Exploratory_Data_Analysis

October 8, 2024

EXPLORATORY DATA ANALYSIS

[ ]:
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
```

Importing the two csv datasets and merging them into one

[ ]:
```
table_chemicals = pd.read_csv("chemicals-in-cosmetics-.csv")  #Chemicals␣
 ↪dataset from Kaggle
table_cosmetics = pd.read_csv("cosmetics.csv")  # We use this dataset to get␣
 ↪the skin type information we need for each Brand
merged_table = pd.merge(table_chemicals, table_cosmetics, left_on='BrandName',␣
 ↪right_on='Brand') #BrandName and Brand are the key columns we can use to do␣
 ↪innerjoin
merged_table.head(20)
```

[ ]:
```
    CDPHId                                       ProductName   CSFId  \
0     5391                                    NARS Blush Duo  9763.0
1     5391                                    NARS Blush Duo  9763.0
2     5391                                    NARS Blush Duo  9763.0
3     5391                                    NARS Blush Duo  9763.0
4     5742  SUCCESS AGE SPLENDID - DEEP-ACTION NIGHT CARE …     NaN
5     5742  SUCCESS AGE SPLENDID - DEEP-ACTION NIGHT CARE …     NaN
6     5742  SUCCESS AGE SPLENDID - DEEP-ACTION NIGHT CARE …     NaN
7     5742  SUCCESS AGE SPLENDID - DEEP-ACTION NIGHT CARE …     NaN
8     5742  SUCCESS AGE SPLENDID - DEEP-ACTION NIGHT CARE …     NaN
9     5742  SUCCESS AGE SPLENDID - DEEP-ACTION NIGHT CARE …     NaN
10    5743  SPECIALISTES - CREME CAMPHREA - ANTI-BLEMISH CARE     NaN
11    5743  SPECIALISTES - CREME CAMPHREA - ANTI-BLEMISH CARE     NaN
12    5743  SPECIALISTES - CREME CAMPHREA - ANTI-BLEMISH CARE     NaN
13    5743  SPECIALISTES - CREME CAMPHREA - ANTI-BLEMISH CARE     NaN
14    5743  SPECIALISTES - CREME CAMPHREA - ANTI-BLEMISH CARE     NaN
15    5743  SPECIALISTES - CREME CAMPHREA - ANTI-BLEMISH CARE     NaN
16    5744  TERRACOTTA TEINT D'AILLEURS - SUN-KISSED TINTE…     NaN
17    5744  TERRACOTTA TEINT D'AILLEURS - SUN-KISSED TINTE…     NaN
18    5744  TERRACOTTA TEINT D'AILLEURS - SUN-KISSED TINTE…     NaN
```

```
19    5744  TERRACOTTA TEINT D'AILLEURS - SUN-KISSED TINTE…     NaN

             CSF  CompanyId            CompanyName BrandName  \
0   Hungry Heart        127  Shiseido America, Inc.      NARS
1   Hungry Heart        127  Shiseido America, Inc.      NARS
2   Hungry Heart        127  Shiseido America, Inc.      NARS
3   Hungry Heart        127  Shiseido America, Inc.      NARS
4            NaN        298               GUERLAIN  GUERLAIN
5            NaN        298               GUERLAIN  GUERLAIN
6            NaN        298               GUERLAIN  GUERLAIN
7            NaN        298               GUERLAIN  GUERLAIN
8            NaN        298               GUERLAIN  GUERLAIN
9            NaN        298               GUERLAIN  GUERLAIN
10           NaN        298               GUERLAIN  GUERLAIN
11           NaN        298               GUERLAIN  GUERLAIN
12           NaN        298               GUERLAIN  GUERLAIN
13           NaN        298               GUERLAIN  GUERLAIN
14           NaN        298               GUERLAIN  GUERLAIN
15           NaN        298               GUERLAIN  GUERLAIN
16           NaN        298               GUERLAIN  GUERLAIN
17           NaN        298               GUERLAIN  GUERLAIN
18           NaN        298               GUERLAIN  GUERLAIN
19           NaN        298               GUERLAIN  GUERLAIN

    PrimaryCategoryId                  PrimaryCategory  SubCategoryId  …  \
0                  44  Makeup Products (non-permanent)             45  …
1                  44  Makeup Products (non-permanent)             45  …
2                  44  Makeup Products (non-permanent)             45  …
3                  44  Makeup Products (non-permanent)             45  …
4                  90               Skin Care Products             97  …
5                  90               Skin Care Products             97  …
6                  90               Skin Care Products             97  …
7                  90               Skin Care Products             97  …
8                  90               Skin Care Products             97  …
9                  90               Skin Care Products             97  …
10                 90               Skin Care Products            161  …
11                 90               Skin Care Products            161  …
12                 90               Skin Care Products            161  …
13                 90               Skin Care Products            161  …
14                 90               Skin Care Products            161  …
15                 90               Skin Care Products            161  …
16                 44  Makeup Products (non-permanent)             50  …
17                 44  Makeup Products (non-permanent)             50  …
18                 44  Makeup Products (non-permanent)             50  …
19                 44  Makeup Products (non-permanent)             50  …

       Brand                                               Name Price  Rank  \
0       NARS                Gentle Oil-Free Eye Makeup Remover    25   4.3
1       NARS                      Total Replenishing Eye Cream    58   3.3
2       NARS  Pure Radiant Tinted Moisturizer Broad Spectrum…   45   4.4
3       NARS    Radiance Primer Broad Spectrum SPF 35 Sunscreen    36   4.1
4   GUERLAIN      Midnight Secret Late Night Recovery Treatment    29   4.2
5   GUERLAIN                 Abeille Royale Youth Watery Oil    50   4.1
6   GUERLAIN                       Lingerie de Peau BB Cream    54   4.3
7   GUERLAIN               Abeille Royale Daily Repair Serum   150   3.6
8   GUERLAIN   Orchidee Imperiale The Eye and Lip Contour Cream   200   3.0
9   GUERLAIN                  Orchidée Impériale Eye Serum   230   5.0
10  GUERLAIN      Midnight Secret Late Night Recovery Treatment    29   4.2
11  GUERLAIN                 Abeille Royale Youth Watery Oil    50   4.1
12  GUERLAIN                       Lingerie de Peau BB Cream    54   4.3
13  GUERLAIN               Abeille Royale Daily Repair Serum   150   3.6
14  GUERLAIN   Orchidee Imperiale The Eye and Lip Contour Cream   200   3.0
15  GUERLAIN                  Orchidée Impériale Eye Serum   230   5.0
16  GUERLAIN      Midnight Secret Late Night Recovery Treatment    29   4.2
17  GUERLAIN                 Abeille Royale Youth Watery Oil    50   4.1
18  GUERLAIN                       Lingerie de Peau BB Cream    54   4.3
19  GUERLAIN               Abeille Royale Daily Repair Serum   150   3.6

                                          Ingredients Combination Dry Normal  \
0   Water, Methyl Trimethicone, Isopropyl Isostear…           0   0      0
1                            Visit the NARS boutique           0   0      0
2                            Visit the NARS boutique           0   0      0
3   Water, Caprylyl Methicone, Dipropylene Glycol,…           0   0      0
4                        Visit the Guerlain boutique           1   1      1
5   -Black Bee Honey -Ouessant Honey: Repairs skin…           1   1      1
6   -Titanium Dioxide 3.55%: Sunscreen. -Octinoxat…           1   1      1
7                                            #NAME?           0   0      0
8                        Visit the Guerlain boutique           1   1      1
9                        Visit the Guerlain boutique           0   0      0
10                       Visit the Guerlain boutique           1   1      1
11  -Black Bee Honey -Ouessant Honey: Repairs skin…           1   1      1
12  -Titanium Dioxide 3.55%: Sunscreen. -Octinoxat…           1   1      1
13                                           #NAME?           0   0      0
14                       Visit the Guerlain boutique           1   1      1
15                       Visit the Guerlain boutique           0   0      0
16                       Visit the Guerlain boutique           1   1      1
17  -Black Bee Honey -Ouessant Honey: Repairs skin…           1   1      1
18  -Titanium Dioxide 3.55%: Sunscreen. -Octinoxat…           1   1      1
19                                           #NAME?           0   0      0

   Oily Sensitive
0     0         0
1     0         0
2     0         0
```

```
3       0           0
4       1           1
5       1           0
6       1           1
7       0           0
8       1           1
9       0           0
10      1           1
11      1           0
12      1           1
13      0           0
14      1           1
15      0           0
16      1           1
17      1           0
18      1           1
19      0           0

[20 rows x 33 columns]
```

We analyzed the toxins most used in the merged dataset and for each toxic chemical we will have a **TOXIN_ISSUE** column which we will create and map the column based on the **ChemicalName** column already present

We will first get the list of the chemical toxins and their respective properties:

