Module 10: Logscale

In [1]:
```
import matplotlib.pyplot as plt
import pandas as pd
import seaborn as sns
import numpy as np
import scipy.stats as ss
import vega_datasets
import math
%matplotlib inline
```

Ratio and logarithm

If you use linear scale to visualize ratios, it can be quite misleading.

Let's first create some ratios.

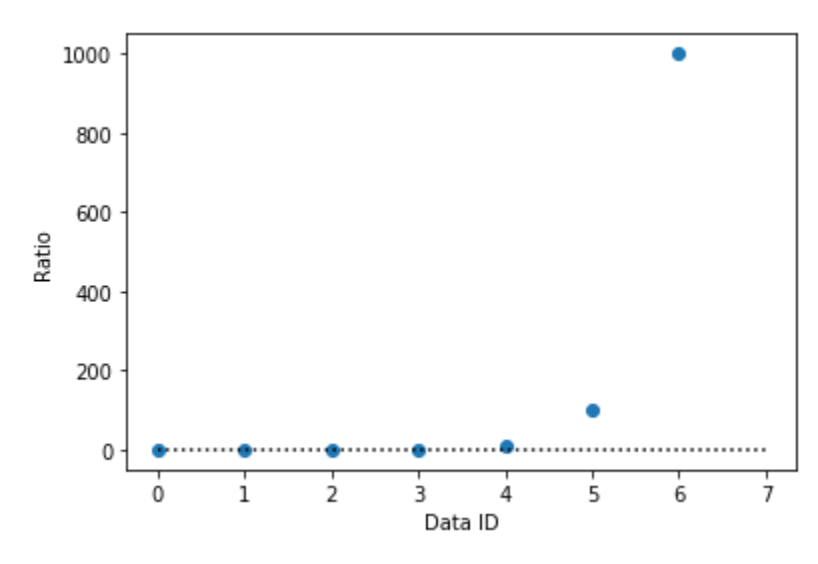
In [2]:
```
x = np.array([1,    1,   1,  1, 10, 100, 1000])
y = np.array([1000, 100, 10, 1, 1,  1,   1   ])
ratio = x/y
print(ratio)
```

```
[1.e-03 1.e-02 1.e-01 1.e+00 1.e+01 1.e+02 1.e+03]
```

Q: Plot on the linear scale using the `scatter()` function. Also draw a horizontal line at ratio=1 for a reference.

In [3]:
```
rang_len = range(len(ratio))
plt.scatter(rang_len,ratio)
plt.plot(range(8), [0,0,0,0,0,0,0,0], ls=':', color='black')
plt.xlabel('Data ID')
plt.ylabel('Ratio')
```

Out[3]:
```
Text(0, 0.5, 'Ratio')
```



Q: Explain what's bad about this plot.

In [4]:
```
'''for Ratio axis, if x<y, it plots only using Ratio<1, otherwise Ratio>1, thus it is unfair for x<y
and y>x situation.'''
```

Out[4]:
```
'for Ratio axis, if x<y, it plots only using Ratio<1, otherwise Ratio>1, thus it is unfair for x
<y and y>x situation.'
```

Q: Can you fix it?

In [5]:
```
# Implement

x = np.array([1,    1,   1,  1, 10, 100, 1000])
y = np.array([1000, 100, 10, 1, 1,  1,   1   ])
ratio = x/y.tolist()

print(ratio)
```

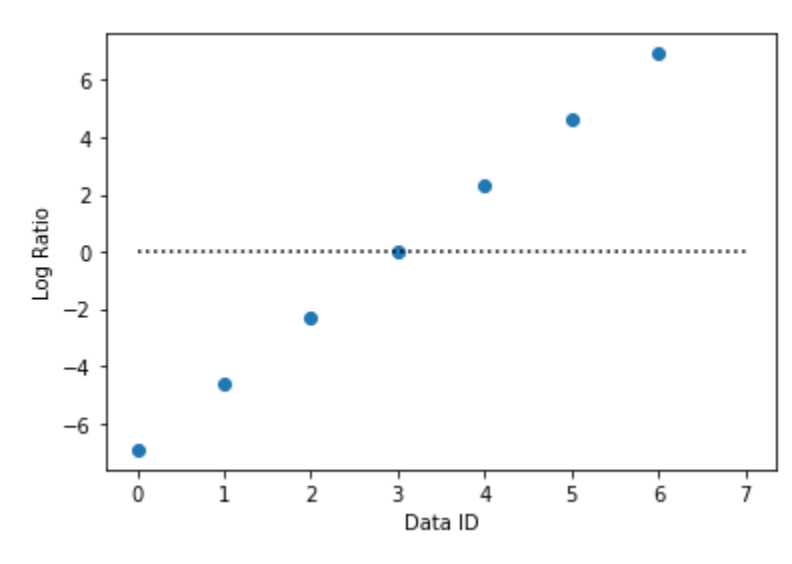
```
[1.e-03 1.e-02 1.e-01 1.e+00 1.e+01 1.e+02 1.e+03]
```

