years a...
    2       Great place for kids and families to do sports...
    3         He was able to fit me in at the last minute. A...
    4     I have had good experiences here for the past ...
  ...                                                   ...
 9996   Store was disorganized and sales representativ...
 9997   Treated as a number, not a patient. Rushed by ...
 9998      This is such a great place to grab dinner. The...
 9999     Dividers and spots clearly marked on floor, pl...
10000        Travelers, this is the cape cod thrift store e...
10001 rows × 1 columns
```

```
# pip install pandas transformers openpyxl

# from google.colab import drive
# drive.mount('/content/drive')

# import pandas as pd
# df_reviews_30 = pd.read_excel('/content/drive/MyDrive/Reviews std DAT490.xlsx')
# df_reviews_30.head()

# from transformers import pipeline

# classifier = pipeline("zero-shot-classification", model="facebook/bart-large-mnli")
# labels = ["positive", "neutral", "negative"]
# score = []
# for review in df_reviews_30['Reviews']:
#   prediction = classifier(review, candidate_labels=labels)
#   top_label = prediction["labels"][0]
#   score.append(top_label)

# df_reviews_30['Sentiment'] = score
# df_reviews_30

# df_reviews_30.to_excel('/content/drive/MyDrive/Reviews std DAT490 labelled.xlsx')
```

```
!pip install vaderSentiment
```

```
Collecting vaderSentiment
  Downloading vaderSentiment-3.3.2-py2.py3-none-any.whl.metadata (572 bytes)
Requirement already satisfied: requests in /usr/local/lib/python3.11/dist-packages (from vaderSentiment) (2.32.3)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.11/dist-packages (from requests->vaderSentiment) (3.4.
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.11/dist-packages (from requests->vaderSentiment) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.11/dist-packages (from requests->vaderSentiment) (2.3.0)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.11/dist-packages (from requests->vaderSentiment) (2025.1.31)
Downloading vaderSentiment-3.3.2-py2.py3-none-any.whl (125 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 126.0/126.0 kB 4.0 MB/s eta 0:00:00
Installing collected packages: vaderSentiment
Successfully installed vaderSentiment-3.3.2
```

```
from textblob import TextBlob
from vaderSentiment.vaderSentiment import SentimentIntensityAnalyzer
from tqdm import tqdm

tqdm.pandas()  # Progress bar for apply
```

```
analyzer = SentimentIntensityAnalyzer()

def get_textblob_polarity(text):
    try:
        return TextBlob(text).sentiment.polarity
    except:
        return None

def get_vader_compound(text):
    try:
        return analyzer.polarity_scores(text)["compound"]
    except:
        return None
```

```
# Assuming df["reviews"] contains your text
df_sample_pandas["vader_polarity"] = df_sample_pandas["reviews"].progress_apply(get_textblob_polarity)
df_sample_pandas["textblob_sentiment_score"] = df_sample_pandas["reviews"].progress_apply(get_vader_compound)
```

```
100%|██████████| 10001/10001 [00:03<00:00, 2803.51it/s]
100%|██████████| 10001/10001 [00:03<00:00, 2917.04it/s]
```

```
def label_textblob(p):
    if p >= 0.05:
        return "Positive"
    elif p <= -0.05:
        return "Negative"
    else:
        return "Neutral"

def label_vader(s):
    if s >= 0.05:
        return "Positive"
    elif s <= -0.05:
        return "Negative"
    else:
        return "Neutral"

# 🔄 Updated column names
df_sample_pandas["textblob_label"] = df_sample_pandas["vader_polarity"].apply(label_textblob)
```

```
df_sample_pandas["vader_label"] = df_sample_pandas["textblob_sentiment_score"].apply(label_vader)
df_sample_pandas.head()
```

	gmap_id	customer_name	rating	reviews	time	avg_rating	category	latitude	longitude
0	0x0:0xde4ab363e58baf8	Glen Sikorski	5	Nice clean place and very friendly staff. Only...	1619963856471	4.2	Restaurant, Bar, Caterer, Event venue	45.120739	-91.448845
1	0x145e95d513a77c99:0x7aad3c9a54c17e9f	stephen travers	5	This company helped us buy our land 15 years a...	1621983091409	3.4	Property management company, Real estate agency	29.730017	-99.075182
2	0x14e037302ebfe6bd:0x483c80e39ebb0ab7	Shawn Bebej	5	Great place for kids and families to do sports...	1578142093772	4.9	Non-profit organization	34.233393	-118.590456

