# UseCase_AssociationRulesMining

December 17, 2024

# 1 Module 11: Association Rules Mining and Recommendation Systems

## 1.1 Case Study – 1

[1]:
```
# 1. Import Libraries and Load Data
# Install mlxtend if not already installed

try:
    from mlxtend.frequent_patterns import apriori, association_rules
except ImportError:
    import sys
    !{sys.executable} -m pip install mlxtend
    # !{sys.executable} -m pip install --force-reinstall --upgrade mlxtend

# 1. Import Libraries
import pandas as pd
from mlxtend.frequent_patterns import apriori, association_rules
import warnings
warnings.filterwarnings('ignore')

# Load datasets
df_ratings = pd.read_csv('BX-Book-Ratings.csv', encoding='ISO-8859-1')
df_books = pd.read_csv('BX-Books.csv', encoding='ISO-8859-1')
df_users = pd.read_csv('BX-Users.csv', encoding='ISO-8859-1')

# Check data
print("Ratings Data:\n", df_ratings.head())
print("Books Data:\n", df_books.head())
print("Users Data:\n", df_users.head())

# Check the null values
print(df_ratings.isnull().sum(), '\n')
print(df_books.isnull().sum(),'\n')
print(df_users.isnull().sum(),'\n')
```

```python
print(df_ratings.info(), '\n')
print(df_books.info(),'\n')
print(df_users.info(),'\n')
```

```
Collecting mlxtend
  Using cached mlxtend-0.23.3-py3-none-any.whl.metadata (7.3 kB)
Collecting scipy>=1.2.1 (from mlxtend)
  Using cached scipy-1.14.1-cp310-cp310-win_amd64.whl.metadata (60 kB)
Collecting numpy>=1.16.2 (from mlxtend)
  Using cached numpy-2.2.0-cp310-cp310-win_amd64.whl.metadata (60 kB)
Collecting pandas>=0.24.2 (from mlxtend)
  Using cached pandas-2.2.3-cp310-cp310-win_amd64.whl.metadata (19 kB)
Collecting scikit-learn>=1.3.1 (from mlxtend)
  Using cached scikit_learn-1.6.0-cp310-cp310-win_amd64.whl.metadata (15 kB)
Collecting matplotlib>=3.0.0 (from mlxtend)
  Using cached matplotlib-3.10.0-cp310-cp310-win_amd64.whl.metadata (11 kB)
Collecting joblib>=0.13.2 (from mlxtend)
  Using cached joblib-1.4.2-py3-none-any.whl.metadata (5.4 kB)
Collecting contourpy>=1.0.1 (from matplotlib>=3.0.0->mlxtend)
  Using cached contourpy-1.3.1-cp310-cp310-win_amd64.whl.metadata (5.4 kB)
Collecting cycler>=0.10 (from matplotlib>=3.0.0->mlxtend)
  Using cached cycler-0.12.1-py3-none-any.whl.metadata (3.8 kB)
Collecting fonttools>=4.22.0 (from matplotlib>=3.0.0->mlxtend)
  Using cached fonttools-4.55.3-cp310-cp310-win_amd64.whl.metadata (168 kB)
Collecting kiwisolver>=1.3.1 (from matplotlib>=3.0.0->mlxtend)
  Using cached kiwisolver-1.4.7-cp310-cp310-win_amd64.whl.metadata (6.4 kB)
Collecting packaging>=20.0 (from matplotlib>=3.0.0->mlxtend)
  Using cached packaging-24.2-py3-none-any.whl.metadata (3.2 kB)
Collecting pillow>=8 (from matplotlib>=3.0.0->mlxtend)
  Using cached pillow-11.0.0-cp310-cp310-win_amd64.whl.metadata (9.3 kB)
Collecting pyparsing>=2.3.1 (from matplotlib>=3.0.0->mlxtend)
  Using cached pyparsing-3.2.0-py3-none-any.whl.metadata (5.0 kB)
Collecting python-dateutil>=2.7 (from matplotlib>=3.0.0->mlxtend)
  Using cached python_dateutil-2.9.0.post0-py2.py3-none-any.whl.metadata (8.4
kB)
Collecting pytz>=2020.1 (from pandas>=0.24.2->mlxtend)
  Using cached pytz-2024.2-py2.py3-none-any.whl.metadata (22 kB)
Collecting tzdata>=2022.7 (from pandas>=0.24.2->mlxtend)
  Using cached tzdata-2024.2-py2.py3-none-any.whl.metadata (1.4 kB)
Collecting threadpoolctl>=3.1.0 (from scikit-learn>=1.3.1->mlxtend)
  Using cached threadpoolctl-3.5.0-py3-none-any.whl.metadata (13 kB)
Collecting six>=1.5 (from python-dateutil>=2.7->matplotlib>=3.0.0->mlxtend)
  Using cached six-1.17.0-py2.py3-none-any.whl.metadata (1.7 kB)
Using cached mlxtend-0.23.3-py3-none-any.whl (1.4 MB)
Using cached joblib-1.4.2-py3-none-any.whl (301 kB)
Using cached matplotlib-3.10.0-cp310-cp310-win_amd64.whl (8.0 MB)
