Data Exploration

May 5, 2020

[3]:
```python
import os
print("cwd:", os.getcwd())
```

```
cwd: /Users/jsennett/Code/top-k-insights/report/notebooks
```

[209]:
```python
import pandas as pd
import numpy as np
import scipy
import heapq
import scipy.stats
import matplotlib.pyplot as plt
```

0.1 Number of papers per author

[ ]:
```python
filename = "/Users/jsennett/Code/top-k-insights/data/
 ↪all-author-paper-counts-by-year.csv"
df = pd.read_csv(filename, encoding='mac_roman')
```

[30]:
```python
print(len(data), "rows (4.4 million)")
print(df.columns)
df.head()
```

```
4395104 rows (4.4 million)
Index(['num_papers', 'year', 'authid', 'rank', 'log_rank', 'log_num_papers'],
dtype='object')
```

[30]:

	num_papers	year	authid	rank	log_rank	log_num_papers
0	1	1990	0	1571776.0	20.583964	0.000000
1	4	1990	1	329751.0	18.331018	2.000000
2	5	1990	3	230373.0	17.813612	2.321928
3	1	1990	4	1571777.0	20.583965	0.000000
4	1	1990	7	1571778.0	20.583966	0.000000

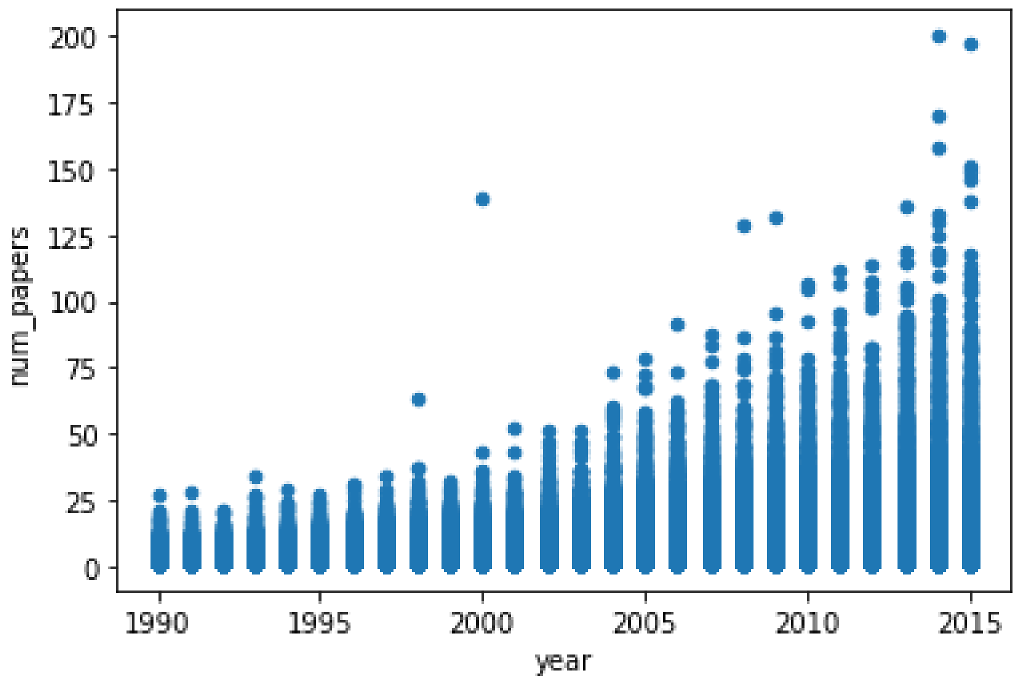
[20]:
```python
df.describe()
```

[20]:

	num_papers	year	authid
count	4.395104e+06	4.395104e+06	4.395104e+06
mean	1.980562e+00	2.007571e+03	5.751863e+05
std	2.490828e+00	6.059493e+00	4.682082e+05
min	1.000000e+00	1.990000e+03	0.000000e+00
25%	1.000000e+00	2.004000e+03	1.710480e+05
50%	1.000000e+00	2.009000e+03	4.489020e+05
75%	2.000000e+00	2.012000e+03	9.167660e+05
max	2.000000e+02	2.015000e+03	1.691340e+06

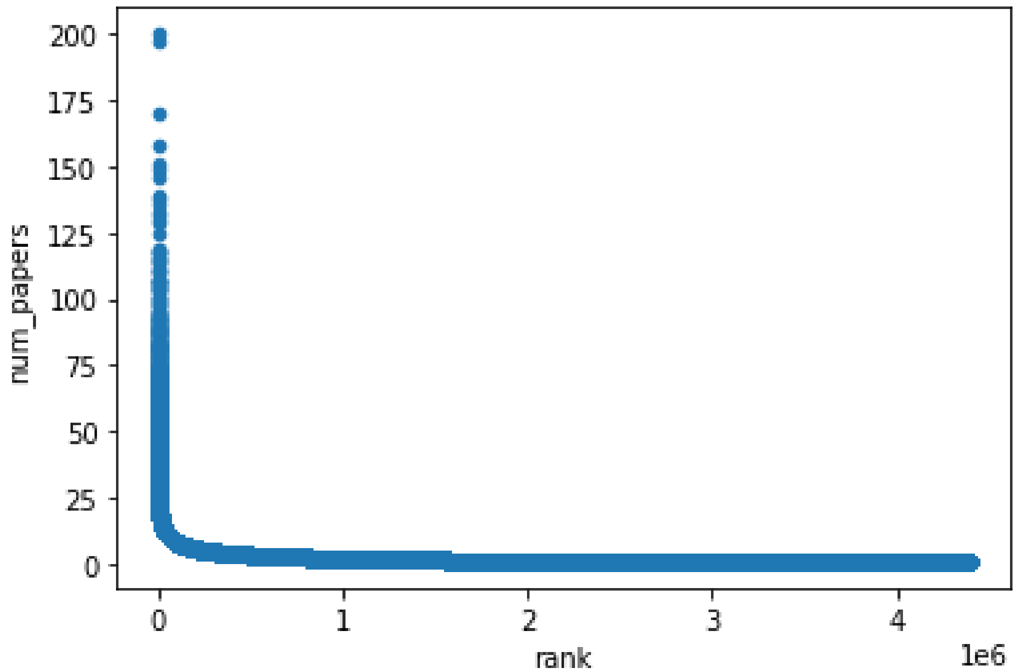
[23]:
```
# Scatter plots of some relevant measures
df.plot.scatter('year', 'num_papers')
```

[23]: <matplotlib.axes._subplots.AxesSubplot at 0x12a1a0d30>



[28]:
```
# Plot num_papers versus rank
df['rank'] = df['num_papers'].rank(method='first', ascending=False)
df.plot.scatter('rank', 'num_papers')
```

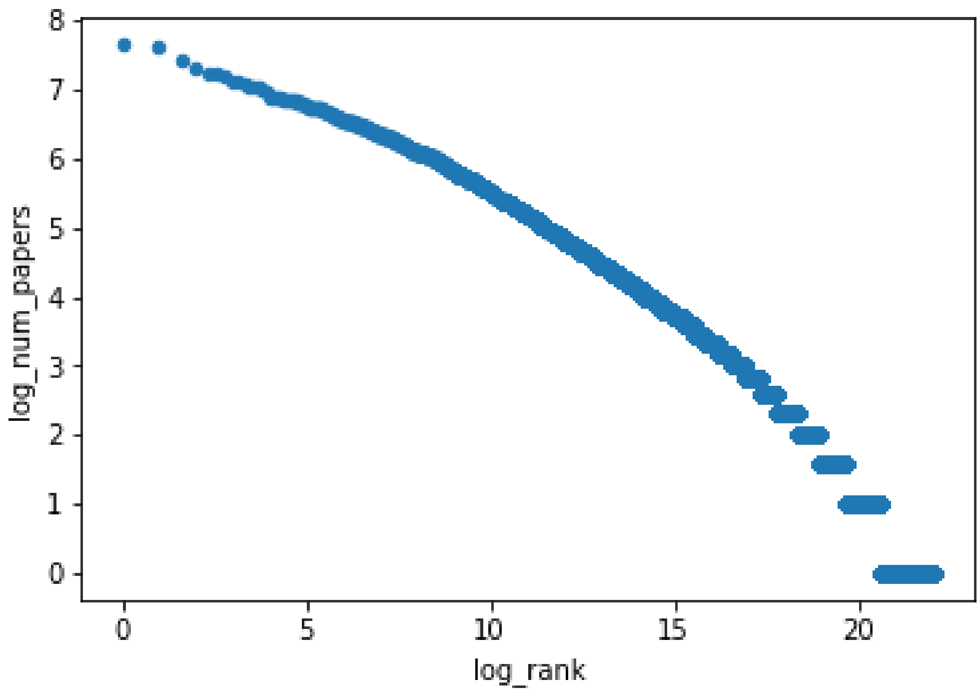
[28]: <matplotlib.axes._subplots.AxesSubplot at 0x127102e80>



