Python Code for QSS Chapter 5: Discovery

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First Printing

Section 5.1: Textual Data

Section 5.1.1: The Disputed Authorship of 'The Federalist Papers'

Importing textual data into a DataFrame

[ ]:

```python
import pandas as pd
import numpy as np
import glob

# Get a list of all txt files in the federalist directory
file_paths = glob.glob('federalist/*.txt')

# Create an empty list
file_contents = []

# Read txt files into the empty list
for file in file_paths:
    # with: open and close file automatically
    # open(file, 'r'): open file in read mode
    # assign opened file to f
    with open(file, 'r') as f:
        file_contents.append(f.read())

# Take a look at the first 100 characters of essay number 10
file_contents[9][:100]
```

[ ]:

```
'AMONG the numerous advantages promised by a well-constructed Union, none \n
deserves to be mor'
```

[ ]:

```python
# Create a data frame with essay number, a placeholder for author, and the text
federalist = pd.DataFrame({'fed_num': np.arange(1,86), 'author': None,
                           'text': file_contents})

# store authorship information
hamilton = ([1] + list(range(6,10)) + list(range(11, 14)) +
            list(range(15, 18)) + list(range(21, 37)) + list(range(59, 62)) +
            list(range(65, 86)))

madison = [10] + [14] + list(range(37, 49)) + [58]
```

```
jay = list(range(2,6)) + [64]

joint = [18, 19, 20] # Madison and Hamilton

# store conditions for authorship
conditions = [
      federalist['fed_num'].isin(hamilton),
      federalist['fed_num'].isin(madison),
      federalist['fed_num'].isin(jay),
      federalist['fed_num'].isin(joint)
]

choices  = ['Hamilton', 'Madison', 'Jay', 'Joint']

# populate the author column; assign 'Disputed' to unassigned essays
federalist['author'] = np.select(conditions, choices, 'Disputed')

federalist
```

[ ]:

```
    fed_num    author                                               text
0         1  Hamilton  AFTER an unequivocal experience of the ineffic…
1         2       Jay  WHEN the people of America reflect that they a…
2         3       Jay  IT IS not a new observation that the people of…
3         4       Jay  MY LAST paper assigned several reasons why the…
4         5       Jay  QUEEN ANNE, in her letter of the 1st July, 170…
..      …       …                                                 …
80       81  Hamilton  LET US now return to the partition of the judi…
81       82  Hamilton  THE erection of a new government, whatever car…
82       83  Hamilton  THE objection to the plan of the convention, w…
83       84  Hamilton  IN THE course of the foregoing review of the C…
84       85  Hamilton  ACCORDING to the formal division of the subjec…

[85 rows x 3 columns]
```

[ ]:

```
federalist['author'].value_counts()
```

[ ]:

```
author
Hamilton    51
Madison     15
Disputed    11
Jay          5
Joint        3
Name: count, dtype: int64
```

Pre-processing textual data

[ ]:

```python
import re # regular expressions
import string # string manipulation
import nltk # natural language toolkit

# Pre-process the text using regular expressions, list comprehensions, apply()

# make lower case and remove punctuation
federalist['text_processed'] = (
    federalist['text'].apply(lambda x: "".join(
        [word.lower() for word in x if word not in string.punctuation])
    )
)

federalist[['text', 'text_processed']].head()
```

[ ]:

```
                                                text  \
0  AFTER an unequivocal experience of the ineffic…
1  WHEN the people of America reflect that they a…
2  IT IS not a new observation that the people of…
3  MY LAST paper assigned several reasons why the…
4  QUEEN ANNE, in her letter of the 1st July, 170…

                                      text_processed
0  after an unequivocal experience of the ineffic…
1  when the people of america reflect that they a…
2  it is not a new observation that the people of…
3  my last paper assigned several reasons why the…
4  queen anne in her letter of the 1st july 1706 …
```

[ ]:

```python
# download stopwords: only need to run once
# nltk.download('stopwords')

# save and inspect stopwords
stopwords = nltk.corpus.stopwords.words('english')
stopwords[:10]
```

[ ]:

```
['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're"]
```

[ ]:

```python
stopwords[-10:] # interestingly, includes wouldn't but not would
```

[ ]:

```
['shouldn',
 "shouldn't",
 'wasn',
 "wasn't",
 'weren',
 "weren't",
 'won',
 "won't",
 'wouldn',
 "wouldn't"]
```

[ ]:

```
type(stopwords)
```

[ ]:

```
list
```

We can add to the list as appropriate. For example, ‘would’ is included in many stopword dictionaries.

[ ]:

```
stopwords.append('would')
```

[ ]:

```
# instantiate the Porter stemmer to stem the words
ps = nltk.PorterStemmer()

'''
It is more efficient to define a function to apply to the text column than to
use a lambda function for every step.
'''
def preprocess_text(text):
    # make lower case
    text = text.lower()
    # remove punctuation
    text = "".join([word for word in text if word not in string.punctuation])
    # remove numbers
    text = re.sub('[0-9]+', '', text)
    # create a list of individual tokens, removing whitespace
    tokens = re.split('\W+', text)
    # remove stopwords
    tokens = [word for word in tokens if word not in stopwords]
    # remove any empty strings associated with trailing spaces
    tokens = [word for word in tokens if word !='']
    # finally, stem each word
    tokens = [ps.stem(word) for word in tokens]
    return tokens

# apply function to the text column; no need for lambda with a named function
federalist['text_processed'] = federalist['text'].apply(preprocess_text)

federalist[['text', 'text_processed']].head()
```

[ ]:

```
                                                text  \
0  AFTER an unequivocal experience of the ineffic…
1  WHEN the people of America reflect that they a…
2  IT IS not a new observation that the people of…
3  MY LAST paper assigned several reasons why the…
4  QUEEN ANNE, in her letter of the 1st July, 170…
```

```
                                      text_processed
0  [unequivoc, experi, ineffici, subsist, feder, …
1  [peopl, america, reflect, call, upon, decid, q…
2  [new, observ, peopl, countri, like, american, …
3  [last, paper, assign, sever, reason, safeti, p…
4  [queen, ann, letter, st, juli, scotch, parliam…
```

[ ]:
```
# each element of the text_processed column is a list of tokens
type(federalist['text_processed'][0])
```

[ ]:
```
list
```

[ ]:
```
# compare the pre-processed text to the original text for essay number 10
federalist['text_processed'][9][:15]
```

[ ]:
```
['among',
 'numer',
 'advantag',
 'promis',
 'wellconstruct',
 'union',
 'none',
 'deserv',
 'accur',
 'develop',
 'tendenc',
 'break',
 'control',
 'violenc',
 'faction']
```

[ ]:
```
federalist['text'][9][:100]
```

[ ]:
```
'AMONG the numerous advantages promised by a well-constructed Union, none \n
deserves to be mor'
```

Section 5.1.2: Document-Term Matrix

[ ]:
```
from sklearn.feature_extraction.text import CountVectorizer

'''
Instantiate the CountVectorizer and pass the preprocess_text function to the
analyzer argument.
'''
count_vect = CountVectorizer(analyzer=preprocess_text)

# transform the text_processed column into a document-term matrix
```

```
dtm = count_vect.fit_transform(federalist['text'])

# the dtm is a sparse matrix
type(dtm)
```

```
[ ]: scipy.sparse._csr.csr_matrix
```

```
[ ]: # convert the sparse matrix to a dense matrix and store in a DataFrame
     dtm_mat = pd.DataFrame(dtm.toarray(),
                            columns=count_vect.get_feature_names_out())

     dtm_mat.iloc[:,:10].head()
```

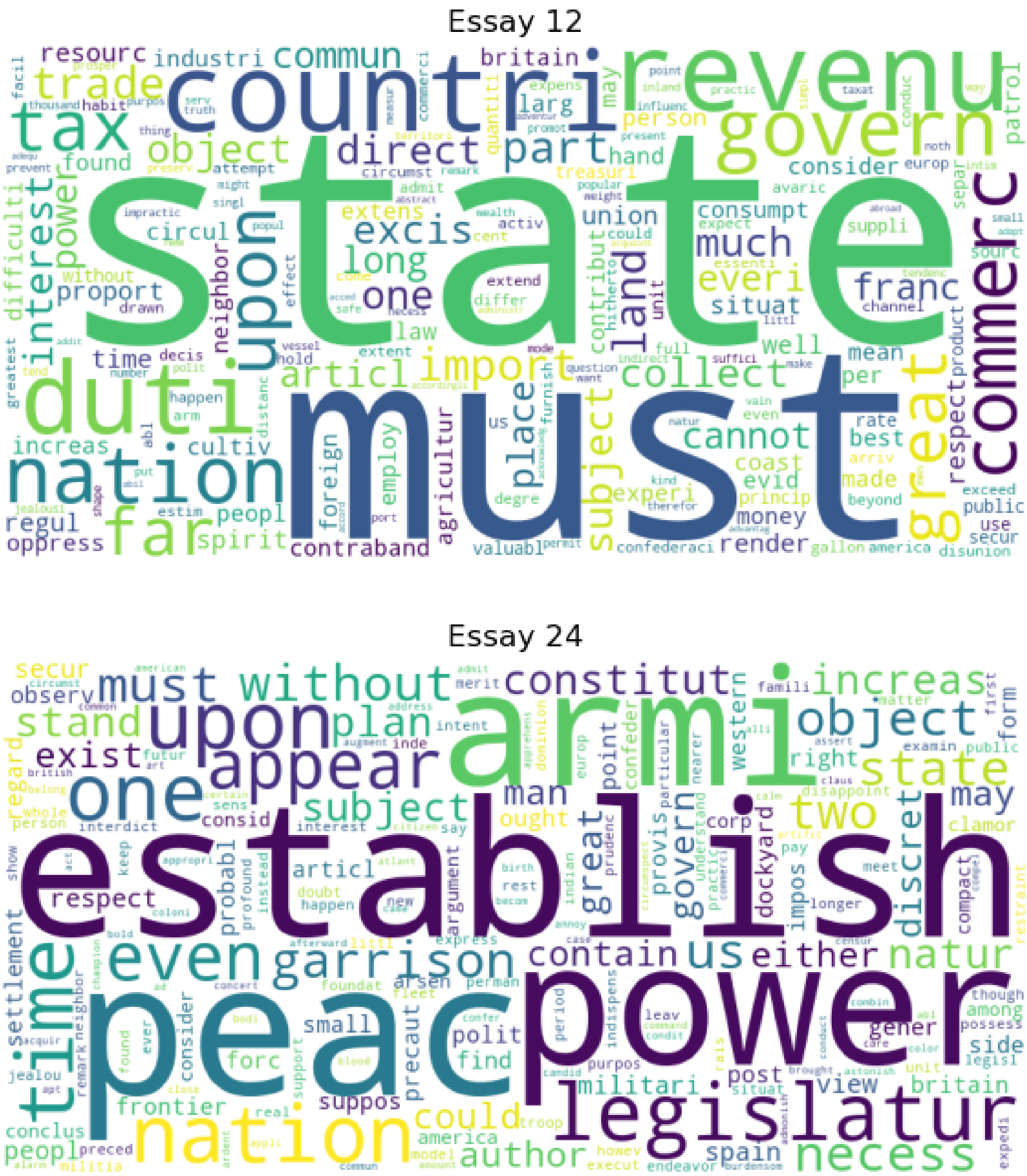
```
[ ]:    abandon  abat  abb  abet  abhorr  abil  abject  abl  ablest  abolish
     0        0     0    0     0       0     0       0    1       0        0
     1        0     0    0     0       0     1       0    0       0        0
     2        0     0    0     0       0     0       0    2       0        0
     3        0     0    0     0       0     0       0    1       1        0
     4        0     0    0     0       0     0       0    0       0        0
```

Section 5.1.3: Topic Discovery

```
[ ]: from wordcloud import WordCloud
     import matplotlib.pyplot as plt

     essay_12 = dtm_mat.iloc[11,:]
     essay_24 = dtm_mat.iloc[23,:]

     # Essay 12 word cloud
     wordcloud_12 = WordCloud(
         width=800, height=400, background_color ='white'
     ).generate_from_frequencies(essay_12)

     # Essay 24 word cloud
     wordcloud_24 = WordCloud(
         width=800, height=400, background_color ='white'
     ).generate_from_frequencies(essay_24)

     # plot word clouds vertically
     fig, axs = plt.subplots(2, 1, figsize=(8,8))

     axs[0].imshow(wordcloud_12)
     axs[0].axis('off')
     axs[0].set_title('Essay 12')

     axs[1].imshow(wordcloud_24)
     axs[1].axis('off')
```

```
axs[1].set_title('Essay 24')
```

```
[ ]: Text(0.5, 1.0, 'Essay 24')
```



Essay 12

Essay 24

```
[ ]: # Import the tf-idf vectorizer
     from sklearn.feature_extraction.text import TfidfVectorizer

     # Create a tf-idf dtm following the same steps as before
     tfidf_vect = TfidfVectorizer(analyzer=preprocess_text)
```

```
dtm_tfidf = tfidf_vect.fit_transform(federalist['text'])

dtm_tfidf_mat = pd.DataFrame(dtm_tfidf.toarray(),
                             columns=tfidf_vect.get_feature_names_out())

# 10 most important words for Paper No. 12
dtm_tfidf_mat.iloc[11,:].sort_values(ascending=False).head(10)
```

```
[ ]: revenu        0.214827
     state         0.186738
     excis         0.155990
     must          0.149053
     commerc       0.148469
     trade         0.143082
     tax           0.141690
     countri       0.134673
     contraband    0.127014
     patrol        0.127014
     Name: 11, dtype: float64
```

```
[ ]: # 10 most important words for Paper No. 24
     dtm_tfidf_mat.iloc[23,:].sort_values(ascending=False).head(10)
```

```
[ ]: garrison      0.238167
     armi          0.169594
     peac          0.155266
     dockyard      0.141620
     settlement    0.141620
     spain         0.141201
     frontier      0.119084
     establish     0.113686
     western       0.109730
     post          0.105901
     Name: 23, dtype: float64
```

```
[ ]: from sklearn.cluster import KMeans

     '''
     subset The Federalist papers written by Hamilton using the author column of
     the federalist DataFrame
     '''
     dtm_tfidf_hamilton = dtm_tfidf_mat[federalist['author']=='Hamilton']

     k = 4 # number of clusters
     # instantiate the KMeans object; set random_state for reproducibility
     km_out = KMeans(n_clusters=k, n_init=1, random_state=1234)
```

```
# fit the model
km_out.fit(dtm_tfidf_hamilton)

# check convergence; number of iterations may vary
km_out.n_iter_
```

```
[ ]: 2
```

```
[ ]: # create data frame from the cluster centers
     centers = pd.DataFrame(km_out.cluster_centers_,
                            columns=dtm_tfidf_hamilton.columns)

     # extract Hamilton's papers from the federalist DataFrame
     hamilton_df = (federalist.loc[federalist['author']=='Hamilton']
                    .copy().reset_index(drop=True))

     km_out.labels_ # cluster labels
```

```
[ ]: array([3, 1, 3, 1, 3, 3, 1, 1, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 1, 1,
            1, 3, 1, 3, 1, 3, 3, 3, 0, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 0,
            2, 0, 0, 0, 0, 3, 3])
```

```
[ ]: # add the cluster labels + 1 to the Hamilton DataFrame
     hamilton_df['cluster'] = km_out.labels_ + 1

     hamilton_df.head()
```

```
[ ]:    fed_num    author                                               text  \
     0        1  Hamilton  AFTER an unequivocal experience of the ineffic…
     1        6  Hamilton  THE three last numbers of this paper have been…
     2        7  Hamilton  IT IS sometimes asked, with an air of seeming …
     3        8  Hamilton  ASSUMING it therefore as an established truth …
     4        9  Hamilton  A FIRM Union will be of the utmost moment to t…

                                           text_processed  cluster
     0  [unequivoc, experi, ineffici, subsist, feder, …        4
     1  [three, last, number, paper, dedic, enumer, da…        2
     2  [sometim, ask, air, seem, triumph, induc, coul…        4
     3  [assum, therefor, establish, truth, sever, sta…        2
     4  [firm, union, utmost, moment, peac, liberti, s…        4
```

```
[ ]: # store cluster numbers
     clusters = np.arange(1, k+1)
```

```
[ ]: # loop through the clusters and print the 10 most important words
     for i in range(len(clusters)):
         print(f'CLUSTER {clusters[i]}')
```

```
    print('Top 10 words:')
    print(centers.iloc[i].sort_values(ascending=False).head(10))
    # store the essay numbers associated with each cluster
    essays = hamilton_df.loc[hamilton_df['cluster']==clusters[i], 'fed_num']
    print(f'Federalist Papers: {list(essays)}')
    print('\n')
```

```
CLUSTER 1
Top 10 words:
court        0.364607
state        0.178027
juri         0.159888
jurisdict    0.115161
law          0.109597
constitut    0.106743
case         0.100013
may          0.096671
trial        0.092269
tribun       0.086959
Name: 0, dtype: float64
Federalist Papers: [65, 78, 80, 81, 82, 83]


CLUSTER 2
Top 10 words:
state     0.186586
nation    0.110258
power     0.108624
govern    0.108323
revenu    0.096897
upon      0.092661
tax       0.081861
taxat     0.081696
war       0.079932
union     0.075792
Name: 1, dtype: float64
Federalist Papers: [6, 8, 12, 13, 30, 31, 32, 34, 36]


CLUSTER 3
Top 10 words:
senat      0.137996
presid     0.128147
execut     0.114111
offic      0.103012
power      0.100565
appoint    0.094708
upon       0.086095
```

```
state      0.082605
might      0.079387
may        0.078676
Name: 2, dtype: float64
Federalist Papers: [66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 79]


CLUSTER 4
Top 10 words:
state        0.173878
govern       0.125864
power        0.094566
nation       0.092389
upon         0.090669
may          0.087997
constitut    0.072944
union        0.066470
peopl        0.058425
author       0.054832
Name: 3, dtype: float64
Federalist Papers: [1, 7, 9, 11, 15, 16, 17, 21, 22, 23, 24, 25, 26, 27, 28, 29,
33, 35, 59, 60, 61, 84, 85]
```

A few themes that emerge:

- Cluster 1: courts, law, jurisprudence
- Cluster 2: state power, tax, revenue
- Cluster 3: institutional design, executive, legislature
- Cluster 4: state power, national government

Section 5.1.4: Authorship Prediction

[ ]:

```python
import statsmodels.formula.api as smf

'''
Customize the preprocessing function to make stemming and stopword removal
optional and to optionally return strings instead of lists of tokens.
'''
def preprocess_text(text, remove_stopwords=True, stem=True,
                    return_string=False):
    # make lower case
    text = text.lower()
    # remove punctuation
    text = "".join([word for word in text if word not in string.punctuation])
    # remove numbers
    text = re.sub('[0-9]+', '', text)
    # create a list of individual tokens, removing whitespace
    tokens = re.split('\W+', text)
    # remove stopwords if remove_stopwords=True
    if remove_stopwords:
        tokens = [word for word in tokens if word not in stopwords]
    # remove any empty strings associated with trailing spaces
    tokens = [word for word in tokens if word !='']
    # stem each word if stem=True
    if stem:
        tokens = [ps.stem(word) for word in tokens]
    if return_string:
        return ' '.join(tokens)
    else:
        return tokens

# If we preprocess before using the CountVectorizer, it expects strings
federalist['text_processed_v2'] = (
    federalist['text'].apply(lambda x: preprocess_text(
        x, stem=False, remove_stopwords=False, return_string=True))
)

federalist['text_processed_v2'].head()
```

[ ]:

```
0    after an unequivocal experience of the ineffic…
1    when the people of america reflect that they a…
2    it is not a new observation that the people of…
3    my last paper assigned several reasons why the…
4    queen anne in her letter of the st july to the…
Name: text_processed_v2, dtype: object
```

[ ]:

```
# this time, do not pass the preprocess_text function to the analyzer argument
count_vect1 = CountVectorizer()

dtm1 = count_vect1.fit_transform(federalist['text_processed_v2'])

dtm1_mat = pd.DataFrame(dtm1.toarray(),
                        columns=count_vect1.get_feature_names_out())

# term frequency per 1000 words
row_sums = dtm1_mat.sum(axis='columns')
tfm = dtm1_mat.div(row_sums, axis='rows')*1000

# words of interest
words = ['although', 'always', 'commonly', 'consequently', 'considerable',
         'enough', 'there', 'upon', 'while', 'whilst']

# select only these words
```

```
tfm = tfm.loc[:, words]

# average among Hamilton/Madison essays
tfm_ave = (pd.concat(
    [tfm.loc[federalist['author']=='Hamilton'].sum(axis='rows') / len(hamilton),
     tfm.loc[federalist['author']=='Madison'].sum(axis='rows') / len(madison)],
     axis=1
)).T # transpose

tfm_ave
```

```
[ ]:    although    always  commonly  consequently  considerable    enough  \
     0  0.013654  0.577750  0.203337      0.019854      0.417913  0.303319
     1  0.212740  0.158571  0.000000      0.353982      0.126829  0.000000

           there      upon     while    whilst
     0  3.395702  3.380919  0.282721  0.005320
     1  0.876109  0.156989  0.000000  0.300338
```

```
[ ]: # add tfm to the federalist data frame
     federalist = pd.concat([federalist, tfm], axis=1)

     select_vars = ['fed_num', 'author'] + words

     hm_data = (
         federalist.loc[federalist['author'].isin(['Hamilton', 'Madison']),
                        select_vars]
     ).copy()

     hm_data['author'] = np.where(hm_data['author'] == "Hamilton", 1, -1)

     hm_data.head()
```

```
[ ]:    fed_num  author  although    always  commonly  consequently  considerable  \
     0        1       1       0.0  0.647668  0.647668           0.0      0.000000
     5        6       1       0.0  0.000000  0.000000           0.0      1.059883
     6        7       1       0.0  0.000000  0.453926           0.0      0.000000
     7        8       1       0.0  1.547189  0.515730           0.0      0.515730
     8        9       1       0.0  0.000000  0.000000           0.0      0.520562

          enough     there      upon     while  whilst
     0  0.647668  1.295337  3.886010  0.000000     0.0
     5  0.529942  4.239534  2.119767  0.000000     0.0
     6  0.000000  4.085338  4.993191  0.000000     0.0
     7  1.031460  1.031460  1.547189  0.000000     0.0
     8  0.520562  1.561687  2.082249  0.520562     0.0
```

```
[ ]: hm_model = 'author ~ upon + there + consequently + whilst'

     hm_fit = smf.ols(hm_model, data=hm_data).fit()

     hm_fit.params
```

```
[ ]: Intercept      -0.271853
     upon            0.218922
     there           0.124089
     consequently   -0.556267
     whilst         -0.821720
     dtype: float64
```

```
[ ]: hm_fitted = hm_fit.fittedvalues

     np.std(hm_fitted)
```

```
[ ]: 0.7128452675676532
```

Section 5.1.5: Cross-Validation

In Progress