```
[ ]: chemical_properties = {
         "Aloe vera, whole leaf extract": "Benefits: Soothes skin, reduces␣
     ↪inflammation, hydrates. Risks: Can cause stomach issues and may be␣
     ↪carcinogenic if taken in large amounts. Safe Use: Avoid high oral doses;␣
     ↪aloin should be less than 10 ppm.",
         "Benzophenone-3": "Benefits: UV protection in sunscreens. Risks: May cause␣
     ↪allergies and hormonal imbalance. Safe Use: Keep below 6% concentration in␣
     ↪products.",
         "Benzophenone-4": "Benefits: UV protection for skin and hair. Risks: May␣
     ↪cause skin irritation. Safe Use: Use below 10% concentration.",
         "Butylated hydroxyanisole": "Benefits: Prevents spoilage in food and␣
     ↪cosmetics. Risks: Linked to cancer and hormone issues. Safe Use: Less than 0.
     ↪5% in products.",
         "Caffeine": "Benefits: Reduces puffiness, improves circulation. Risks: Can␣
     ↪irritate skin; high oral doses can cause anxiety. Safe Use: Topical use is␣
     ↪safe; keep oral intake under 400 mg/day.",
         "Carbon black": "Benefits: Provides deep black color in cosmetics. Risks:␣
     ↪Inhalation can cause respiratory issues and cancer risk. Safe Use: Safe in␣
     ↪non-airborne forms.",
         "Carbon black (airborne, unbound particles of respirable size)": "Benefits:␣
     ↪None for cosmetics. Risks: Causes lung damage and cancer when inhaled. Safe␣
     ↪Use: Avoid inhalation; use in controlled environments.",
    "Cocamide MEA": "Benefits: Improves foam and texture in shampoos. Risks:␣
↪Skin/eye irritation; may form carcinogenic by-products. Safe Use: Avoid with␣
↪nitrosating agents; use below 10%.",
    "Mica": "Benefits: Adds shimmer and shine to cosmetics. Risks: Inhalation␣
↪of powder form can cause lung issues. Safe Use: Safe in creams; avoid␣
↪inhaling mica dust.",
    "Retinyl palmitate": "Benefits: Anti-aging, improves skin renewal. Risks:␣
↪Increases skin sensitivity and sunburn risk. Safe Use: Use less than 1%␣
↪topically; avoid high oral doses.",
    "Titanium dioxide": "Benefits: UV Protection, gentle on skin, and great for␣
↪makeup. Risks: avoid inhalation of powdered forms. Safe Use: Safe when␣
↪applied topically."
}

chemical_properties
```

[ ]:
```
{'Aloe vera, whole leaf extract': 'Benefits: Soothes skin, reduces inflammation,
hydrates. Risks: Can cause stomach issues and may be carcinogenic if taken in
large amounts. Safe Use: Avoid high oral doses; aloin should be less than 10
ppm.',
 'Benzophenone-3': 'Benefits: UV protection in sunscreens. Risks: May cause
allergies and hormonal imbalance. Safe Use: Keep below 6% concentration in
products.',
 'Benzophenone-4': 'Benefits: UV protection for skin and hair. Risks: May cause
skin irritation. Safe Use: Use below 10% concentration.',
 'Butylated hydroxyanisole': 'Benefits: Prevents spoilage in food and cosmetics.
Risks: Linked to cancer and hormone issues. Safe Use: Less than 0.5% in
products.',
 'Caffeine': 'Benefits: Reduces puffiness, improves circulation. Risks: Can
irritate skin; high oral doses can cause anxiety. Safe Use: Topical use is safe;
keep oral intake under 400 mg/day.',
 'Carbon black': 'Benefits: Provides deep black color in cosmetics. Risks:
Inhalation can cause respiratory issues and cancer risk. Safe Use: Safe in non-
airborne forms.',
 'Carbon black (airborne, unbound particles of respirable size)': 'Benefits:
None for cosmetics. Risks: Causes lung damage and cancer when inhaled. Safe Use:
Avoid inhalation; use in controlled environments.',
 'Cocamide MEA': 'Benefits: Improves foam and texture in shampoos. Risks:
Skin/eye irritation; may form carcinogenic by-products. Safe Use: Avoid with
nitrosating agents; use below 10%.',
 'Mica': 'Benefits: Adds shimmer and shine to cosmetics. Risks: Inhalation of
powder form can cause lung issues. Safe Use: Safe in creams; avoid inhaling mica
dust.',
 'Retinyl palmitate': 'Benefits: Anti-aging, improves skin renewal. Risks:
Increases skin sensitivity and sunburn risk. Safe Use: Use less than 1%
topically; avoid high oral doses.',
 'Titanium dioxide': 'Benefits: UV Protection, gentle on skin, and great for
makeup. Risks: avoid inhalation of powdered forms. Safe Use: Safe when applied
topically.'}
```

We will now add this column into the merged dataset based on the ChemicalName column

```
[ ]: def get_chemical_properties(chemical_name):
         return chemical_properties.get(chemical_name, "NA")  #We will give no␣
      ↪specific properties for products without chemicalname
     merged_table['Chemical_Properties'] = merged_table['ChemicalName'].
      ↪apply(get_chemical_properties)
     merged_table.head(20)
```

```
[ ]:    CDPHId                                    ProductName   CSFId  \
    0     5391                                 NARS Blush Duo  9763.0
    1     5391                                 NARS Blush Duo  9763.0
    2     5391                                 NARS Blush Duo  9763.0
    3     5391                                 NARS Blush Duo  9763.0
    4     5742  SUCCESS AGE SPLENDID - DEEP-ACTION NIGHT CARE …     NaN
    5     5742  SUCCESS AGE SPLENDID - DEEP-ACTION NIGHT CARE …     NaN
    6     5742  SUCCESS AGE SPLENDID - DEEP-ACTION NIGHT CARE …     NaN
    7     5742  SUCCESS AGE SPLENDID - DEEP-ACTION NIGHT CARE …     NaN
    8     5742  SUCCESS AGE SPLENDID - DEEP-ACTION NIGHT CARE …     NaN
    9     5742  SUCCESS AGE SPLENDID - DEEP-ACTION NIGHT CARE …     NaN
    10    5743  SPECIALISTES - CREME CAMPHREA - ANTI-BLEMISH CARE     NaN
    11    5743  SPECIALISTES - CREME CAMPHREA - ANTI-BLEMISH CARE     NaN
    12    5743  SPECIALISTES - CREME CAMPHREA - ANTI-BLEMISH CARE     NaN
    13    5743  SPECIALISTES - CREME CAMPHREA - ANTI-BLEMISH CARE     NaN
    14    5743  SPECIALISTES - CREME CAMPHREA - ANTI-BLEMISH CARE     NaN
    15    5743  SPECIALISTES - CREME CAMPHREA - ANTI-BLEMISH CARE     NaN
    16    5744  TERRACOTTA TEINT D'AILLEURS - SUN-KISSED TINTE…     NaN
    17    5744  TERRACOTTA TEINT D'AILLEURS - SUN-KISSED TINTE…     NaN
    18    5744  TERRACOTTA TEINT D'AILLEURS - SUN-KISSED TINTE…     NaN
    19    5744  TERRACOTTA TEINT D'AILLEURS - SUN-KISSED TINTE…     NaN

                 CSF  CompanyId             CompanyName BrandName  \
    0   Hungry Heart        127  Shiseido America, Inc.      NARS
    1   Hungry Heart        127  Shiseido America, Inc.      NARS
    2   Hungry Heart        127  Shiseido America, Inc.      NARS
    3   Hungry Heart        127  Shiseido America, Inc.      NARS
    4            NaN        298                GUERLAIN  GUERLAIN
    5            NaN        298                GUERLAIN  GUERLAIN
    6            NaN        298                GUERLAIN  GUERLAIN
    7            NaN        298                GUERLAIN  GUERLAIN
    8            NaN        298                GUERLAIN  GUERLAIN
    9            NaN        298                GUERLAIN  GUERLAIN
    10           NaN        298                GUERLAIN  GUERLAIN
    11           NaN        298                GUERLAIN  GUERLAIN
```

```
12          NaN       298              GUERLAIN  GUERLAIN
13          NaN       298              GUERLAIN  GUERLAIN
14          NaN       298              GUERLAIN  GUERLAIN
15          NaN       298              GUERLAIN  GUERLAIN
16          NaN       298              GUERLAIN  GUERLAIN
17          NaN       298              GUERLAIN  GUERLAIN
18          NaN       298              GUERLAIN  GUERLAIN
19          NaN       298              GUERLAIN  GUERLAIN