Using cached numpy-2.2.0-cp310-cp310-win_amd64.whl (12.9 MB)
Using cached pandas-2.2.3-cp310-cp310-win_amd64.whl (11.6 MB)
```

```
Using cached scikit_learn-1.6.0-cp310-cp310-win_amd64.whl (11.1 MB)
Using cached scipy-1.14.1-cp310-cp310-win_amd64.whl (44.8 MB)
Using cached contourpy-1.3.1-cp310-cp310-win_amd64.whl (218 kB)
Using cached cycler-0.12.1-py3-none-any.whl (8.3 kB)
Using cached fonttools-4.55.3-cp310-cp310-win_amd64.whl (2.2 MB)
Using cached kiwisolver-1.4.7-cp310-cp310-win_amd64.whl (55 kB)
Using cached packaging-24.2-py3-none-any.whl (65 kB)
Using cached pillow-11.0.0-cp310-cp310-win_amd64.whl (2.6 MB)
Using cached pyparsing-3.2.0-py3-none-any.whl (106 kB)
Using cached python_dateutil-2.9.0.post0-py2.py3-none-any.whl (229 kB)
Using cached pytz-2024.2-py2.py3-none-any.whl (508 kB)
Using cached threadpoolctl-3.5.0-py3-none-any.whl (18 kB)
Using cached tzdata-2024.2-py2.py3-none-any.whl (346 kB)
Using cached six-1.17.0-py2.py3-none-any.whl (11 kB)
Installing collected packages: pytz, tzdata, threadpoolctl, six, pyparsing,
pillow, packaging, numpy, kiwisolver, joblib, fonttools, cycler, scipy, python-
dateutil, contourpy, scikit-learn, pandas, matplotlib, mlxtend
  Attempting uninstall: pytz
    Found existing installation: pytz 2024.2
    Uninstalling pytz-2024.2:
      Successfully uninstalled pytz-2024.2
  Attempting uninstall: tzdata
    Found existing installation: tzdata 2024.2
    Uninstalling tzdata-2024.2:
      Successfully uninstalled tzdata-2024.2
  Attempting uninstall: threadpoolctl
    Found existing installation: threadpoolctl 3.5.0
    Uninstalling threadpoolctl-3.5.0:
      Successfully uninstalled threadpoolctl-3.5.0
  Attempting uninstall: six
    Found existing installation: six 1.17.0
    Uninstalling six-1.17.0:
      Successfully uninstalled six-1.17.0
  Attempting uninstall: pyparsing
    Found existing installation: pyparsing 3.2.0
    Uninstalling pyparsing-3.2.0:
      Successfully uninstalled pyparsing-3.2.0
  Attempting uninstall: pillow
    Found existing installation: pillow 11.0.0
    Uninstalling pillow-11.0.0:
      Successfully uninstalled pillow-11.0.0
  Attempting uninstall: packaging
    Found existing installation: packaging 24.2
    Uninstalling packaging-24.2:
      Successfully uninstalled packaging-24.2
  Attempting uninstall: numpy
    Found existing installation: numpy 2.2.0
    Uninstalling numpy-2.2.0:
```

```
      Successfully uninstalled numpy-2.2.0
  Attempting uninstall: kiwisolver
    Found existing installation: kiwisolver 1.4.7
    Uninstalling kiwisolver-1.4.7:
      Successfully uninstalled kiwisolver-1.4.7
  Attempting uninstall: joblib
    Found existing installation: joblib 1.4.2
    Uninstalling joblib-1.4.2:
      Successfully uninstalled joblib-1.4.2
  Attempting uninstall: fonttools
    Found existing installation: fonttools 4.55.3
    Uninstalling fonttools-4.55.3:
      Successfully uninstalled fonttools-4.55.3
  Attempting uninstall: cycler
    Found existing installation: cycler 0.12.1
    Uninstalling cycler-0.12.1:
      Successfully uninstalled cycler-0.12.1
  Attempting uninstall: scipy
    Found existing installation: scipy 1.14.1
    Uninstalling scipy-1.14.1:
      Successfully uninstalled scipy-1.14.1
  Attempting uninstall: python-dateutil
    Found existing installation: python-dateutil 2.9.0.post0
    Uninstalling python-dateutil-2.9.0.post0:
      Successfully uninstalled python-dateutil-2.9.0.post0
  Attempting uninstall: contourpy
    Found existing installation: contourpy 1.3.1
    Uninstalling contourpy-1.3.1:
      Successfully uninstalled contourpy-1.3.1
  Attempting uninstall: scikit-learn
    Found existing installation: scikit-learn 1.6.0
    Uninstalling scikit-learn-1.6.0:
      Successfully uninstalled scikit-learn-1.6.0
  Attempting uninstall: pandas
    Found existing installation: pandas 2.2.3
    Uninstalling pandas-2.2.3:
      Successfully uninstalled pandas-2.2.3
  Attempting uninstall: matplotlib
    Found existing installation: matplotlib 3.10.0
    Uninstalling matplotlib-3.10.0:
      Successfully uninstalled matplotlib-3.10.0
  Attempting uninstall: mlxtend
    Found existing installation: mlxtend 0.23.3
    Uninstalling mlxtend-0.23.3:
      Successfully uninstalled mlxtend-0.23.3
Successfully installed contourpy-1.3.1 cycler-0.12.1 fonttools-4.55.3
joblib-1.4.2 kiwisolver-1.4.7 matplotlib-3.10.0 mlxtend-0.23.3 numpy-2.2.0
packaging-24.2 pandas-2.2.3 pillow-11.0.0 pyparsing-3.2.0 python-
```

```
dateutil-2.9.0.post0 pytz-2024.2 scikit-learn-1.6.0 scipy-1.14.1 six-1.17.0
threadpoolctl-3.5.0 tzdata-2024.2
Ratings Data:
   user_id        isbn  rating
0   276725  034545104X       0
1   276726   155061224       5
2   276727   446520802       0
3   276729  052165615X       3
4   276729   521795028       6
Books Data:
        isbn                                         book_title  \
0  195153448                                Classical Mythology
1    2005018                                       Clara Callan
2   60973129                               Decision in Normandy
3  374157065  Flu: The Story of the Great Influenza Pandemic…
4  393045218                             The Mummies of Urumchi

            book_author year_of_publication                   publisher
0    Mark P. O. Morford                2002     Oxford University Press
1  Richard Bruce Wright                2001       HarperFlamingo Canada
2          Carlo D'Este                1991             HarperPerennial
3      Gina Bari Kolata                1999        Farrar Straus Giroux
4       E. J. W. Barber                1999  W. W. Norton &amp; Company
Users Data:
   user_id                            Location   Age
0        1                  nyc, new york, usa   NaN
1        2           stockton, california, usa  18.0
2        3     moscow, yukon territory, russia   NaN
3        4           porto, v.n.gaia, portugal  17.0
4        5  farnborough, hants, united kingdom   NaN
user_id    0
isbn       0
rating     0
dtype: int64

isbn                   0
book_title             0
book_author            2
year_of_publication    0
publisher              2
dtype: int64

user_id         0
Location        1
Age        110763
dtype: int64

<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 1048575 entries, 0 to 1048574
Data columns (total 3 columns):
 #   Column   Non-Null Count    Dtype
---  ------   --------------    -----
 0   user_id  1048575 non-null  int64
 1   isbn     1048575 non-null  object
 2   rating   1048575 non-null  int64
dtypes: int64(2), object(1)
memory usage: 24.0+ MB
None

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 271379 entries, 0 to 271378
Data columns (total 5 columns):
 #   Column               Non-Null Count   Dtype
---  ------               --------------   -----
 0   isbn                 271379 non-null  object
 1   book_title           271379 non-null  object
 2   book_author          271377 non-null  object
 3   year_of_publication  271379 non-null  object
 4   publisher            271377 non-null  object
dtypes: object(5)
memory usage: 10.4+ MB
None

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 278859 entries, 0 to 278858
Data columns (total 3 columns):
 #   Column    Non-Null Count   Dtype
---  ------    --------------   -----
 0   user_id   278859 non-null  object
 1   Location  278858 non-null  object
 2   Age       168096 non-null  float64
dtypes: float64(1), object(2)
memory usage: 6.4+ MB
None
```

[2]:

```
# Cleaning the Data:

# Replace missing Location values with 'Unknown Location'
df_users['Location'].fillna('Unknown Location', inplace=True)

# Replace missing Age values with the median age
df_users['Age'].fillna(df_users['Age'].median(), inplace=True)

# Replace missing values in df_books
```

```
df_books['book_author'].fillna('Unknown Author', inplace=True)
df_books['publisher'].fillna('Unknown Publisher', inplace=True)

# Verify updated null values
print("Updated Null Values in df_books:\n", df_books.isnull().sum(), '\n')
print("Updated Null Values in df_users:\n", df_users.isnull().sum(), '\n')
```

```
Updated Null Values in df_books:
 isbn                   0
book_title             0
book_author            0
year_of_publication    0
publisher              0
dtype: int64

Updated Null Values in df_users:
 user_id     0
Location    0
Age         0
dtype: int64
```

[3]:

```
# The MemoryError occurs because the pivot operation generates a massive matrix
# (61K rows × 128K columns), which consumes too much memory.
# Focusing on a smaller subset of the data will address this.

# To reduce memory usage and focus on meaningful data, you can filter users
# who have interacted with a significant number of books
# (e.g., users who have rated or rented a certain threshold of books).
# This helps limit the size of the user-book matrix while keeping high-quality␣
↪data.

# Step 1: Filter ratings (remove 0 ratings)
df_ratings_filtered = df_ratings[df_ratings['rating'] > 0]

# Step 2: Count the number of books each user interacted with
user_book_counts = df_ratings_filtered['user_id'].value_counts()

# Step 3: Filter users who interacted with significant books (threshold = 5)
threshold = 20
users_significant = user_book_counts[user_book_counts >= threshold].index

# Filter the ratings data for these users
df_ratings_filtered = df_ratings_filtered[df_ratings_filtered['user_id'].
↪isin(users_significant)]

# Step 4: Merge with books data
```

```python
df_merged = pd.merge(df_ratings_filtered, df_books, on='isbn', how='left')

# Keep only necessary columns
df_merged = df_merged[['user_id', 'book_title']]

# Step 5: Build the User-Book Matrix
user_book_matrix = df_merged.pivot_table(index='user_id',
                                         columns='book_title',
                                         aggfunc='size',
                                         fill_value=0)

# Convert to binary format (1 if user interacted with a book)
user_book_matrix = user_book_matrix.applymap(lambda x: 1 if x > 0 else 0)

print("User-Book Matrix (Filtered):\n", user_book_matrix.head())
print(f"Shape of the User-Book Matrix: {user_book_matrix.shape}")
```

```
User-Book Matrix (Filtered):
 book_title   A Light in the Storm: The Civil War Diary of Amelia Martin,
Fenwick Island, Delaware, 1861 (Dear America)  \
user_id
183                                                          0
242                                                          0
254                                                          0
392                                                          0
507                                                          0

book_title   Dark Justice  \
user_id
183                     0
242                     0
254                     0
392                     0
507                     0

book_title   Earth Prayers From around the World: 365 Prayers, Poems, and
Invocations for Honoring the Earth  \
user_id
183                                                          0
242                                                          0
254                                                          0
392                                                          0
507                                                          0

book_title   Final Fantasy Anthology: Official Strategy Guide (Brady Games)  \
user_id
183                                                          0
242                                                          0
```

```
254                                                        0
392                                                        0
507                                                        0

book_title   Flight of Fancy: American Heiresses (Zebra Ballad Romance)  \
user_id
183                                                        0
242                                                        0
254                                                        0
392                                                        0
507                                                        0

book_title   Garfield Bigger and Better (Garfield (Numbered Paperback))  \
user_id
183                                                        0
242                                                        0
254                                                        0
392                                                        0
507                                                        0

book_title   God's Little Promise Book  \
user_id
183                                 0
242                                 0
254                                 0
392                                 0
507                                 0

book_title   Good Wives: Image and Reality in the Lives of Women in Northern New
England, 1650-1750  \
user_id
183                                                        0
242                                                        0
254                                                        0
392                                                        0
507                                                        0

book_title   Goosebumps Monster Edition 1: Welcome to Dead House, Stay Out of
the Basement, and Say Cheese and Die!  \
user_id
183                                                        0
242                                                        0
254                                                        0
392                                                        0
507                                                        0

book_title   Highland Desire (Zebra Splendor Historical Romances)  …  \
user_id                                                           …
```

```
183                                                         0      …
242                                                         0      …
254                                                         0      …
392                                                         0      …
507                                                         0      …

book_title  Ã?ngeles fugaces (Falling Angels)  Ã?Â?. Kolumnen.  Ã?Â?a  \
user_id
183                                         0                0      0
242                                         0                0      0
254                                         0                0      0
392                                         0                0      0
507                                         0                0      0

book_title  Ã?Â?ber das Fernsehen.  Ã?Â?ber den ProzeÃ?Â? der Zivilisation 1.  \
user_id
183                              0                                          0
242                              0                                          0
254                              0                                          0
392                              0                                          0
507                              0                                          0

book_title  Ã?Â?ber den ProzeÃ?Â? der Zivilisation 2.  Ã?Â?ber die Freiheit.  \
user_id
183                                                 0                      0
242                                                 0                      0
254                                                 0                      0
392                                                 0                      0
507                                                 0                      0

book_title  Ã?Â?rger mit Produkt X. Roman.  Ã?Â?stlich der Berge.  \
user_id
183                                      0                      0
242                                      0                      0
254                                      0                      0
392                                      0                      0
507                                      0                      0

book_title  Ã?Â?thique en toc
user_id
183                        0
242                        0
254                        0
392                        0
507                        0

[5 rows x 96073 columns]
Shape of the User-Book Matrix: (3359, 96073)
```

[12]:
```
user_book_matrix
```

[12]:
```
book_title   A Light in the Storm: The Civil War Diary of Amelia Martin, Fenwick
Island, Delaware, 1861 (Dear America)  \
user_id
183                                                                         0
242                                                                         0
254                                                                         0
392                                                                         0
507                                                                         0
…                                                                         …
278356                                                                      0
278418                                                                      0
278582                                                                      0
278633                                                                      0
278843                                                                      0

book_title   Dark Justice  \
user_id
183                     0
242                     0
254                     0
392                     0
507                     0
…                     …
278356                  0
278418                  0
278582                  0
278633                  0
278843                  0

book_title   Earth Prayers From around the World: 365 Prayers, Poems, and
Invocations for Honoring the Earth  \
user_id
183                                                                         0
242                                                                         0
254                                                                         0
392                                                                         0
507                                                                         0
…                                                                         …
278356                                                                      0
278418                                                                      0
278582                                                                      0
278633                                                                      0
278843                                                                      0

book_title   Final Fantasy Anthology: Official Strategy Guide (Brady Games)  \
```

```
user_id
183                                                                  0
242                                                                  0
254                                                                  0
392                                                                  0
507                                                                  0
…                                                                   …
278356                                                               0
278418                                                               0
278582                                                               0
278633                                                               0
278843                                                               0

book_title   Flight of Fancy: American Heiresses (Zebra Ballad Romance)  \
user_id
183                                                                  0
242                                                                  0
254                                                                  0
392                                                                  0
507                                                                  0
…                                                                   …
278356                                                               0
278418                                                               0
278582                                                               0
278633                                                               0
278843                                                               0

book_title   Garfield Bigger and Better (Garfield (Numbered Paperback))  \
user_id
183                                                                  0
242                                                                  0
254                                                                  0
392                                                                  0
507                                                                  0
…                                                                   …
278356                                                               0
278418                                                               0
278582                                                               0
278633                                                               0
278843                                                               0

book_title   God's Little Promise Book  \
user_id
183                                  0
242                                  0
254                                  0
392                                  0
```

```
507                                 0
…                               …
278356                              0
278418                              0
278582                              0
278633                              0
278843                              0

book_title   Good Wives: Image and Reality in the Lives of Women in Northern New
England, 1650-1750  \
user_id
183                                                    0
242                                                    0
254                                                    0
392                                                    0
507                                                    0
…                                                  …
278356                                                 0
278418                                                 0
278582                                                 0
278633                                                 0
278843                                                 0

book_title   Goosebumps Monster Edition 1: Welcome to Dead House, Stay Out of
the Basement, and Say Cheese and Die!  \
user_id
183                                                    0
242                                                    0
254                                                    0
392                                                    0
507                                                    0
…                                                  …
278356                                                 0
278418                                                 0
278582                                                 0
278633                                                 0
278843                                                 0

book_title   Highland Desire (Zebra Splendor Historical Romances)  …  \
user_id                                                           …
183                                                    0      …
242                                                    0      …
254                                                    0      …
392                                                    0      …
507                                                    0      …
…                                                  …     …
278356                                                 0      …
```

```
278418                                                    0    …
278582                                                    0    …
278633                                                    0    …
278843                                                    0    …

book_title  Ã?ngeles fugaces (Falling Angels)  Ã?Â?. Kolumnen.  Ã?Â?a  \
user_id
183                                         0               0      0
242                                         0               0      0
254                                         0               0      0
392                                         0               0      0
507                                         0               0      0
…                                         …              …    …
278356                                      0               0      0
278418                                      0               0      0
278582                                      0               0      0
278633                                      0               0      0
278843                                      0               0      0

book_title  Ã?Â?ber das Fernsehen.  Ã?Â?ber den ProzeÃ?Â? der Zivilisation 1.  \
user_id
183                              0                                         0
242                              0                                         0
254                              0                                         0
392                              0                                         0
507                              0                                         0
…                              …                                        …
278356                           0                                         0
278418                           0                                         0
278582                           0                                         0
278633                           0                                         0
278843                           0                                         0

book_title  Ã?Â?ber den ProzeÃ?Â? der Zivilisation 2.  Ã?Â?ber die Freiheit.  \
user_id
183                                                 0                     0
242                                                 0                     0
254                                                 0                     0
392                                                 0                     0
507                                                 0                     0
…                                                …                    …
278356                                              0                     0
278418                                              0                     0
278582                                              0                     0
278633                                              0                     0
278843                                              0                     0
```

```
book_title  Ã?Â?rger mit Produkt X. Roman.  Ã?Â?stlich der Berge.  \
user_id
183                                      0                      0
242                                      0                      0
254                                      0                      0
392                                      0                      0
507                                      0                      0
…                                    …                      …
278356                                   0                      0
278418                                   0                      0
278582                                   0                      0
278633                                   0                      0
278843                                   0                      0

book_title  Ã?Â?thique en toc
user_id
183                      0
242                      0
254                      0
392                      0
507                      0
…                      …
278356                   0
278418                   0
278582                   0
278633                   0
278843                   0

[3359 rows x 96073 columns]
```

[6]:

```python
# Apply Association Rule Mining
# We will use the Apriori algorithm to find frequently rented books and␣
↪generate association rules.

import mlxtend
print(mlxtend.__version__)

# Step 1: Apply the Apriori algorithm
min_support = 0.01 # min_support stands for minimum support: threshold that␣
↪determines how frequently an item or itemset must appear in the dataset to␣
↪be considered "frequent.
frequent_itemsets = apriori(user_book_matrix, min_support=min_support,␣
↪use_colnames=True)

print("\nFrequent Itemsets:")
print(frequent_itemsets)
```

```python
# Step 2: Generate association rules with a dummy 'num_itemsets'
#rules = association_rules(frequent_itemsets, metric="lift", min_threshold=1.0)
rules = association_rules(frequent_itemsets, metric="lift", min_threshold=1.0,␣
↪num_itemsets=len(frequent_itemsets))

# Step 3: Sort and display the rules
rules = rules.sort_values(by="confidence", ascending=False)
print("\nTop Association Rules:")
print(rules[['antecedents', 'consequents', 'support', 'confidence', 'lift']].
↪head())
```

```
0.23.3

Frequent Itemsets:
      support                                          itemsets
0    0.021137                                            (1984)
1    0.028580                              (1st to Die: A Novel)
2    0.021137                                      (2nd Chance)
3    0.010717                             (84 Charing Cross Road)
4    0.015779                                (A Bend in the Road)
..        …                                                 …
376  0.014290  (Harry Potter and the Sorcerer's Stone (Book 1…
377  0.011015  (Harry Potter and the Sorcerer's Stone (Harry …
378  0.010420  (Harry Potter and the Order of the Phoenix (Bo…
379  0.014290  (Harry Potter and the Chamber of Secrets (Book…
380  0.013397  (Harry Potter and the Chamber of Secrets (Book…

[381 rows x 2 columns]

Top Association Rules:
                                          antecedents  \
125  (Harry Potter and the Chamber of Secrets (Book…
104  (Harry Potter and the Order of the Phoenix (Bo…
93   (Harry Potter and the Sorcerer's Stone (Book 1…
127  (Harry Potter and the Sorcerer's Stone (Book 1…
58   (Harry Potter and the Sorcerer's Stone (Book 1…

                                          consequents   support  confidence  \
125  (Harry Potter and the Prisoner of Azkaban (Boo…  0.013397    0.978261
104  (Harry Potter and the Prisoner of Azkaban (Boo…  0.010420    0.972222
93   (Harry Potter and the Prisoner of Azkaban (Boo…  0.014290    0.960000
127  (Harry Potter and the Chamber of Secrets (Book…  0.013397    0.937500
58   (Harry Potter and the Chamber of Secrets (Book…  0.013695    0.920000

          lift
125  21.337521
104  21.205808
93   20.939221
```

```
127   17.398135
58    17.073370
```

[8]:
```python
rules[ (rules['lift'] >= 10) &
       (rules['confidence'] >= 0.8) ]
```

[8]:
```
                                           antecedents  \
125  (Harry Potter and the Chamber of Secrets (Book…
104  (Harry Potter and the Order of the Phoenix (Bo…
93   (Harry Potter and the Sorcerer's Stone (Book 1…
127  (Harry Potter and the Sorcerer's Stone (Book 1…
58   (Harry Potter and the Sorcerer's Stone (Book 1…
76   (Harry Potter and the Sorcerer's Stone (Book 1…
110  (Harry Potter and the Chamber of Secrets (Book…
132  (Harry Potter and the Sorcerer's Stone (Book 1…
111  (Harry Potter and the Chamber of Secrets (Book…
124  (Harry Potter and the Chamber of Secrets (Book…
68   (Harry Potter and the Chamber of Secrets (Book…
50   (Harry Potter and the Chamber of Secrets (Book…
87   (Harry Potter and the Order of the Phoenix (Bo…
92   (Harry Potter and the Sorcerer's Stone (Book 1…
86   (Harry Potter and the Order of the Phoenix (Bo…
44   (Harry Potter and the Chamber of Secrets (Book…
113  (Harry Potter and the Order of the Phoenix (Bo…
74   (Harry Potter and the Chamber of Secrets (Book…
63   (Harry Potter and the Sorcerer's Stone (Harry …
98   (Harry Potter and the Sorcerer's Stone (Harry …
52   (Harry Potter and the Goblet of Fire (Book 4),…
70   (Harry Potter and the Order of the Phoenix (Bo…

                                           consequents  antecedent support  \
125  (Harry Potter and the Prisoner of Azkaban (Boo…            0.013695
104  (Harry Potter and the Prisoner of Azkaban (Boo…            0.010717
93   (Harry Potter and the Prisoner of Azkaban (Boo…            0.014885
127  (Harry Potter and the Chamber of Secrets (Book…            0.014290
58   (Harry Potter and the Chamber of Secrets (Book…            0.014885
76   (Harry Potter and the Chamber of Secrets (Book…            0.016969
110  (Harry Potter and the Prisoner of Azkaban (Boo…            0.015779
132  (Harry Potter and the Chamber of Secrets (Book…            0.014885
111     (Harry Potter and the Goblet of Fire (Book 4))            0.016374
124     (Harry Potter and the Goblet of Fire (Book 4))            0.015481
68   (Harry Potter and the Prisoner of Azkaban (Boo…            0.019053
50   (Harry Potter and the Prisoner of Azkaban (Boo…            0.028878
87      (Harry Potter and the Goblet of Fire (Book 4))            0.020244
92      (Harry Potter and the Goblet of Fire (Book 4))            0.016969
86   (Harry Potter and the Prisoner of Azkaban (Boo…            0.020542
44      (Harry Potter and the Goblet of Fire (Book 4))            0.019053
```

| | | |
|---|---|---|
| 113 | (Harry Potter and the Chamber of Secrets (Book… | 0.017267 |
| 74 | (Harry Potter and the Prisoner of Azkaban (Boo… | 0.018756 |
| 63 | (Harry Potter and the Chamber of Secrets (Book… | 0.013397 |
| 98 | (Harry Potter and the Prisoner of Azkaban (Boo… | 0.013397 |
| 52 | (Harry Potter and the Chamber of Secrets (Book… | 0.030068 |
| 70 | (Harry Potter and the Chamber of Secrets (Book… | 0.020244 |

| | consequent support | support | confidence | lift | representativity | \ |
|---|---|---|---|---|---|---|
| 125 | 0.045847 | 0.013397 | 0.978261 | 21.337521 | 1.0 | |
| 104 | 0.045847 | 0.010420 | 0.972222 | 21.205808 | 1.0 | |
| 93 | 0.045847 | 0.014290 | 0.960000 | 20.939221 | 1.0 | |
| 127 | 0.053885 | 0.013397 | 0.937500 | 17.398135 | 1.0 | |
| 58 | 0.053885 | 0.013695 | 0.920000 | 17.073370 | 1.0 | |
| 76 | 0.053885 | 0.015481 | 0.912281 | 16.930115 | 1.0 | |
| 110 | 0.045847 | 0.014290 | 0.905660 | 19.753982 | 1.0 | |
| 132 | 0.031557 | 0.013397 | 0.900000 | 28.519811 | 1.0 | |
| 111 | 0.042274 | 0.014290 | 0.872727 | 20.644302 | 1.0 | |
| 124 | 0.042274 | 0.013397 | 0.865385 | 20.470612 | 1.0 | |
| 68 | 0.045847 | 0.016374 | 0.859375 | 18.744420 | 1.0 | |
| 50 | 0.045847 | 0.024710 | 0.855670 | 18.663610 | 1.0 | |
| 87 | 0.042274 | 0.017267 | 0.852941 | 20.176263 | 1.0 | |
| 92 | 0.042274 | 0.014290 | 0.842105 | 19.919941 | 1.0 | |
| 86 | 0.045847 | 0.017267 | 0.840580 | 18.334463 | 1.0 | |
| 44 | 0.042274 | 0.015779 | 0.828125 | 19.589239 | 1.0 | |
| 113 | 0.053885 | 0.014290 | 0.827586 | 15.358354 | 1.0 | |
| 74 | 0.045847 | 0.015481 | 0.825397 | 18.003298 | 1.0 | |
| 63 | 0.053885 | 0.011015 | 0.822222 | 15.258809 | 1.0 | |
| 98 | 0.045847 | 0.011015 | 0.822222 | 17.934055 | 1.0 | |
| 52 | 0.053885 | 0.024710 | 0.821782 | 15.250643 | 1.0 | |
| 70 | 0.053885 | 0.016374 | 0.808824 | 15.010156 | 1.0 | |

| | leverage | conviction | zhangs_metric | jaccard | certainty | kulczynski |
|---|---|---|---|---|---|---|
| 125 | 0.012769 | 43.891039 | 0.966368 | 0.290323 | 0.977216 | 0.635234 |
| 104 | 0.009928 | 34.349509 | 0.963166 | 0.225806 | 0.970888 | 0.599747 |
| 93 | 0.013608 | 23.853826 | 0.966631 | 0.307692 | 0.958078 | 0.635844 |
| 127 | 0.012627 | 15.137839 | 0.956186 | 0.244565 | 0.933940 | 0.593059 |
| 58 | 0.012892 | 11.826436 | 0.955655 | 0.248649 | 0.915444 | 0.587072 |
| 76 | 0.014566 | 10.785710 | 0.957176 | 0.279570 | 0.907285 | 0.599787 |
| 110 | 0.013567 | 10.114022 | 0.964597 | 0.301887 | 0.901127 | 0.608674 |
| 132 | 0.012927 | 9.684430 | 0.979517 | 0.405405 | 0.896741 | 0.662264 |
| 111 | 0.013598 | 7.524986 | 0.967401 | 0.322148 | 0.867109 | 0.605378 |
| 124 | 0.012742 | 7.114532 | 0.966106 | 0.302013 | 0.859443 | 0.591143 |
| 68 | 0.015500 | 6.785088 | 0.965038 | 0.337423 | 0.852618 | 0.608259 |
| 50 | 0.023386 | 6.610917 | 0.974563 | 0.494048 | 0.848735 | 0.697316 |
| 87 | 0.016411 | 6.512533 | 0.970075 | 0.381579 | 0.846450 | 0.630696 |
| 92 | 0.013573 | 6.065595 | 0.966195 | 0.317881 | 0.835136 | 0.590067 |
| 86 | 0.016325 | 5.985142 | 0.965287 | 0.351515 | 0.832920 | 0.608602 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 44 | 0.014973 | 5.572221 | 0.967383 | 0.346405 | 0.820538 | 0.600682 |
| 113 | 0.013360 | 5.487467 | 0.951315 | 0.251309 | 0.817767 | 0.546390 |
| 74 | 0.014621 | 5.464695 | 0.962507 | 0.315152 | 0.817007 | 0.581530 |
| 63 | 0.010293 | 5.321896 | 0.947153 | 0.195767 | 0.812097 | 0.513321 |
| 98 | 0.010401 | 5.367111 | 0.957062 | 0.228395 | 0.813680 | 0.531241 |
| 52 | 0.023089 | 5.308756 | 0.963397 | 0.417085 | 0.811632 | 0.640173 |
| 70 | 0.015283 | 4.948909 | 0.952664 | 0.283505 | 0.797935 | 0.556345 |

[ ]: