notebook

June 21, 2021

1 Using Recommender Systems

Student name: Jonathan Lee Student pace: Full Time Scheduled project review date/time: June 22, 2pm Instructor name: James Irving Blog post URL:

1.1 Overview

This project uses the Surprise package from scikit with Amazon review data of Luxury Beauty products to build a recommendation system. In this analysis, we find that out of KNN methods, Singular Value Decomposition, and Alternating Least Squares methods, Singular Value Decomposition was the best performing model for our selected data. We also examine what the optimal hyperparameters are for this particular dataset.

1.2 Business Problem

Our client is a beauty product retailer that currently carries a small handful of Amazon's top featured brands and products. We want to optimize a recommender system based on Amazon reviews that as accurately as possible predicts other products that customers would be likely to enjoy. Using this optimized recommender system, we will move forward with the goal of using our client's customer preferences to extract insights into what other brands/products would be successful if our client were to add them to their product offering. ***Questions to address:*** **What is the best type of model to use to build a recommender system to work with this dataset? * What are the optimal hyperparameters to use during the modeling process? * Assuming that our client currently carries the most popular products found on Amazon, what other products can we recommend adding to inventory?** *

1.3 Data Understanding

In this analysis, we use Amazon review data and product metadata featured in the following paper:

Justifying recommendations using distantly-labeled reviews and fined-grained aspects

Jianmo Ni, Jiacheng Li, Julian McAuley

Empirical Methods in Natural Language Processing (EMNLP), 2019

Due to the large size of the complete dataset and hardware limitations, we will complete the analysis with only reviews and metadata from the luxury beauty product category.

Let's begin by doing some Exploratory Data Analysis.

[111]:
```
# Import standard packages
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

np.random.seed(27)

%matplotlib inline
```

[112]:
```
# Set theme and style for plots
sns.set_theme('talk')
sns.set_style('darkgrid')
```

[113]:
```
# Load review dataset and metadata
review_df = pd.read_csv('data/Luxury_Beauty.csv', names=['asin', 'user',␣
 ↪'rating', 'timestamp'])
meta_df = pd.read_json('data/meta_Luxury_Beauty.json.gz', lines=True)
display(review_df, meta_df)
```

```
             asin            user  rating   timestamp
0      B00004U9V2  A1Q6MUU0B2ZDQG     2.0  1276560000
1      B00004U9V2  A3HO2SQDCZIE9S     5.0  1262822400
2      B00004U9V2  A2EM03F99X3RJZ     5.0  1524009600
3      B00004U9V2   A3Z74TDRGD0HU     5.0  1524009600
4      B00004U9V2  A2UXFNW9RTL4VM     5.0  1523923200
…             …               …     …          …
574623 B01HIQEOLO   AHYJ78MVF4UQO     5.0  1489968000
574624 B01HIQEOLO  A1L2RT7KBNK02K     5.0  1477440000
574625 B01HIQEOLO  A36MLXQX9WPPW9     5.0  1475193600
574626 B01HJ2UY0W  A23DRCOMC2RIXF     1.0  1480896000
574627 B01HJ2UY1G   AJEDVHTLS9P3V     5.0  1484352000

[574628 rows x 4 columns]
```

```
      category tech1  \
0           []
1           []
2           []
3           []
4           []
…        …   …
12294       []
12295       []
12296       []
12297       []
12298       []
```

```
                                                                                ␣
 ↪              description  \
0       [After a long day of handling thorny situations, our new hand therapy␣
 ↪pump is just the help you …
1       [If you haven't experienced the pleasures of bathing in the Dead Sea,␣
 ↪Bath Crystals are the next…
2       [Rich, black mineral mud, harvested from the banks of the Dead Sea, is␣
 ↪comprised of layer upon l…
3       [This liquid soap with convenient pump dispenser is formulated with␣
 ↪conditioning extracts of sag…
4       [Remember why you love your favorite blanket? The soft, comforting␣
 ↪feeling of wrapping it around…
…                                                                               ␣
 ↪                     …
12294  [, CND Craft Culture Collection: Patina Buckle, Discover the beauty of␣
 ↪artisanal design. Distres…
12295  [CND Shellac was designed to be used as a system. Featuring a Base Coat,␣
 ↪Color Coat, and Top Coa…
12296  [CND Shellac was designed to be used as a system. Featuring a Base Coat,␣
 ↪Color Coat, and Top Coa…
12297  [The I AM JUICY COUTURE girl is once again taking a strong stance by␣
 ↪declaring her love for the …
12298  [I Love Juicy Couture Eau De Parfum Spray 3.4 Oz./ 100 Ml for Women by␣
 ↪Juicy Couture, Juicy Cout…

      fit  \
0
1
2
3
4
…    ..
12294
12295
12296
12297
12298


                                                                                ␣
 ↪      title  \
0       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump -␣
 ↪250g/8.8 OZ
1                                                                               ␣
 ↪AHAVA Bath Salts
2                                                AHAVA Dead Sea Mineral Mud, 8.5␣
 ↪oz, Pack of 4
```

```
3                                  Crabtree &amp;amp; Evelyn Hand Soap, Gardeners,␣
↪10.1 fl. oz.
4                                                                        Soy␣
↪Milk Hand Crme
…                                                                              ␣
↪      …
12294                                              CND Shellac Power Polish,␣
↪Patina Buckle
12295                                                CND Shellac power polish␣
↪denim patch
12296                                                          CND Shellac,␣
↪Leather Satchel
12297                     Juicy Couture I Love Juicy Couture, 1.7 fl. Oz.,␣
↪perfume for women
12298                     Juicy Couture I Love Juicy Couture, 3.4 fl. Oz.,␣
↪perfume for women

                                                                               ␣
↪                 also_buy  \
0      [B00GHX7H0A, B00FRERO7G, B00R68QXCS, B000Z65AZE, B07GFHJRMX, B074KGBGL7,␣
↪B00R68QXJG, B00025WYZC,…
1                                                                              ␣
↪                       []
2                                                                              ␣
↪                       []
3                                                                              ␣
↪                       []
4      [B000NZT6KM, B001BY229Q, B008J724QY, B0009YGKJ2, B001JB55SQ, B000M3OR7C,␣
↪B00J0A3ZCQ, B00SKBJ4L2,…
…                                                                              ␣
↪                     …
12294  [B003ONLAXQ, B00YDEZ9T6, B074KHRD13, B00R3PZK14, B074KJZJYW, B01KTKO4CU,␣
↪B01MT91G4R, B00DP64TLM,…
12295  [B003ONLAXQ, B003OH0KBA, B004LEMWGG, B01MT91G4R, B00AAV7H14, B074KBT2NM,␣
↪B004N2SQUC, B00DP64TLM,…
12296  [B003ONLAXQ, B003OH0KBA, B004LEMWGG, B01MT91G4R, B00AAV7H14, B074KBT2NM,␣
↪B004N2SQUC, B00DP64TLM,…
12297                                                                          ␣
↪                       []
12298                                                                          ␣
↪              [B071NZZW3K]

      tech2 brand feature                                        rank  \
0                      []          4,324 in Beauty & Personal Care (
1                      []      1,633,549 in Beauty & Personal Care (
2                      []  1,806,710 in Beauty &amp;amp; Personal Care (
```

```
3                    []                                                  []
4                    []     42,464 in Beauty &amp;amp; Personal Care (
…     …   …      …                                                    …
12294                []         88,740 in Beauty & Personal Care (
12295                []        122,331 in Beauty & Personal Care (
12296                []        168,028 in Beauty & Personal Care (
12297                []        490,755 in Beauty & Personal Care (
12298                []        181,383 in Beauty & Personal Care (


                                                                                                                ␣
 ↪                also_view  \
0      [B00FRERO7G, B00GHX7H0A, B07GFHJRMX, B00TJ3NBN2, B00K0BT82G, B00R68QXCS,␣
 ↪B074KGBGL7, B075MH4Q9L,…
1                                                                                                               ␣
 ↪                      []
2                                                                                                               ␣
 ↪                      []
3      [B00004U9V2, B00GHX7H0A, B00FRERO7G, B00R68QXCS, B00K0BT82G, B071G8FG2N,␣
 ↪B07FYFXBK8, B00TJ3NBN2,…
4                                                                                                               ␣
 ↪                      []
…                                                                                                               ␣
 ↪                     …
12294  [B00D2VMUA2, B074KJZJYW, B074KHRD13, B073SB9JWB, B00R3PZK14, B0721YJ13B,␣
 ↪B01KTK04CU, B00EFGDYZS,…
12295  [B00D2VMUA2, B01L0EV8X2, B004LEMWGG, B00EFGDYZS, B074KHRD13, B00R3PZK14,␣
 ↪B074KJZJYW, B074KBT2NM,…
12296  [B00D2VMUA2, B01L0EV8X2, B004LEMWGG, B00EFGDYZS, B074KHRD13, B00R3PZK14,␣
 ↪B074KJZJYW, B074KBT2NM,…
12297  [B0757439SY, B01HJ2UY1G, B01KX3TK7C, B01LX71LJV, B07K1Y92VL, B07GBSC3L2,␣
 ↪B00ZCFJE7I, B076LKLB5G,…
12298  [B0757439SY, B01LX71LJV, B01HJ2UY0W, B07GBSC3L2, B07K1Y92VL, B00ZCFJE7I,␣
 ↪B00M9BS1EU, B00KYAYL2E,…


                                                                                                                ␣
 ↪                  details  \
0      {'
    Product Dimensions:
    ': '2.2 x 2.2 x 7 inches ; 8.8 ounces', 'Shipping Weight:': '14…
1      {'
    Product Dimensions:
    ': '3 x 3.5 x 6 inches ; 2.2 pounds', 'Shipping Weight:': '2.6 p…
2      {'
    Product Dimensions:
    ': '5.1 x 3 x 5.5 inches ; 2.48 pounds', 'Shipping Weight:': '2…
3      {'
    Product Dimensions:
```

```
    ': '2.6 x 2.6 x 6.7 inches ; 1.5 pounds', 'Shipping Weight:': '1…
4      {'
    Product Dimensions:
    ': '7.2 x 2.2 x 7.2 inches ; 4 ounces', 'Shipping Weight:': '7.2…
…                                                                    ␣
 ↪                    …
12294  {'
    Item Weight:
    ': '0.48 ounces', 'Shipping Weight:': '1.4 ounces (', 'Domestic Shippin…
12295          {'Shipping Weight:': '1.4 ounces (', 'ASIN:': 'B01HIQHQU0', 'Item␣
 ↪model number:': 'C40625'}
12296  {'Shipping Weight:': '1.4 ounces (', 'Domestic Shipping: ': 'Item can be␣
 ↪shipped within U.S.', '…
12297  {'
    Product Dimensions:
    ': '3.3 x 2.7 x 4.6 inches', 'Shipping Weight:': '8 ounces (', '…
12298  {'
    Product Dimensions:
    ': '3.3 x 3.2 x 5.1 inches ; 13.8 ounces', 'Shipping Weight:': '…

            main_cat similar_item date   price        asin  \
0      Luxury Beauty                NaT  $30.00  B00004U9V2
1      Luxury Beauty                NaT          B0000531EN
2      Luxury Beauty                NaT          B0000532JH
3      Luxury Beauty                NaT  $15.99  B00005A77F
4      Luxury Beauty                NaT  $18.00  B00005NDTD
…                …           …  …      …         …
12294  Luxury Beauty                NaT  $15.95  B01HIQIEYC
12295  Luxury Beauty                NaT  $15.95  B01HIQHQU0
12296  Luxury Beauty                NaT  $15.95  B01HIQEOLO
12297  Luxury Beauty                NaT  $76.00  B01HJ2UY0W
12298  Luxury Beauty                NaT  $96.00  B01HJ2UY1G

                                                                     ␣
 ↪                  imageURL  \
0      [https://images-na.ssl-images-amazon.com/images/I/41ClX6BRvZL.
 ↪_SX50_SY65_CR,0,0,50,65_.jpg, http…
1                                                                    ␣
 ↪                        []
2              [https://images-na.ssl-images-amazon.com/images/I/41O1luEZuHL.
 ↪_SX50_SY65_CR,0,0,50,65_.jpg]
3      [https://images-na.ssl-images-amazon.com/images/I/31BBeRbXZsL.
 ↪_SX50_SY65_CR,0,0,50,65_.jpg, http…
4      [https://images-na.ssl-images-amazon.com/images/I/31agMAVCHtL.
 ↪_SX50_SY65_CR,0,0,50,65_.jpg, http…
…                                                                    ␣
 ↪                    …
```

```
12294                                                                          ␣
 ↪                        []
12295                                                                          ␣
 ↪                        []
12296        [https://images-na.ssl-images-amazon.com/images/I/41epzK1J%2BXL.
 ↪_SX50_SY65_CR,0,0,50,65_.jpg]
12297  [https://images-na.ssl-images-amazon.com/images/I/51vValOSv9L.
 ↪_SX50_SY65_CR,0,0,50,65_.jpg, http…
12298  [https://images-na.ssl-images-amazon.com/images/I/51rHh0s4XWL.
 ↪_SX50_SY65_CR,0,0,50,65_.jpg, http…


                                                                               ␣
 ↪          imageURLHighRes
0      [https://images-na.ssl-images-amazon.com/images/I/41ClX6BRvZL.jpg, https:/
 ↪/images-na.ssl-images-…
1                                                                              ␣
 ↪                        []
2                                          [https://images-na.ssl-images-amazon.com/
 ↪images/I/41O1luEZuHL.jpg]
3      [https://images-na.ssl-images-amazon.com/images/I/31BBeRbXZsL.jpg, https:/
 ↪/images-na.ssl-images-…
4      [https://images-na.ssl-images-amazon.com/images/I/31agMAVCHtL.jpg, https:/
 ↪/images-na.ssl-images-…
…                                                                              ␣
 ↪                      …
12294                                                                          ␣
 ↪                        []
12295                                                                          ␣
 ↪                        []
12296                                      [https://images-na.ssl-images-amazon.com/
 ↪images/I/41epzK1J%2BXL.jpg]
12297  [https://images-na.ssl-images-amazon.com/images/I/51vValOSv9L.jpg, https:/
 ↪/images-na.ssl-images-…
12298  [https://images-na.ssl-images-amazon.com/images/I/51rHh0s4XWL.jpg, https:/
 ↪/images-na.ssl-images-…

[12299 rows x 19 columns]
```

[114]:
```
# Drop duplicates and timestamp column from review table
review_df.drop_duplicates(inplace=True)
review_df.drop('timestamp', axis=1, inplace=True)
review_df
```

[114]:

	asin	user	rating
0	B00004U9V2	A1Q6MUU0B2ZDQG	2.0
1	B00004U9V2	A3HO2SQDCZIE9S	5.0

```
2       B00004U9V2  A2EM03F99X3RJZ     5.0
3       B00004U9V2   A3Z74TDRGD0HU     5.0
4       B00004U9V2  A2UXFNW9RTL4VM     5.0
…              …              …     …
574623  B01HIQEOLO   AHYJ78MVF4UQO     5.0
574624  B01HIQEOLO  A1L2RT7KBNK02K     5.0
574625  B01HIQEOLO  A36MLXQX9WPPW9     5.0
574626  B01HJ2UY0W  A23DRCOMC2RIXF     1.0
574627  B01HJ2UY1G   AJEDVHTLS9P3V     5.0

[538082 rows x 3 columns]
```

[115]:
```
# Slice asin and title columns from metadata table
meta_df = meta_df[['asin','title']]
```

[116]:
```
# Drop duplicates from metadata table
meta_df.drop_duplicates(inplace=True)
meta_df
```

[116]:
```
             asin  \
0      B00004U9V2
1      B0000531EN
2      B0000532JH
3      B00005A77F
4      B00005NDTD
…           …
12294  B01HIQIEYC
12295  B01HIQHQU0
12296  B01HIQEOLO
12297  B01HJ2UY0W
12298  B01HJ2UY1G

       title
0      Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump -
250g/8.8 OZ
1
AHAVA Bath Salts
2                                                AHAVA Dead Sea Mineral Mud, 8.5
oz, Pack of 4
3                                  Crabtree &amp;amp; Evelyn Hand Soap, Gardeners,
10.1 fl. oz.
4                                                                          Soy
Milk Hand Crme
…
…
12294                                                CND Shellac Power Polish,
Patina Buckle
```

```
12295                                                  CND Shellac power polish
denim patch
12296                                                            CND Shellac,
Leather Satchel
12297                    Juicy Couture I Love Juicy Couture, 1.7 fl. Oz.,
perfume for women
12298                    Juicy Couture I Love Juicy Couture, 3.4 fl. Oz.,
perfume for women

[12111 rows x 2 columns]
```

[117]:
```
# Combine review data and metadata to create catalog table
catalog_df = review_df.merge(meta_df, how='left', on='asin')
catalog_df
```

[117]:
```
              asin            user  rating  \
0       B00004U9V2  A1Q6MUU0B2ZDQG     2.0
1       B00004U9V2  A3HO2SQDCZIE9S     5.0
2       B00004U9V2  A2EM03F99X3RJZ     5.0
3       B00004U9V2   A3Z74TDRGD0HU     5.0
4       B00004U9V2  A2UXFNW9RTL4VM     5.0
…              …              …     …
538077  B01HIQEOLO   AHYJ78MVF4UQO     5.0
538078  B01HIQEOLO  A1L2RT7KBNK02K     5.0
538079  B01HIQEOLO  A36MLXQX9WPPW9     5.0
538080  B01HJ2UY0W  A23DRCOMC2RIXF     1.0
538081  B01HJ2UY1G   AJEDVHTLS9P3V     5.0

        title
0       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
1       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
2       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
3       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
4       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
…
…
538077                                                           CND Shellac,
Leather Satchel
538078                                                           CND Shellac,
Leather Satchel
538079                                                           CND Shellac,
Leather Satchel
```

```
538080                    Juicy Couture I Love Juicy Couture, 1.7 fl. Oz.,
perfume for women
538081                    Juicy Couture I Love Juicy Couture, 3.4 fl. Oz.,
perfume for women

[538082 rows x 4 columns]
```

[118]:
```
# Drop duplicates from merged catalog table
catalog_df.drop_duplicates(inplace=True)
catalog_df
```