[29]:
```
df['log_rank'] = scipy.log2(df['rank'])
df['log_num_papers'] = scipy.log2(df['num_papers'])
df.plot.scatter('log_rank', 'log_num_papers')
```

```
/Users/jsennett/.pyenv/versions/3.6.1/envs/topk/lib/python3.6/site-
packages/ipykernel_launcher.py:1: DeprecationWarning: scipy.log2 is deprecated
and will be removed in SciPy 2.0.0, use numpy.lib.scimath.log2 instead
  """Entry point for launching an IPython kernel.
/Users/jsennett/.pyenv/versions/3.6.1/envs/topk/lib/python3.6/site-
packages/ipykernel_launcher.py:2: DeprecationWarning: scipy.log2 is deprecated
and will be removed in SciPy 2.0.0, use numpy.lib.scimath.log2 instead
```

[29]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x12a110eb8>
```



0.2 All papers

[5]:
```
papers_filename = "/Users/jsennett/Code/top-k-insights/data/all-papers.csv"
p_df = pd.read_csv(papers_filename, encoding='mac_roman', dtype = {'school':␣
 ↪str})
```

[6]:
```
print(len(p_df), "rows (4.4 million)")
print(p_df.columns)
p_df.head()
```

```
2991406 rows (4.4 million)
Index(['paperid', 'venue_name', 'year', 'school', 'venue_type'], dtype='object')
```

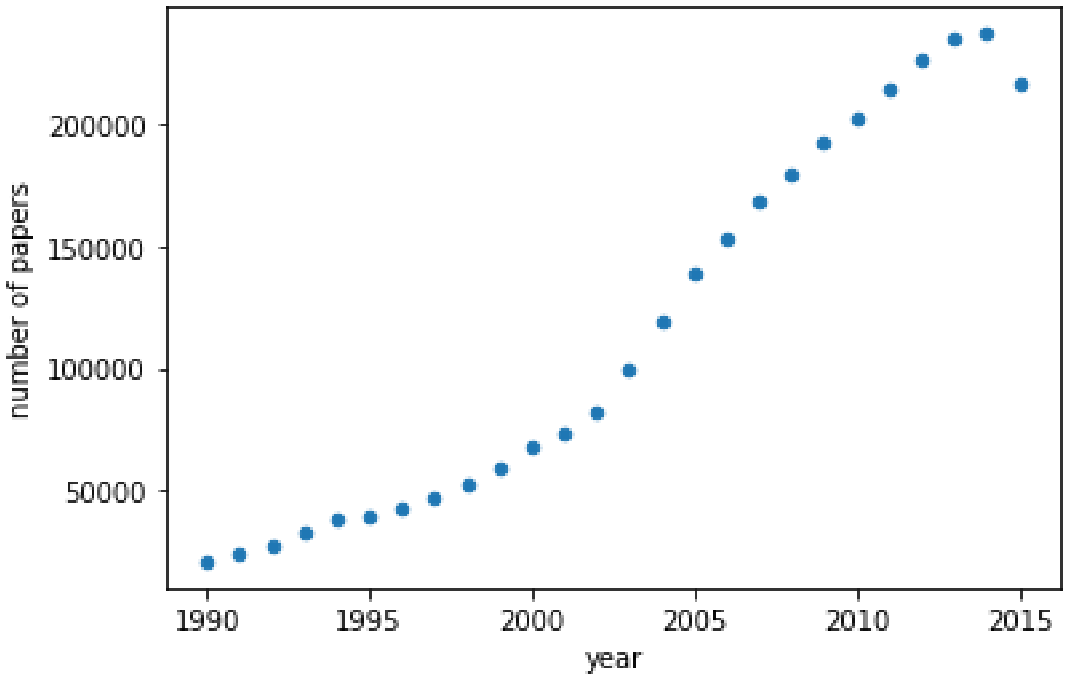
[6]:

	paperid	venue_name	year	school	venue_type
0	5389	Future Generation Comp. Syst.	2004	NaN	0
1	5390	Future Generation Comp. Syst.	2010	NaN	0
2	5407	Future Generation Comp. Syst.	2009	NaN	0
3	5414	Future Generation Comp. Syst.	2001	NaN	0
4	5449	Future Generation Comp. Syst.	2004	NaN	0

[7]:
```
# Insight: positive trend of paper counts over year considering the full set of␣
 ↪data
p_df.groupby('year')\
```

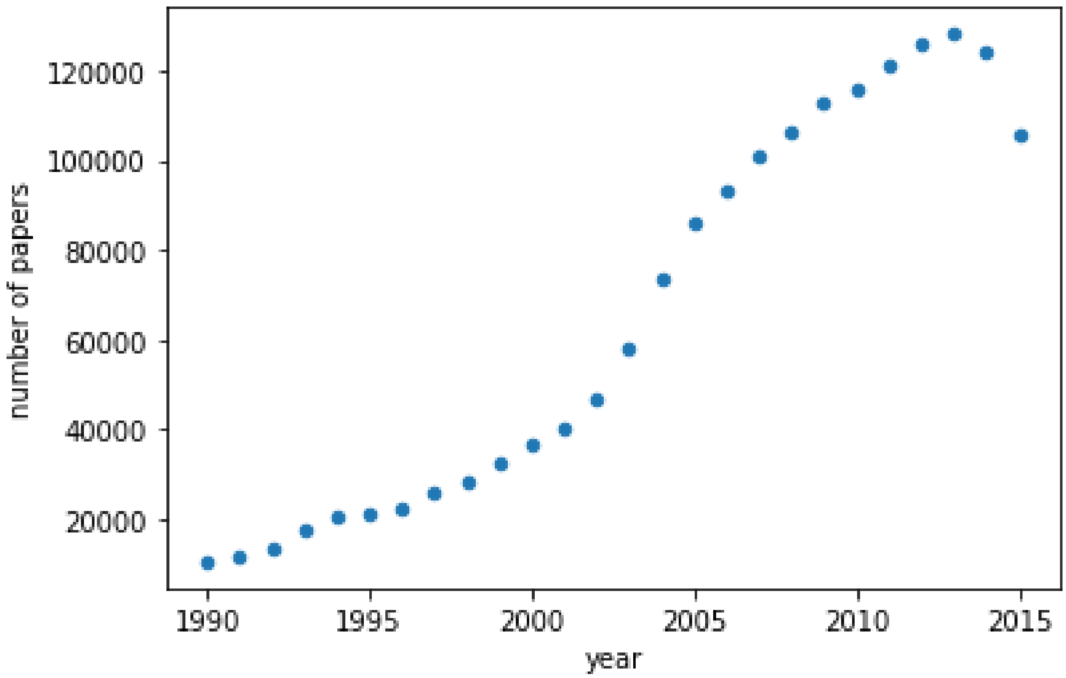
```
    .agg('count')\
    .reset_index()\
    .rename(columns={'paperid':'number of papers'})\
    .plot.scatter('year', 'number of papers')
```

[7]: <matplotlib.axes._subplots.AxesSubplot at 0x1035bbdd8>



[8]:
```
# Insight: positive trend of paper counts over year considering the full set of␣
↪data
p_df[p_df['venue_type'] == 1].groupby('year')\
    .agg('count')\
    .reset_index()\
    .rename(columns={'paperid':'number of papers'})\
    .plot.scatter('year', 'number of papers')
```

[8]: <matplotlib.axes._subplots.AxesSubplot at 0x10412fd30>



[9]:
```
p_df[p_df['venue_type'] == 0]['year'].value_counts()
```

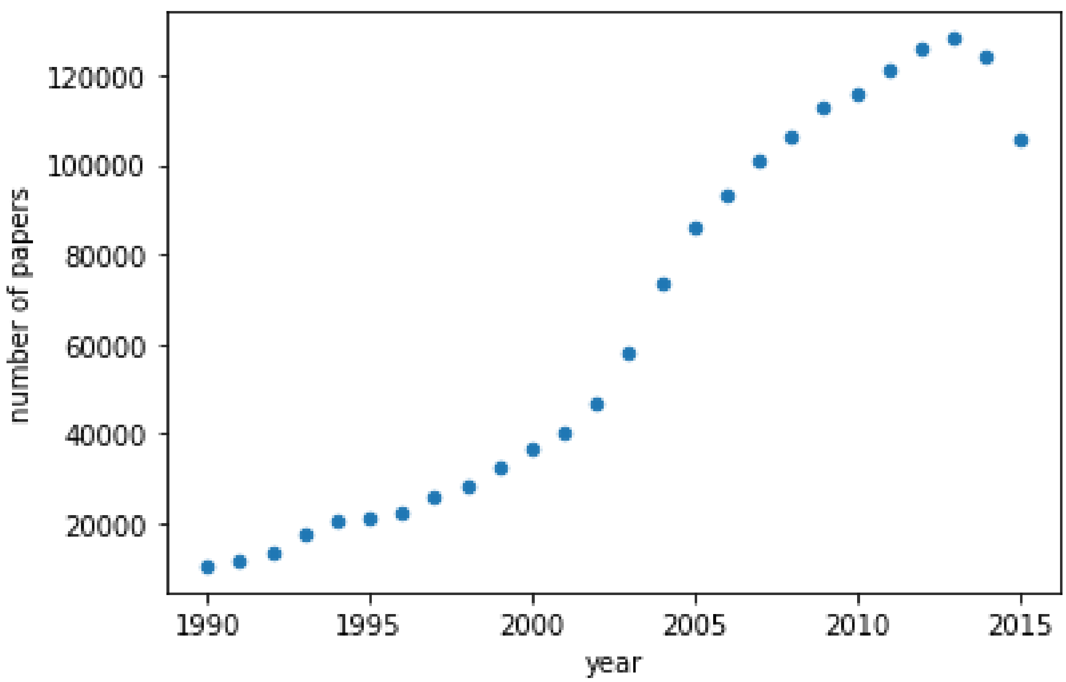
[9]:
```
2014    113308
2015    111441
2013    107439
2012    100868
2011     92914
2010     86390
2009     79643
2008     72474
2007     66958
2006     59665
2005     52474
2004     44429
2003     40648
2002     35316
2001     32921
2000     30846
1999     26084
1998     23625
1997     21491
1996     20078
1995     18390
1994     16810
1993     15366
```