```
from transformers import pipeline
from tqdm import tqdm

# Enable progress bar
tqdm.pandas()

# Load zero-shot classification pipeline with BART
zero_shot_classifier = pipeline("zero-shot-classification", model="facebook/bart-large-mnli")
```

```
config.json:  100%                                          1.15k/1.15k  [00:00<00:00,  74.2kB/s]
Xet Storage is enabled for this repo, but the 'hf_xet' package is not installed. Falling back to regular HTTP download. For better perfo
WARNING:huggingface_hub.file_download:Xet Storage is enabled for this repo, but the 'hf_xet' package is not installed. Falling back to r
model.safetensors:  100%                                         1.63G/1.63G  [00:10<00:00,  244MB/s]
tokenizer_config.json:  100%                                     26.0/26.0  [00:00<00:00,  2.94kB/s]
vocab.json:  100%                                           899k/899k  [00:00<00:00,  21.7MB/s]
merges.txt:  100%                                           456k/456k  [00:01<00:00,  335kB/s]
tokenizer.json:  100%                                       1.36M/1.36M  [00:00<00:00,  30.7MB/s]
```

```
candidate_labels = ["positive", "neutral", "negative"]

def classify_bart(text):
    try:
        result = zero_shot_classifier(text, candidate_labels)
        return result["labels"][0].capitalize()  # Most likely label
    except:
        return None  # Handle any errors gracefully
```

```
df_sample_pandas["bart_label"] = df_sample_pandas["reviews"].progress_apply(classify_bart)
```

```
  0%|          | 10/10001 [00:02<22:20,  7.45it/s]You seem to be using the pipelines sequentially on GPU. In order to maximize efficienc
100%|██████████| 10001/10001 [14:47<00:00, 11.27it/s]
```

```
df_sample_pandas.head()
```

	gmap_id	customer_name	rating	reviews	time	avg_rating	category	latitude	longitude
0	0x0:0xde4ab363e58baf8	Glen Sikorski	5	Nice clean place and very friendly staff. Only...	1619963856471	4.2	Restaurant, Bar, Caterer, Event venue	45.120739	-91.448845
1	0x145e95d513a77c99:0x7aad3c9a54c17e9f	stephen travers	5	This company helped us buy our land 15 years a...	1621983091409	3.4	Property management company, Real estate agency	29.730017	-99.075182
2	0x14e037302ebfe6bd:0x483c80e39ebb0ab7	Shawn Bebej	5	Great place for kids and families to do sports...	1578142093772	4.9	Non-profit organization	34.233393	-118.590456
3	0x14e3db41cf753ebd:0x1d6536e7c20051ef	L C	5	He was able to fit me in at the	1616604264474	4.8	Window tinting	33.546954	-112.202525

```
import pandas as pd

# Count label frequencies per method
label_counts = pd.DataFrame({
    "TextBlob": df_sample_pandas["textblob_label"].value_counts(),
    "VADER": df_sample_pandas["vader_label"].value_counts(),
    "BART": df_sample_pandas["bart_label"].value_counts()
}).fillna(0).astype(int)

# Reorder rows for consistency
label_counts = label_counts.reindex(["Positive", "Neutral", "Negative"])
```

```
# Melt into long format
df_melted = label_counts.T.reset_index().melt(
    id_vars="index", var_name="Sentiment", value_name="Count"
)
df_melted.rename(columns={"index": "Method"}, inplace=True)
```

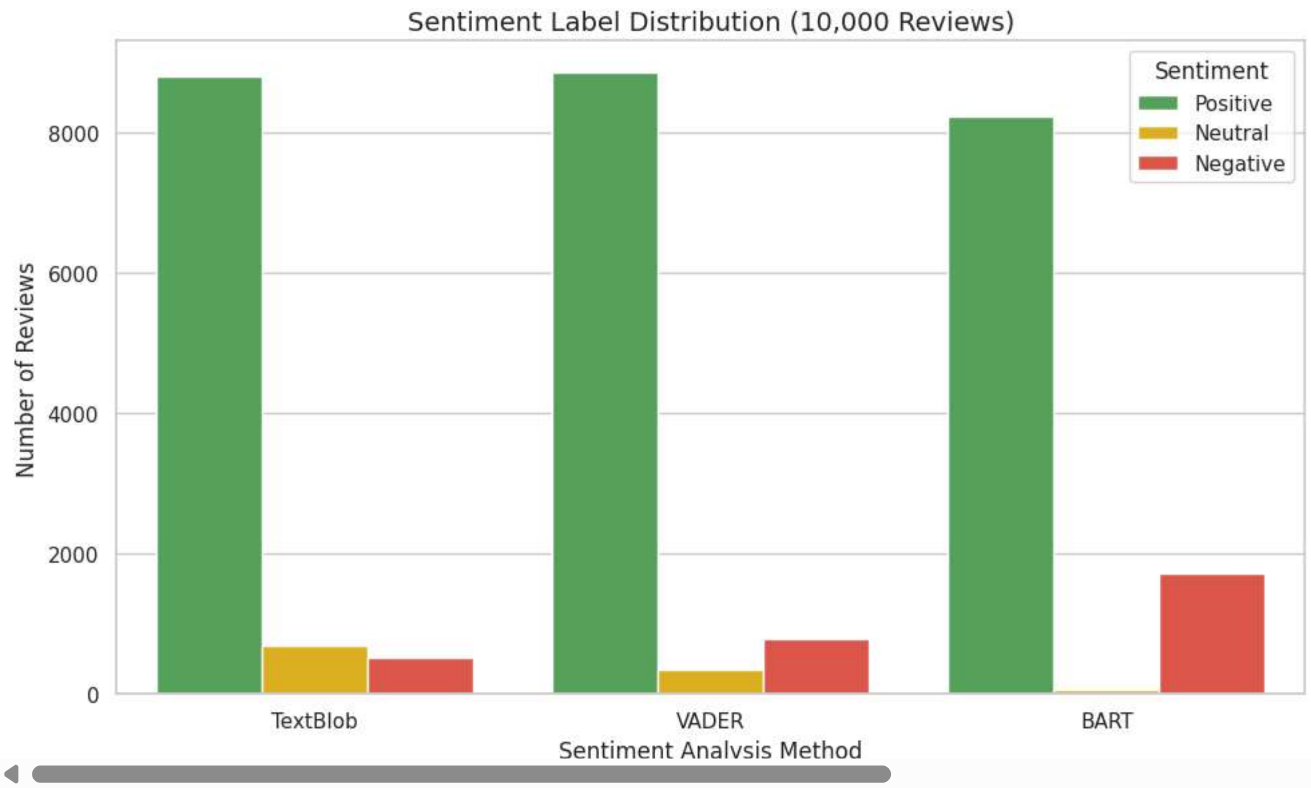
```
import seaborn as sns
import matplotlib.pyplot as plt

# Set seaborn style
sns.set(style="whitegrid")

# Define consistent color palette
palette = {
    "Positive": "#4CAF50",
    "Neutral": "#FFC107",
    "Negative": "#F44336"
}

# Create grouped bar plot
plt.figure(figsize=(10, 6))
sns.barplot(
    data=df_melted,
    x="Method", y="Count", hue="Sentiment",
        palette=palette
    )

    # Customize the chart
    plt.title("Sentiment Label Distribution (10,000 Reviews)", fontsize=14)
    plt.xlabel("Sentiment Analysis Method")
    plt.ylabel("Number of Reviews")
    plt.legend(title="Sentiment")
    plt.tight_layout()
    plt.show()
```


Sentiment Label Distribution (10,000 Reviews)
Sentiment
Positive
Neutral
Negative
Number of Reviews
TextBlob
VADER
BART
Sentiment Analysis Method