[118]:
```
              asin            user  rating  \
0       B00004U9V2  A1Q6MUU0B2ZDQG     2.0
1       B00004U9V2  A3HO2SQDCZIE9S     5.0
2       B00004U9V2  A2EM03F99X3RJZ     5.0
3       B00004U9V2   A3Z74TDRGD0HU     5.0
4       B00004U9V2  A2UXFNW9RTL4VM     5.0
…              …              …     …
538077  B01HIQEOLO   AHYJ78MVF4UQO     5.0
538078  B01HIQEOLO  A1L2RT7KBNK02K     5.0
538079  B01HIQEOLO  A36MLXQX9WPPW9     5.0
538080  B01HJ2UY0W  A23DRCOMC2RIXF     1.0
538081  B01HJ2UY1G   AJEDVHTLS9P3V     5.0

        title
0       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
1       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
2       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
3       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
4       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
…
…
538077                                                    CND Shellac,
Leather Satchel
538078                                                    CND Shellac,
Leather Satchel
538079                                                    CND Shellac,
Leather Satchel
538080                    Juicy Couture I Love Juicy Couture, 1.7 fl. Oz.,
perfume for women
538081                    Juicy Couture I Love Juicy Couture, 3.4 fl. Oz.,
perfume for women
```

```
[536295 rows x 4 columns]
```

[119]:
```
catalog_df.isna().sum()
```

[119]:
```
asin        0
user        0
rating      0
title     184
dtype: int64
```

[120]:
```
catalog_df.dropna(inplace=True)
catalog_df
```

[120]:
```
              asin            user  rating  \
0       B00004U9V2  A1Q6MUU0B2ZDQG     2.0
1       B00004U9V2  A3HO2SQDCZIE9S     5.0
2       B00004U9V2  A2EM03F99X3RJZ     5.0
3       B00004U9V2   A3Z74TDRGD0HU     5.0
4       B00004U9V2  A2UXFNW9RTL4VM     5.0
…              …              …     …
538077  B01HIQEOLO   AHYJ78MVF4UQO     5.0
538078  B01HIQEOLO  A1L2RT7KBNK02K     5.0
538079  B01HIQEOLO  A36MLXQX9WPPW9     5.0
538080  B01HJ2UY0W  A23DRCOMC2RIXF     1.0
538081  B01HJ2UY1G   AJEDVHTLS9P3V     5.0

        title
0       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
1       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
2       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
3       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
4       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
…
…
538077                                                  CND Shellac,
Leather Satchel
538078                                                  CND Shellac,
Leather Satchel
538079                                                  CND Shellac,
Leather Satchel
538080                    Juicy Couture I Love Juicy Couture, 1.7 fl. Oz.,
```

```
perfume for women
538081                      Juicy Couture I Love Juicy Couture, 3.4 fl. Oz.,
perfume for women

[536111 rows x 4 columns]
```

[121]:
```
# Check datatype of columns
catalog_df.dtypes
```

[121]:
```
asin       object
user       object
rating    float64
title      object
dtype: object
```

[122]:
```
# Check how many unique values for asin
catalog_df['asin'].nunique()
```

[122]:
```
12111
```

[123]:
```
# Check how many unique values for title
catalog_df['title'].nunique()
```

[123]:
```
11719
```

[124]:
```
# Check how many unique values for user
catalog_df['user'].nunique()
```

[124]:
```
416077
```

[125]:
```
# Check distribution of ratings
catalog_df['rating'].value_counts().sort_index(ascending=False)
```

[125]:
```
5.0    355360
4.0     65885
3.0     39428
2.0     27830
1.0     47608
Name: rating, dtype: int64
```

[126]:
```
# Check distribution of ratings in percent
catalog_df['rating'].value_counts(normalize=True).sort_index(ascending=False)
```

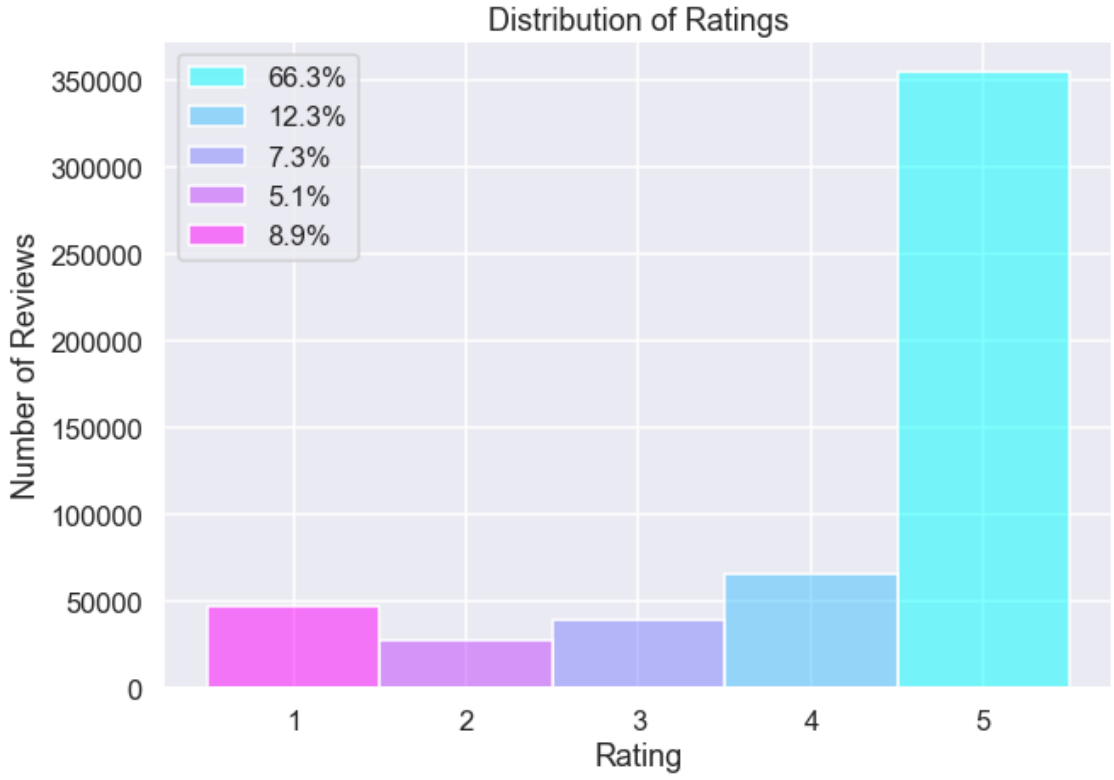
[126]:
```
5.0    0.662848
4.0    0.122894
3.0    0.073544
2.0    0.051911
```

```
1.0    0.088803
Name: rating, dtype: float64
```

[219]:
```
# Create bar plot of rating distribution
fig, ax = plt.subplots(figsize=(10,7))

g = sns.histplot(data=catalog_df, x='rating', hue='rating', palette='cool_r',␣
 ↪discrete=True, legend=True)

ax.set_title('Distribution of Ratings')
ax.set_xlabel('Rating')
ax.set_ylabel('Number of Reviews')
ax.set_xticks([1,2,3,4,5])
ax.legend(['66.3%','12.3%','7.3%','5.1%','8.9%']);
```



[266]:
```
# Get number of ratings per user
freq_df = catalog_df.groupby('user').agg('count').reset_index()
freq_df
```

[266]:

	user	product_code	rating	title
0	0	1	1	1
1	1	1	1	1

```
2            2             3       3      3
3            3             2       2      2
4            4             2       2      2
…          …             …       …    …
416072  416072             1       1      1
416073  416073             1       1      1
416074  416074             1       1      1
416075  416075             1       1      1
416076  416076             1       1      1

[416077 rows x 4 columns]
```

[267]:
```
freq_df.describe()
```

[267]:
```
                user   product_code         rating          title
count  416077.000000  416077.000000  416077.000000  416077.000000
mean   208038.000000       1.288490       1.288490       1.288490
std    120111.228314       1.130142       1.130142       1.130142
min         0.000000       1.000000       1.000000       1.000000
25%    104019.000000       1.000000       1.000000       1.000000
50%    208038.000000       1.000000       1.000000       1.000000
75%    312057.000000       1.000000       1.000000       1.000000
max    416076.000000     119.000000     119.000000     119.000000
```

[271]:
```
# Create table with number of users vs number of ratings per user
plot_df = freq_df.groupby('product_code').agg('count')[:10]
plot_df
```