```
1992    13455
1991    11976
1990    10266
Name: year, dtype: int64
```

[10]:
```
p_df['M'] = 1
```

[11]:
```
# Insight: positive trend of paper counts over year considering the full set of␣
↪data
p_df[p_df['venue_type'] == 1].groupby('year')\
    .agg('count')\
    .reset_index()\
    .rename(columns={'paperid':'number of papers'})\
    .plot.scatter('year', 'number of papers')
```

[11]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1166d72b0>
```

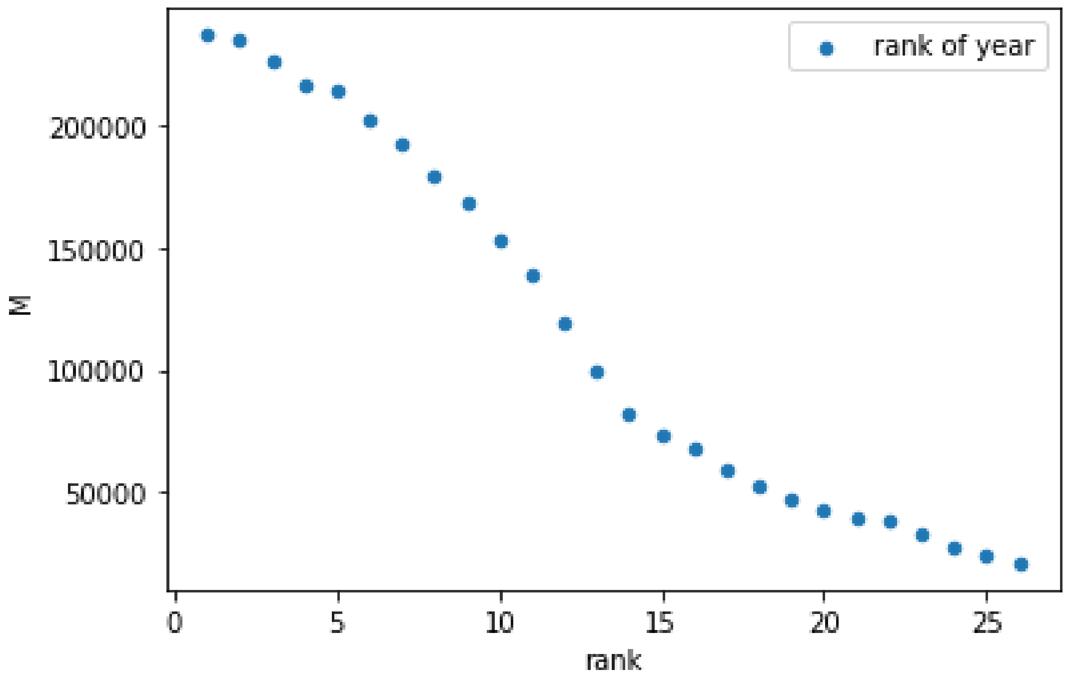


[32]:
```
def scatter(df, dimension):
    return df.groupby(dimension)\
        .agg('count')\
        .reset_index()\
        .rename(columns={'paperid':'number of papers'})\
        .plot.scatter(dimension, 'number of papers')
```

[23]:
```
def rank_scatter(df, dimension):
    rank_df = df.groupby(dimension).agg('count').reset_index()
    rank_df['rank'] = rank_df['M'].rank(method='first', ascending=False)
    return rank_df.plot.scatter(x='rank', y='M', label='rank of ' + dimension)
```

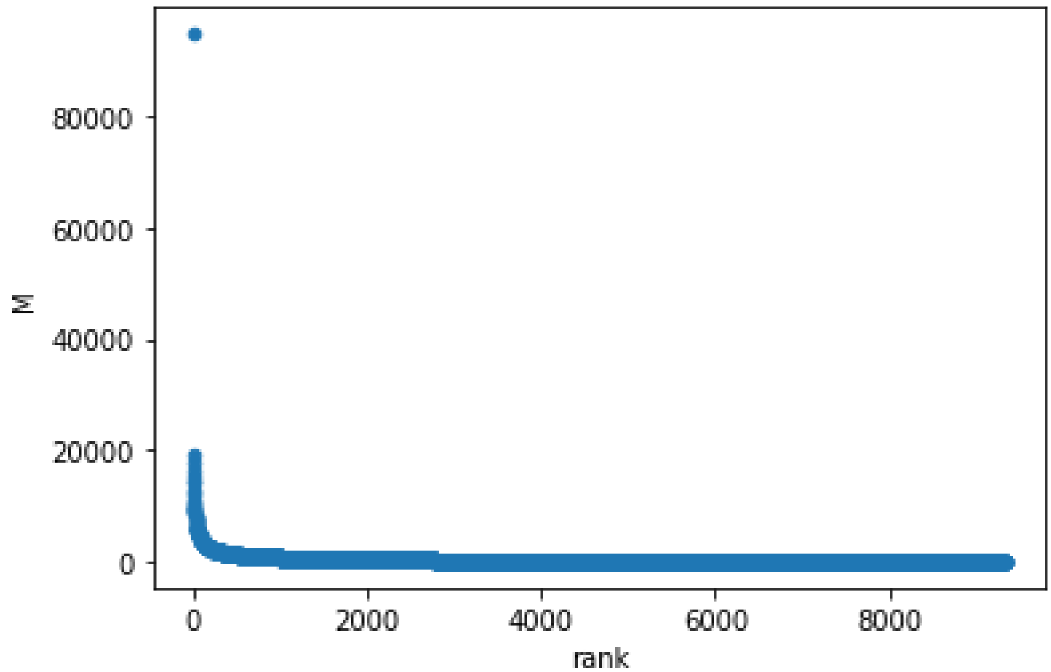
[26]:
```
rank_scatter(p_df, 'year')
```

[26]: <matplotlib.axes._subplots.AxesSubplot at 0x1169f4a90>



[15]:
```
venue_ranks['rank'] = venue_ranks['M'].rank(method='first', ascending=False)
venue_ranks.plot.scatter(x='rank', y='M')
```

[15]: <matplotlib.axes._subplots.AxesSubplot at 0x116402128>



[20]:
```
p_df['paperid'].rank()
```

[20]:
```
0          4674.0
1          4675.0
2          4692.0
3          4699.0
4          4734.0
            …
2991401    4583.0
2991402    4617.0
2991403    4627.0
2991404    4646.0
2991405    4653.0
Name: paperid, Length: 2991406, dtype: float64
```

[ ]:
```
p_df.groupby('venue_name').agg('count').head().rank()

df['rank'] = df['num_papers'].rank(method='first', ascending=False)
```

[41]:
```
result_set = p_df.groupby(['venue_name', 'year']).agg({'M':'sum'}).reset_index()
result_set['M'] = result_set.sort_values("year")['M'].diff()
result_set.head()
```

[41]:
```
        venue_name  year     M
0  "CloudCom-Asia  2015   7.0
1            #MSM  2011  -3.0
2            #MSM  2012 -13.0
3            #MSM  2013 -74.0
4            #MSM  2014 -78.0
```

[ ]:
```
result_set['absM'] = abs(result_set['M'])
```

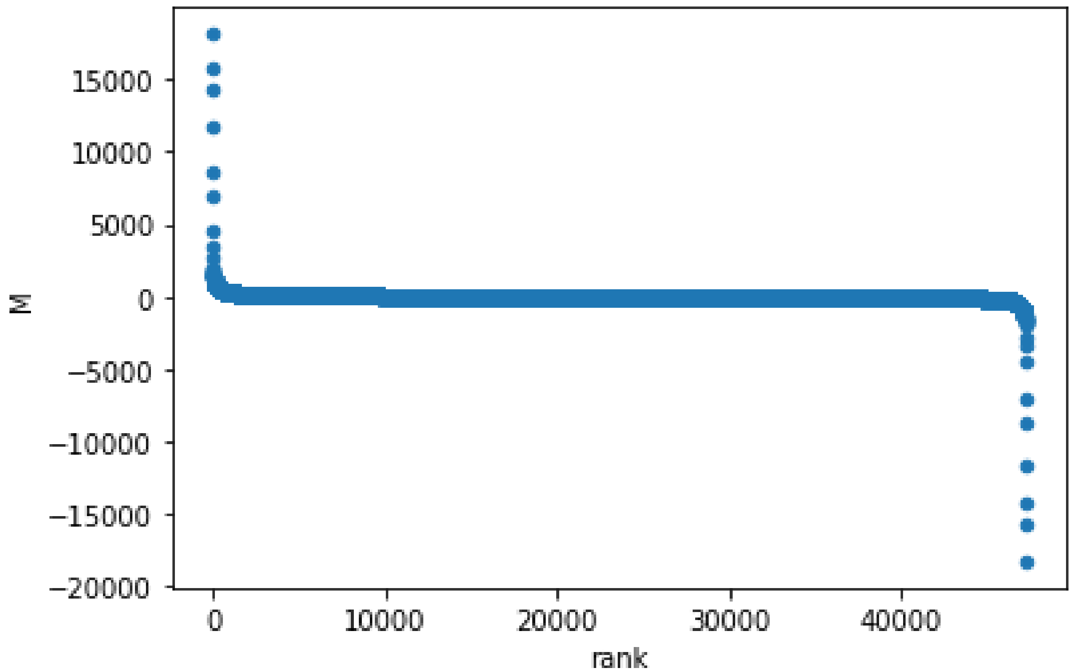
[ ]:
```
rank_scatter(result_set, 'absM')
```

[49]:
```
import scipy
result_set['logabsM'] = scipy.log2(result_set['absM'])
result_set['logrank'] = scipy.log2(result_set['M'].rank(method='first',␣
 ↪ascending=False))
```

```
/Users/jsennett/.pyenv/versions/3.6.1/envs/topk/lib/python3.6/site-
packages/ipykernel_launcher.py:2: DeprecationWarning: scipy.log2 is deprecated
and will be removed in SciPy 2.0.0, use numpy.lib.scimath.log2 instead

/Users/jsennett/.pyenv/versions/3.6.1/envs/topk/lib/python3.6/site-
packages/numpy/lib/scimath.py:122: RuntimeWarning: invalid value encountered in
less
  if any(isreal(x) & (x < 0)):
/Users/jsennett/.pyenv/versions/3.6.1/envs/topk/lib/python3.6/site-
packages/numpy/lib/scimath.py:412: RuntimeWarning: divide by zero encountered in
log2
  return nx.log2(x)
/Users/jsennett/.pyenv/versions/3.6.1/envs/topk/lib/python3.6/site-
packages/ipykernel_launcher.py:3: DeprecationWarning: scipy.log2 is deprecated
and will be removed in SciPy 2.0.0, use numpy.lib.scimath.log2 instead
  This is separate from the ipykernel package so we can avoid doing imports
until
```

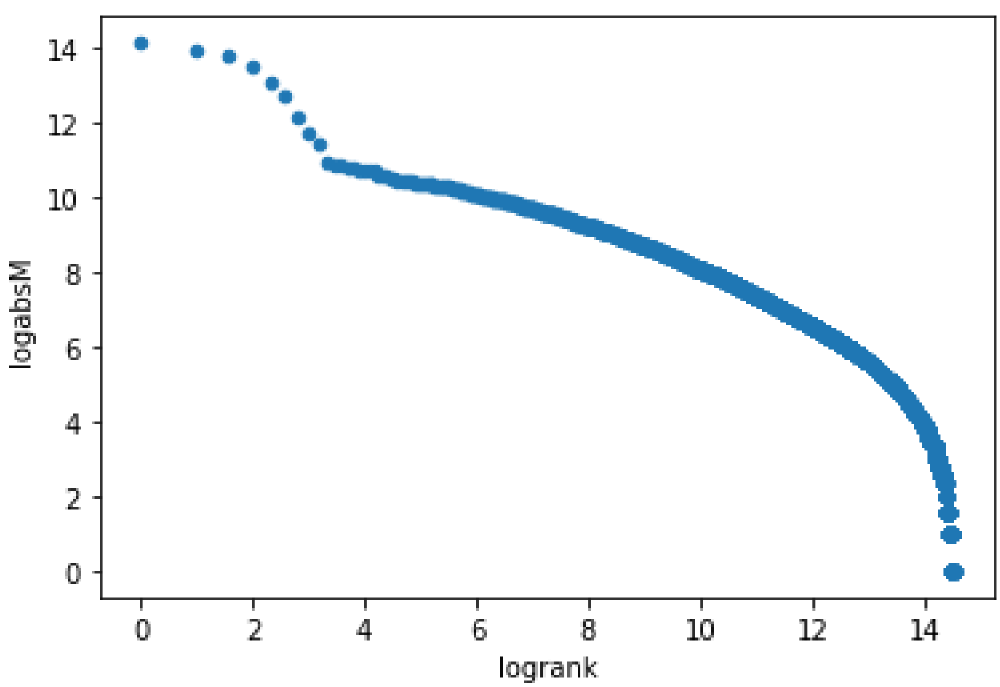
[63]:
```
result_set['rank'] = result_set['M'].rank(method='first', ascending=False)
result_set.plot.scatter('rank', 'M')
```

[63]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x12d765ba8>
```



[68]:
```
result_set[result_set['M'] > 0].plot.scatter('logrank', 'logabsM')
```

[68]: <matplotlib.axes._subplots.AxesSubplot at 0x1242ac358>



[ ]:
```
result_set[result_set['M'] > 50].plot.scatter('rank', 'M')
```

[ ]:
```
cutoff = 0.2
result_set[result_set['rank'] < cutoff * len(result_set)].plot.
↪scatter('logrank', 'logabsM')
```

[108]:
```
# pct of total:
pct_of_total = p_df.copy()
```

[109]:
```
pct_of_total = pct_of_total.groupby(['venue_name']).agg({'M':'sum'})
pct_of_total = pct_of_total.reset_index(drop=False)
pct_of_total.head()
```

[109]:

	venue_name	M
0	"CloudCom-Asia	29
1	#MSM	64
2	10th Anniversary Colloquium of UNU/IIST	26
3	15. WLP	12
4	1999 ACM SIGMOD Workshop on Research Issues in…	12

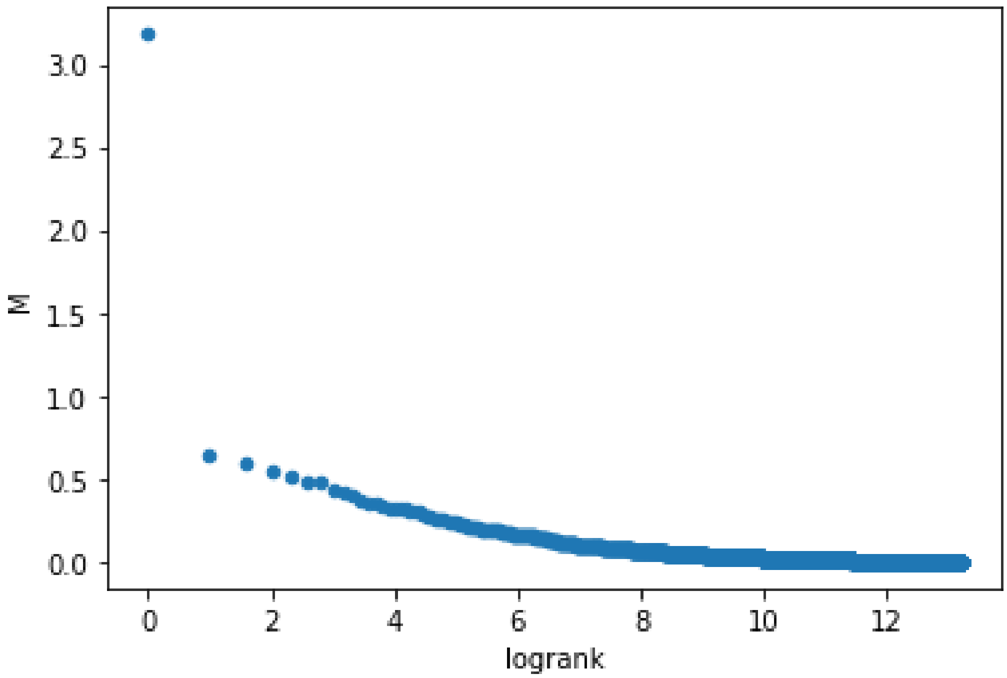
[110]:
```
pct_of_total['M'] = 100 * pct_of_total['M'] / sum(pct_of_total['M'])
```

[ ]:
```
pct_of_total['rank'] = pct_of_total['M'].rank(method='first', ascending=False)
pct_of_total.plot.scatter('rank', 'M')
```

[ ]:
```
pct_of_total['logrank'] = scipy.log2(pct_of_total['rank'])
pct_of_total['logM'] = scipy.log2(pct_of_total['M'])
pct_of_total.plot.scatter('logrank', 'logM')
```

[114]:
```
pct_of_total.plot.scatter('logrank', 'M')
```

[114]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x11e80d208>
```




```
[ ]: pct_of_total['M'] = 100 * result_set['M'] / sum(result_set['M'])
     result_set['M'] = 100 * result_set[self.measure] / sum(result_set[self.measure])
     p_df.head()
```

```
[127]: # Validate composite extractor result sets
       """
       INFO:root:Valid SG/CE combo: subspace({'year': 2000}), dim(venue_type),␣
        ↪ce([['count', 'count'], ['pct', 'year']])
       INFO:root:extract_result_set({'year': 2000}, venue_type, [['count', 'count'],␣
        ↪['pct', 'year']]
       INFO:root:RESULT SET:
            venue_type  year  count mod2         M
       10            0  2000  30846    *  2.363180
       36            1  2000  36539    *  2.175786
       62            3  2000     43    *  0.633844
       """
       print(100 * len(p_df[(p_df['year']==2000) & (p_df['venue_type'] == 0)]) /␣
        ↪len(p_df[p_df['venue_type']==0]))
       print(100 * len(p_df[(p_df['year']==2000) & (p_df['venue_type'] == 1)]) /␣
        ↪len(p_df[p_df['venue_type']==1]))
       print(100 * len(p_df[(p_df['year']==2000) & (p_df['venue_type'] == 3)]) /␣
        ↪len(p_df[p_df['venue_type']==3]))
```

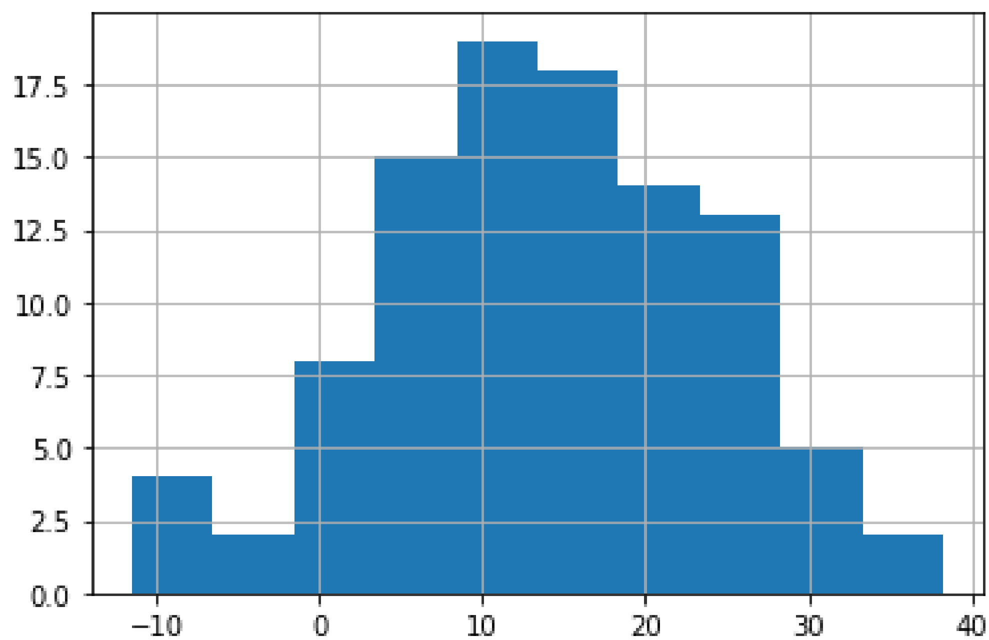
```
2.3631801727605293
2.175786183558252
```

```
0.6338443396226415
```

```
[ ]: """
INFO:root:extract_result_set({'year': 2000}, venue_type, [['count', 'count'],␣
 ↪['delta_prev', 'year']]
returning result set:

    venue_type  year  count mod2     M
1            0  2000  30846    *  4762
3            1  2000  36539    *  3805
5            3  2000     43    *     3
"""
print(len(p_df[(p_df['year'] == 2000) & (p_df['venue_type'] == 0)]) -␣
 ↪len(p_df[(p_df['year'] == 1999) & (p_df['venue_type'] == 0)]))
print(len(p_df[(p_df['year'] == 2000) & (p_df['venue_type'] == 1)]) -␣
 ↪len(p_df[(p_df['year'] == 1999) & (p_df['venue_type'] == 1)]))
print(len(p_df[(p_df['year'] == 2000) & (p_df['venue_type'] == 3)]) -␣
 ↪len(p_df[(p_df['year'] == 1999) & (p_df['venue_type'] == 3)]))
```

```
[134]: x = pd.DataFrame([10 * np.random.normal() + 15 for _ in range(100)],␣
 ↪columns=['M'])
x['M'].hist()
```

```
[134]: <matplotlib.axes._subplots.AxesSubplot at 0x11efa0ba8>
```



[ ]:
```
max(x['M'])
scipy.stats.norm.pdf()
```

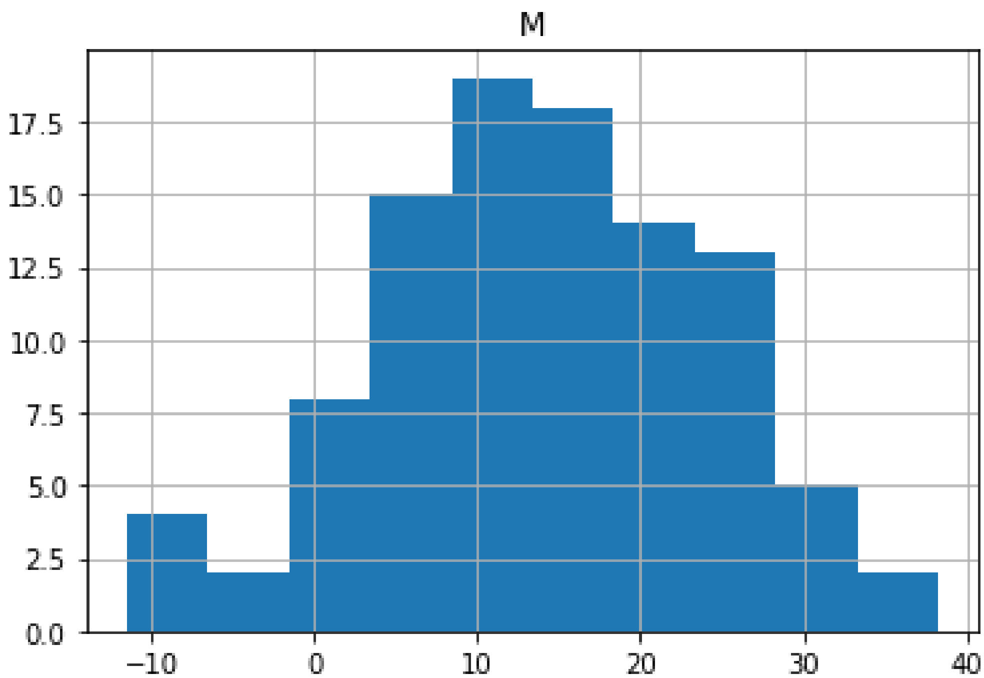
[ ]:
```
(38 - x['M'].mean()) / x['M'].std()
```

[ ]:
```
scipy.stats.norm.ppf(100/)
```

[ ]:
```
x.rank(method='first', ascending=False)
```

[147]:
```
x.hist()
```

[147]:
```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x13f067eb8>]],
      dtype=object)
```



[156]:
```
x['rank'] = x['M'].rank(ascending=True, method='first')
x['pct'] = x['rank'] / (len(x)+1)
x['Z'] = (x['M'] - x['M'].mean()) / x['M'].std()
x['predZ'] = scipy.stats.norm.pdf(x['pct'])
x['pred'] = x['pct'] * x['M'].std() + x['M'].mean()
```

[ ]:
```
x['pred'].hist()
```

[166]:
```
x.head(25)
```

[166]:

	M	rank	pct	Z	predZ	pred
0	6.771423	22.0	0.217822	-0.700520	0.389589	15.949612
1	38.250489	100.0	0.990099	2.449180	0.244366	23.667987
2	-8.598282	3.0	0.029703	-2.238366	0.398766	14.069496
3	19.697190	73.0	0.722772	0.592793	0.307236	20.996242
4	-2.258100	6.0	0.059406	-1.603987	0.398239	14.366356
5	28.667375	94.0	0.930693	1.490323	0.258714	23.074266
6	7.262322	25.0	0.247525	-0.651402	0.386906	16.246473
7	30.158047	96.0	0.950495	1.639475	0.253940	23.272173
8	24.714445	85.0	0.841584	1.094804	0.279971	22.183684
9	-0.213637	8.0	0.079208	-1.399424	0.397693	14.564263
10	16.941651	62.0	0.613861	0.317082	0.330433	19.907753
11	-11.494205	1.0	0.009901	-2.528124	0.398923	13.871589
12	13.252900	47.0	0.465347	-0.052003	0.358004	18.423450
13	13.814717	52.0	0.514851	0.004211	0.349422	18.918218
14	7.703141	27.0	0.267327	-0.607295	0.384939	16.444380
15	2.012392	13.0	0.128713	-1.176694	0.395651	15.059031
16	21.757046	76.0	0.752475	0.798896	0.300578	21.293102
17	23.147003	80.0	0.792079	0.937971	0.291524	21.688916
18	20.522275	74.0	0.732673	0.675349	0.305030	21.095195
19	24.218423	84.0	0.831683	1.045174	0.282299	22.084730
20	17.951269	65.0	0.643564	0.418101	0.324320	20.204614
21	7.833889	28.0	0.277228	-0.594213	0.383903	16.543334
22	23.822498	82.0	0.811881	1.005559	0.286931	21.886823
23	23.863100	83.0	0.821782	1.009621	0.284620	21.985777
24	11.288491	42.0	0.415842	-0.248556	0.365898	17.928683

[176]:

```
x.head()
```

[176]:

	M
0	6.771423
1	38.250489
2	-8.598282
3	19.697190
4	-2.258100

[177]:

```
xmean = x['M'].mean()
xstd = x["M"].std()
```

[ ]:

```
x['rank'] = x['M'].rank(method='first')
x.plot.scatter('rank', 'M')
```

[184]:

```

```

[193]:

```
(1 - scipy.stats.norm.cdf(x_max_Z)) / (.01)
```

[193]: 0.5536938553650228

[198]:
```python
alpha = 1/100
x_max_p = 1 - scipy.stats.norm.cdf(x_max_Z)
print(x_max_p)
```

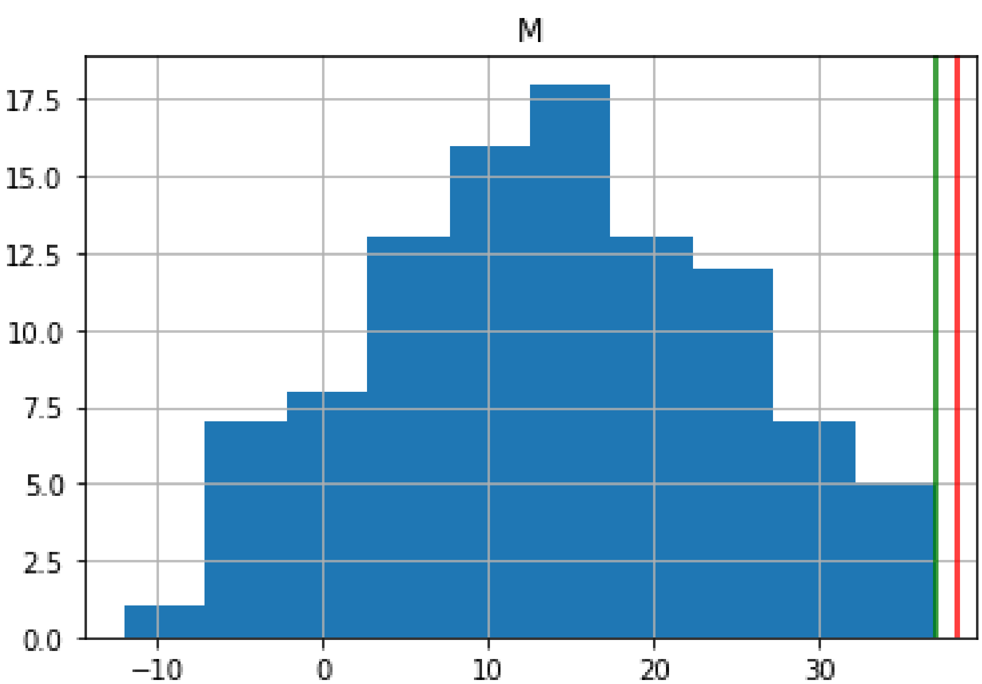
```
0.005536938553650228
```

[ ]:
```python
significance = max(1 - x_max_p / alpha, 0.0)
print(significance)
```

[ ]:
```python

```

[234]:
```python
x = pd.DataFrame([10 * np.random.normal() + 15 for _ in range(100)], columns=['M'])
x_max = max(x['M'])
x_mean = x.drop(x['M'].idxmax())['M'].mean()
x_std = x.drop(x['M'].idxmax())['M'].std()
x_max_Z = (x_max - x_mean)/x_std
x_max_p = 1 - scipy.stats.norm.cdf(x_max_Z)

x.hist()
plt.axvline(scipy.stats.norm.ppf(.99)  * x_std + x_mean, color='r')
plt.axvline(x_max, color='g')
print("significance:", max(1 - x_max_p / alpha, 0.0))
```

```
significance: 0.0
```

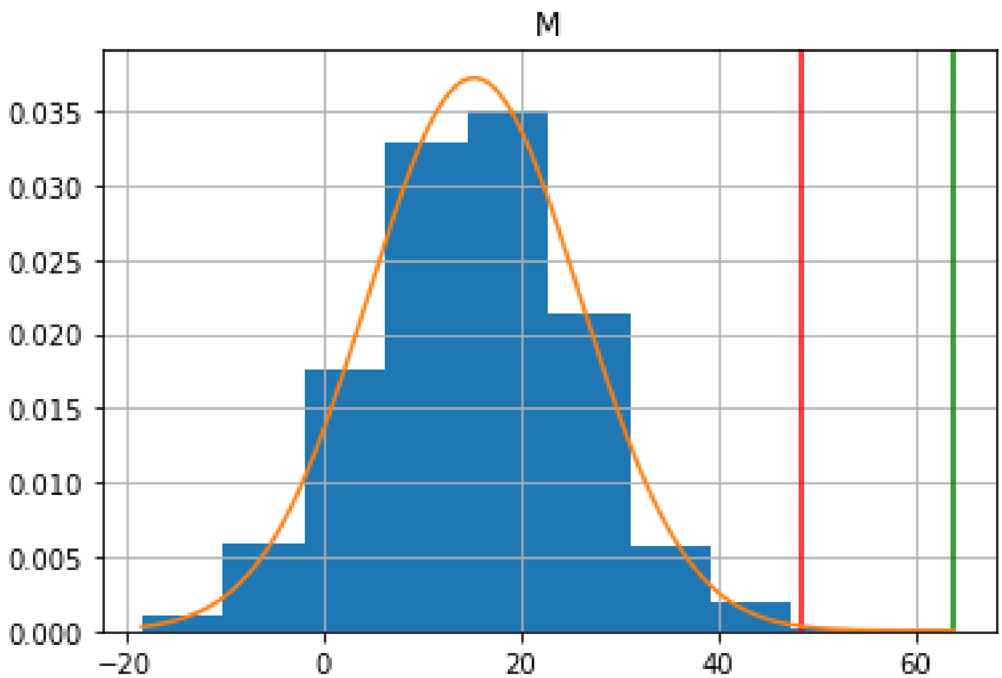


[ ]:
```
x = pd.DataFrame([10 * np.random.normal() + 15 for _ in range(100)],␣
↪columns=['M'])
x_max = max(x['M'])
x_mean = x.drop(x['M'].idxmax())['M'].mean()
x_std = x.drop(x['M'].idxmax())['M'].std()
x_max_Z = (x_max - x_mean)/x_std
x_max_p = 1 - scipy.stats.norm.cdf(x_max_Z)

x.hist()
plt.axvline(scipy.stats.norm.ppf(.99)  * x_std + x_mean, color='r')
plt.axvline(x_max, color='g')
print("significance:", max(1 - x_max_p / alpha, 0.0))
```

[346]:
```
def simulate(n):
    x = pd.DataFrame([10 * np.random.normal() + 15 for _ in range(n)],␣
↪columns=['M'])
    x_max = max(x['M'])
    alpha = 1/n

    x_mean = x['M'].mean()
    x_std = x['M'].std()
    x_max_Z = (x_max - x_mean)/x_std
    x_max_p = 1 - scipy.stats.norm.cdf(x_max_Z)

    x.hist(density=True)
    plt.axvline(scipy.stats.norm.ppf(1-1/n) * x_std + x_mean, color='r',␣
↪label='expected max val')
    plt.axvline(x_max, color='g', label='actual max val')

    # plot normal dist
    x_axis = np.arange(min(x['M']), max(x['M']), .001)
    plt.plot(x_axis, scipy.stats.norm.pdf(x_axis,x_mean,x_std))
    # Mean = 0, SD = 2.

    print("significance:", max(1 - x_max_p / alpha, 0.0))
    print("x_max_p", x_max_p)
    print("alpha (1/n)", alpha)
```

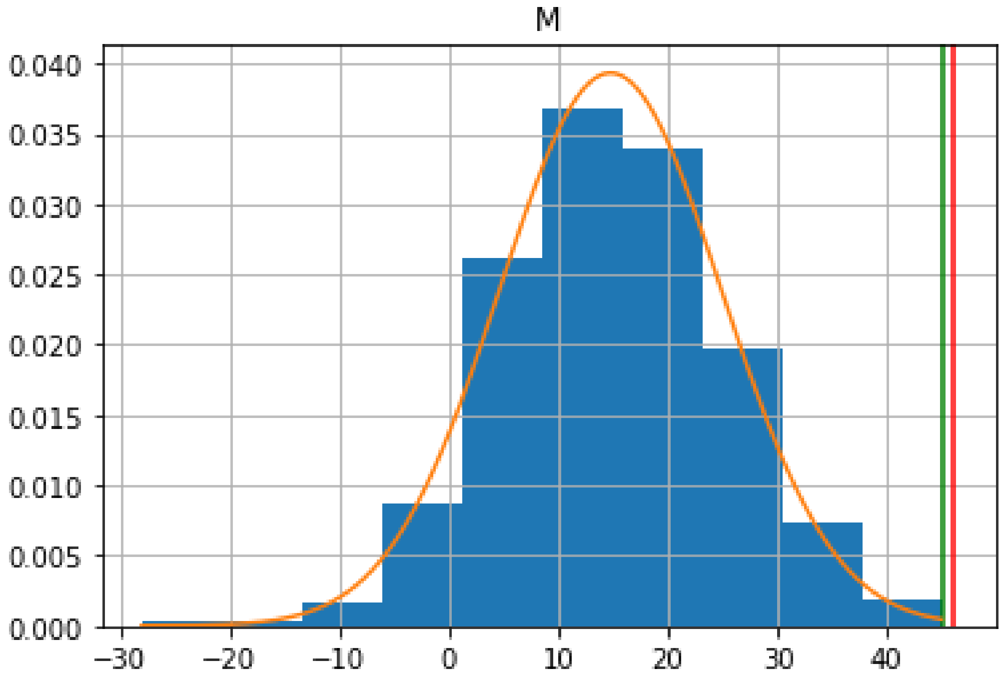
[348]:
```
simulate(1000)
```

```
significance: 0.9971802493782258
x_max_p 2.8197506217741974e-06
alpha (1/n) 0.001
```



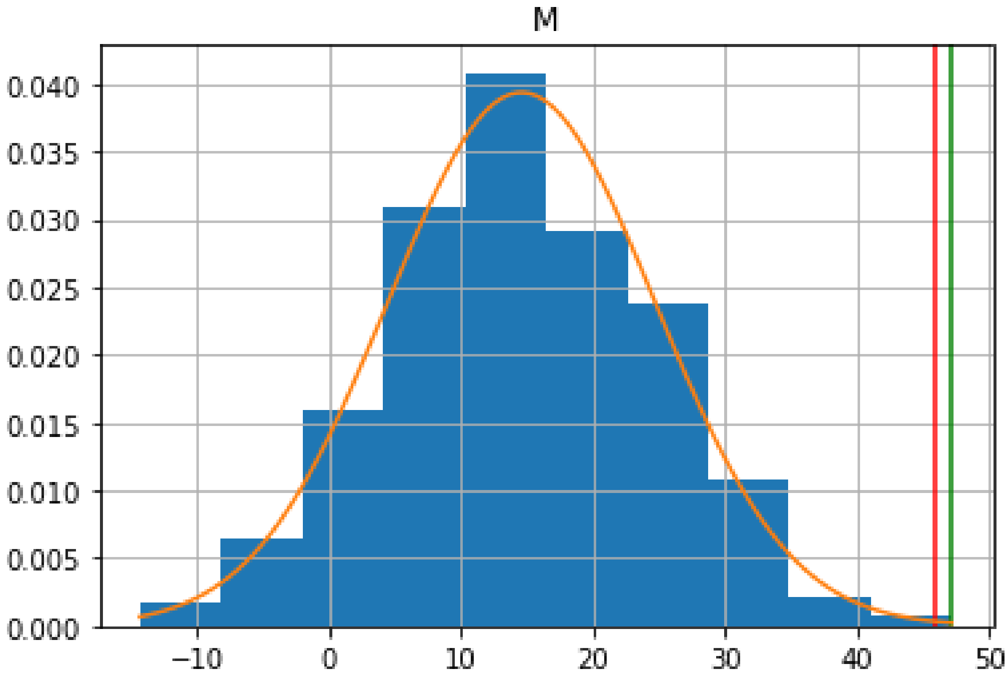
[351]:
```
simulate(1000)
```

```
significance: 0.0
x_max_p 0.0014602342050724637
alpha (1/n) 0.001
```



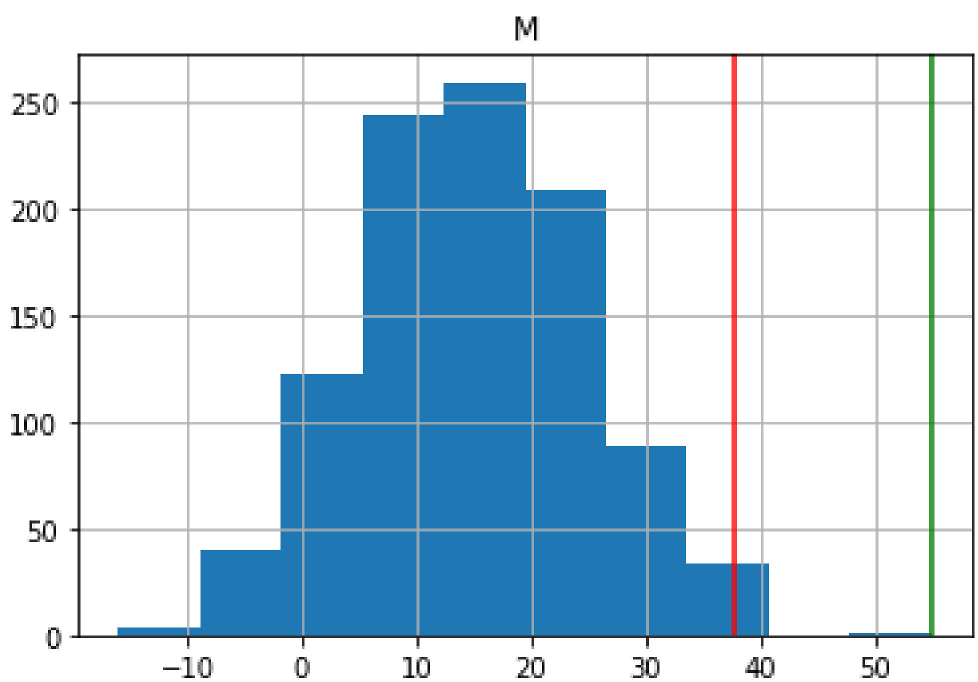
[353]:
```
simulate(1000)
```

```
significance: 0.352953613979355 65
x_max_p 0.0006470463860206443
alpha (1/n) 0.001
```



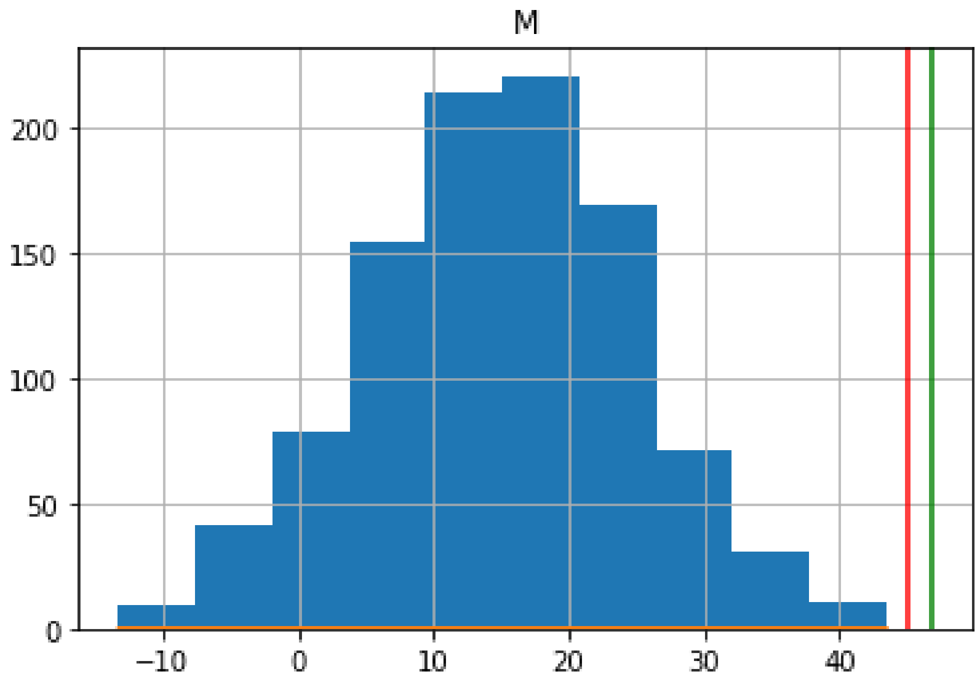
[241]:
```
simulate(1000)
```

```
significance: 0.997779697503486
```



[279]:
```
simulate(1000)
```

```
significance: 0.9470496492825933
```



[ ]:
```
scipy.stats.norm.ppf(.5, x_mean, x_std)
```

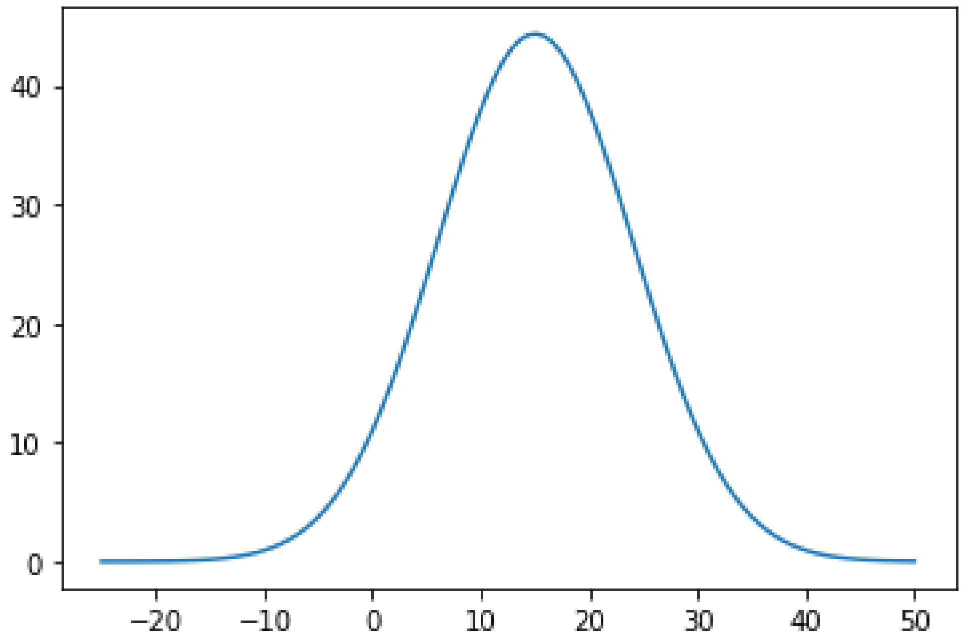
[ ]:
```
scipy.stats.norm.pdf(x_mean, x_mean, x_std)
```

[290]:
```
x_std
```

[290]:
```
9.039491770341439
```

[293]:
```
x_min = -25
x_max = 50
mean = 15
std = 9
x = np.linspace(x_min, x_max, 100)
y = scipy.stats.norm.pdf(x,mean,std) * 1000
plt.plot(x, y)
```

[293]:
```
[<matplotlib.lines.Line2D at 0x131f88dd8>]
```



[ ]:
```python
import numpy as np
from scipy.stats import norm
import matplotlib.pyplot as plt
```

[ ]:
```python
# Plot the histogram.
plt.hist(data, bins=25, density=True, alpha=0.6, color='g')

# Plot the PDF.
xmin, xmax = plt.xlim()
x = np.linspace(xmin, xmax, 100)
p = norm.pdf(x, mu, std)
plt.plot(x, p, 'k', linewidth=2)
title = "Fit results: mu = %.2f,  std = %.2f" % (mu, std)
plt.title(title)

plt.show()
```

[ ]:
```python
p_df[p_df['venue_name'] == 'CoRR']
```

[ ]:
```python
result_set = p_df
analysis_dimension = 'venue_name'
subspace = {'venue_name':'CoRR'}
result_set[result_set[analysis_dimension] == subspace[analysis_dimension]]
```

[405]:
```
p_df = p_df.fillna('')
school_size = p_df.groupby('school').agg({"M":"sum"})
school_size[school_size['M'] > len(p_df) * .01]
```

[405]:
```
              M
school
        2984622
```

[ ]:
```
p_df = pd.read_csv(papers_filename, encoding='mac_roman', dtype = {'school':
↪str})
```

[409]:
```
len(p_df)
```

[409]: 0.9493745166098949