Data Bootcamp: Zipf's Law

Jack (Quan Cheng) Xie
Prof. Michael Waugh
Data Bootcamp
21 December 2017

Project Overview

The *Zipf law* is a linguistic phenomenon where only a few percentage of words have most of the usage in any language. This is sometimes known as the lower law, the Pareto principle (https://en.wikipedia.org/wiki/Pareto_principle), or the 80/20 rule--a catchy name for a Pareto distribution where 80% of effects come from 20% of causes.

This Pareto principle does not only appears in linguistics, but in many places. Some famous (or infamouse) examples are income and wealth inequality (top 20% earners make 80% of income), software optimization (20% of bugs cause 80% of crashes), website traffic, etc. There are some cool youtube videos about this the phenomenon: The Zipf Mystery (https://www.youtube.com/watch?v=fCn8zs912OE) --- Unfair (https://www.youtube.com/watch?v=xFmCZKq3o58).

The idea of the project is to observe this Zipf phenomenon in our daily life, specifically in the online space. We rank words by their frequencies from three different environments: Reddit, The New York Times, and Twitter. We can compare they vary through their word frequency density distributions.

As the Pareto principle follows some kind of negative exponential relationship, we can also compare the lingustic environments through parameters of exponential functions.

The Important Imports

In [1]:

```
import pandas as pd
import json
import requests, io
import csv

# For opening Zip and bz2 files
import zipfile as zf
import bz2
import shutil
import os

# For miscellaneous stuff
import time
import datetime as dt
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline

# For Stats
import statsmodels.api as sm
import statsmodels.formula.api as smf

from IPython.display import display, clear_output

#import nltk as nltk
```

```
/anaconda/lib/python3.6/site-packages/statsmodels/compat/pandas.py:56:
FutureWarning: The pandas.core.datetools module is deprecated and will
be removed in a future version. Please use the pandas.tseries module in
stead.
  from pandas.core import datetools
```

Accessing the Data

In [2]:

```
def df_summary(dataframe):

    '''A function to summarize shape, columns,
    index, and return a DataFrame head-preview.'''

    print('Shape:', dataframe.shape, '\n')
    print('Columns:', list(dataframe.columns),'\n')
    print('Index:', dataframe.index)
    display(dataframe.head())
```

Data I. Reddit Archives

Our first data source is from Pushshift.io (https://pushshift.io/what-is-pushshift-io/). Pushshift is an open data initiative that ingests data from social media sites. We access the data from this URL (https://files.pushshift.io/reddit/comments/). We are going to access their Reddit comments archives. The archives contains .bz2 files for each month between 2006 to 2017.

Some of the files are very big, so we will only use January data from a few years. Otherwise some of our data manipulations will take too long to run. We won't even use all of the data we do access, so for our purposes, just a few years provides a sufficient sample.

In [3]:

```python
def get_reddit_file(file_name):

    '''Get and open Pushshift Reddit bz2 file'''

    url = 'https://files.pushshift.io/reddit/comments/'
    # Print the file our function is fetching so we can keep track
    print('Fetching:', file_name)
    resp = requests.get(url+file_name)
    # Print the request response
    print(file_name,resp)
    result = bz2.BZ2File(io.BytesIO(resp.content)) # Open the bz2 file
    clear_output() # Clear our print output after we have the file

    return result
```

In [4]:

```python
# Combining bz2 files into one json
def get_reddit_archives(end_year):

    '''Gets Pushshift archive data between 2006 and end_year'''

    # Make list of year strings for our file names
    years = list(range(2006,end_year+1))
    for y in range(len(years)):
        years[y] = str(years[y])

    # Make list of file names with different years
    file_list = list()
    initial = 'RC_2006-01.bz2' # Access Data from 2006-01 to end_year-01
    for year in years:
        file_list.append(initial.replace('2006',year))

    # Read lines from the bz files directly to our output with JSON
    result = list()
    for file in file_list:
        bz_file = get_reddit_file(file)
        linelist = bz_file.readlines()
        for line in linelist:
            result.append(json.loads(line))

    return result
```

In [5]:

```
# Executing get function
t0 = time.time() # Time how long our pull function takes

all_archives = get_reddit_archives(2010) # Access data from 2006

t1 = time.time()
print('Time required: ', round(t1-t0),'seconds') # Print elpased time
```

```
Time required:  484 seconds
```

In [6]:

```
# Pandas DataFrame (This takes a minute too)
reddit = pd.DataFrame(all_archives)
```

In [7]:

```
# We're only take last 100,000 to make our lives a little easier
reddit = reddit.tail(100000)

df_summary(reddit)

    # We can upload the DataFrame to a csv to avoid repulling
    # the data every time we want to work from it.
#reddit.to_csv('reddit_sample.csv')
```

```
Shape: (100000, 23)

Columns: ['archived', 'author', 'author_flair_css_class', 'author_flair
_text', 'body', 'controversiality', 'created_utc', 'distinguished', 'do
wns', 'edited', 'gilded', 'id', 'link_id', 'name', 'parent_id', 'remova
l_reason', 'retrieved_on', 'score', 'score_hidden', 'stickied', 'subred
dit', 'subreddit_id', 'ups']

Index: RangeIndex(start=4373742, stop=4473742, step=1)
```

	archived	author	author_flair_css_class	author_flair_text	body
4373742	True	[deleted]	None	None	Pani Poni Dash
4373743	True	Unlucky13	None	None	I got called in last time it snowed this year,...
4373744	True	[deleted]	None	None	For real. I don't go to church and I'm pretty ...
4373745	True	showmesomescars	None	None	can't go wrong with "am i wrong".
4373746	True	[deleted]	None	None	probably

5 rows × 23 columns

Data II. New York Times Article API

The second text source we use is a New York Times article search API (https://developer.nytimes.com/article_search_v2.json#/Documentation). We can't get full articles from the API, but we can get "snippets."

Since the API has an access frequency limit, we can only get a small sample from the data. We will crawl the data verrry slowly so our API key doesn't get timed out.

UPDATE: The crawl functions doesn't seem to work anymore, so we will turn to the csv saved from before, posted on my github (https://github.com/qcx201/work_in_progress/blob/master/nyt.csv).

In [8]:

```
# List of years for crawl (str) from 2006 to 2017
years = list(range(2006,2017+1))
for y in range(len(years)):
    years[y] = str(years[y])

# List of months for crawl (str)
months = list()
for m in range(1,12+1):
    if m < 10:
        months.append('0'+str(m))
    else:
        months.append(str(m))

# We won't end up using days to iterate, but it may come in handy
def days(month):

    '''Returns list of days in a given month'''

    m30 = ['04','06','09','11'] # 30-day months
    res = list()
    for d in range(1,10):
        res.append('0'+str(d))
    if month == '02': # Feb 28-days
        for d in range(10,28+1):
            res.append(str(d))
    elif month in m30: # 30-day months
        for d in range(10,30+1):
            res.append(str(d))
    else: # 31-day months
        for d in range(10,31+1):
            res.append(str(d))
    return res
```

In [9]:

```
# Retreiving data 'documents' from API call
def get_articles(year, month, day):

    '''Get data for articles from API.'''

    url = "https://api.nytimes.com/svc/search/v2/articlesearch.json"

    nyt_key = '7b36694d6ed447e4a3da0b2bf411d0f8'
        # backup API keys if one gets timed out
    #nyt_key = 'e3fba4ee4f0944619aa6e7be1fc73eab'
    #nyt_key = '770978643efb463e84871368163388d7'

    parameters = {'api-key' : nyt_key,
              'begin_date' : year+month+day,
              'sort' : 'oldest'}

    resp = requests.get(url, params = parameters)
    data = resp.json()

    articles = data(year, month, day)['response']['docs']

    return articles
```

In [10]:

```
def get_nyt():

    '''Scrape API with iteration'''

    result = list()
    for year in years:
        print('Start:', year)

        for month in months: # We can get 10 articles for each month
            for day in ['01','15']: # Two start dates in the month

                try: # try to get article with our function above
                    docs = get_articles(year, month, day)
                except: # Sleep to wait it out if timed out
                    print(year, month, day, 'Sleep')
                    # Tells us it's sleeping
                    time.sleep(10)
                    docs = get_articles(year, month, day)

                for article in docs:
                    result.append(article)
                print(year, month, day) # Status check
                time.sleep(2) # Sleep to wait
        print(year, 'OK') # Tell us a year is done
    clear_output() # Clear status print updates
    return result
```

In [11]:

```
# Executing... Wish me luck!
t0 = time.time()

nyt_api = get_nyt()

t1 = time.time()
print('Time required: ', round(t1-t0),'seconds')
```

```
Start: 2006
2006 01 01 Sleep

---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call l
ast)
<ipython-input-10-b36587a96bdd> in get_nyt()
     12                 try: # try to get article with our function abo
ve
---> 13                     docs = get_articles(year, month, day)
     14                 except: # Sleep to wait it out if timed out

<ipython-input-9-47bb837cd0ba> in get_articles(year, month, day)
     19
---> 20     articles = data(year, month, day)['response']['docs']
     21

TypeError: 'dict' object is not callable

During handling of the above exception, another exception occurred:

TypeError                                 Traceback (most recent call l
ast)
<ipython-input-11-51b4f50aba50> in <module>()
      2 t0 = time.time()
      3
----> 4 nyt_api = get_nyt()
      5
      6 t1 = time.time()

<ipython-input-10-b36587a96bdd> in get_nyt()
     16                     # Tells us it's sleeping
     17                     time.sleep(10)
---> 18                     docs = get_articles(year, month, day)
     19
     20                 for article in docs:

<ipython-input-9-47bb837cd0ba> in get_articles(year, month, day)
     18     data = resp.json()
     19
---> 20     articles = data(year, month, day)['response']['docs']
     21
     22     return articles

TypeError: 'dict' object is not callable
```

```
In [ ]: # Pandas DataFrame and summarize
        nyt = pd.DataFrame(nyt_api)
        df_summary(nyt) # We should get around 2880 instances
        #nyt.to_csv('nyt.csv') # Upload
```

New York Times: Backup Plan

Looks like there are some problems with crawling the nyt API. We will use the backup csv from when this crawl did work.

In [12]:

```
url = 'https://raw.githubusercontent.com/qcx201/work_in_progress/master/
nyt.csv'
nyt = pd.read_csv(url)
df_summary(nyt) # We should get around 2880 instances
#nyt.to_csv('nyt.csv') # Upload
```

```
Shape: (2870, 21)

Columns: ['Unnamed: 0', '_id', 'abstract', 'blog', 'byline', 'document_
type', 'headline', 'keywords', 'multimedia', 'new_desk', 'print_page',
'pub_date', 'score', 'section_name', 'slideshow_credits', 'snippet', 's
ource', 'type_of_material', 'uri', 'web_url', 'word_count']

Index: RangeIndex(start=0, stop=2870, step=1)
```

	Unnamed: 0	_id	abstract	blog	byline	document_type
0	0	4fd24e778eb7c8105d7f036c	NaN	{}	{'original': 'By ALISON BERKLEY', 'person': [{...	article
1	1	4fd24e778eb7c8105d7f0372	George Ernsberger letter on Jesse Green's arti...	{}	NaN	article
2	2	4fd24e778eb7c8105d7f037b	NaN	{}	{'original': 'By KELLY FEENEY', 'person': [{'f...	article
3	3	4fd24e778eb7c8105d7f0381	British and Dutch researchers conduct study on...	{}	{'original': 'By ALEX WILLIAMS', 'person': [{'...	article
4	4	4fd24e778eb7c8105d7f038a	NaN	{}	{'original': 'By HOWARD MARKEL', 'person': [{'...	article

5 rows × 21 columns

Data III. Twitter Collection

We get Twitter data from another dataset host: Followthehashtag (http://www.followthehashtag.com/datasets/free-twitter-dataset-usa-200000-free-usa-tweets/).

The data contains 200,000 US tweets collected over 48 hours in April of 2016. The dataset comes from excel files in a zip.

In [13]:

```
# Accessing the zip file
url = 'http://followthehashtag.com/content/uploads/USA-Geolocated-tweets
-free-dataset-Followthehashtag.zip'

t0 = time.time()
resp = requests.get(url) # Get file
tw_zip = zf.ZipFile(io.BytesIO(resp.content)) # Open Zip
t1 = time.time() # Thank god... it doesn't take forever
print('Time required: ', round(t1-t0),'seconds')
```

```
Time required:  118 seconds
```

In [14]:

```
twfilenames = tw_zip.namelist() # Get list of files in zip
for i in range(len(twfilenames)):
    print('File',str(i)+': ',twfilenames[i])
# The file we want is number 7 in the list
```

```
File 0:  heatmap_x_usa_x_filter_nativeretweets.xlsx
File 1:  __MACOSX/
File 2:  __MACOSX/._heatmap_x_usa_x_filter_nativeretweets.xlsx
File 3:  coverage_x_usa_x_filter_nativeretweets.xlsx
File 4:  __MACOSX/._coverage_x_usa_x_filter_nativeretweets.xlsx
File 5:  geolocation_x_usa_x_filter_nativeretweets.xlsx
File 6:  __MACOSX/._geolocation_x_usa_x_filter_nativeretweets.xlsx
File 7:  dashboard_x_usa_x_filter_nativeretweets.xlsx
File 8:  __MACOSX/._dashboard_x_usa_x_filter_nativeretweets.xlsx
```

In [15]:

```
# Read to DataFrame with Pandas... easy!
twitter = pd.read_excel(tw_zip.open(tw_zip.namelist()[7]),
                        sheet_name = 'Stream')
```

In [16]:

```
# Get rid of spaces in column names
twitter_cols = list(twitter.columns)
new_twitter_cols = [twitter_cols[i].
                    replace(' ','_') for i in range(len(twitter_cols))]
twitter.columns = new_twitter_cols
```

```
In [17]: # Summarize DataFrame
         df_summary(twitter)

         #twitter.to_csv('twitter.csv')
```

```
Shape: (204820, 19)

Columns: ['Tweet_Id', 'Date', 'Hour', 'User_Name', 'Nickname', 'Bio',
'Tweet_content', 'Favs', 'RTs', 'Latitude', 'Longitude', 'Country', 'Pl
ace_(as_appears_on_Bio)', 'Profile_picture', 'Followers', 'Following',
'Listed', 'Tweet_language_(ISO_639-1)', 'Tweet_Url']

Index: RangeIndex(start=0, stop=204820, step=1)
```

	Tweet_Id	Date	Hour	User_Name	Nickname	
0	721318437075685382	2016-04-16	12:44	Bill Schulhoff	BillSchulhoff	Husband,Dad,GrandDad,(Minister, Umpire...
1	721318436173979648	2016-04-16	12:44	Daniele Polis	danipolis	Viagens, geek, moda, batc laranja, cabelos c...
2	721318434169102336	2016-04-16	12:44	Kasey Jacobs	KJacobs27	Norwich University Class c
3	721318429844582400	2016-04-16	12:44	Stan Curtis	stncurtis	transcendental music, art sake, craf...
4	721318429081407488	2016-04-16	12:44	Dave Borzymowski	wi_borzo	When in doubt....Panic.

Data Cleaning

We can now clean the data. We remove all the columns other than the text and date columns. Then we get rid of undesirable columns with NaN values. Then we clean the texts for any symbols that might throw our word frequency distribution off.

Cleaning Reddit

In [18]:

```
    # Our saved csv
#reddit = pd.read_csv('reddit_sample.csv')

reddit = reddit[['created_utc','body']]
#reddit.set_index('created_utc', inplace = True)
reddit.head()
reddit = reddit.dropna()
```

In [19]:

```
# Drop "[deleted]" and "[removed]" text bodies
deleted = list()

for i in range(len(reddit)):
    if reddit.body.iloc[i] == '[deleted]' or reddit.body.iloc[i] == '[re
moved]':
        deleted.append(reddit.index[i])
reddit = reddit.drop(deleted)
```

In [20]:

```
# Cleaning UTC date

    # Clean str UTCs and non-UTC values in UTC column
non_int = list()
for i in range(len(reddit)):
    if type(reddit.created_utc.iloc[i]) == str:
        # All our UTCs should have at least 10 digits
        if len(reddit.created_utc.iloc[i])<10:
            # Index the 'bad' UTCs
            non_int.append(reddit.index[i])
reddit = reddit.drop(non_int) # Drop the bad UTCs

reddit['created_utc'] = reddit.created_utc.astype(int)

# Convert utc to datetime
test = reddit.head()

    # Make list of date from utc to datetime
dates = list()
for utc in reddit.created_utc:
    dates.append(dt.datetime.fromtimestamp(utc))

    # Add dates list to dataframe
reddit['dates'] = dates
    # Delete UTC column
reddit.drop(['created_utc'],axis=1,inplace=True)

display(reddit.tail())
```

	body	dates
4473736	.. is that.. why yes it is! k-lite codec pack!...	2010-01-31 18:59:53
4473737	Why not include the flight costs too?	2010-01-31 18:59:54
4473738	How, is that humanly, possible.\n\n,	2010-01-31 18:59:55
4473739	I wouldn't be surprised if the XBLA/PSN/Wii Vi...	2010-01-31 18:59:56
4473740	Pidgeon.	2010-01-31 18:59:56

Text Cleaning Function

We will use this function to clean our other datasets too.

In [21]:
```
def clean_text(df,text_col_name):

    '''Cleans text column in dataframe'''

    # Make all upper case
    df[text_col_name] = df[text_col_name].str.upper()

    # Remove numbers and symbols
    symbols = '`-=~!@#$%^&*()_+[]\{}|;:,./<>?"1234567890'

    for s in symbols:
        df[text_col_name] = df[text_col_name].str.replace(s,'')

    # Split strings in their columns
    df[text_col_name] = df[text_col_name].str.split()
    return df
```

In [22]:
```
# Execute clean text function
reddit = clean_text(reddit,'body')
display(reddit.head())

    # Rename the variable so we can access this database later
feed_reddit = reddit
```

	body	dates
4373742	[PANI, PONI, DASH]	2010-01-30 14:18:35
4373743	[I, GOT, CALLED, IN, LAST, TIME, IT, SNOWED, T...	2010-01-30 14:18:37
4373744	[FOR, REAL, I, DON'T, GO, TO, CHURCH, AND, I'M...	2010-01-30 14:18:37
4373745	[CAN'T, GO, WRONG, WITH, AM, I, WRONG]	2010-01-30 14:18:38
4373746	[PROBABLY]	2010-01-30 14:18:38

Cleaning New York Times

```
In [23]: # The same drill

         #nyt = pd.read_csv('nyt.csv')

         nyt = nyt[['pub_date','snippet']]
         nyt = nyt.dropna()

         # Drop duplicates from articles that were crawled twice in the same mont
         h
         nyt = nyt.drop_duplicates()

         nyt = clean_text(nyt,'snippet')
         display(nyt.head())

         feed_nyt = nyt
```

	pub_date	snippet
0	2006-01-01T00:00:00Z	[WHILE, JET, SETTERS, SCHUSS, DOWN, THE, GROOM...
1	2006-01-01T00:00:00Z	[THANKS, FOR, JESSE, GREEN'S, TERRIFIC, ARTICL...
2	2006-01-01T00:00:00Z	[THE, WORD, FAMIGLIA, IN, A, FOOD, STORE'S, NA...
3	2006-01-01T00:00:00Z	[AS, PEOPLE, WAKE, UP, FROM, ANOTHER, NEW, YEA...
4	2006-01-01T00:00:00Z	[WILD, BIRDS, HAVE, COMPLETED, THEIR, SEASONAL...

Cleaning Twitter

```
In [24]: # Once more unto the trenches, dear friends

         #twitter = pd.read_csv('twitter.csv')

         twitter = twitter[['Date','Tweet_content']]
         twitter = clean_text(twitter,'Tweet_content')

         display(twitter.head())

         feed_twitter = twitter
```

	Date	Tweet_content
0	2016-04-16	[WIND, MPH, NNE, BAROMETER, IN, RISING, SLOWLY...
1	2016-04-16	[PAUSA, PRO, CAFÉ, ANTES, DE, EMBARCAR, NO, PR...
2	2016-04-16	[GOOD, MORNING, MORNING, SATURDAY, DINER, VT, ...
3	2016-04-16	[GRATEFULDEAD, RECORDSTOREDAYUS, 🌹🌹🌹, TOMS, MU...
4	2016-04-16	[EGG, IN, A, MUFFIN, ROCKET, BABY, BAKERY, ROC...

Word Frequency Distribution

Now we can manipulate the word lists in the DataFrames columns to make new DataFrames we can manipulate for our graphs.

In [25]:

```
def word_freq(name, feed_df):

    '''Returns database of words and their frequency. Input name
    of DataFrames (for our merge later) and the feed DataFrames'''

    # Creating the word frequency distribution

        # Create list of all words in the dataframe
    words = list()
    for i in range(len(feed_df)):
        words.extend(feed_df.iloc[i])

        # Create list of unique words
    word_set = list(set(words))

        # Create list of unique words and their frequency
    word_freq = list()
    for i in word_set:
        word_freq.append([i,words.count(i)])


    # Creating
    word = name+'_word'
    freq = name+'_freq'
    labels = [word,freq]

    df = pd.DataFrame.from_records(word_freq, columns=labels)
    df = df.sort_values([freq,word],ascending = [0,1])
    df = df.reset_index().drop('index',axis=1)

    return df
```

In [26]:

```
def word_perc(name, df, numwords):

    '''Outputs word frequency in percentages. Input numwords
    for number of words to make our population.'''

    y_var = name+'_perc'

    # Determine length of the
    if type(numwords) == str:
        if numwords.lower() == 'all':
            df = df
    elif type(numwords) == int or type(numwords) == float:
        df = df.head(int(numwords))
    else:
        print('List length error')

    freq = name+'_freq'
    #df[xvar] = (df.index+1)
    df[y_var] = (df[freq])/(df[freq].agg('sum'))*100

    df

    return df
```

In [27]:

```
def perc_cum(df):

    """Returns cumulative frequency percentage.
    Requires word_perc() first."""

    for col in df.columns:
        if 'perc' in col:
            name = col

    cum_list = list()
    perc = 0

    for i in range(len(df)):
        perc += df[name].iloc[i]
        cum_list.append(perc)
    df[name+'_cum'] = cum_list

    return df
```

Word Frequency Dataframes

Now we use the functions above to create our DataFrames.

```
In [28]: # We use .head() to limit the Dataframe size...
         # Otherwise proceesing the data would take too long

         t0 = time.time()

         # Feed into frequency function
         reddit_all = word_freq('reddit',feed_reddit.body.head(10000))
         nyt_all = word_freq('nyt',feed_nyt.snippet)
         twitter_all = word_freq('twitter',feed_twitter.Tweet_content.head(10000
         ))

         t1 = time.time()
         print('Time required: ', round(t1-t0),'seconds')
```

```
Time required:  209 seconds
```

```
In [29]: # Number of words we want to rank. We're going to do the top 100 words f
         or now.
         # Either an integer or 'all'. I wouldn't recommend 'all'
         num_ranked_words = 100
```

Reddit

In [30]:

```
# Get freq percentage and cumulative percentage
reddit = word_perc('reddit',reddit_all,num_ranked_words)
reddit = perc_cum(reddit)

clear_output() # Clear warning output from function

display(reddit.head())
display(reddit.tail())
```

	reddit_word	**reddit_freq**	**reddit_perc**	**reddit_perc_cum**
0	THE	15396	8.460363	8.460363
1	TO	9825	5.399004	13.859368
2	A	9007	4.949499	18.808867
3	AND	7776	4.273044	23.081911
4	I	7744	4.255459	27.337370

	reddit_word	**reddit_freq**	**reddit_perc**	**reddit_perc_cum**
95	THOSE	479	0.263219	98.963611
96	RIGHT	477	0.262120	99.225731
97	INTO	470	0.258273	99.484004
98	SHOULD	470	0.258273	99.742277
99	BEING	469	0.257723	100.000000

New York Times

```
In [31]: # Same same
         nyt = word_perc('nyt',nyt_all,num_ranked_words)
         nyt = perc_cum(nyt)

         clear_output() # Clear warning output from function

         display(nyt.head())
         display(nyt.tail())
```

	nyt_word	nyt_freq	nyt_perc	nyt_perc_cum
0	THE	1774	13.994951	13.994951
1	OF	1039	8.196592	22.191543
2	A	945	7.455033	29.646576
3	AND	880	6.942253	36.588829
4	TO	642	5.064689	41.653518

	nyt_word	nyt_freq	nyt_perc	nyt_perc_cum
95	TIMES	28	0.220890	99.147996
96	CHICKEN	27	0.213001	99.360997
97	LOVE	27	0.213001	99.573998
98	MOTHER	27	0.213001	99.786999
99	TIME	27	0.213001	100.000000

Twitter

In [32]:

```
# Same same
twitter = word_perc('twitter',twitter_all,num_ranked_words)
twitter = perc_cum(twitter)

clear_output() # Clear warning output from functions

display(twitter.head())
display(twitter.tail())
```

	twitter_word	twitter_freq	twitter_perc	twitter_perc_cum
0	IN	2501	6.168759	6.168759
1	JOB	1871	4.614853	10.783612
2	THE	1721	4.244876	15.028488
3	TO	1681	4.146215	19.174703
4	AT	1664	4.104284	23.278988

	twitter_word	twitter_freq	twitter_perc	twitter_perc_cum
95	ONE	138	0.340379	98.673014
96	CITY	137	0.337913	99.010927
97	CARE	135	0.332980	99.343906
98	CALIFORNIA	133	0.328047	99.671953
99	JOIN	133	0.328047	100.000000

Word Rank (Combining all platforms)

In [40]:

```
# We merge the three dataframes into one dataframe called wordrank
    # Merge reddit and nyt
wordrank = pd.merge(reddit,nyt,how='outer',right_index=True,left_index=True)
    # Merge wordrank with twitter
wordrank = pd.merge(wordrank,twitter,how='outer',right_index=True,left_index=True)
    # Add work rank column for our regression later
wordrank['rank'] = (wordrank.index+1)

display(wordrank.head(15))
display(wordrank.tail(15))
```

	reddit_word	reddit_freq	reddit_perc	reddit_perc_cum	nyt_word	nyt_freq	nyt_perc
0	THE	15396	8.460363	8.460363	THE	1774	13.994951
1	TO	9825	5.399004	13.859368	OF	1039	8.196592
2	A	9007	4.949499	18.808867	A	945	7.455033
3	AND	7776	4.273044	23.081911	AND	880	6.942253
4	I	7744	4.255459	27.337370	TO	642	5.064689
5	OF	7388	4.059831	31.397202	IN	611	4.820133
6	YOU	5485	3.014101	34.411302	BY	342	2.698012
7	THAT	5460	3.000363	37.411665	ON	310	2.445566
8	IS	5334	2.931124	40.342789	FOR	308	2.429789
9	IT	5144	2.826715	43.169504	IS	286	2.256232
10	IN	5080	2.791546	45.961050	WITH	261	2.059009
11	FOR	3176	1.745266	47.706316	THAT	208	1.640896
12	ON	2635	1.447977	49.154293	AT	195	1.538340
13	ARE	2507	1.377639	50.531932	THIS	152	1.199116
14	THIS	2419	1.329282	51.861214	WAS	151	1.191228

	reddit_word	reddit_freq	reddit_perc	reddit_perc_cum	nyt_word	nyt_freq	nyt_perc
85	VERY	537	0.295091	96.170416	MY	30	0.236668
86	ALSO	532	0.292343	96.462759	BEEN	29	0.228779
87	WHY	528	0.290145	96.752904	LIST	29	0.228779
88	WELL	525	0.288496	97.041401	MAKE	29	0.228779
89	YOU'RE	524	0.287947	97.329348	YOUR	29	0.228779
90	GO	515	0.283001	97.612349	FOOD	28	0.220890
91	THAT'S	511	0.280803	97.893152	FORMER	28	0.220890
92	BEEN	496	0.272560	98.165712	JUST	28	0.220890
93	COULD	491	0.269813	98.435525	LIFE	28	0.220890
94	TOO	482	0.264867	98.700392	SHE	28	0.220890
95	THOSE	479	0.263219	98.963611	TIMES	28	0.220890
96	RIGHT	477	0.262120	99.225731	CHICKEN	27	0.213001
97	INTO	470	0.258273	99.484004	LOVE	27	0.213001
98	SHOULD	470	0.258273	99.742277	MOTHER	27	0.213001
99	BEING	469	0.257723	100.000000	TIME	27	0.213001

Looking at the table

Something interesting from glancing at the table is type of words that show up in the top ranks. In Reddit and NYT, it's sort of what one would expect, words like "the", "to", "a"--determiner, prepositions, conjunctions--the connective tissues of grammar. Even the rank of those words are strikingly similar.

However, with Twitter that's not the case. We see some more non-grammar words pop up on the top. Maybe, because of Twitter's character limit, people tend to omit those grammar words more for economoy of language. Maybe that'll translate to lesser "inequality" in the word frequency (maybe Twitter is the great democratizer we've all been waiting for?).

The 80/20 Rule

Let's plot the word frequency distribution based on the 80/20 cutoff. With the function below, we can compare the total frequency percentage of the top 20% used words, and the % rank at the 80% cumulative use.

We also include the log-rank to log-frequency regression statistics, which we will go further into when we plot data against our Zipf functions.

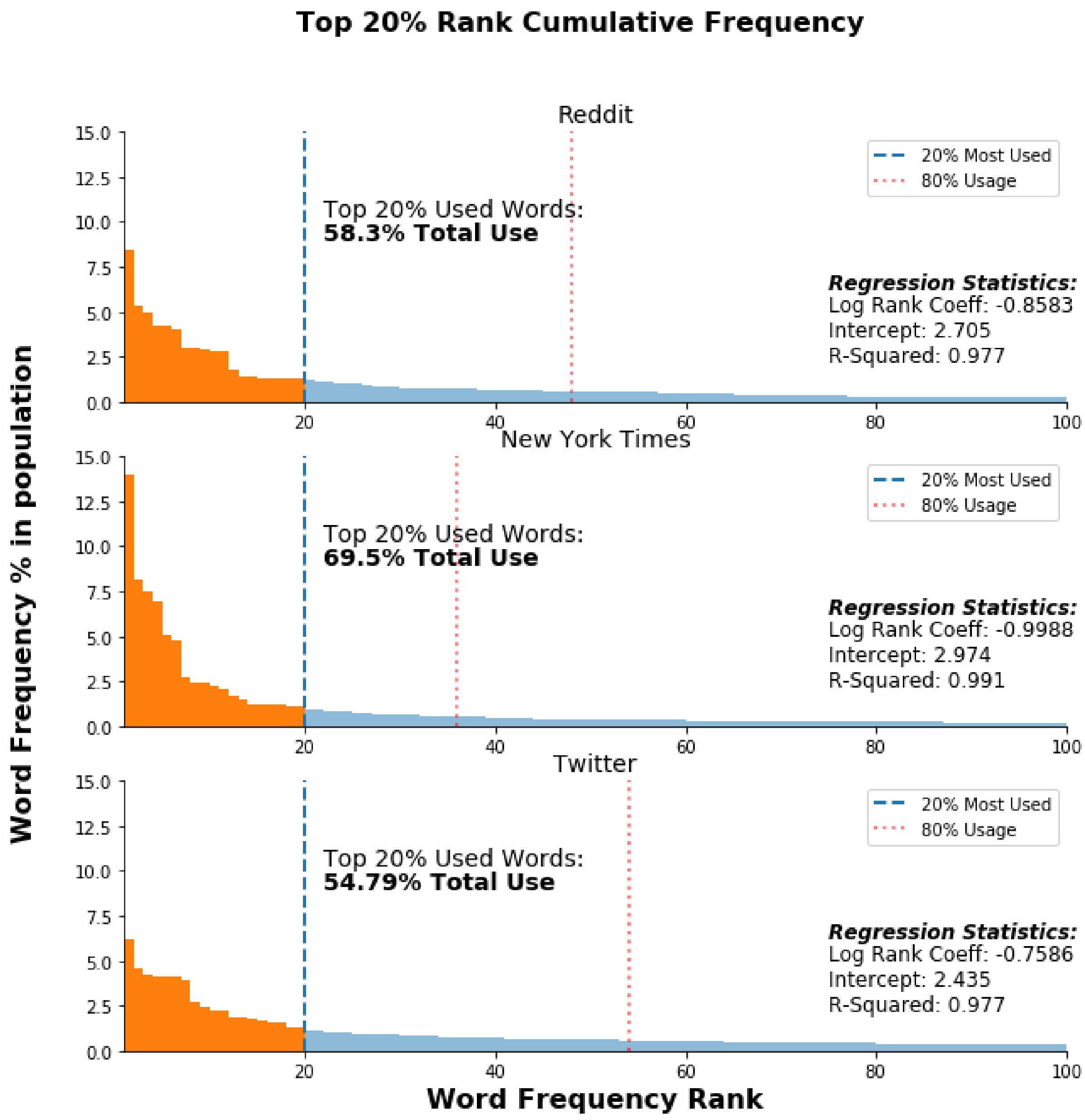
In [34]:

```
def plot_8020(show,show_regression,show_pred):

    '''Plot frequency density bar graph showing top 20% words used'''

        # Plot three figures stacked ontop each other
    fig, ax = plt.subplots(3, figsize = (10,10))

    top20 = round(.2*len(wordrank)) - 1 # position of 20th ranked word
 (-1 for indexing)

        # Plot title
    plt.suptitle('Top 20% Rank Cumulative Frequency', size = 16, fontwei
ght = 'bold')

        #list of source names to iterate with
    source_list = ['reddit','nyt','twitter']

    for i in range(len(source_list)):

        ######################### Print Regression results #############
###############
        results = smf.ols("np.log({yvar}_perc) ~ np.log(rank)"
                          .format(yvar = source_list[i]), data=wordrank)
.fit()
        coeff = results.params['np.log(rank)']
        intercept = results.params['Intercept']

        if show_regression == True:

            # Print Regression Statistics
            m1 = 'Log Rank Coeff: '+str(round(coeff,4))
            m2 = 'Intercept: '+str(round(intercept,3))
            m3 = 'R-Squared: '+str(round(results.rsquared,3))

            statistics = '\n'.join([m1,m2,m3])

            ax[i].text(75,6,'Regression Statistics:',
                    horizontalalignment='left',verticalalignment='botto
m',
                    size=12,fontweight='bold',fontstyle='italic')

            ax[i].text(75,6,statistics,
                    horizontalalignment='left', verticalalignment='top',
                    size=12)
        ####################################################################
############

            # Plot the frequency density distribution
        ax[i].bar(wordrank['rank'], wordrank[source_list[i]+'_perc'],
                  align='edge', width=1,alpha=.5)

            # Plot prediction line
        if show_pred == True:

            ax[i].plot(wordrank['rank'],np.exp(intercept)*wordrank['ran
k']**coeff,
                      label = 'Prediction',alpha = .6, linewidth = 4,
                       linestyle = '-.',color = 'tab:purple')

            # Index for 80% cumulative frequency
        cumfreq80 = wordrank.index[wordrank[source_list[i]+'_perc_cum']
> 80][0]

        # Show top 20% words
        if show == 20:

            ax[i].bar(wordrank['rank'].head(top20),
                      wordrank[source_list[i]+'_perc'].head(top20),
                      align='edge', width=1,alpha=1)

            ax[i].set_xlim(1,len(wordrank))
            ax[i].set_ylim(0,15)

            ax[i].set_title('\n'+source_list[i].title(),size = 14)

            # Construct message
            cum_freq_str = str(round(wordrank[source_list[i]+'_perc_cum'
].loc[top20],2))

            message1 = "Top 20% Used Words:"
            message2 =  cum_freq_str + '% Total Use'

            # Print line and message
            ax[i].axvline(x=top20+1, label= "20% Most Used", linestyle=
'--', linewidth=2)
            ax[i].text(top20+3, 10, message1, horizontalalignment='left'
,
                       verticalalignment='bottom',size=14)
            ax[i].text(top20+3, 10, message2, horizontalalignment='left'
,fontweight='bold',
                       verticalalignment='top',size=14)
            # 80% Line
            ax[i].axvline(x=cumfreq80+1, label= "80% Usage", linestyle=
':',
                          linewidth=2, color ='r', alpha=.5)

        # Show 80% Cumulative distribution
        elif show == 80:

            ax[i].bar(wordrank['rank'], wordrank[source_list[i]+'_perc'
], color = 'tab:blue',
                      align='edge', width=1, alpha=.5)

            ax[i].bar(wordrank['rank'].head(cumfreq80),
                      wordrank[source_list[i]+'_perc'].head(cumfreq80),
color = 'tab:orange',
                      align='edge', width=1, alpha=1)

            ax[i].set_xlim(1,len(wordrank))
            ax[i].set_ylim(0,15)

            ax[i].set_title('\n'+source_list[i].title(),size = 14)

            # Construct message
            rank_str = str(cumfreq80/len(wordrank)*100)

            cumfreq_str= str(round(wordrank[source_list[i]+'_perc_cum'][
cumfreq80],2))
            message1 = cumfreq_str + "% Total Use:"
            message2 = "Top " + rank_str +'% Used Words\nRank '+str(cumf
req80)

            # Print line and message
            ax[i].axvline(x=cumfreq80+1, label= "80% Usage",
                          linestyle='--', linewidth=2, color ='r', alpha
=1)
            ax[i].text(cumfreq80+3, 10, message1,
                       horizontalalignment='left',verticalalignment='bot
tom', size = 14)
            ax[i].text(cumfreq80+3, 10, message2,
                       horizontalalignment='left',verticalalignment='to
p',
                       fontweight='bold', size = 14)
            # 20% Line
            ax[i].axvline(x=top20+1, label= "20% Most Used",
                          linestyle=':', linewidth=2,alpha = .5)

        ################################################################
############

        ax[i].spines["right"].set_visible(False)
        ax[i].spines["top"].set_visible(False)

        ax[i].legend()
```

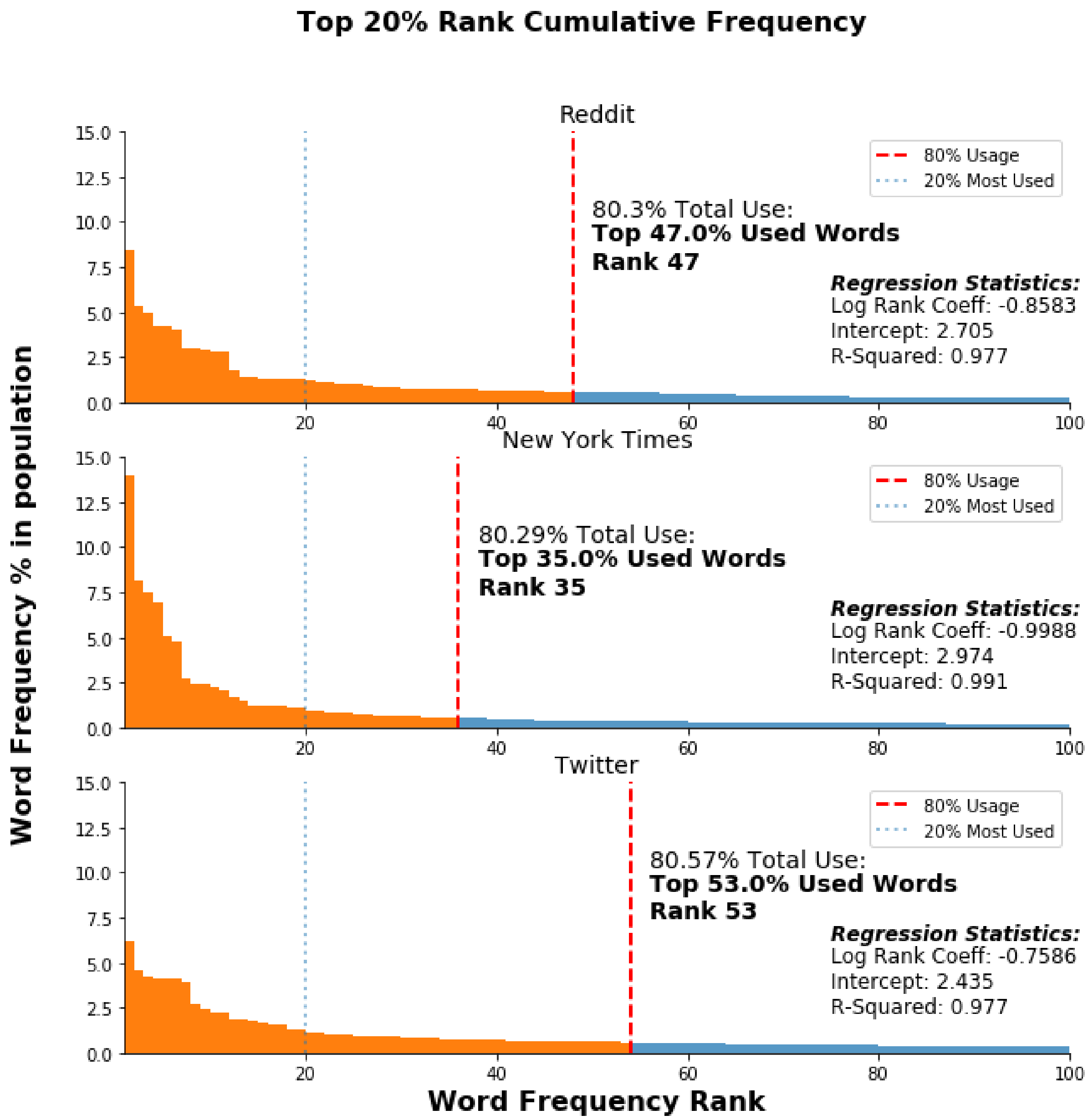
```
    # Some leftover formatting stuff
    ax[1].set_title("New York Times",size = 14)
    ax[2].set_xlabel("Word Frequency Rank", size=16,fontweight='bold')
    ax[1].set_ylabel('Word Frequency % in population\n', size = 16,fontw
eight='bold')

    plt.show()
```

In [35]:

```
# Plot 20
plot_8020(20, True, False)
```



```
In [36]: # Plot 80
         plot_8020(80, True, False)
```



80/20? Not really.

We definitely see an curving density distribution, but the exact porportions are not as prononuced as 80/20. Though we've only used the top 100 words, the biggest effect-cause ratio we get is about 70-20, in the NYT.

What's interesting is the difference of the ratios between the platforms. It seems that our suspicions about the formality of language may be correct. The more grammatically rigorous the text source, the higher the frequency inequality.

This higher inequality also correlates to a larger negative Log Rank Coefficient. It seems that the larger the coefficient, the more dramatic the curve.

Zipf!

Now we plot the Zipf with log-frequency and log-word rank to look at the distribution exponent parameter.

We plot the actual data against the regression prediction to see how closely our regression parameter holds.

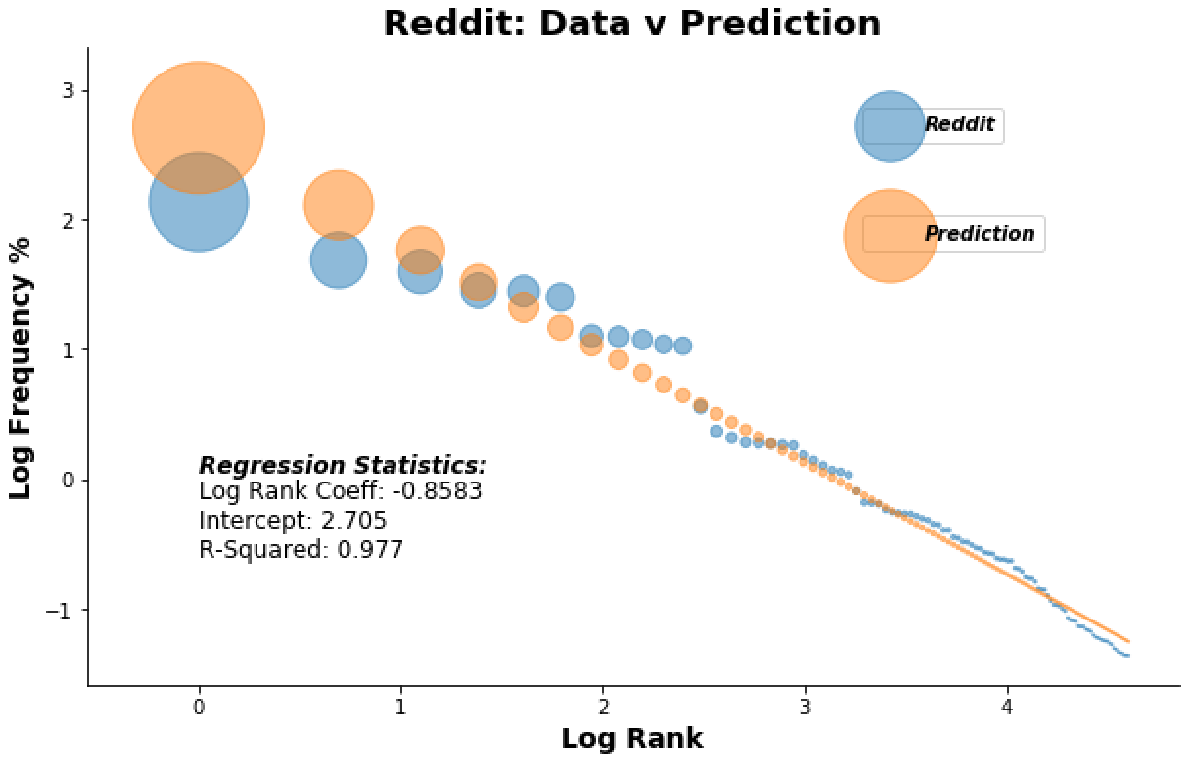
In [37]:

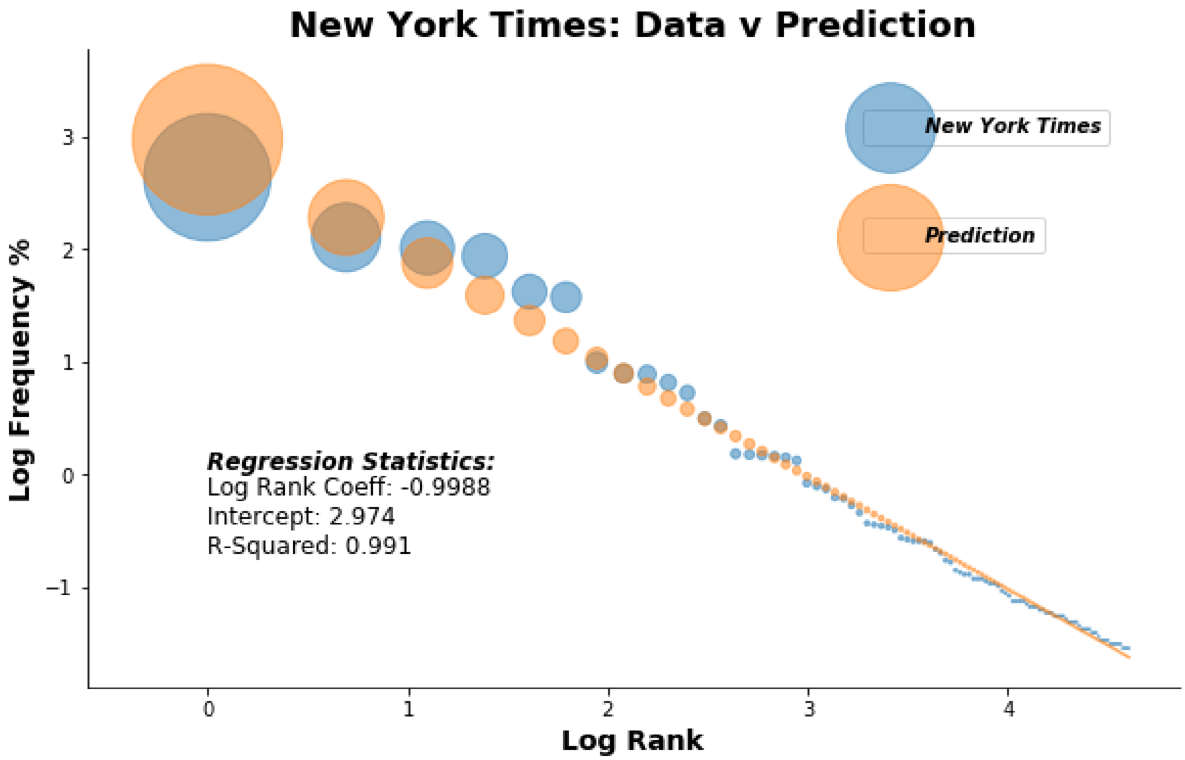
```
def plot_zipf(source, source_name,
              diff_shape, # If the data and prediction (bool)
              show_fit_line, # Show fit line in scatter plot (bool)
              print_summary): # Print stats summary

    '''Plots Zipf relationship on the log-freq log-rank scale'''

    # Rename source for source_perc column index
    source = source + "_perc"

    # Regression results
    results = smf.ols("np.log({yvar}) ~ np.log(rank)".format(yvar = sour
ce),
                      data=wordrank).fit()
    # Plotting
    fig, ax = plt.subplots(figsize = (10,6))

    ax.set_title(source_name+': Data v Prediction', size=18,fontweight=
'bold')

        # Plot data/ The plot sizes are porportional to percentage use
        # and inversely porportional to rank
    data = ax.scatter(np.log(wordrank["rank"]), np.log(wordrank[source
]),
               alpha = .5, s = wordrank[source]*300/wordrank["rank"],
               label = source_name)

        # Plot Prediction
    pred = results.predict(exog = wordrank["rank"])

        # From input shape. If data and prediction are the same shape,
        # it is easier to compare their sizes
    if diff_shape == True:
        shape = 0
    elif diff_shape == False:
        shape = 3

    prediction = ax.scatter(np.log(wordrank["rank"]), pred,
               marker = (6, shape, 0), s = np.exp(pred)*300/wordrank["ra
nk"],
               alpha = .5, #color = 'orange',
               label = 'Prediction')

        # Plot fit line (if True)
    if show_fit_line == True:
            # Data line
        ax.plot(np.log(wordrank["rank"]), np.log(wordrank[source]),
                alpha = .5, linewidth = 2, linestyle=':')
            # Prediction fit line
        ax.plot(np.log(wordrank["rank"]), pred, linewidth = 2, #color =
 'orange',
                alpha = .5,linestyle='-')

        # Formatting
    ax.set_ylabel('Log Frequency %',size=14,fontweight='bold')
    ax.set_xlabel('Log Rank',size=14,fontweight='bold')

    ax.spines["right"].set_visible(False)
    ax.spines["top"].set_visible(False)


    ################ Print Regression Statistics ################
    message1 = 'Log Rank Coeff: '+str(round(results.params['np.log(ran
k)'],4))
    message2 = 'Intercept: '+str(round(results.params['Intercept'],3))
    message3 = 'R-Squared: '+str(round(results.rsquared,3))

    statistics = '\n'.join([message1,message2,message3])

    ax.text(np.log(1),0,'Regression Statistics:',
            horizontalalignment='left',verticalalignment='bottom',
            size=12,fontweight='bold',fontstyle='italic')

    ax.text(np.log(1),0,statistics,
            horizontalalignment='left', verticalalignment='top',
            size=12)
    ################################################################

    # Legend
    legend_prop = dict(size=10,weight='bold',style='italic')
            # Plot the two legends separately
    first_legend = plt.legend(handles=[data], bbox_to_anchor=(.7, .92),
                              prop=legend_prop, loc='upper left')
            # Add fisrt legend
    ax = plt.gca().add_artist(first_legend)
            # Add second legend
    plt.legend(handles=[prediction], bbox_to_anchor=(.7, .75),
               prop=legend_prop,loc='upper left')


    plt.show()

    # Print regression summary if True
    if print_summary == True:
        print(results.summary())
```

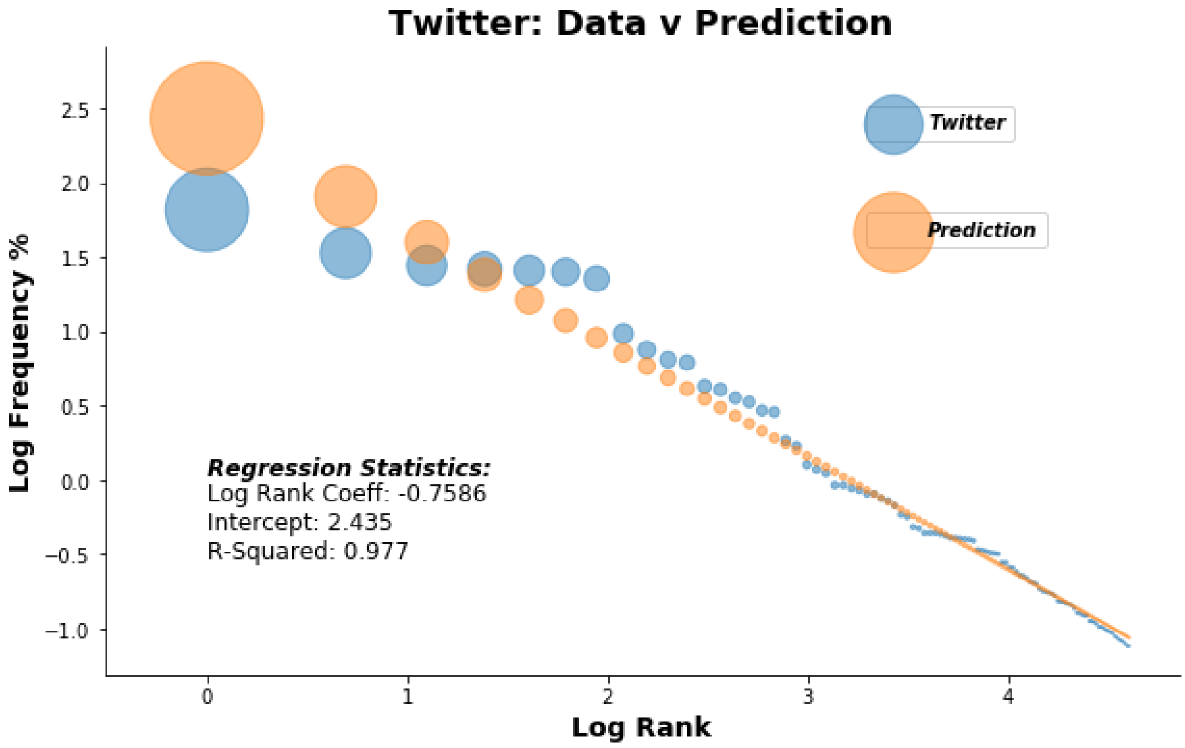
Plot the Zipf!

In [38]:

```
# Plot through iteration
source_list = ['reddit','nyt','twitter']
name_list = ['Reddit','New York Times','Twitter']

# We plot with every False to first get a clean look
for i in range(len(source_list)):
    plot_zipf(source_list[i],name_list[i],False,False,False)
```

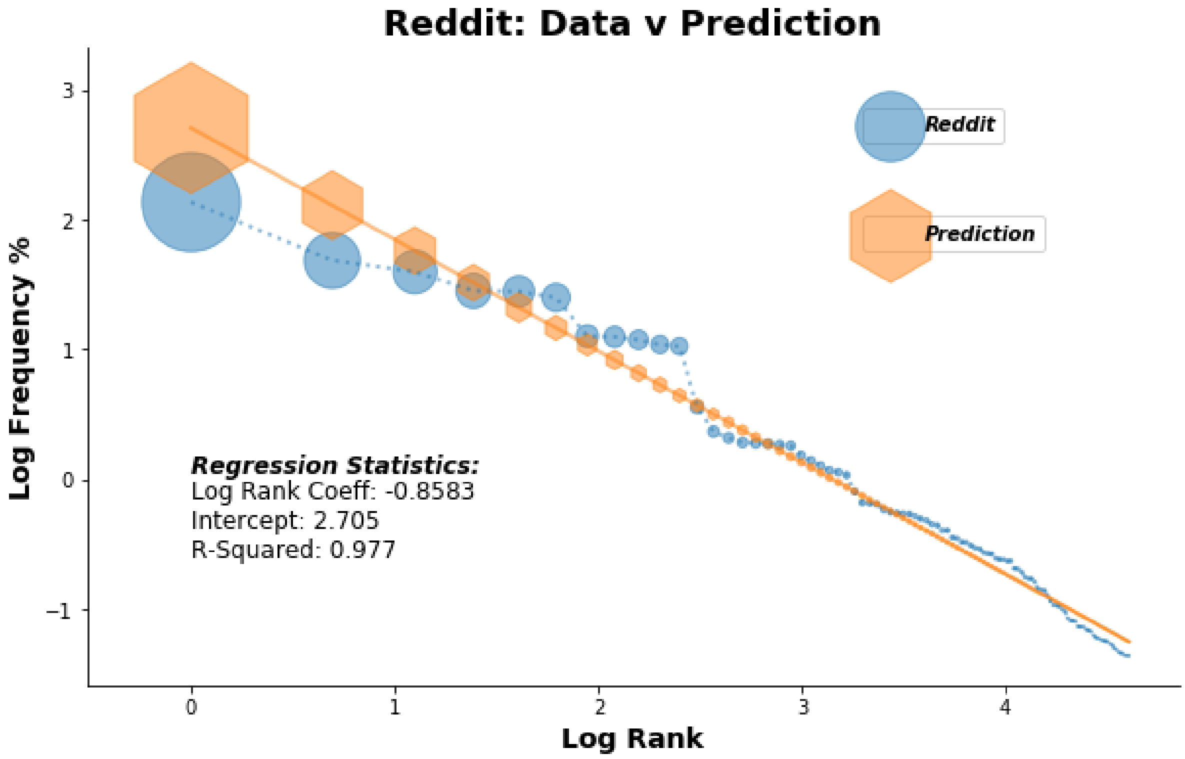

Reddit: Data v Prediction
Reddit
Prediction
Regression Statistics:
Log Rank Coeff: -0.8583
Intercept: 2.705
R-Squared: 0.977
Log Frequency %
3
2
1
0
−1
Log Rank
0
1
2
3
4

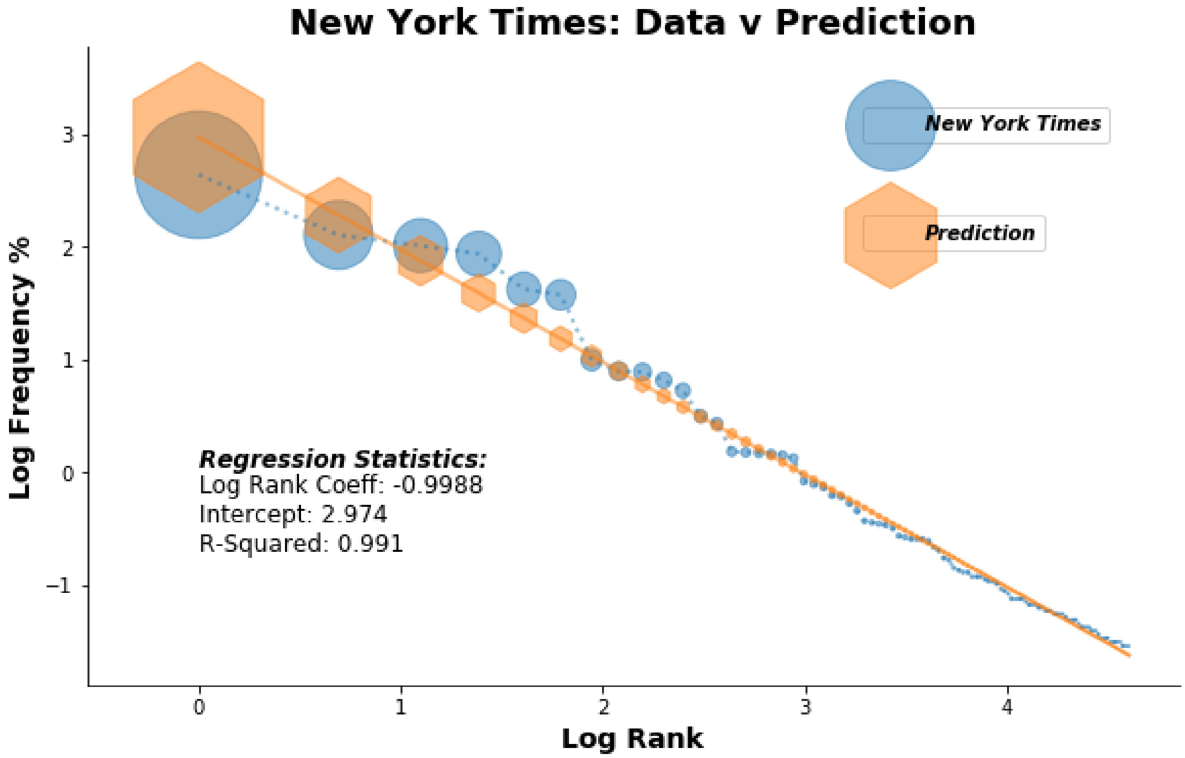

New York Times: Data v Prediction
New York Times
Prediction
Regression Statistics:
Log Rank Coeff: -0.9988
Intercept: 2.974
R-Squared: 0.991
Log Frequency %
3
2
1
0
−1
Log Rank
0
1
2
3
4

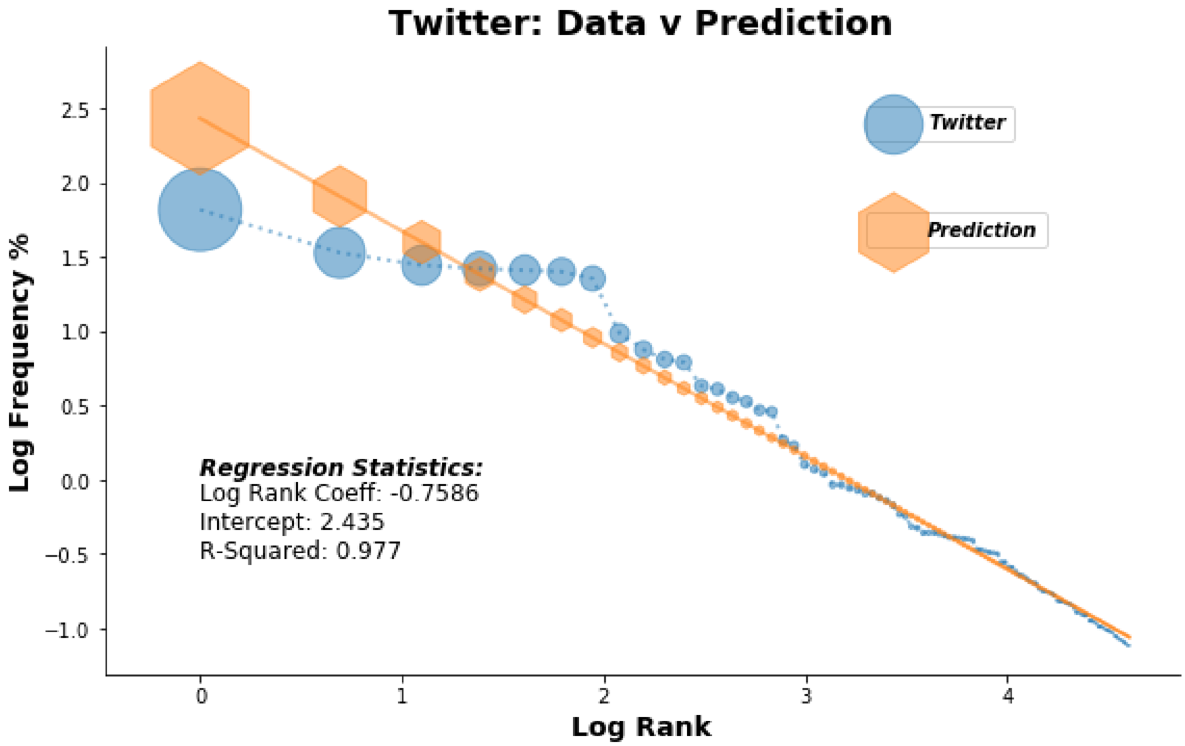

Twitter: Data v Prediction
Twitter
Prediction
Regression Statistics:
Log Rank Coeff: -0.7586
Intercept: 2.435
R-Squared: 0.977
Log Frequency %
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
0
1
2
3
4
Log Rank

In [39]:

```
# Plot through iteration
source_list = ['reddit','nyt','twitter']
name_list = ['Reddit','New York Times','Twitter']

# We plot with fit line and different shapes to better
# distinguish between if in grayscale
for i in range(len(source_list)):
    plot_zipf(source_list[i],name_list[i],True,True,False)
```


Reddit: Data v Prediction
Reddit
Prediction
Regression Statistics:
Log Rank Coeff: -0.8583
Intercept: 2.705
R-Squared: 0.977
Log Frequency %
3
2
1
0
−1
0
1
2
3
4
Log Rank


New York Times: Data v Prediction
New York Times
Prediction
Regression Statistics:
Log Rank Coeff: -0.9988
Intercept: 2.974
R-Squared: 0.991
Log Frequency %
3
2
1
0
−1
0
1
2
3
4
Log Rank



Zipf: Conclusion

So it seems that the graphs hold pretty well. The R-squared on our log-log regression is very high on all three, implying a highly statistically significant exopnential relationship between the rank and the frequency of these words. Even if it's not 80-20, there is some kind of truth to that relationship.

Once again, we see that the fit is just a little better for the New York Times. The relationship between the grammar of the forum and the distribution is with this a little inconclusive, but that may be an interesting next step.