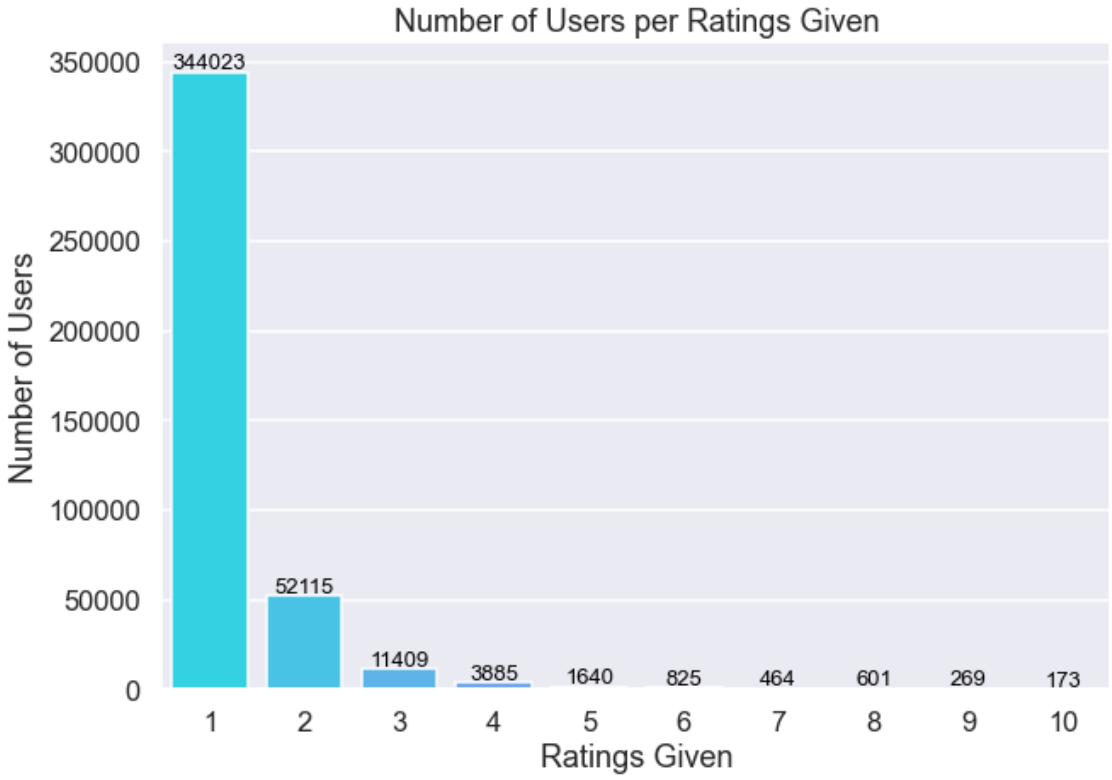
[271]:
```
                user  rating   title
product_code
1             344023  344023  344023
2              52115   52115   52115
3              11409   11409   11409
4               3885    3885    3885
5               1640    1640    1640
6                825     825     825
7                464     464     464
8                601     601     601
9                269     269     269
10               173     173     173
```

[272]:
```
# Create bar plot of users per ratings given
fig, ax = plt.subplots(figsize=(10,7))

g = sns.barplot(data=plot_df, x=plot_df.index, y=plot_df['user'],␣
↪palette='cool')
```

```
ax.set_title('Number of Users per Ratings Given')
ax.set_xlabel('Ratings Given')
ax.set_ylabel('Number of Users')

for p in ax.patches:
             ax.annotate("%.0f" % p.get_height(), (p.get_x() + p.get_width() /␣
 ↪2., p.get_height()),
                 ha='center', va='center', fontsize=13, color='black',␣
 ↪xytext=(0, 5),
                 textcoords='offset points');
```



[128]:
```
# Check measures of central tendency
catalog_df.describe()
```

[128]:

	rating
count	536111.000000
mean	4.219074
std	1.302025
min	1.000000
25%	4.000000
50%	5.000000
75%	5.000000

```
max         5.000000
```

1.3.1 Data Mapping

Now, we map our asin and user codes to integer values in order to optimize memory allocation during the modeling process.

[129]:
```
# Create list of unique asin codes
asin_list = catalog_df['asin'].unique()
```

[130]:
```
# Create an array of integers to map asin codes to
np.arange(len(asin_list))
```

[130]:
```
array([    0,     1,     2, …, 12108, 12109, 12110])
```

[131]:
```
# Construct dictionary using asin and corresponding product code
asin_map = dict(zip(asin_list, np.arange(len(asin_list))))
```

[132]:
```
# Check dictionary format
asin_map
```

[132]:
```
{'B00004U9V2': 0,
 'B00005A77F': 1,
 'B00005NDTD': 2,
 'B00005V50C': 3,
 'B00005V50B': 4,
 'B000066SYB': 5,
 'B000068DWY': 6,
 'B00008WFSM': 7,
 'B0000Y3NO6': 8,
 'B0000ZREXG': 9,
 'B0000ZREXQ': 10,
 'B00011JU6I': 11,
 'B00011QUKW': 12,
 'B00012C5RS': 13,
 'B000142FVW': 14,
 'B000141PIG': 15,
 'B00014351Q': 16,
 'B0001433OU': 17,
 'B000141PYK': 18,
 'B00014340I': 19,
 'B0001435D4': 20,
 'B00014353E': 21,
 'B0001432PK': 22,
 'B00014GT8W': 23,
 'B0001EKVCW': 24,
 'B0001EKVGS': 25,
```

```
'B0001EKTTC': 26,
'B0001EL5KO': 27,
'B0001EL5JA': 28,
'B0001EL9BO': 29,
'B0001EL0WC': 30,
'B0001EL5OU': 31,
'B0001EL59K': 32,
'B0001EL5R2': 33,
'B0001EL4DC': 34,
'B0001EL39C': 35,
'B0001EL5Q8': 36,
'B0001EL4M8': 37,
'B0001EKYEM': 38,
'B0001F3QV4': 39,
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'B0001UWRCI': 42,
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'B0001XDTYA': 44,
'B0001XDUBC': 45,
'B0001XDTWM': 46,
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'B0001Y74TU': 48,
'B0001Y74XG': 49,
'B0001Y74H2': 50,
'B0001Y74KO': 51,
'B0001Y74SG': 52,
'B0001Y74WM': 53,
'B0001Z66UM': 54,
'B0001Z98OC': 55,
'B00021AN4U': 56,
'B00021B3XU': 57,
'B00021AJ5I': 58,
'B00021AKJI': 59,
'B00021CJ56': 60,
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'B00021D2XO': 62,
'B00021D1DK': 63,
'B00021DDBK': 64,
'B00021DOZO': 65,
'B00021DHCU': 66,
'B00021AMZK': 67,
'B00021DXVA': 68,
'B00021CYJW': 69,
'B00021CDQ6': 70,
'B00021DBA8': 71,
'B00021D2Z2': 72,
```

```
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'B00021EA9Y': 78,
'B00021D2TI': 79,
'B00021UR3C': 80,
'B00021E4JO': 81,
'B00021CH4Y': 82,
'B0002279LY': 83,
'B000248HLI': 84,
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'B00025WYZC': 86,
'B00026ITZA': 87,
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'B0002CEIQ8': 90,
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'B0002X3SH2': 113,
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'B0002YYE3S': 117,
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'B0002ZOF2C': 128,
'B0002ZW5UQ': 129,
'B0002ZZT5Y': 130,
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'B00063M3EC': 132,
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'B0006B4VVW': 136,
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'B0006O4M4A': 150,
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'B0006PJRVM': 152,
'B0006PJRRG': 153,
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'B0006PLPDU': 156,
'B0006PLMFQ': 157,
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'B0007CXYA4': 184,
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 'B000YTA4RG': 994,
 'B000Z3ES1O': 995,
 'B000Z4X4EA': 996,
 'B000Z5Y3IO': 997,
 'B000Z5YFY2': 998,
 'B000Z5Y2D6': 999,
 …}
```

[133]:
```
# Map asin to product code integer and check
catalog_df['asin'] = catalog_df['asin'].map(asin_map)
catalog_df
```

[133]:

	asin	user	rating	\
0	0	A1Q6MUU0B2ZDQG	2.0	
1	0	A3HO2SQDCZIE9S	5.0	
2	0	A2EM03F99X3RJZ	5.0	
3	0	A3Z74TDRGDOHU	5.0	
4	0	A2UXFNW9RTL4VM	5.0	
…	…	…	…	

```
538077   6007   AHYJ78MVF4UQO     5.0
538078   6007  A1L2RT7KBNK02K     5.0
538079   6007  A36MLXQX9WPPW9     5.0
538080  12109  A23DRCOMC2RIXF     1.0
538081  12110   AJEDVHTLS9P3V     5.0

        title
0       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
1       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
2       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
3       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
4       Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
…
…
538077                                                    CND Shellac,
Leather Satchel
538078                                                    CND Shellac,
Leather Satchel
538079                                                    CND Shellac,
Leather Satchel
538080                     Juicy Couture I Love Juicy Couture, 1.7 fl. Oz.,
perfume for women
538081                     Juicy Couture I Love Juicy Couture, 3.4 fl. Oz.,
perfume for women

[536111 rows x 4 columns]
```

[134]:
```
# Rename 'asin' column to 'product_code'
catalog_df = catalog_df.rename(columns={'asin': 'product_code'})
```

[135]:
```
# Create list of unique users
user_list = catalog_df['user'].unique()
```

[136]:
```
# Create an array of integers to map user codes to
np.arange(len(user_list))
```

[136]:
```
array([     0,      1,      2, …, 416074, 416075, 416076])
```

[137]:
```
# Construct dictionary using user code and corresponding integer
user_map = dict(zip(user_list, np.arange(len(user_list))))
```