In [6]:
```
log_ratio = [math.log(a) for a in ratio]
print(log_ratio)

rang_len = range(len(log_ratio))
plt.scatter(rang_len, log_ratio)
plt.plot(range(8), [0,0,0,0,0,0,0,0], ls=':', color='black')
plt.xlabel('Data ID')
plt.ylabel('Log Ratio')
```

```
[-6.907755278982137, -4.605170185988091, -2.3025850929940455, 0.0, 2.302585092994046, 4.60517018
5988092, 6.907755278982137]
```

Out[6]:
```
Text(0, 0.5, 'Log Ratio')
```



Log-binning

Let's first see what happens if we do not use the log scale for a dataset with a heavy tail.

Q: Load the movie dataset from `vega_datasets` and remove the NaN rows based on the following three columns: `IMDB_Rating`, `IMDB_Votes`, `Rotten_Tomatoes_Rating`.

In [7]:
```
# TODO
movies = vega_datasets.data.movies()
movies = movies.dropna(subset=['IMDB_Rating', 'IMDB_Votes', 'Rotten_Tomatoes_Rating'])
len(movies)
```

Out[7]:
```
2260
```

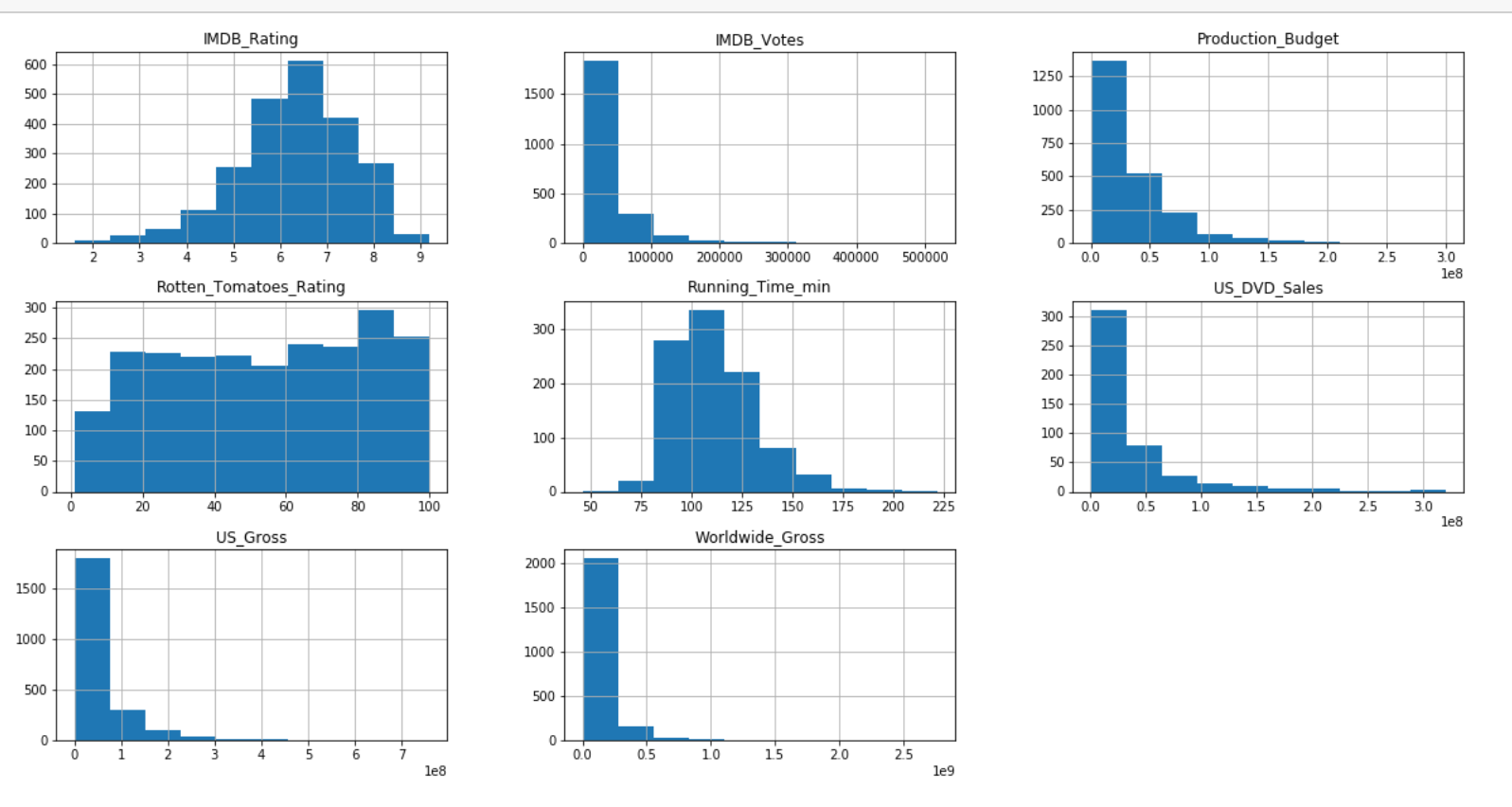
In [8]:
```
type(movies)
```

Out[8]:
```
pandas.core.frame.DataFrame
```

If you simply call `hist()` method with a dataframe object, it identifies all the numeric columns and draw a histogram for each.

Q: draw all possible histograms of the movie dataframe. Adjust the size of the plots if needed.

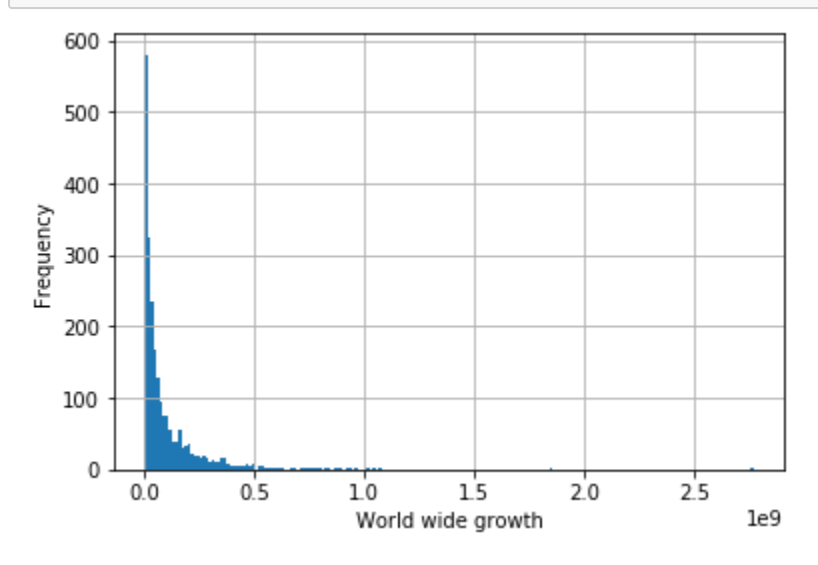
In [9]:
```
ax = movies.hist(figsize=(20, 10))
```



As we can see, a majority of the columns are not normally distributed. In particular, if you look at the worldwide gross variable, you only see a couple of meaningful data from the histogram. Is this a problem of resolution? How about increasing the number of bins?

Q: Play with the number of bins, and then increase the number of bins to 200.

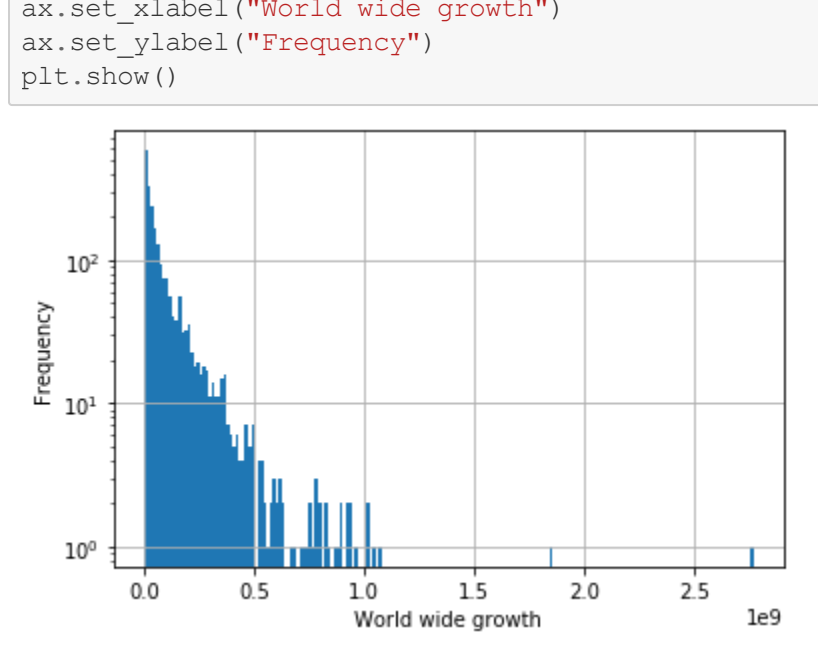
In [10]:
```
ax = movies.Worldwide_Gross.hist(bins=200)
ax.set_xlabel("World wide growth")
ax.set_ylabel("Frequency")
plt.show()
```



Maybe a bit more useful, but it doesn't tell anything about the data distribution above certain point.

Q: How about changing the vertical scale to logarithmic scale?

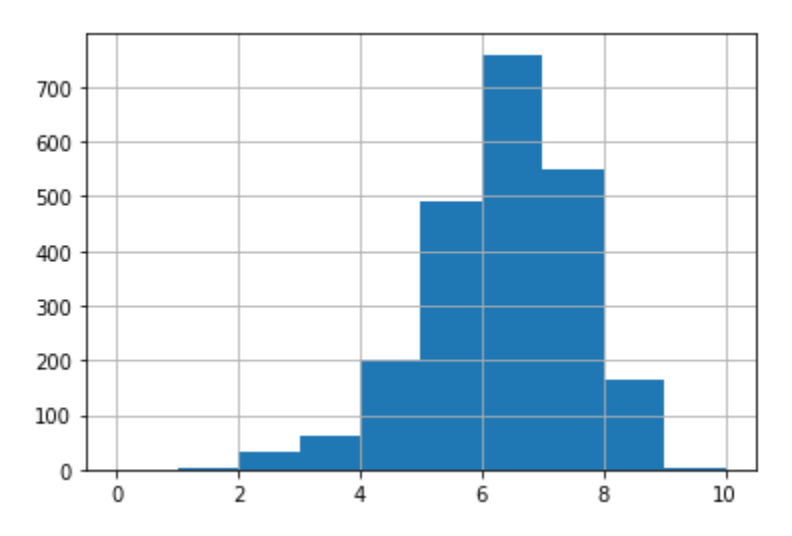
In [11]:
```
# Implement
ax = movies.Worldwide_Gross.hist(log=True, bins=200)
ax.set_xlabel("World wide growth")
ax.set_ylabel("Frequency")
plt.show()
```



Now, let's try log-bin. Recall that when plotting histgrams we can specify the edges of bins through the `bins` parameter. For example, we can specify the edges of bins to [1, 2, 3, ... , 10] as follows.

In [12]:
```
movies.IMDB_Rating.hist(bins=range(0,11))
```

Out[12]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1a18821050>
```



Here, we can specify the edges of bins in a similar way. Instead of specifying on the linear scale, we do it on the log space. Some useful resources:

- Google query: python log-bin
- numpy.logspace
- numpy.linspace vs numpy.logspace

Hint: since $10^{\text{start}} = \text{min(Worldwide_Gross)}$, $\text{start} = \log_{10}(\text{min(Worldwide_Gross)})$

In [13]:
```
min(movies.Worldwide_Gross)
```

Out[13]:
```
0.0
```

Because there seems to be movie(s) that made $0, and because log(0) is undefined & log(1) = 0, let's add 1 to the variable.

In [14]:
```
movies.Worldwide_Gross = movies.Worldwide_Gross+1.0
```

In [15]:
```
movies.Worldwide_Gross
```

Out[15]:
```
4         1087522.0
8         6341826.0
9        20400001.0
10       37600001.0
11       37402878.0
            ...
3195     98690287.0
3196     36851126.0
3198     12506189.0
3199    141475337.0
3200    233700001.0
Name: Worldwide_Gross, Length: 2260, dtype: float64
```

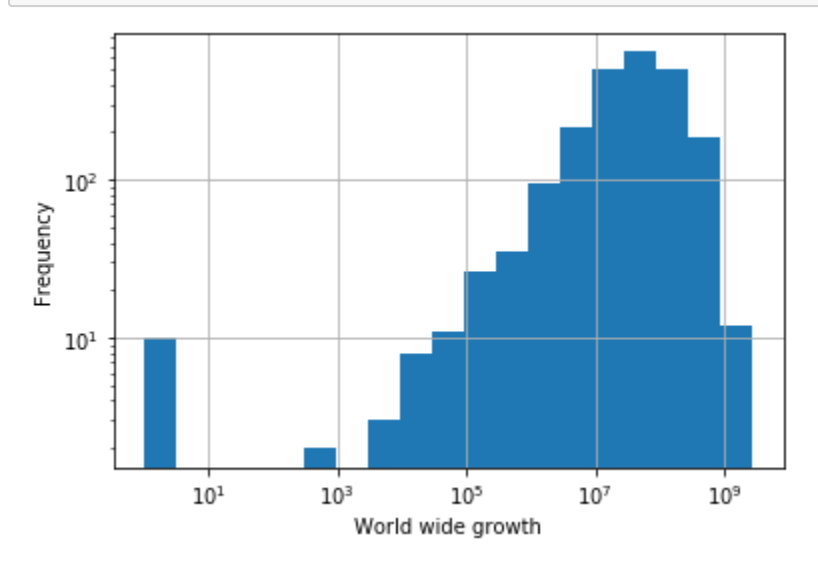
Q: now create logarithmic bins. Create 20 bins from the minimum value to the maximum value.

In [16]:
```
start = min(movies.Worldwide_Gross)
end = max(movies.Worldwide_Gross)
print(start, end)
bins = np.logspace(np.log10(start), np.log10(end), 20)
print(bins)
```

```
1.0 2767891500.0
[1.00000000e+00 3.14018485e+00 9.86076088e+00 3.09646119e+01
 9.72346052e+01 3.05334634e+02 9.58807191e+02 3.01083182e+03
 9.45456845e+03 2.96890926e+04 9.32292387e+04 2.92757043e+05
 9.19311230e+05 2.88680720e+06 9.06510822e+06 2.84661155e+07
 8.93888645e+07 2.80697558e+08 8.81442219e+08 2.76789150e+09]
```

Now we can plot a histgram with log-bin. Set both axis to be log-scale.

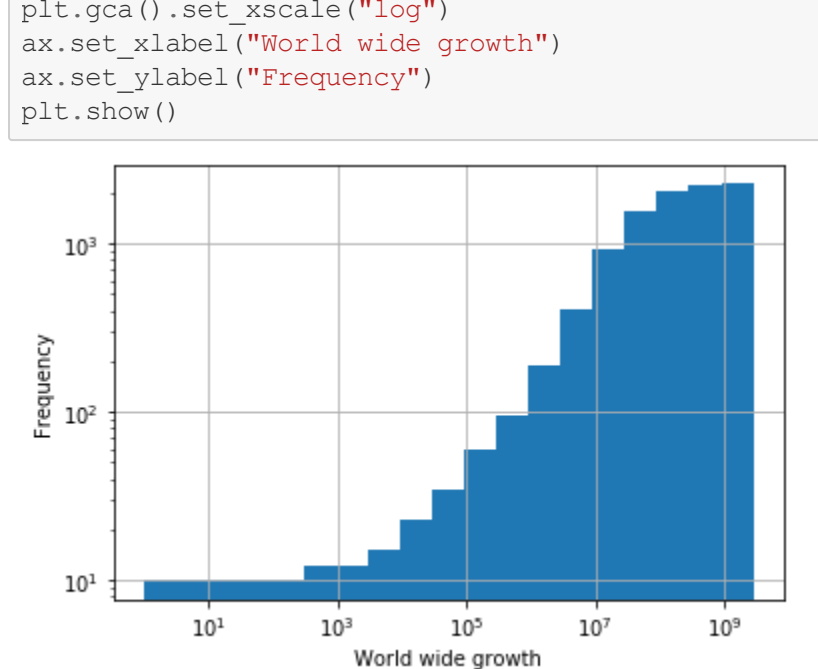
In [17]:
```
ax = movies.Worldwide_Gross.hist(log=True, bins=bins)
plt.gca().set_xscale("log")
ax.set_xlabel("World wide growth")
ax.set_ylabel("Frequency")
plt.show()
```



What is going on? Is this the right plot?

Q: explain and fix

In [18]:
```
ax = movies.Worldwide_Gross.hist(log=True, bins=bins, cumulative=True)
plt.gca().set_xscale("log")
ax.set_xlabel("World wide growth")
ax.set_ylabel("Frequency")
plt.show()
```



Q: Can you explain the plot? Why are there gaps?

In [19]:
```
'''It was not cumulative, now there are no gap.'''
```

Out[19]:
```
'It was not cumulative, now there are no gap.'
```

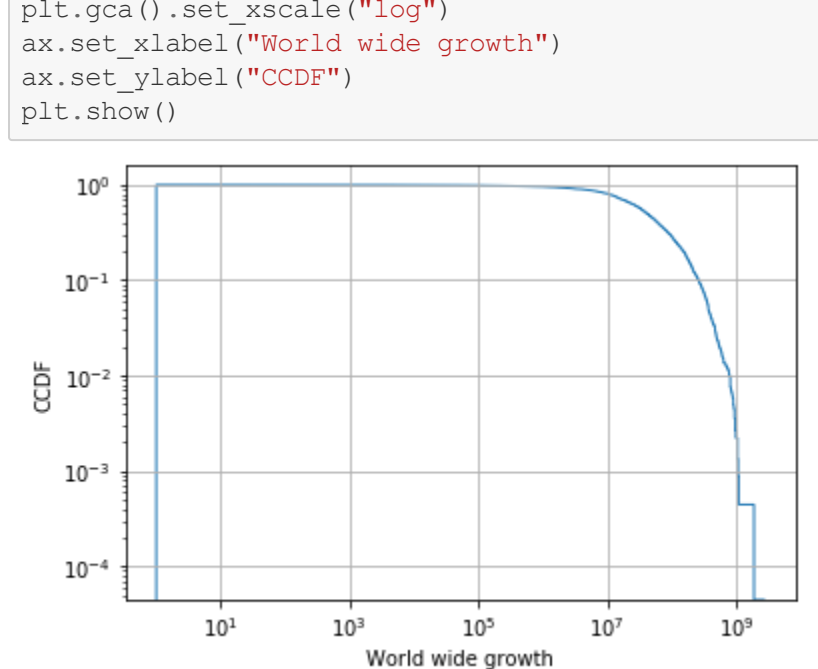
CCDF

CCDF is a nice alternative to examine distributions with heavy tails. The idea is same as CDF, but the direction of aggregation is opposite. We have done CDF before. It's just a small change to that code.

Q: Draw a CCDF in log-log scale

In [20]:
```
bins = np.logspace(np.log10(start), np.log10(end), 1000)
```

In [21]:
```
ax = movies.Worldwide_Gross.hist(log=True, bins=bins, cumulative=-1, histtype="step", density=True)
plt.gca().set_xscale("log")
ax.set_xlabel("World wide growth")
ax.set_ylabel("CCDF")
plt.show()
```



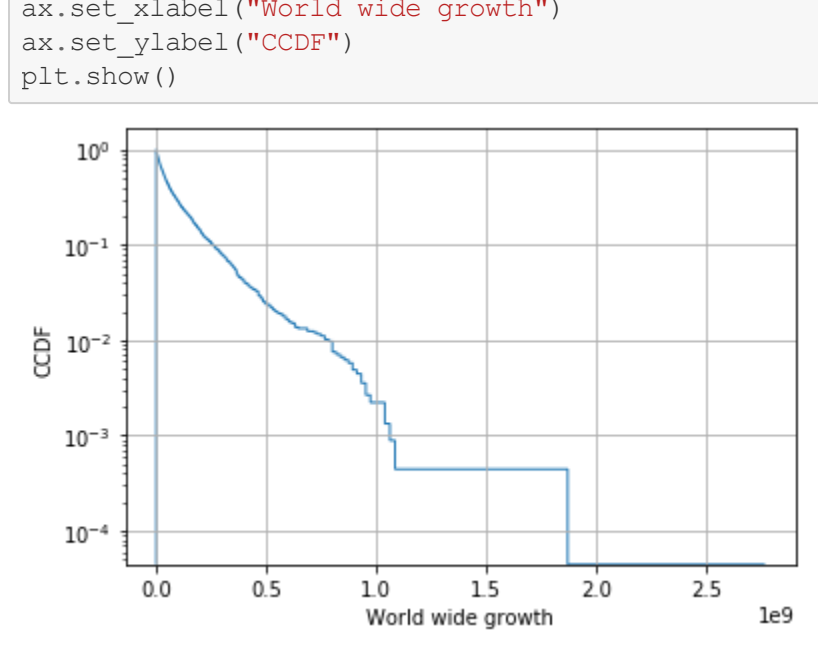
We can also try in semilog scale (only one axis is in a log-scale), where the horizontal axis is linear.

Q: Draw a CCDF in semilog scale

In [105]:
```
data_r = pd.DataFrame(movies.Worldwide_Gross.tolist()[::-1], index = movies.index, columns = ['World
wide_Gross'])
```

In [111]:
```
y = [20, 250, 100000]
```

In [115]:
```
ax = movies.Worldwide_Gross.hist(log=True, bins=bins, cumulative=-1, histtype="step", density=True)
plt.gca().set_yscale("log")
ax.set_xlabel("World wide growth")
ax.set_ylabel("CCDF")
plt.show()
```



A straight line in semilog scale means exponential decay (cf. a straight line in log-log scale means power-law decay). So it seems like the amount of money a movie makes across the world follows *roughly* an exponential distribution, while there are some outliers that make insane amount of money.

Q: Which is the most successful movie in our dataset?

You can use the following

- `idxmax()`: https://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.idxmax.html
- `loc`: https://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.loc.html or `iloc`: https://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.iloc.html

Which one should you use, `loc` or `iloc`? How are they different from each other?

In [127]:
```
# Implement
movies.loc[movies.Worldwide_Gross.idxmax()]
```

Out[127]:
```
Title                                 Avatar
US_Gross                         7.60168e+08
Worldwide_Gross                  2.76789e+09
US_DVD_Sales                     1.46154e+08
Production_Budget                   2.37e+08
Release_Date                     Dec 18 2009
MPAA_Rating                            PG-13
Running_Time_min                         NaN
Distributor                 20th Century Fox
Source                   Original Screenplay
Major_Genre                           Action
Creative_Type                Science Fiction
Director                       James Cameron
Rotten_Tomatoes_Rating                    83
IMDB_Rating                              8.3
IMDB_Votes                            261439
Name: 1234, dtype: object
```

In [128]:
```
# Implement
movies.iloc[movies.Worldwide_Gross.idxmax()]
```

Out[128]:
```
Title                               Georgia Rule
US_Gross                             1.88829e+07
Worldwide_Gross                      2.08196e+07
US_DVD_Sales                         1.93823e+07
Production_Budget                          2e+07
Release_Date                         May 11 2007
MPAA_Rating                                    R
Running_Time_min                             111
Distributor                            Universal
Source                       Original Screenplay
Major_Genre                                Drama
Creative_Type                Contemporary Fiction
Director                          Garry Marshall
Rotten_Tomatoes_Rating                        17
IMDB_Rating                                  5.8
IMDB_Votes                                 10902
Name: 1808, dtype: object
```

In [131]:
```
'''loc, because idmax returns the actual index(loc) of the maximum value data not its integer positi
on(iloc)'''
```

Out[131]:
```
'loc, because idmax returns the actual index(loc) of the maximum value data not its integer posi
tion(iloc)'
```