    PrimaryCategoryId                  PrimaryCategory  SubCategoryId  …  \
0                  44  Makeup Products (non-permanent)             45  …
1                  44  Makeup Products (non-permanent)             45  …
2                  44  Makeup Products (non-permanent)             45  …
3                  44  Makeup Products (non-permanent)             45  …
4                  90               Skin Care Products             97  …
5                  90               Skin Care Products             97  …
6                  90               Skin Care Products             97  …
7                  90               Skin Care Products             97  …
8                  90               Skin Care Products             97  …
9                  90               Skin Care Products             97  …
10                 90               Skin Care Products            161  …
11                 90               Skin Care Products            161  …
12                 90               Skin Care Products            161  …
13                 90               Skin Care Products            161  …
14                 90               Skin Care Products            161  …
15                 90               Skin Care Products            161  …
16                 44  Makeup Products (non-permanent)             50  …
17                 44  Makeup Products (non-permanent)             50  …
18                 44  Makeup Products (non-permanent)             50  …
19                 44  Makeup Products (non-permanent)             50  …

                                              Name  Price Rank  \
0                Gentle Oil-Free Eye Makeup Remover     25  4.3
1                      Total Replenishing Eye Cream     58  3.3
2   Pure Radiant Tinted Moisturizer Broad Spectrum…     45  4.4
3     Radiance Primer Broad Spectrum SPF 35 Sunscreen     36  4.1
4       Midnight Secret Late Night Recovery Treatment     29  4.2
5                    Abeille Royale Youth Watery Oil     50  4.1
6                         Lingerie de Peau BB Cream     54  4.3
7                  Abeille Royale Daily Repair Serum    150  3.6
8    Orchidee Imperiale The Eye and Lip Contour Cream    200  3.0
9                      Orchidée Impériale Eye Serum    230  5.0
10      Midnight Secret Late Night Recovery Treatment     29  4.2
11                   Abeille Royale Youth Watery Oil     50  4.1
12                        Lingerie de Peau BB Cream     54  4.3
13                 Abeille Royale Daily Repair Serum    150  3.6
14   Orchidee Imperiale The Eye and Lip Contour Cream    200  3.0
```

```
15                      Orchidée Impériale Eye Serum    230  5.0
16      Midnight Secret Late Night Recovery Treatment     29  4.2
17                  Abeille Royale Youth Watery Oil     50  4.1
18                        Lingerie de Peau BB Cream     54  4.3
19                 Abeille Royale Daily Repair Serum    150  3.6

                                         Ingredients Combination Dry Normal  \
0   Water, Methyl Trimethicone, Isopropyl Isostear…           0   0      0
1                             Visit the NARS boutique           0   0      0
2                             Visit the NARS boutique           0   0      0
3   Water, Caprylyl Methicone, Dipropylene Glycol,…           0   0      0
4                         Visit the Guerlain boutique           1   1      1
5   -Black Bee Honey -Ouessant Honey: Repairs skin…           1   1      1
6   -Titanium Dioxide 3.55%: Sunscreen. -Octinoxat…           1   1      1
7                                             #NAME?           0   0      0
8                         Visit the Guerlain boutique           1   1      1
9                         Visit the Guerlain boutique           0   0      0
10                        Visit the Guerlain boutique           1   1      1
11  -Black Bee Honey -Ouessant Honey: Repairs skin…           1   1      1
12  -Titanium Dioxide 3.55%: Sunscreen. -Octinoxat…           1   1      1
13                                            #NAME?           0   0      0
14                        Visit the Guerlain boutique           1   1      1
15                        Visit the Guerlain boutique           0   0      0
16                        Visit the Guerlain boutique           1   1      1
17  -Black Bee Honey -Ouessant Honey: Repairs skin…           1   1      1
18  -Titanium Dioxide 3.55%: Sunscreen. -Octinoxat…           1   1      1
19                                            #NAME?           0   0      0

   Oily Sensitive                                Chemical_Properties
0     0         0  Benefits: Prevents spoilage in food and cosmet…
1     0         0  Benefits: Prevents spoilage in food and cosmet…
2     0         0  Benefits: Prevents spoilage in food and cosmet…
3     0         0  Benefits: Prevents spoilage in food and cosmet…
4     1         1  Benefits: UV Protection, gentle on skin, and g…
5     1         0  Benefits: UV Protection, gentle on skin, and g…
6     1         1  Benefits: UV Protection, gentle on skin, and g…
7     0         0  Benefits: UV Protection, gentle on skin, and g…
8     1         1  Benefits: UV Protection, gentle on skin, and g…
9     0         0  Benefits: UV Protection, gentle on skin, and g…
10    1         1  Benefits: UV Protection, gentle on skin, and g…
11    1         0  Benefits: UV Protection, gentle on skin, and g…
12    1         1  Benefits: UV Protection, gentle on skin, and g…
13    0         0  Benefits: UV Protection, gentle on skin, and g…
14    1         1  Benefits: UV Protection, gentle on skin, and g…
15    0         0  Benefits: UV Protection, gentle on skin, and g…
16    1         1  Benefits: UV Protection, gentle on skin, and g…
17    1         0  Benefits: UV Protection, gentle on skin, and g…
```

```
18    1         1  Benefits: UV Protection, gentle on skin, and g…
19    0         0  Benefits: UV Protection, gentle on skin, and g…

[20 rows x 34 columns]
```

Now let us perfom some tasks done before we proceed with the EDA

Let us calculate the number of duplicates

```
[ ]: original_rows = len(merged_table)
     merged_table = merged_table.drop_duplicates()
     new_rows = len(merged_table)
     print(f"{original_rows - new_rows} ")  # we get 0 so no duplicate entries. This␣
       ↪is mostly because each product has a different usecase - soap, facewash,␣
       ↪conditioner, etc
```

```
0
```

Set precision

```
[ ]: pd.set_option('display.float_format', '{:.2f}'.format) #setting precision to .2f
     summary_stats = merged_table.describe()
     # summary_stats
```

We will calculate the Variance, Inter-Quartile Range and Standard Deviation of the Price column as it can be used as the standard column to compare the data prices

```
[ ]: price_variance = np.var(merged_table['Price'],ddof=1) #https://pandas.pydata.
       ↪org/docs/reference/api/pandas.DataFrame.var.html --> ddof is 0 by default we␣
       ↪have to take 1
                                                       #https://stackoverflow.
       ↪com/questions/31886826/numpy-1-degree-of-freedom
     print("variance of price is: ",price_variance)

     price_standard_deviation = np.std(merged_table['Price'],ddof=1)  #https://numpy.
       ↪org/doc/stable/reference/generated/numpy.std.html --> ddof is 0 by default␣
       ↪we have taken 1
     print("standard deviation of price: ", price_standard_deviation)

     #According to https://stackoverflow.com/questions/23228244/
       ↪how-do-you-find-the-iqr-in-numpy there is no method in numpy to directly␣
       ↪call for quartile range
     iqr = np.subtract(*np.percentile(merged_table['Price'], [75, 25]))
     print("Inter-Quartile Range is: ", iqr)
```

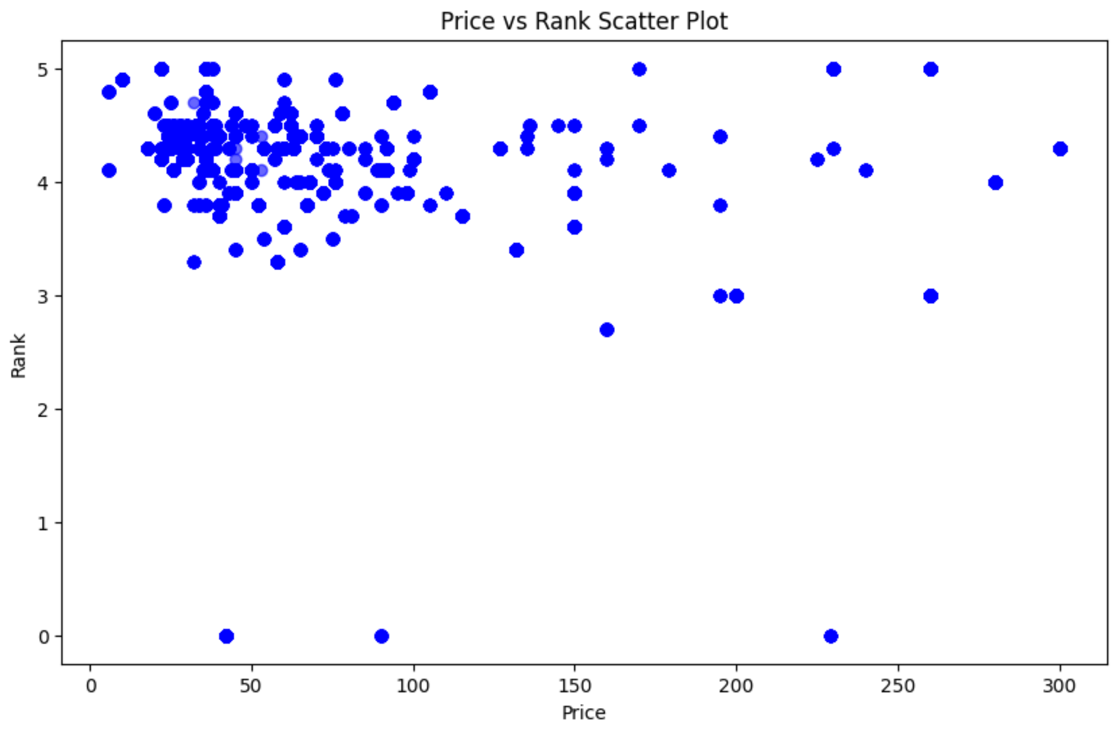
```
variance of price is:  3591.083145454786
standard deviation of price:  59.925646808814555
Inter-Quartile Range is:  38.0
```

Now let us begin with our EDA Hypothesis

1 Hypothesis 1 : Higher the Price, Higher the Rank ANIRUDH NADIG (50613184)

[ ]:
```
# We will use basics of matplotlib and have a scatter plot - https://www.
↪w3schools.com/python/matplotlib_scatter.asp
plt.figure(figsize=(10, 6))

x=merged_table['Price']
y=merged_table['Rank']
plt.scatter(x,y, color='blue', alpha=0.6)
plt.title("Price vs Rank Scatter Plot")
plt.xlabel("Price")
plt.ylabel("Rank")
```

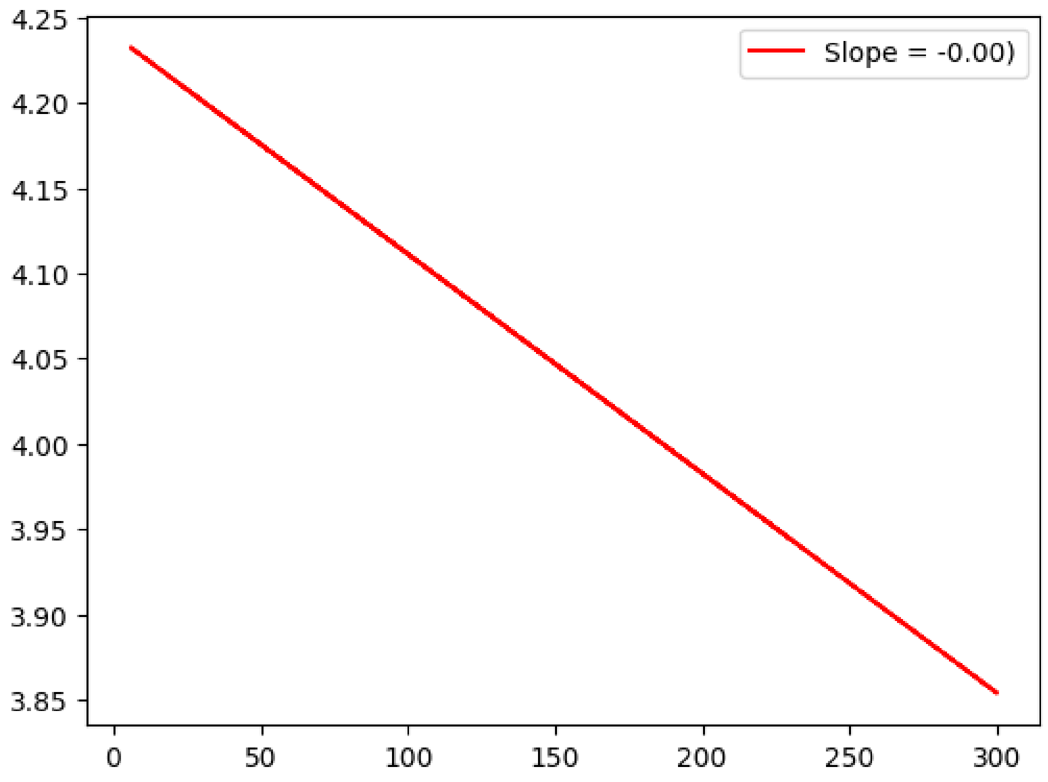
[ ]:
```
Text(0, 0.5, 'Rank')
```



[ ]:
```
#We dont seem to have any conclusive proof that higher the price higher the␣
↪Rating so we will need to find the correlation between the price and rank
#We will use linear regression to find the correlation
correlation = np.corrcoef(x, y)[0, 1] #https://numpy.org/doc/2.0/reference/
↪generated/numpy.corrcoef.html
print(correlation)
# Fit a linear regression line (trend line)
```

```
m, b = np.polyfit(x, y, 1) #we have used polyfit as we need to solve the least␣
 ↪square method
plt.plot(x, m*x + b, color='red', label=f"Slope = {m:.2f})") #I have set␣
 ↪precision as 2
plt.legend()
plt.show()
```

```
-0.12837509002196287
```

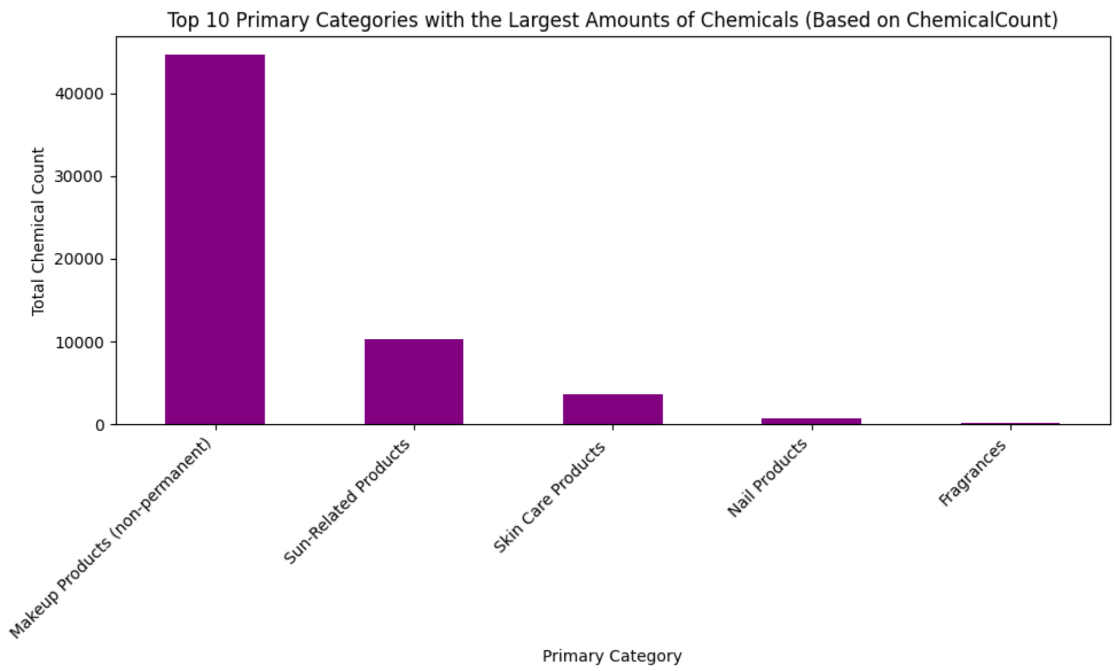


Conclusion to Hypothesis - The Rank does NOT increase with Price as seen above as the slope is extremely small which indicates almost non existent relationship between the two

2 Hypothesis 2: Makeup Products have the highest amount of chemicals in them –> RACHANA DHARMAVARAM (50604169)

[ ]:
```
primary_category_chemicals = merged_table.
 ↪groupby('PrimaryCategory')['ChemicalCount'].sum().
 ↪sort_values(ascending=False)
top_10_primary_categories = primary_category_chemicals.head(5)
```

```
# We will plot the top 10 Primary Categories with the largest amounts of␣
↪chemicals
plt.figure(figsize=(10, 6))
top_10_primary_categories.plot(kind='bar', color='purple')
plt.title('Top 10 Primary Categories with the Largest Amounts of Chemicals␣
↪(Based on ChemicalCount)')
plt.xlabel('Primary Category')
plt.ylabel('Total Chemical Count')
plt.xticks(rotation=45, ha='right')
plt.tight_layout()
plt.show()
```



From the above graph it is evidently clear that makeup products as a cosmetic category has the most number of chemicals. We have taken the category and taken summation of the chemicalcount

[ ]:
```

```

3 Hypothesis 3: Most of the toxic heavy chemicals are still in use –> ANIRUDH NADIG 50613184

[ ]:
```
#For the best reference we will take the original chemicals dataset to see the␣
↪status of the products with heavy metals

#Let us provide a list of heavy metals
```

```
heavy_metals =['arsenic', 'mercury', 'cadmium', 'benzene', 'chromium',␣
 ↪'nickel', 'selenium', 'bha', 'bht', 'butylated hydroxyanisole', 'butylated␣
 ↪hydroxytoluene',
                'coal tar', 'dea', 'diethanolamine', 'tea', 'triethanolamine',
                'dbp', 'formaldehyde','dmdm', 'diazolidinyl', 'imidazolidinyl',␣
 ↪'methenamine', 'quaternium-15',
                 'paraben', 'musk', 'moskene', 'peg', 'polyethylene', 'propylene␣
 ↪glycol',
                 'ethoxylates', 'petrolatum', 'mineral oil', 'polycyclic',␣
 ↪'pah', 'siloxane',
                 'cyclomethicone', 'sodium laureth', 'sles', 'sls', 'sodium␣
 ↪lauryl', 'triclosan']  # have tried to make the list more readable, these␣
 ↪are the chemicals i found to be heavy metals

#Now let us take the original dataset before merging (chemicals in cosmetics␣
 ↪dataset) --> table_chemicals
heavy_metals2 = [metal.lower() for metal in heavy_metals] #chemicalnames are␣
 ↪inconsistent with their naming convention, changing their name to all lower␣
 ↪cases
contains_heavy_metals = table_chemicals['ChemicalName'].apply(lambda x:␣
 ↪any(metal in str(x).lower() for metal in heavy_metals2))
heavy_metals_in_products = table_chemicals[contains_heavy_metals]


heavy_metals_removed =␣
 ↪heavy_metals_in_products[heavy_metals_in_products['ChemicalDateRemoved'].
 ↪notnull()]
print(f"Total number of products containing heavy metals:␣
 ↪{heavy_metals_in_products.shape[0]}")
print(f"Total number of products where heavy metals have been removed:␣
 ↪{heavy_metals_removed.shape[0]}")
print("Heavy Metals Found in Products:")
print(heavy_metals_in_products[['ChemicalName', 'ChemicalDateRemoved']].head())
print("\nHeavy Metals Removed from Products:")
print(heavy_metals_removed[['ChemicalName', 'ChemicalDateRemoved']].head())
```

```
Total number of products containing heavy metals: 4854
Total number of products where heavy metals have been removed: 529
Heavy Metals Found in Products:
                        ChemicalName ChemicalDateRemoved
1              Distillates (coal tar)                 NaN
31            Cocamide diethanolamine          12/30/2010
49            Cocamide diethanolamine                 NaN
62   Chromium (hexavalent compounds)                 NaN
310          Butylated hydroxyanisole                 NaN
```

```
Heavy Metals Removed from Products:
                  ChemicalName ChemicalDateRemoved
31     Cocamide diethanolamine          12/30/2010
497    Cocamide diethanolamine          11/23/2009
498    Cocamide diethanolamine          09/02/2009
499    Cocamide diethanolamine          09/02/2009
501   Lauramide diethanolamine          11/23/2009
```

It seems in the original cosmetics dataset, most of the heavy metals arent removed! We will look closer into the products themselves now..

```
[ ]: #Note- the dataset is only till 2020 so the chemicals havent been removed as of␣
      ↪2020


     products = []
     for index, row in table_chemicals.iterrows():
         chemical_name = str(row['ChemicalName']).lower()
         # print(chemical_name)
         for metal in heavy_metals:
             if metal.lower() in chemical_name:
                 products.append(row)
                 # print(products)
                 break
     heavy_metals_in_products = pd.DataFrame(products) # we take this datframe to␣
      ↪display the required information

     product_columns= ['CompanyName', 'BrandName', 'SubCategory', 'PrimaryCategory',␣
      ↪'ChemicalName']
     heavy_metals_list= heavy_metals_in_products[product_columns]
     print(heavy_metals_list.head())
```

```
                       CompanyName    BrandName  \
1             J. Strickland & Co.     Glover's
31           GOJO Industries, Inc.        GOJO
49                     Dermalogica  Dermalogica
62                     Dermalogica  Dermalogica
310  Physician's Care Alliance, LLC     PCA Skin

                                   SubCategory  \
1     Hair Shampoos (making a cosmetic claim)
31               Hand Cleansers and Sanitizers
49                       Scrubs and Exfoliants
62                       Scrubs and Exfoliants
310  Skin Astringent (making a cosmetic claim)

                      PrimaryCategory                   ChemicalName
1    Hair Care Products (non-coloring)           Distillates (coal tar)
```

```
31               Personal Care Products         Cocamide diethanolamine
49                        Bath Products         Cocamide diethanolamine
62                        Bath Products  Chromium (hexavalent compounds)
310                   Skin Care Products        Butylated hydroxyanisole
```

```
[ ]: #Let us print the company which seems to have the most number of Toxic chemicals
     company = heavy_metals_in_products.groupby('CompanyName').size().
      ↪sort_values(ascending=False) #https://stackoverflow.com/questions/27842613/
      ↪pandas-groupby-then-sort-within-groups
     print(company)
     #We also might want to check for the subcategory, where these products are used
     category = heavy_metals_in_products.groupby(['CompanyName','SubCategory']).
      ↪size().sort_values(ascending=False)
     print(category)
```

```
CompanyName
NYX Los Angeles, Inc.                              1124
Demeter Fragrance Library, Inc.                     238
Greenbrier International, Inc.                      174
MAESA LLC                                           166
American International Industries                   161
                                                   …
Perfect Angel Cosmetics & Health CO., Limited         1
Pearlosophy USA, LLC                                  1
Bonne Bell, LLC                                       1
Tupperware U.S., Inc.                                 1
Natural Solter S.L.                                   1
Length: 243, dtype: int64
CompanyName                                 SubCategory
NYX Los Angeles, Inc.                       Lip Color - Lipsticks, Liners, and
Pencils     594
                                            Eye Shadow
268
Demeter Fragrance Library, Inc.             Body Washes and Soaps
238
NYX Los Angeles, Inc.                       Lip Gloss/Shine
191
MAESA LLC                                   Lip Gloss/Shine
104
      …
Imperial Dax Hair Care Inc.                 Other Hair Care Product
1
ITALIAN GROUP SRL                           Hair Shampoos (making a cosmetic claim)
1
                                            Body Washes and Soaps
1
IPD Inc                                     Skin Moisturizers (making a cosmetic
claim)      1
```

```
L&S Cosmetics & Toiletries (M) Sdn Bhd  Hair Shampoos (making a cosmetic claim)
1
Length: 693, dtype: int64
```

Lipsticks are the category with the most number of heavy metals

Now let us make sure for our skin care recommendation system we can limit the number of heavy metals from the original dataset (We dont want to recommend the toxic chemicals) , let us check this

```
[ ]: #We will use a similar method as done for the original dataset for the␣
      ↪merged_dataset which is labelled as merged_table

     merged_products =[]

     for index, row in merged_table.iterrows():
         chemical_name = str(row['ChemicalName']).lower()
         for metal in heavy_metals:
             if metal.lower() in chemical_name:
                 merged_products.append(row)
                 break

     heavy_metals_in_products_merged = pd.DataFrame(merged_products)
     total_products_with_heavy_metals = heavy_metals_in_products_merged.shape[0]
     print(f"Total number of heavy metal containing products in our merged dataset :␣
      ↪{total_products_with_heavy_metals}")
     product_columns= ['CompanyName', 'BrandName', 'SubCategory', 'PrimaryCategory',␣
      ↪'ChemicalName']
     heavy_metals_list_merged_table= heavy_metals_in_products_merged[product_columns]
     print(heavy_metals_list_merged_table)
```

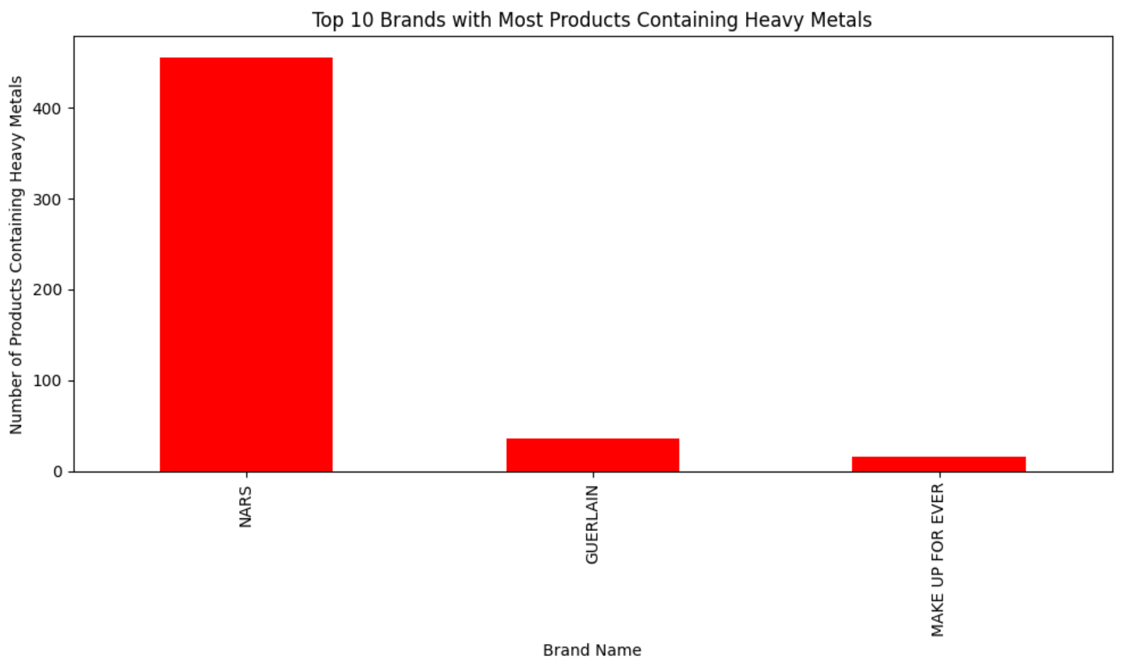
```
Total number of heavy metal containing products in our merged dataset : 508
                 CompanyName         BrandName                SubCategory  \
0      Shiseido America, Inc.              NARS                    Blushes
1      Shiseido America, Inc.              NARS                    Blushes
2      Shiseido America, Inc.              NARS                    Blushes
3      Shiseido America, Inc.              NARS                    Blushes
530             Nars Cosmetics              NARS                    Blushes
…                          …                 …                          …
49461        MAKE UP FOR EVER  MAKE UP FOR EVER  Mascara/Eyelash Products
49462        MAKE UP FOR EVER  MAKE UP FOR EVER  Mascara/Eyelash Products
49463        MAKE UP FOR EVER  MAKE UP FOR EVER  Mascara/Eyelash Products
52342        MAKE UP FOR EVER  MAKE UP FOR EVER  Mascara/Eyelash Products
52343        MAKE UP FOR EVER  MAKE UP FOR EVER  Mascara/Eyelash Products

                      PrimaryCategory             ChemicalName
0      Makeup Products (non-permanent)  Butylated hydroxyanisole
1      Makeup Products (non-permanent)  Butylated hydroxyanisole
2      Makeup Products (non-permanent)  Butylated hydroxyanisole
```

```
3      Makeup Products (non-permanent)  Butylated hydroxyanisole
530    Makeup Products (non-permanent)  Butylated hydroxyanisole
…                                  …                         …
49461  Makeup Products (non-permanent)            Triethanolamine
49462  Makeup Products (non-permanent)            Triethanolamine
49463  Makeup Products (non-permanent)            Triethanolamine
52342  Makeup Products (non-permanent)            Triethanolamine
52343  Makeup Products (non-permanent)            Triethanolamine

[508 rows x 5 columns]
```

As we can see we have severly limited the amount of products with toxic metals. Now let us see what all chemicals we still have left which have toxins

```
[ ]: #let us take the count of heavy metals

heavy_metal_counts = {}
for metal in heavy_metals:
    count = heavy_metals_in_products_merged['ChemicalName'].str.lower().str.
 ↪contains(metal.lower()).sum()
    heavy_metal_counts[metal] = count

# print(f"heavy metals count : {heavy_metal_counts}")
counts_df = pd.DataFrame(list(heavy_metal_counts.items()), columns=['Heavy␣
 ↪Metal', 'Count'])
heavy_metals_merged_brand_count =heavy_metals_in_products_merged.
 ↪groupby('BrandName').size().sort_values(ascending=False)
print(heavy_metals_merged_brand_count)

#It seems only three brands have some sort of toxic metals in our datasets!

#heavy metal count with brands
plt.figure(figsize=(10, 6))
heavy_metals_merged_brand_count.head(3).plot(kind='bar', color='red')
plt.title('Top 10 Brands with Most Products Containing Heavy Metals')
plt.xlabel('Brand Name')
plt.ylabel('Number of Products Containing Heavy Metals')
# plt.xticks(rotation=45, ha='right')
plt.tight_layout()
plt.show()
```

```
BrandName
NARS                456
GUERLAIN             36
MAKE UP FOR EVER     16
dtype: int64
```



```
[ ]: #let us see which sub category these products from these three brands lie in

     sub_category_merged = heavy_metals_in_products_merged.groupby('SubCategory').
      ↪size().sort_values(ascending=False)
     print(sub_category_merged)
```

```
SubCategory
Eye Shadow                    268
Blushes                       180
Mascara/Eyelash Products       50
Face Powders                    8
Foundations and Bases           2
dtype: int64
```

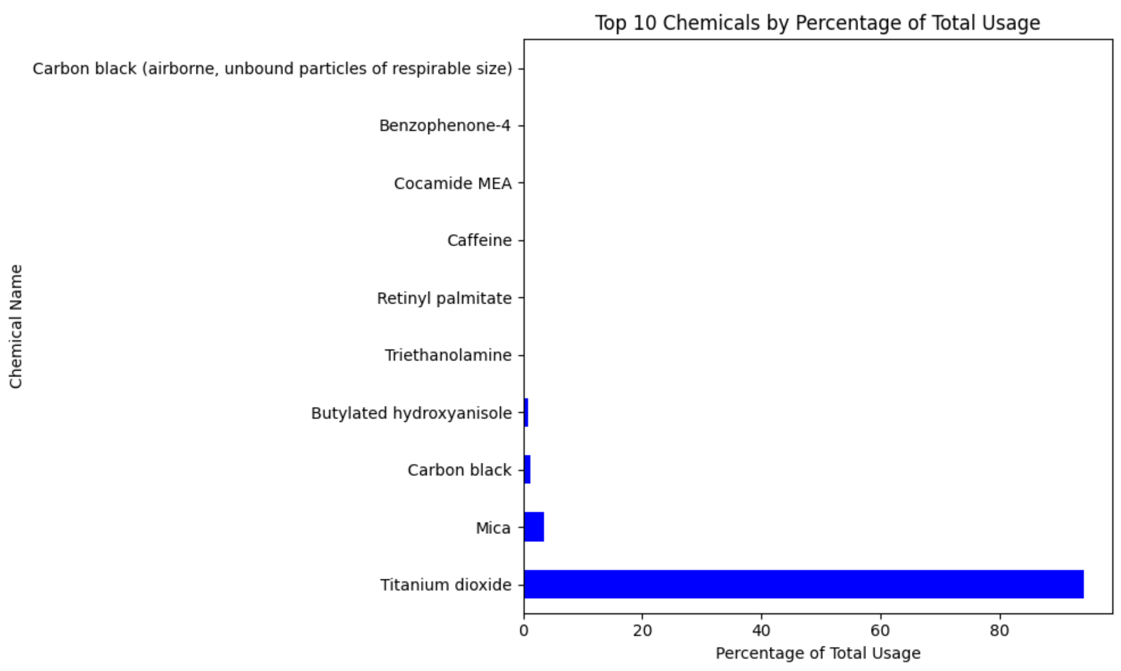
4 Hypothesis 4: Most of the chemicals used for our Merged Dataset have very minimal Chemical Side affects– Satya Vaishnavi Jami (50592365)

```
[ ]: #let us first get the total number of chemicals by percentage of unique values

     # we will take number of occurences of unique chemical/ total number of␣
      ↪chemical occurences * 100

     chemical_counts = merged_table['ChemicalName'].value_counts()
```

```
total_chemical_count = chemical_counts.sum()
print(f"total_chemical_count - {total_chemical_count}")
percentage = chemical_counts / total_chemical_count * 100
print(percentage)
```

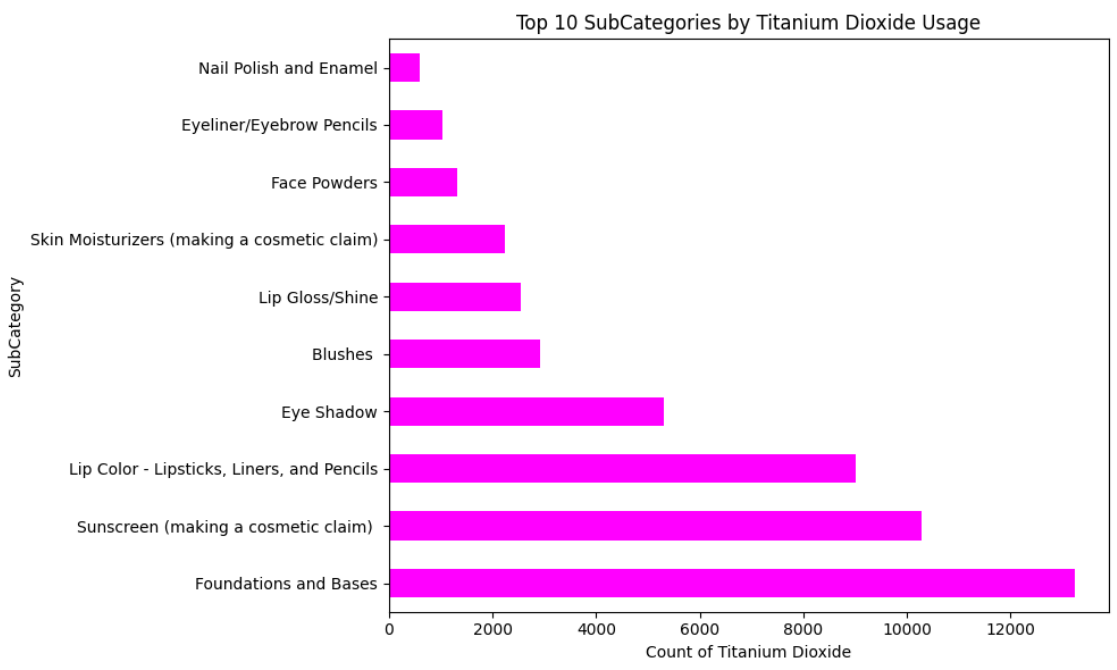
```
total_chemical_count - 53763
ChemicalName
Titanium dioxide                                                94.27
Mica                                                             3.43
Carbon black                                                     1.16
Butylated hydroxyanisole                                         0.85
Triethanolamine                                                  0.09
Retinyl palmitate                                                0.06
Caffeine                                                         0.04
Cocamide MEA                                                     0.02
Benzophenone-4                                                   0.02
Carbon black (airborne, unbound particles of respirable size)    0.02
Aloe vera, whole leaf extract                                    0.01
Benzophenone-3                                                   0.01
Name: count, dtype: float64
```

[ ]:
```
#Let us now plot the graph for the above for a clearer picture

plt.figure(figsize=(10, 6))
percentage.head(10).plot(kind='barh', color='blue') #we will take top 10
plt.title('Top 10 Chemicals by Percentage of Total Usage')
plt.xlabel('Percentage of Total Usage')
plt.ylabel('Chemical Name')
plt.tight_layout()
plt.show()
```



A huge majority of chemicals for our dataset has Titanium Dioxide whose toxicity is almost null. Now let us see where Titanium Dioxide is used in terms of category

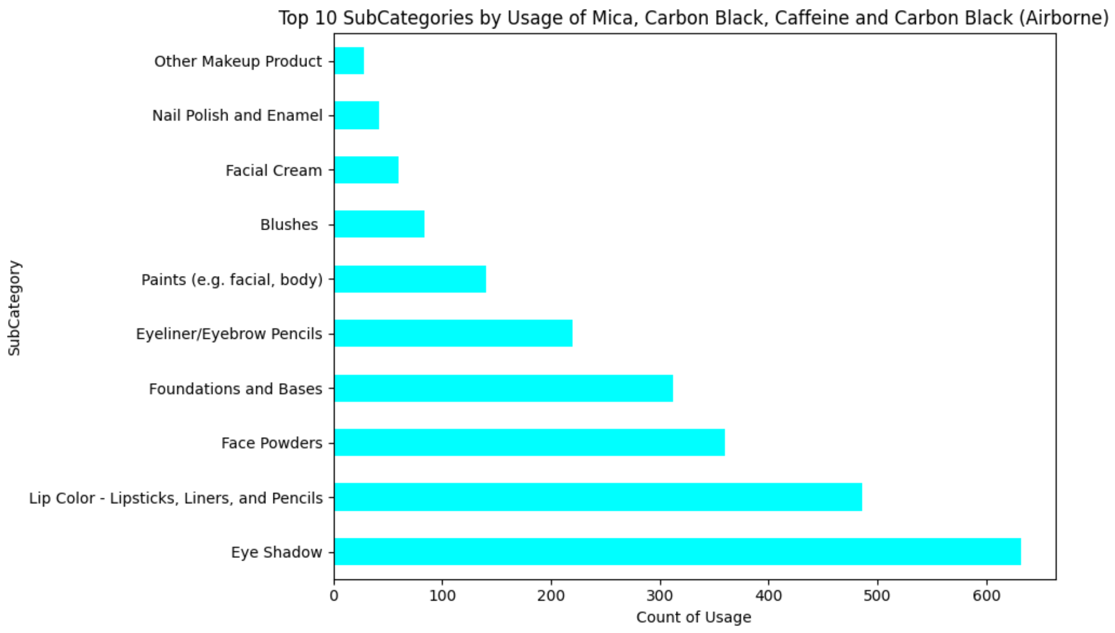
```
[ ]: #Which sub category of products is Titanium Dioxide used for primarily

titanium = merged_table[merged_table['ChemicalName'].str.contains('Titanium␣
 ↪dioxide', case=False, na=False)]
titanium_sub = titanium.groupby('SubCategory').size().
 ↪sort_values(ascending=False)
titanium_sub.head(10)

#now let us see the table for this with the top 10 values
top_10 = titanium_sub.head(10)
plt.figure(figsize=(10, 6))
top_10.plot(kind='barh', color='magenta')
plt.title('Top 10 SubCategories by Titanium Dioxide Usage')
plt.xlabel('Count of Titanium Dioxide')
plt.ylabel('SubCategory')
plt.tight_layout()
plt.show()
```



5 Hypothesis 5 : Color adding chemicals in products are mainly used for makeup products Satya Vaishnavi Jami (50592365)

[ ]:
```
#let us first sort by the ChemicalName =Mica, Carbon Black, Carbon black␣
↪(airborne, unbound particles of respirable size), Caffeine

color_chemicals =['Mica', 'Carbon Black', 'Carbon black (airborne, unbound␣
↪particles of respirable size)', 'Caffeine']
color_chemicals_filtered= merged_table[merged_table['ChemicalName'].str.
↪contains('|'.join(color_chemicals), case=False, na=False)] #we use the OR␣
↪operand here as we need any of the target chemicals in the ChemicalName
# color_chemicals_filtered.head(5)
subcategory_color= color_chemicals_filtered.groupby('SubCategory').size().
↪sort_values(ascending=False)
subcategory_color.head(10)

#We will now plot this to give a visualization
plt.figure(figsize=(10, 6))
top_10_color_categories = subcategory_color.head(10)
top_10_color_categories.plot(kind='barh', color='cyan')
plt.title('Top 10 SubCategories by Usage of Mica, Carbon Black, Caffeine and␣
↪Carbon Black (Airborne)')
plt.xlabel('Count of Usage')
plt.ylabel('SubCategory')
plt.tight_layout()
plt.show()
```

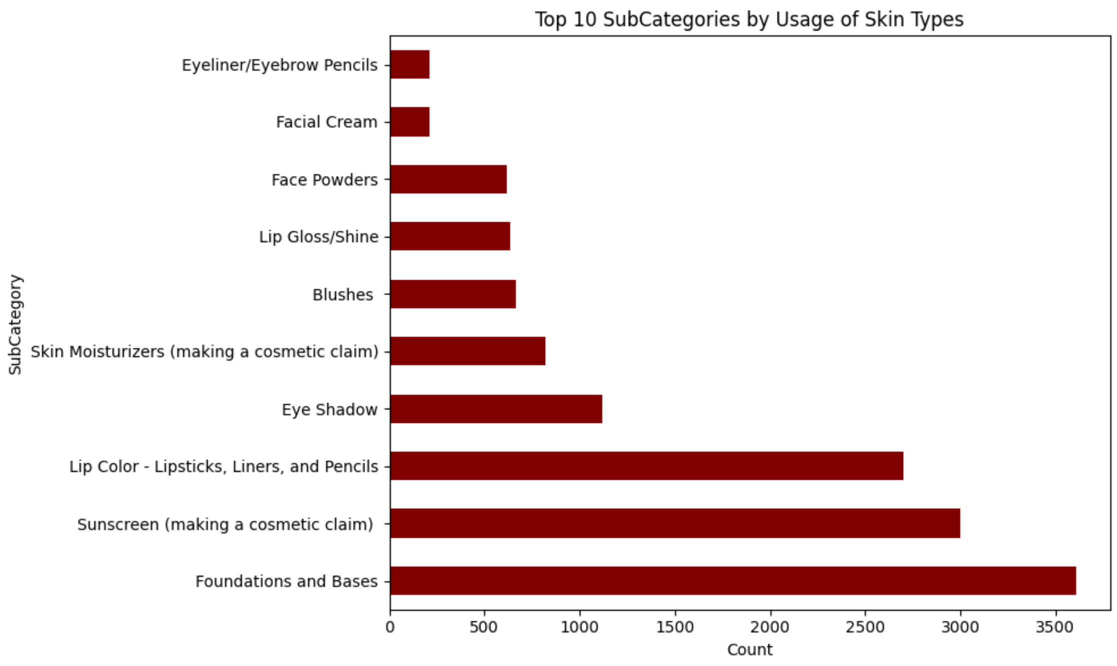
```
<ipython-input-21-e8f4c199934c>:4: UserWarning: This pattern is interpreted as a
regular expression, and has match groups. To actually get the groups, use
str.extract.
  color_chemicals_filtered= merged_table[merged_table['ChemicalName'].str.contai
ns('|'.join(color_chemicals), case=False, na=False)] #we use the OR operand here
as we need any of the target chemicals in the ChemicalName
```



6 Hypothesis 6 : Skin Type Analysis RACHANA DHARMAVARAM (50604169)

```
[ ]: #Let us take all records where skin types =1 , we will ignore combination kin␣
     ↪type for now as we need the oily, dry and sensitive data

     skin_type = merged_table[ (merged_table['Dry'] == 1) & (merged_table['Normal']␣
     ↪== 1) & (merged_table['Oily'] == 1) & (merged_table['Sensitive'] == 1)]
     #let  us group by the skin type
     skin_type_sub = skin_type.groupby('SubCategory').size().
     ↪sort_values(ascending=False) #https://pandas.pydata.org/docs/reference/api/
     ↪pandas.DataFrame.groupby.html
     skin_type_sub.head(10)

     #Foundations and bases follwed by sunscreen are for almost all skin types
```

```
plt.figure(figsize=(10, 6))
skin_type_sub.head(10).plot(kind='barh', color='maroon')
plt.title('Top 10 SubCategories by Usage of Skin Types')
plt.xlabel('Count')
plt.ylabel('SubCategory')
plt.tight_layout()
```

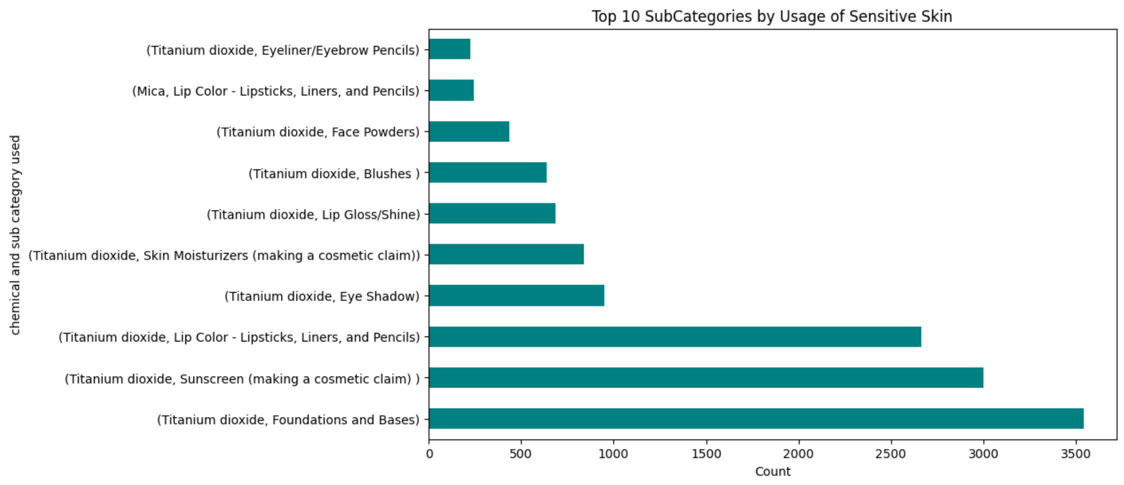


Now for a person who has sensitive skin let us categorize the products and see which brand has the most number of products available to them

For sensitive people let us see which sub categories of products are most available for which chemical

```
[ ]: sensitive_skin = merged_table[merged_table['Sensitive'] == 1]
     sensitive_skin_count = sensitive_skin.groupby(['ChemicalName', 'SubCategory']).
      ↪size().sort_values(ascending=False) #with this we can display two values on␣
      ↪the y axis Chemical/Sub category with Sensitive=1 vs count
     sensitive_skin_count.head(10)
     plt.figure(figsize=(10, 6))
     sensitive_skin_count.head(10).plot(kind='barh', color='teal')
     plt.title('Top 10 SubCategories by Usage of Sensitive Skin')
     plt.xlabel('Count')
     plt.ylabel('chemical and sub category used')
     plt.tight_layout
```

```
[ ]: <function matplotlib.pyplot.tight_layout(*, pad=1.08, h_pad=None, w_pad=None,
     rect=None)>
```

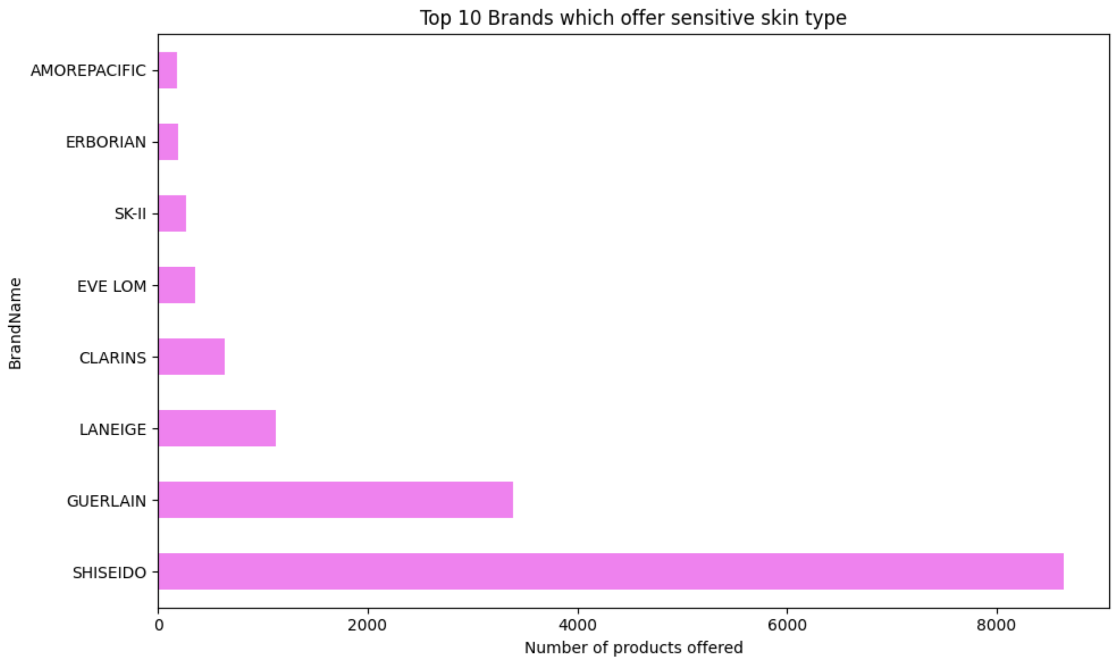


Now let us see for sensitive skin types which brands offer the most number of products

```
[ ]: #We will begin by first sorting brandname
     sensitive_skin_brandname = sensitive_skin.groupby('BrandName').size().
      ↪sort_values(ascending=False)
     # sensitive_skin_brandname

     print(f"The brands offering the most number of products for sensitive skin␣
      ↪types are : {sensitive_skin_brandname.head(10)}")
     #there are 8 main brands offering products for skin type = sensitive

     plt.figure(figsize=(10, 6))
     sensitive_skin_brandname.head(10).plot(kind='barh', color='violet')
     plt.title('Top 10 Brands which offer sensitive skin type')
     plt.xlabel('Number of products offered')
     plt.ylabel('BrandName')
     plt.tight_layout()
     plt.show()
```

```
The brands offering the most number of products for sensitive skin types are :
BrandName
SHISEIDO        8640
GUERLAIN        3387
LANEIGE         1120
CLARINS          636
EVE LOM          354
SK-II            270
ERBORIAN         188
```

```
AMOREPACIFIC      180
dtype: int64
```


Top 10 Brands which offer sensitive skin type
AMOREPACIFIC
ERBORIAN
SK-II
EVE LOM
CLARINS
LANEIGE
GUERLAIN
SHISEIDO
BrandName
Number of products offered