[138]:
```
# Check dictionary format
user_map
```

[138]:
```
{'A1Q6MUUOB2ZDQG': 0,
 'A3HO2SQDCZIE9S': 1,
 'A2EMO3F99X3RJZ': 2,
 'A3Z74TDRGDOHU': 3,
 'A2UXFNW9RTL4VM': 4,
 'AXX5G4LFF12R6': 5,
 'A7GUKMOJT2NR6': 6,
 'A3FU4L59BHA9FY': 7,
 'A1AMNMIPQMXH9M': 8,
 'A3DMBDTA8VGWSX': 9,
 'A16ODTI3H7VHLQ': 10,
 'A1H41DKPDPVAOR': 11,
 'A2BDI7THUMJ8V': 12,
 'AM7EBP5TRX7AC': 13,
 'A31FOVCS3WTWPT': 14,
 'AXUU8F9EM6U3E': 15,
 'A24B46V78ATNRP': 16,
 'ABUBKML2EONCG': 17,
 'A2UA6E1RVG3C1I': 18,
 'A1TRMJHEDGXOHF': 19,
 'A2TTJS62322SXW': 20,
 'AX2K33SNI3WHN': 21,
 'ALX99DYO827ZK': 22,
 'A3PVVQ9MHYFTV9': 23,
 'A22NEUQTKWQM98': 24,
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 'A2QPHVVXS9FUBS': 35,
 'AL63CNA6X6IX8': 36,
 'A2N6AACMA6WOMN': 37,
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 'A2R9R1DJ9RHXOX': 40,
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 'A3CG9DJUY5F2UY': 42,
 'AEDOSTGV48XO9': 43,
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```

[139]:
```
# Map asin to product code integer and check
catalog_df['user'] = catalog_df['user'].map(user_map)
catalog_df
```

[139]:
```
        product_code    user  rating  \
0                  0       0     2.0
1                  0       1     5.0
2                  0       2     5.0
3                  0       3     5.0
4                  0       4     5.0
…                …      …      …
538077          6007  194409     5.0
538078          6007  175285     5.0
538079          6007  416075     5.0
538080         12109  416076     1.0
538081         12110    4344     5.0

        title
0       Crabtree &amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
1       Crabtree &amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
2       Crabtree &amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
3       Crabtree &amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
4       Crabtree &amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
…
```

```
…
538077                                                        CND Shellac,
Leather Satchel
538078                                                        CND Shellac,
Leather Satchel
538079                                                        CND Shellac,
Leather Satchel
538080                    Juicy Couture I Love Juicy Couture, 1.7 fl. Oz.,
perfume for women
538081                    Juicy Couture I Love Juicy Couture, 3.4 fl. Oz.,
perfume for women

[536111 rows x 4 columns]
```

[140]:
```
# Convert to more efficient integer types
catalog_df['rating']=catalog_df['rating'].astype(np.int8)
catalog_df['product_code']=catalog_df['product_code'].astype(np.int32)
catalog_df['user']=catalog_df['user'].astype(np.int32)
```

[141]:
```
# Check data types
catalog_df.dtypes
```

[141]:
```
product_code     int32
user             int32
rating            int8
title           object
dtype: object
```

[142]:
```
# Create dataframe with user item rating
df = catalog_df[['user', 'product_code', 'rating']]
```

[143]:
```
# Save csv file to use in Databricks ALS model
# catalog_df.to_csv(r'data/Luxury_Beauty_reduced.csv', index=False)
```

1.4 Data Modeling

Describe and justify the process for analyzing or modeling the data.

Questions to consider: * How did you analyze or model the data? * How did you iterate on your initial approach to make it better? * Why are these choices appropriate given the data and the business problem? ***

[36]:
```
# If using Colab, install Surprise
# %pip install scikit-surprise
```

[37]:
```
# Import necessary packages for building recommender system
from surprise import Dataset, Reader
from surprise import accuracy
from surprise.prediction_algorithms import knns
from surprise.similarities import cosine, msd, pearson
from surprise.model_selection import cross_validate, train_test_split
from surprise.prediction_algorithms import SVD
from surprise.model_selection import GridSearchCV
```

[38]:
```
# Create reader object and format review data for processing
reader = Reader(line_format = 'user item rating', sep = ',')
data = Dataset.load_from_df(df, reader=reader)
```

[39]:
```
# Create train test split
trainset, testset = train_test_split(data, test_size=0.25, random_state=27)
```

1.4.1 KNN Basic

[40]:
```
# KNN Basic with cosine similarity
KNN_basic_cos = knns.KNNBasic(sim_options={'name': 'cosine',
                                           'user_based': False}).fit(trainset)
cross_validate(KNN_basic_cos, data, verbose= True, n_jobs=-1)
```

```
Computing the cosine similarity matrix…
Done computing similarity matrix.
Evaluating RMSE, MAE of algorithm KNNBasic on 5 split(s).

                  Fold 1  Fold 2  Fold 3  Fold 4  Fold 5  Mean    Std
RMSE (testset)    1.2632  1.2684  1.2633  1.2602  1.2582  1.2627  0.0035
MAE (testset)     0.9401  0.9429  0.9395  0.9383  0.9365  0.9395  0.0021
Fit time          12.39   13.05   12.40   11.11   9.69    11.73   1.20
Test time         2.51    1.55    1.29    1.20    1.01    1.51    0.53
```

[40]:
```
{'test_rmse': array([1.26322435, 1.2683995 , 1.26330598, 1.2601787 ,
1.25821732]),
 'test_mae': array([0.94014167, 0.94290605, 0.93953202, 0.93834403,
0.93647552]),
 'fit_time': (12.394513845443726,
  13.051391839981079,
  12.402780055999756,
  11.109658002853394,
  9.691288948059082),
 'test_time': (2.51012921333313,
  1.5471067428588867,
  1.2913436889648438,
  1.1951408386230469,
  1.0125072002410889)}
```

[41]:
```
# KNN Basic with pearson correlation similarity
KNN_basic_pearson = knns.KNNBasic(sim_options={'name': 'pearson',
                                               'user_based': False}).
 ↪fit(trainset)
cross_validate(KNN_basic_pearson, data, verbose= True, n_jobs=-1)
```

```
Computing the pearson similarity matrix…
Done computing similarity matrix.
Evaluating RMSE, MAE of algorithm KNNBasic on 5 split(s).

                  Fold 1  Fold 2  Fold 3  Fold 4  Fold 5  Mean    Std
RMSE (testset)    1.2612  1.2494  1.2628  1.2675  1.2569  1.2596  0.0061
MAE (testset)     0.9569  0.9504  0.9583  0.9623  0.9552  0.9566  0.0039
Fit time          15.41   16.18   15.14   14.86   12.43   14.80   1.27
Test time         2.32    2.30    1.65    1.40    1.22    1.78    0.45
```

[41]:
```
{'test_rmse': array([1.26120969, 1.24943058, 1.26283388, 1.26754131,
1.25687472]),
 'test_mae': array([0.95694535, 0.95038497, 0.95833556, 0.96234921,
0.95516655]),
 'fit_time': (15.406261920928955,
  16.182607889175415,
  15.141387939453125,
  14.860498905181885,
  12.429369926452637),
 'test_time': (2.3215370178222656,
  2.2979378700256348,
  1.648961067199707,
  1.4007959365844727,
  1.2209749221801758)}
```

1.4.2 KNN With Means

[42]:
```
# KNN with Means with cosine similarity
KNN_mean_cos = knns.KNNWithMeans(sim_options={'name': 'cosine', 'user_based':␣
 ↪False}).fit(trainset)
cross_validate(KNN_mean_cos, data, verbose= True, n_jobs=-1)
```

```
Computing the cosine similarity matrix…
Done computing similarity matrix.
Evaluating RMSE, MAE of algorithm KNNWithMeans on 5 split(s).

                  Fold 1  Fold 2  Fold 3  Fold 4  Fold 5  Mean    Std
RMSE (testset)    1.2635  1.2616  1.2630  1.2581  1.2585  1.2609  0.0023
MAE (testset)     0.9441  0.9444  0.9443  0.9425  0.9421  0.9435  0.0010
Fit time          12.01   14.22   13.11   12.40   10.36   12.42   1.28
Test time         2.75    1.54    1.35    1.17    1.10    1.58    0.60
```

[42]:
```
{'test_rmse': array([1.26353617, 1.26155318, 1.26295602, 1.25806818,
1.25848398]),
 'test_mae': array([0.94411476, 0.94443751, 0.94429647, 0.94253575,
0.94209396]),
 'fit_time': (12.01341700553894,
  14.222296237945557,
  13.110795021057129,
  12.402044296264648,
  10.356725931167603),
 'test_time': (2.747220993041992,
  1.5414340496063232,
  1.3490848541259766,
  1.1718180179595947,
  1.0963139533996582)}
```

[43]:
```
# KNN with Means with pearson correlation similarity
KNN_mean_pearson = knns.KNNWithMeans(sim_options={'name': 'pearson',␣
 ↪'user_based': False}).fit(trainset)
cross_validate(KNN_mean_pearson, data, verbose= True, n_jobs=-1)
```

```
Computing the pearson similarity matrix…
Done computing similarity matrix.
Evaluating RMSE, MAE of algorithm KNNWithMeans on 5 split(s).

                  Fold 1  Fold 2  Fold 3  Fold 4  Fold 5  Mean    Std
RMSE (testset)    1.2587  1.2616  1.2565  1.2576  1.2662  1.2601  0.0035
MAE (testset)     0.9545  0.9561  0.9531  0.9522  0.9599  0.9551  0.0027
Fit time          17.51   16.78   15.75   13.94   13.02   15.40   1.69
Test time         2.01    1.97    1.80    1.60    1.24    1.72    0.28
```

[43]:
```
{'test_rmse': array([1.25871611, 1.26155307, 1.25654958, 1.25755658,
1.26615351]),
 'test_mae': array([0.95446218, 0.95605427, 0.95305145, 0.95218445,
0.95985022]),
 'fit_time': (17.50693988800049,
  16.778023958206177,
  15.749869108200073,
  13.94059705734253,
  13.021985054016113),
 'test_time': (2.007986307144165,
  1.9656472206115723,
  1.7970101833343506,
  1.6038339138031006,
  1.2383232116699219)}
```

1.4.3 KNN With Z-Score

[44]:
```
# KNN with Z-score with pearson baseline correlation similarity
KNN_z_pearson = knns.KNNWithZScore(sim_options={'name': 'pearson_baseline',␣
 ↪'user_based': False}).fit(trainset)
cross_validate(KNN_z_pearson, data, verbose= True, n_jobs=-1)
```

```
Estimating biases using als…
Computing the pearson_baseline similarity matrix…
Done computing similarity matrix.
Evaluating RMSE, MAE of algorithm KNNWithZScore on 5 split(s).

                  Fold 1  Fold 2  Fold 3  Fold 4  Fold 5  Mean    Std
RMSE (testset)    1.2555  1.2566  1.2563  1.2693  1.2604  1.2596  0.0051
MAE (testset)     0.9466  0.9488  0.9487  0.9563  0.9505  0.9502  0.0033
Fit time          12.28   15.14   15.15   13.53   11.97   13.61   1.35
Test time         3.33    2.12    1.46    1.13    1.14    1.84    0.83
```

[44]:
```
{'test_rmse': array([1.2555194 , 1.25657864, 1.25633644, 1.26925501,
1.26040508]),
 'test_mae': array([0.94655318, 0.94882369, 0.94870317, 0.95634638,
0.95052545]),
 'fit_time': (12.276482105255127,
  15.140854835510254,
  15.14690899848938,
  13.531788110733032,
  11.972956895828247),
 'test_time': (3.330242872238159,
  2.124812126159668,
  1.46340012550354,
  1.1309051513671875,
  1.1364779472351074)}
```

1.4.4 KNN Baseline

[45]:
```
# KNN Baseline with pearson baseline similarity
KNN_base_pearson= knns.KNNBaseline(sim_options={'name': 'pearson_baseline',␣
 ↪'user_based': False}).fit(trainset)
cross_validate(KNN_base_pearson, data, verbose= True, n_jobs=-1)
```

```
Estimating biases using als…
Computing the pearson_baseline similarity matrix…
Done computing similarity matrix.
Evaluating RMSE, MAE of algorithm KNNBaseline on 5 split(s).

                  Fold 1  Fold 2  Fold 3  Fold 4  Fold 5  Mean    Std
RMSE (testset)    1.2227  1.2217  1.2241  1.2254  1.2270  1.2242  0.0019
MAE (testset)     0.9114  0.9096  0.9111  0.9130  0.9117  0.9114  0.0011
```

```
Fit time          13.56   14.18   13.18   13.48   11.07   13.09   1.06
Test time         2.44    1.96    1.75    1.11    1.20    1.69    0.49
```

[45]:
```
{'test_rmse': array([1.22267553, 1.22173688, 1.22414958, 1.22538799,
1.22703904]),
 'test_mae': array([0.91141176, 0.90962671, 0.91110502, 0.91299398,
0.91167086]),
 'fit_time': (13.555114984512329,
  14.175155878067017,
  13.184942960739136,
  13.479915857315063,
  11.069278955459595),
 'test_time': (2.436112880706787,
  1.962660789489746,
  1.7475488185882568,
  1.1110868453979492,
  1.2049570083618164)}
```

1.4.5 SVD

[46]:
```
# Train basic SVD model
svd = SVD(random_state=27)
svd.fit(trainset)
```

[46]:
```
<surprise.prediction_algorithms.matrix_factorization.SVD at 0x7fa064fd92b0>
```

[47]:
```
# Get predictions on test data and print RMSE
predictions= svd.test(testset)
print(accuracy.rmse(predictions), accuracy.mae(predictions))
```

```
RMSE: 1.2343
MAE:  0.9513
1.2343058409785395 0.9513405014854374
```

[50]:
```
# Gridsearch #1
param_grid = {'n_factors':[110, 130],'n_epochs': [25, 30], 'lr_all': [0.025, 0.
 ↪05],
              'reg_all': [0.1, 0.2]}
svd_grid1 = GridSearchCV(SVD,param_grid=param_grid,joblib_verbose=5, n_jobs=-1)
svd_grid1.fit(data)
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   2 tasks      | elapsed:  1.5min
[Parallel(n_jobs=-1)]: Done  56 tasks      | elapsed: 11.5min
[Parallel(n_jobs=-1)]: Done  80 out of  80 | elapsed: 17.0min finished
```

[51]:
```
# Print results from gridsearch #1
svd_grid1.best_params
```

[51]:
```
{'rmse': {'n_factors': 130, 'n_epochs': 30, 'lr_all': 0.025, 'reg_all': 0.1},
 'mae': {'n_factors': 110, 'n_epochs': 30, 'lr_all': 0.05, 'reg_all': 0.1}}
```

[57]:
```
# Use best params to get RMSE and MAE on test data
svd = SVD(n_factors=130, n_epochs=30, lr_all=0.025, reg_all=0.1,␣
 ↪random_state=27)
svd.fit(trainset)
predictions = svd.test(testset)
accuracy.rmse(predictions)
accuracy.mae(predictions)
```

```
RMSE: 1.2182
MAE:  0.9285
```

[57]:
```
0.9285218562243839
```

[58]:
```
# Gridsearch #2
param_grid = {'n_factors':[130, 150],'n_epochs': [30, 40], 'lr_all': [0.01, 0.
 ↪025],
              'reg_all': [0.05, 0.1]}
svd_grid2 = GridSearchCV(SVD,param_grid=param_grid,joblib_verbose=5, n_jobs=-1)
svd_grid2.fit(data)
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   2 tasks      | elapsed:  2.0min
[Parallel(n_jobs=-1)]: Done  56 tasks      | elapsed: 17.1min
[Parallel(n_jobs=-1)]: Done  80 out of  80 | elapsed: 25.0min finished
```

[59]:
```
# Print results from gridsearch #2
svd_grid2.best_params
```

[59]:
```
{'rmse': {'n_factors': 150, 'n_epochs': 40, 'lr_all': 0.025, 'reg_all': 0.1},
 'mae': {'n_factors': 130, 'n_epochs': 40, 'lr_all': 0.025, 'reg_all': 0.05}}
```

[60]:
```
# Use best params to get RMSE and MAE on test data
svd = SVD(n_factors=150, n_epochs=40, lr_all=0.025, reg_all=0.1,␣
 ↪random_state=27)
svd.fit(trainset)
predictions = svd.test(testset)
print(accuracy.rmse(predictions))
print(accuracy.mae(predictions))
```

```
RMSE: 1.2174
1.217377443190885
```

```
MAE:  0.9259
0.9258506393305158
```

[61]:
```
# Gridsearch #3
param_grid = {'n_factors':[150, 200],'n_epochs': [40, 50], 'lr_all': [0.025],
              'reg_all': [0.1]}
svd_grid_final = GridSearchCV(SVD,param_grid=param_grid,joblib_verbose=5,␣
 ↪n_jobs=-1)
svd_grid_final.fit(data)
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   2 tasks      | elapsed:  2.9min
[Parallel(n_jobs=-1)]: Done  10 out of  20 | elapsed:  6.6min remaining:  6.6min
[Parallel(n_jobs=-1)]: Done  15 out of  20 | elapsed:  7.5min remaining:  2.5min
[Parallel(n_jobs=-1)]: Done  20 out of  20 | elapsed:  9.7min remaining:    0.0s
[Parallel(n_jobs=-1)]: Done  20 out of  20 | elapsed:  9.7min finished
```

[62]:
```
# Print results from final gridsearch
svd_grid_final.best_params
```

[62]:
```
{'rmse': {'n_factors': 150, 'n_epochs': 50, 'lr_all': 0.025, 'reg_all': 0.1},
 'mae': {'n_factors': 150, 'n_epochs': 50, 'lr_all': 0.025, 'reg_all': 0.1}}
```

[63]:
```
# Use best params to get RMSE and MAE on test data
svd = SVD(lr_all=0.025, n_epochs=50, n_factors=150, reg_all=0.1,␣
 ↪random_state=27)
svd.fit(trainset)
predictions = svd.test(testset)
print(accuracy.rmse(predictions))
print(accuracy.mae(predictions))
```

```
RMSE: 1.2171
1.2171440876076423
MAE:  0.9237
0.9237444509387739
```

1.5 Evaluation

Evaluate how well your work solves the stated business problem.

Questions to consider: * How do you interpret the results? * How well does your model fit your data? How much better is this than your baseline model? * How confident are you that your results would generalize beyond the data you have? * How confident are you that this model would benefit the business if put into use? ***

1.6 Making Recommendations

[64]:
```
# Set pandas options to increase max column width and row number
pd.options.display.max_colwidth = 100
pd.options.display.max_rows = 500
catalog_df
```

[64]:
```
        product_code    user  rating  \
0                  0       0       2
1                  0       1       5
2                  0       2       5
3                  0       3       5
4                  0       4       5
…                …      …      …
538077          6007  194409       5
538078          6007  175285       5
538079          6007  416075       5
538080         12109  416076       1
538081         12110    4344       5

        title
0       Crabtree &amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
1       Crabtree &amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
2       Crabtree &amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
3       Crabtree &amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
4       Crabtree &amp; Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump
- 250g/8.8 OZ
…
…
538077                                                                CND Shellac,
Leather Satchel
538078                                                                CND Shellac,
Leather Satchel
538079                                                                CND Shellac,
Leather Satchel
538080                     Juicy Couture I Love Juicy Couture, 1.7 fl. Oz.,
perfume for women
538081                     Juicy Couture I Love Juicy Couture, 3.4 fl. Oz.,
perfume for women

[536111 rows x 4 columns]
```

[70]:
```
lookup_df = catalog_df.drop_duplicates('product_code')
lookup_df = lookup_df[['product_code', 'title']]
lookup_df
```

[70]:
```
        product_code  \
0                  0
559                1
567                2
637                3
653                4
…                …
538039         12106
538040         12107
538064         12108
538080         12109
538081         12110

                     title
0                    Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand
Therapy Pump - 250g/8.8 OZ
559                                                  Crabtree &amp;amp; Evelyn Hand
Soap, Gardeners, 10.1 fl. oz.
567
Soy Milk Hand Crme
637
Supersmile Powdered Mouthrinse
653     Supersmile Professional Teeth Whitening Toothpaste  Recommended By
Cosmetic Dentists, CLINICALLY…
…
…
538039                          St. Tropez Self Tan Bronzing Mousse, 8 fl. oz.
&amp;amp; Applicator Mitt Bundle
538040                                              Klorane Conditioner with
Pomegranate - Color-Treated Hair
538064
CND Shellac, Brick Knit
538080                                   Juicy Couture I Love Juicy Couture, 1.7
fl. Oz., perfume for women
538081                                   Juicy Couture I Love Juicy Couture, 3.4
fl. Oz., perfume for women

[12111 rows x 2 columns]
```

[71]:
```
# Create function to look up product codes
def product_search():
    """
    Prompts user to look up product name and returns product code.
```

```
    Args:

    Returns:
        search_results (DataFrame) : DataFrame including results of searched
        product name
    """

    # Prompt user for item name
    query_product = input('Search a brand or product: ')

    # Prompt user for number of results desired
    num_results = int(input('Up to how many results would you like to see? '))

    # Slice catalog_df to return DataFrame with results containing query
    search_results = lookup_df[lookup_df['title'].str\
                            .contains(query_product, case=False, na=False)]\
                            .head(num_results)

    return search_results
```

[74]:
```
# Look up sample product codes
product_search()
```

```
Search a brand or product: occitane
Up to how many results would you like to see? 50
```

[74]:

	product_code	\
42058	248	
64232	419	
64237	420	
68427	467	
78840	590	
111450	825	
123318	1005	
125755	1037	
164790	1444	
164795	1445	
164798	1446	
164800	1447	
164802	1448	
164814	1449	
164847	1450	
164910	1451	
165438	1452	
165878	1453	
165994	1454	

166737	1458
166757	1459
166760	1460
166764	1461
166802	1462
167083	1463
167463	1464
167557	1465
167905	1466
167906	1467
168052	1468
196513	1772
199220	1798
214876	1921
220233	1975
220994	1987
233598	2121
233740	2122
242129	2251
248637	2319
261398	2458
261461	2463
262925	2481
266260	2531
270368	2599
270382	2600
274309	2658
274820	2666
274859	2667
283179	2789
285452	2816

	title
42058	L'Occitane Cleansing Verbena Liquid with Organic Verbena Extract
64232	L'Occitane Almond Milk Concentrate, 7 fl. oz.
64237	L'Occitane Refreshing Verbena Eau de Toilette, 3.3 fl. oz.
68427	L'Occitane Citrus Verbena Summer Fragrance
78840	L'Occitane Green Tea Eau de Toilette, 0.6 fl. oz.
111450	L'Occitane Citrus Verbena Daily Use Shampoo, 8.4 fl. oz.
123318	L'Occitane 15% Shea Butter Foot Cream Enriched with Lavender & Arnica, 5.2 oz.

125755 L'Occitane Cherry Blossom Eau de Toilette, 3.4 fl. oz.
164790 L'Occitane Immortelle Precious Night Cream, 1.7 oz.
164795 L'Occitane CADE Shaving Cream for Men, 5.2 oz.
164798 L'Occitane Shea Butter Anti-Drying Lip Balm
164800 L'Occitane Extra-Gentle Vegetable Based Soap Enriched with Shea Butter
164802 L'Occitane Soothing Cade After Shave Balm for Men with Shea Butter, 2.5 fl. oz.
164814 L'Occitane L'OCCITAN Shaving Gel for Men, 5.1 Fl Oz
164847 L'Occitane Men's Fresh L'Occitan Shower Gel for Body & Hair, 8.4 fl. oz.
164910 L'Occitane Cade Shaving Oil for Men, 1 fl. oz.
165438 L'Occitane Aluminum Salts Free & Alcohol-Free Eau des Baux Deodorant for Men, 2.6 oz.
165878 L'Occitane Cleansing & Softening Almond Shower Oil, 8.4 fl. oz.
165994 L'Occitane Men's Reinvigorating Cade Shower Gel for Body & Hair, 8.4 fl. oz.
166737 L'Occitane Verbena Body Lotion, 8.4 fl. oz.
166757 L'Occitane Shea Butter Ultra Rich Face Cream, 1.7 oz.
166760 L'Occitane Shea Butter Body Lotion, 8.4 fl. oz.
166764 L'Occitane Moisturizing 25% Shea Butter Ultra-Rich Body Cream, 6.9 oz
166802 L'Occitane Shea Butter Liquid Hand Soap
167083 L'Occitane 20% Shea Butter Hand Cream, 5.2 fl. oz.
167463 L'Occitane Shea Butter Extra-Gentle Lotion for Hands & Body, 10.1 fl. oz.
167557 L'Occitane Lavender Body Lotion, 2.5 fl. oz.
167905 L'Occitane Immortelle Precious Cream, 1.7 oz.
167906 L'Occitane Immortelle Brightening Cleansing Foam, 5.1 fl. oz.
168052 L'Occitane Shea Butter Hand Cream, 1 oz.
196513 L'Occitane Rose 4 Reines

```
Eau de Toilette, 2.5 fl. oz.
199220            L'Occitane Moisturizing L'Occitan After Shave Balm for Men
with Shea Butter, 2.5 fl. oz.
214876                                                          L'Occitane Shea
Butter Hand Cream, 5.2 oz.
220233                                L'Occitane Immortelle Brightening
Cleansing Foam Refill, 10.1 fl. oz.
220994
L'Occitane Hand Cream, 1 oz.
233598  L'Occitane Eco-Cert Organic Certified &amp;amp; Fair Trade Approved Pure
Shea Butter Enriched with V…
233740                                                      L'Occitane
Immortelle Divine Eyes, 0.5 fl. oz.
242129                           L'Occitane Gentle &amp;amp; Ultra-Rich Body Scrub
with 10% Shea Butter, 7 oz.
248637                                        L'Occitane Immortelle Brightening
Instant Exfoliator, 2.6 oz.
261398                                                        L'Occitane
Angelica Hydration Cream, 1.7 oz.
261461                          L'Occitane Moisturizing 15% Shea Butter Ultra-
Rich Body Lotion, 8.4 fl. oz.
262925
L'Occitane Moisturizing Hand Lotion
266260                                             L'Occitane Verbena
Moisturizing Hand Lotion, 10.1 fl. oz.
270368                                                     L'Occitane Lavender
Eau de Cologne, 10.1 fl. oz.
270382                                              L'Occitane Organic Hand
Purifying Gel, Lavender, 1.7 oz.
274309                                                          L'Occitane
Lavender Shower Gel, 8.4 fl. oz.
274820         L'Occitane Immortelle Precious Eye Balm to Help Reduce the
Appearance of Tired Eyes, 0.5 oz.
274859                                                       L'Occitane Shea
Butter Liquid Soap Eco-Refill
283179              L'Occitane Cade Shaving Cream Enriched with Essential Oils
and Shea Butter, 5.2 fl. oz.
285452                                                 L'Occitane Shea Butter
Ultra Rich Face Cream, 1.7 oz.
```

[73]:
```
# Check last user number
df['user'].sort_values().tail()
```

[73]:
```
538073    416072
538074    416073
538075    416074
538079    416075
```

```
538080    416076
Name: user, dtype: int32
```

[77]:
```python
# Create function to train model on full dataset and return recommendations
def user_ratings(lr_all=0.025, n_epochs=50, n_factors=150, reg_all=0.1,␣
↪random_state=27):
    """
    Prompts user to enter customer's preferred product codes, models SVD
    using ideal hyperparameters, and returns however many predictions
    the user requests.

    Args:
        lr_all : The learning rate for all parameters. Default is ``0.025``.
        n_epochs : The number of iteration of the SGD procedure. Default is
            ``50``.
        n_factors : The number of factors. Default is ``150``.
        reg_all : The regularization term for all parameters. Default is
            ``0.1``.
        random_state (int) : Determines the RNG that will be used for
            initialization. If int, ``random_state`` will be used as a seed
            for a new RNG. This is useful to get the same initialization over
            multiple calls to ``fit()``.  If RandomState instance, this same
            instance is used as RNG. If ``None``, the current RNG from numpy
            is used.  Default is``27``.

    Returns:
        rec_list (DataFrame) : DataFrame recommendations based on new user's
        preferred products.
    """

    # Prompt user for list of product codes
    list_of_products = [int(x) for x in input('Enter product codes preferred \
    by customer (separate by spaces): ').split()]

    # Prompt user for desired number of product recommendations
    num_res = int(input('How many recommendations would you like? '))

    # Create list of ratings to add to dataset
    my_ratings = []
    for product in list_of_products:
        my_ratings.append({'user': 600000, 'product_code': product, \
                           'rating': '5'})

    # Add new ratings to full dataset
    new_ratings_df = df.append(my_ratings,ignore_index=True)

    # Format dataset for modeling
```

```
    reader = Reader(line_format='item user rating')
    new_data = Dataset.load_from_df(new_ratings_df,reader)

    # Train model on full dataset using preset hyperparameters
    svd_ = SVD(lr_all=lr_all, n_epochs=n_epochs, n_factors=n_factors, \
               reg_all=reg_all, random_state=random_state)
    svd_.fit(new_data.build_full_trainset())

    # Create total list of predictions for new user
    list_of_predictions = []
    for item in df['product_code'].unique():
        list_of_predictions.append((item, svd_.predict(600000, item)[3]))

    # Sort predictions from high to low
    ranked_predictions = sorted(list_of_predictions, key=lambda x:x[1], \
                                reverse=True)

    # Create dataframe from ranked predictions
    ranked_df = pd.DataFrame(ranked_predictions, columns=['product_code', \
                                                          'rating'])

    # Merge predictions with lookup df to get product names
    merged_df = ranked_df.merge(lookup_df, how='inner', on='product_code')

    # Create dataframe with requested number of results
    rec_list = merged_df.head(num_res)



    return rec_list
```

[78]:
```
user_ratings()
```

```
Enter product codes preferred     by customer (separate by spaces): 1445 1450
1452
How many recommendations would you like? 20
```

[78]:

	product_code	rating
0	2	5.0
1	28	5.0
2	35	5.0
3	61	5.0
4	69	5.0
5	87	5.0
6	116	5.0
7	147	5.0
8	172	5.0

```
9            201     5.0
10           203     5.0
11           221     5.0
12           225     5.0
13           233     5.0
14           238     5.0
15           248     5.0
16           270     5.0
17           308     5.0
18           315     5.0
19           316     5.0

                  title
0
Soy Milk Hand Crme
1                                          PCA SKIN  Protecting Hydrator Broad
Spectrum SPF 30, 1.7 oz.
2                                                jane iredale So-Bronze,
Bronzing Powder, 0.35 oz
3                                             Borghese Cura-C Anhydrous
Vitamin C Treatment, 1.7 oz.
4                                                                    LORAC
Oil-Free Wet/Dry Powder
5                                                                NEOVA Day
Therapy SPF 30, 1.7 Fl Oz
6                                                 Jurlique Moisture
Replenishing Day Cream, 4.3 oz
7                                           Kneipp Lavender Mineral Bath Salt,
Relaxing, 17.63 fl. oz.
8
NEOVA Squalane, 1.0 Fl Oz
9                                                      Glycolix Elite
Sunscreen SPF 30, 1.6 Fl Oz
10                                                              Archipelago
Lanai Glass Jar Candle
11  bliss High Intensity Hand Cream | Ultra Hydrating &amp;amp; Deeply Moisturizing
for Dry Hands &amp;amp; …
12                                               Elizabeth Arden Fifth
Avenue Eau de Parfum Spray
13                                              Paul Mitchell Soft
Sculpting Spray Gel,16.9 Fl Oz
14                                           Paul Mitchell Freeze and
Shine Super Spray,8.5 Fl Oz
15                                    L'Occitane Cleansing Verbena Liquid with
Organic Verbena Extract
16       Elchim 2001 Professional Hair Dryer High Pressure Turbo Italian 220V
(Will NOT WORK in the US)
```

```
17                                                                    eShare
After Shave Cream, 4 oz.
18  Replenix Green Tea Fortified Antioxidant Cleanser Naturally Soothes and
Hydrates Sensitive Skin,…
19                                                                      NEOVA
Herbal Wash, 8.0 Fl Oz
```

[296]:
```
# View top 10 products with most reviews
top_series = catalog_df['product_code'].value_counts().head(10)
top_df = pd.DataFrame(top_series)
top_df
```

[296]:
```
      product_code
1113          3427
129           3405
3203          3190
1230          3074
651           3013
14            2995
272           2734
744           2681
1249          2635
2980          2532
```

[294]:
```
# Create list of top 10 products with most reviews
top_list = catalog_df['product_code'].value_counts().index[:10].tolist()
top_list
```

[294]:
```
[1113, 129, 3203, 1230, 651, 14, 272, 744, 1249, 2980]
```

[297]:
```
# Merge top_df with lookup_df
new_df = top_df.merge(lookup_df, how='left', left_index=True,␣
 ↪right_on='product_code')
new_df
```

[297]:
```
        product_code  product_code_x  product_code_y  \
130262          1113            3427            1113
20660            129            3405             129
310958          3203            3190            3203
139240          1230            3074            1230
84461            651            3013             651
2388              14            2995              14
44173            272            2734             272
100555           744            2681             744
144056          1249            2635            1249
296513          2980            2532            2980
```

```
                                                    title
130262                                                                                                TOPPIK
Hair Building Fibers
20660                                                                                                 TOPPIK
Hair Building Fibers
310958  HOT TOOLS Professional 24k Gold Extra-Long Barrel Curling Iron/Wand for
Long Lasting Results
139240                                    Mario Badescu Facial Spray with Aloe, Herbs
and Rosewater, 8 oz.
84461                                                          OPI Nail Lacquer, Cajun
Shrimp, 0.5 fl. oz.
2388                                                 OPI Nail Lacquer, Not So Bora-
Bora-ing Pink, 0.5 Fl Oz
44173                                                                              BaBylissPRO
Ceramix Xtreme Dryer
100555                                                                              OPI Nail
Envy Nail Strengthener
144056  HOT TOOLS Professional 24k Gold Extra-Long Barrel Curling Iron/Wand for
Long Lasting Results
296513                                       Proraso Shaving Soap in a Bowl,
Refreshing and Toning, 5.2 oz
```

[281]:
```
new_df.set_index('product_code')
```

[281]:
```
                     title
product_code
14                                                 OPI Nail Lacquer, Not So
Bora-Bora-ing Pink, 0.5 Fl Oz
129
TOPPIK Hair Building Fibers
272
BaBylissPRO Ceramix Xtreme Dryer
651                                                              OPI Nail Lacquer,
Cajun Shrimp, 0.5 fl. oz.
744                                                                          OPI
Nail Envy Nail Strengthener
1113
TOPPIK Hair Building Fibers
1230                                        Mario Badescu Facial Spray with Aloe,
Herbs and Rosewater, 8 oz.
1249          HOT TOOLS Professional 24k Gold Extra-Long Barrel Curling
Iron/Wand for Long Lasting Results
2980                                           Proraso Shaving Soap in a Bowl,
Refreshing and Toning, 5.2 oz
3203          HOT TOOLS Professional 24k Gold Extra-Long Barrel Curling
Iron/Wand for Long Lasting Results
```

[ ]:

[ ]:

[ ]:

[146]:
```
user_ratings()
```

```
Enter product codes preferred     by customer (separate by spaces): 1113 129
3203 1230 651 14 272 744 1249 2980
How many recommendations would you like? 10
```

[146]:

	product_code	rating	\
0	0	5.0	
1	1	5.0	
2	2	5.0	
3	15	5.0	
4	26	5.0	
5	28	5.0	
6	29	5.0	
7	34	5.0	
8	35	5.0	
9	42	5.0	

	title
0	Crabtree & Evelyn - Gardener's Ultra-Moisturising Hand Therapy Pump - 250g/8.8 OZ
1	Crabtree & Evelyn Hand Soap, Gardeners, 10.1 fl. oz.
2	Soy Milk Hand Crme
3	Paul Mitchell Shampoo One
4	Glytone Rejuvenating Mask, 3 oz.
5	PCA SKIN Protecting Hydrator Broad Spectrum SPF 30, 1.7 oz.
6	jane iredale Amazing Base Loose Mineral Powder
7	Glo Skin Beauty Pressed Base - Mineral Makeup Pressed Powder Foundation, 20 Shades|Cruelty Free
8	jane iredale So-Bronze, Bronzing Powder, 0.35 oz
9	Yu-Be: Japan’s secret for dry skin relief. Deep hydrating moisturizing cream for face, han…

[273]:
```
user_ratings()
```

```
Enter product codes preferred     by customer (separate by spaces): 1113 129
3203 1230 651
How many recommendations would you like? 10
```

[273]:
```
   product_code  rating  \
0             0     5.0
1             2     5.0
2            15     5.0
3            21     5.0
4            26     5.0
5            28     5.0
6            29     5.0
7            35     5.0
8            42     5.0
9            58     5.0

                                                title
0                Crabtree &amp;amp; Evelyn - Gardener's Ultra-Moisturising Hand
Therapy Pump - 250g/8.8 OZ
1                                                    Soy Milk Hand Crme
2                                             Paul Mitchell Shampoo One
3                                                                OPI Iceland
Nail Lacquer Collection
4                                                                   Glytone
Rejuvenating Mask, 3 oz.
5                                        PCA SKIN  Protecting Hydrator Broad
Spectrum SPF 30, 1.7 oz.
6                                                  jane iredale Amazing
Base Loose Mineral Powder
7                                                jane iredale So-Bronze,
Bronzing Powder, 0.35 oz
8  Yu-Be: Japan&amp;rsquo;s secret for dry skin relief. Deep hydrating moisturizing
cream for face, han…
9                                                Calvin Klein ETERNITY Eau
de Parfum, 3.4 fl. oz.
```

1.7 Conclusions

Provide your conclusions about the work you've done, including any limitations or next steps.

Questions to consider: * What would you recommend the business do as a result of this work? * What are some reasons why your analysis might not fully solve the business problem? * What else could you do in the future to improve this project? ***

[ ]: