Power Grid

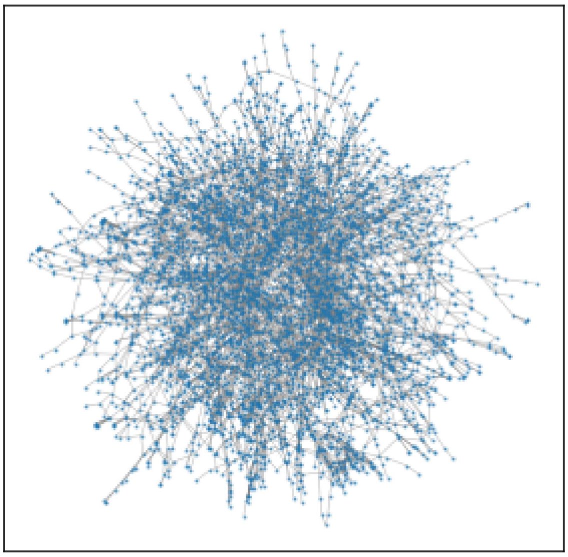
In [62]:

```
import numpy as np
import networkx as nx
G = nx.read_edgelist('networks/networks_barabasi/powergrid.edgelist.txt',create_using=n
x.Graph(), nodetype = int)
```

Visualização

In [63]:

```
plt.figure(figsize=(5,5))
nx.draw_networkx(G, node_size=1, edge_color='grey', alpha=0.5, width=0.5, with_labels=F
alse)
plt.show()
```



Caracterização

In [64]:

```
n = G.number_of_nodes()
m = G.number_of_edges()
print('Número de vértices:', n)
print('Número de arestas:', m)
print('Grafo conexo?',nx.is_connected(G))
```

```
Número de vértices: 4941
Número de arestas: 6594
Grafo conexo? True
```

1) Grau

In [65]:

```
degrees = np.array([val for (node, val) in G.degree()])
```

In [66]:

```
from statistics import median
print('Máximo:', degrees.max())
print('Mínimo:', degrees.min())
print('Média:',degrees.mean())
print('Mediana:', median(degrees))
print('Desvio padrão:', degrees.std())
```

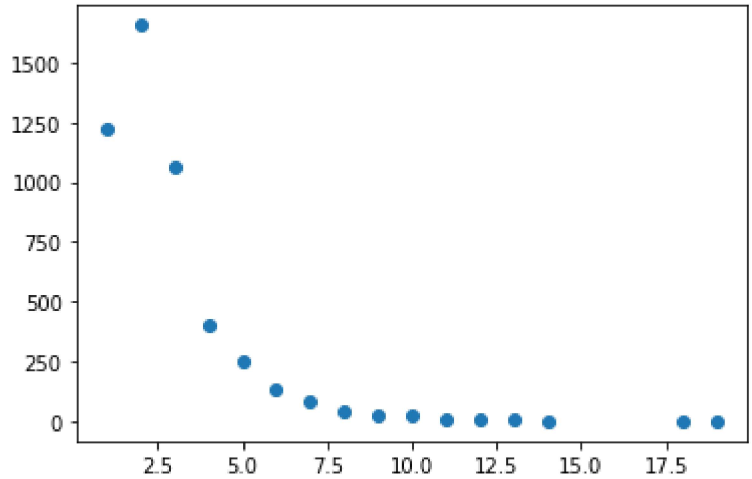
```
Máximo: 19
Mínimo: 1
Média: 2.66909532483303
Mediana: 2
Desvio padrão: 1.7912722617587216
```

Distribuição empírica

PMF:

In [67]:

```
x, f = np.unique(degrees, return_counts=True)
plt.scatter(x,f)
#plt.xticks(range(1,len(f)+1))
plt.show()
```



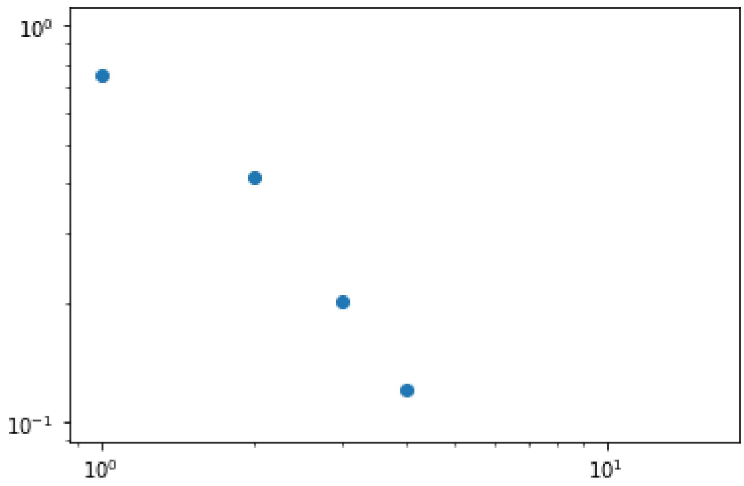
CCDF:

In [68]:

```
cdf = f.cumsum()/f.sum()
ccdf = 1-cdf

# Outro médodo:
#ccdf2 = np.zeros(len(f))
#for k,_ in enumerate(f):
#    ccdf2[k]  = 1-f[0:k+1].sum()

plt.scatter(range(1,len(f)+1),ccdf)
#plt.plot(range(1,len(f)+1),ccdf2)
plt.xscale('log')
plt.yscale('log')
plt.show()
```



2) Distância

Calculando a distância entre cada par de vértices:

In [69]:

```
dist = np.array([])
for v in G.nodes():
    spl = nx.single_source_shortest_path_length(G, v) # distância short path lenght
    spl2 = dict((v2,d) for v2,d in spl.items() if v2 != v) # distância exluindo d(v,v)
    dist = np.append(dist, list(spl2.values()))
```

Estatísticas básicas:

In [70]:

```
print('Máximo:', dist.max())
print('Mínimo:', dist.min())
print('Média:',dist.mean())
print('Mediana:', median(dist))
print('Desvio padrão:', dist.std())
```

```
Máximo: 46.0
Mínimo: 1.0
Média: 18.989185424445708
Mediana: 19.0
Desvio padrão: 6.507554119713548
```

Verificando o cálculo da distância média através do método disponibilizado pela biblioteca:

In [71]:

```
d_mean = nx.average_shortest_path_length(G)
print('Distância média:',d_mean)
```

```
Distância média: 18.989185424445708
```

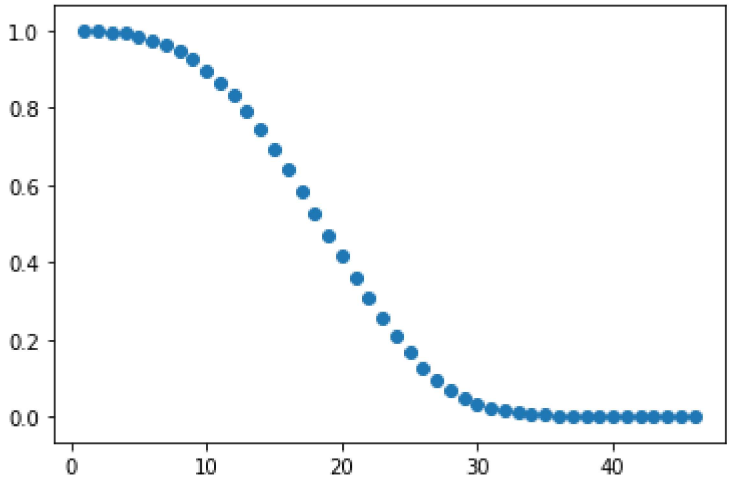
Frequência relativa e CCDF:

In [72]:

```
from scipy.special import comb
Lmax = comb(n,2) # número máximo de arestas

counts, f_d = np.unique(dist, return_counts=True)
cdf = f_d.cumsum()/f_d.sum()
ccdf = 1-cdf

plt.scatter(counts,ccdf)
plt.show()
```



3) Tamanho das componentes conexas

Número de componentes conexas:

In [73]:

```
nx.number_connected_components(G)
```

Out[73]:

```
1
```

Tamanho das componentes:

In [74]:

```
[len(c) for c in sorted(nx.connected_components(G), key=len, reverse=True)]
```

Out[74]:

```
[4941]
```

4) Clusterização

4.1) Clusterização Local

In [75]:

```
cluster = np.array(list(nx.clustering(G).values()))
print('Máximo:', cluster.max())
print('Mínimo:', cluster.min())
print('Média:', cluster.mean())
print('Mediana:', median(cluster))
print('Desvio padrão:', cluster.std())
```

```
Máximo: 1.0
Mínimo: 0.0
Média: 0.08010361108159712
Mediana: 0.0
Desvio padrão: 0.22418727760531196
```

Verificando a clusterização média:

In [76]:

```
nx.average_clustering(G)
```

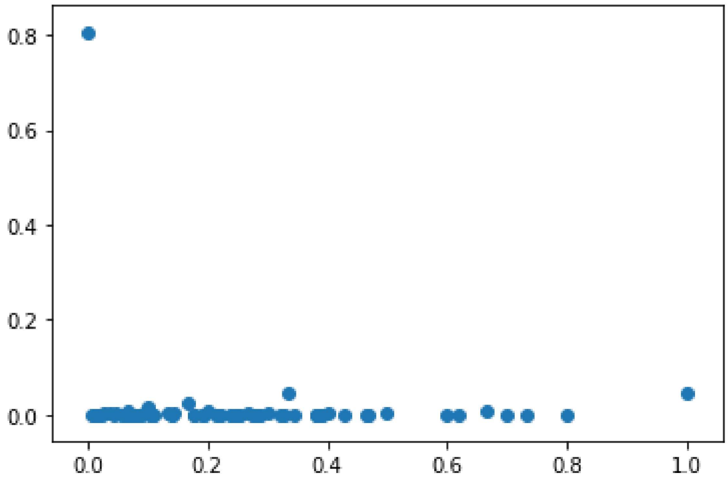
Out[76]:

```
0.08010361108159712
```

PMF:

In [77]:

```
x, f = np.unique(cluster, return_counts=True)
pmf = f/f.sum()
plt.scatter(x,pmf)
plt.show()
```

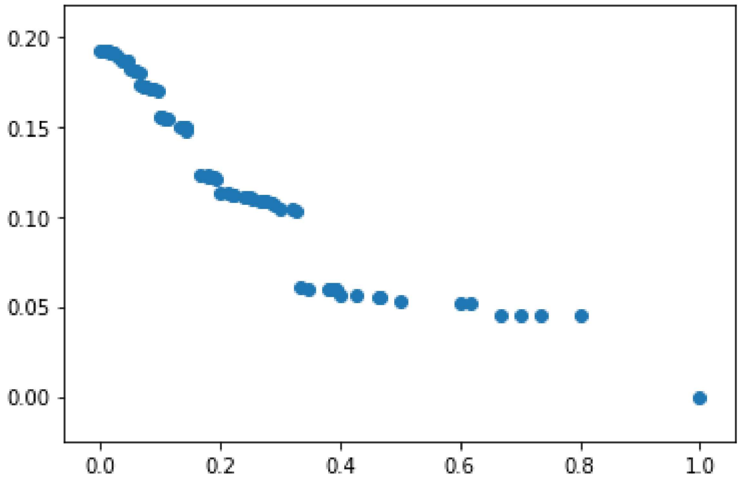


CCDF:

In [78]:

```
x, f = np.unique(cluster, return_counts=True)
cdf = f.cumsum()/f.sum()
ccdf = 1-cdf

plt.scatter(x,ccdf)
plt.show()
```



4.2) Clusterização global

In [79]:

```
n_triang = np.array(list(nx.triangles(G).values())).sum()/3 # método conta 3 vezes o tr
iângula (1x para cada vértice)
print('Número de triângulos:', n_triang)
```

```
Número de triângulos: 651.0
```

Clusterização global:

In [80]:

```
nx.transitivity(G)
```

Out[80]:

```
0.10315322452860086
```

5) Centralidade

5.1) Centralidade de Grau

In [81]:

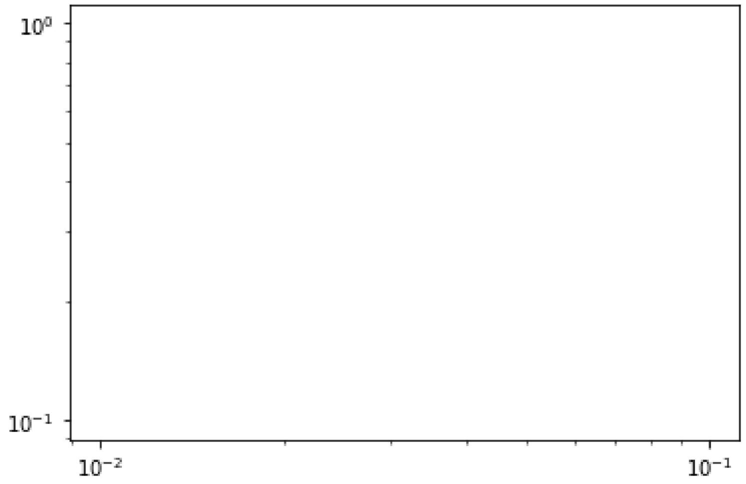
```
cent = np.array(list(nx.degree_centrality(G).values()))
print('Máximo:', cent.max())
print('Mínimo:', cent.min())
print('Média:', cent.mean())
print('Mediana:', median(cent))
print('Desvio padrão:', cent.std())
```

```
Máximo: 0.003846153846153846
Mínimo: 0.00020242914979757084
Média: 0.0005403026973346214
Mediana: 0.0004048582995951417
Desvio padrão: 0.00036260572100378977
```

CCDF:

In [82]:

```
x, f = np.unique(cent, return_counts=True)
cdf = f.cumsum()/f.sum()
ccdf = 1-cdf
plt.scatter(x,ccdf)
plt.xscale('log')
plt.yscale('log')
plt.show()
```



5.2) Betweeness

In [83]:

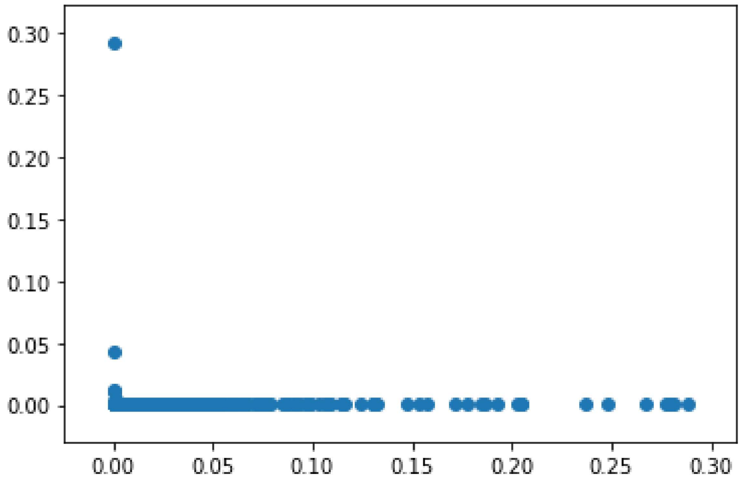
```
btw = np.array(list(nx.betweenness_centrality(G).values()))
print('Máximo:', btw.max())
print('Mínimo:', btw.min())
print('Média:', btw.mean())
print('Mediana:', median(btw))
print('Desvio padrão:', btw.std())
```

```
Máximo: 0.28841562147939637
Mínimo: 0.0
Média: 0.0036422728132103127
Mediana: 0.00040485829959514 17
Desvio padrão: 0.016669177769166967
```

PMF:

In [84]:

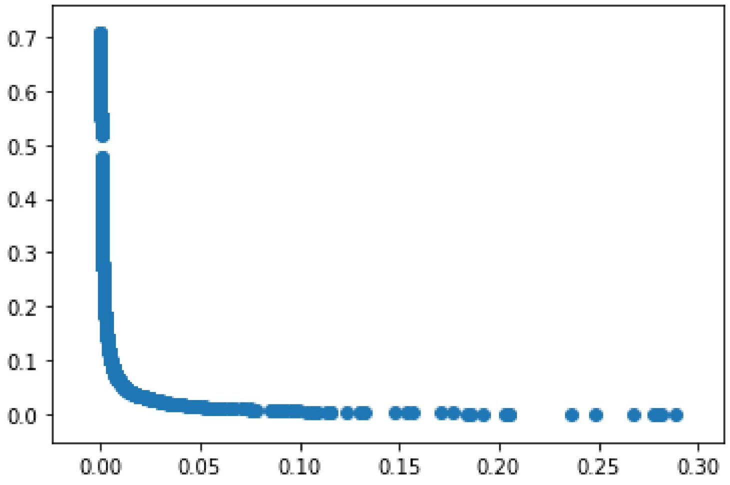
```
x, f = np.unique(btw, return_counts=True)
pmf = f/f.sum()
plt.scatter(x,pmf)
plt.show()
```



CCDF:

In [85]:

```
x, f = np.unique(btw, return_counts=True)
cdf = f.cumsum()/f.sum()
ccdf = 1-cdf
plt.scatter(x,ccdf)
plt.show()
```



Visualziação do Betweenes:

In [86]:

```
#nx.draw_circular(G, node_color=btw, cmap=plt.cm.Blues, with_labels=True)
```

5.3) Closeness

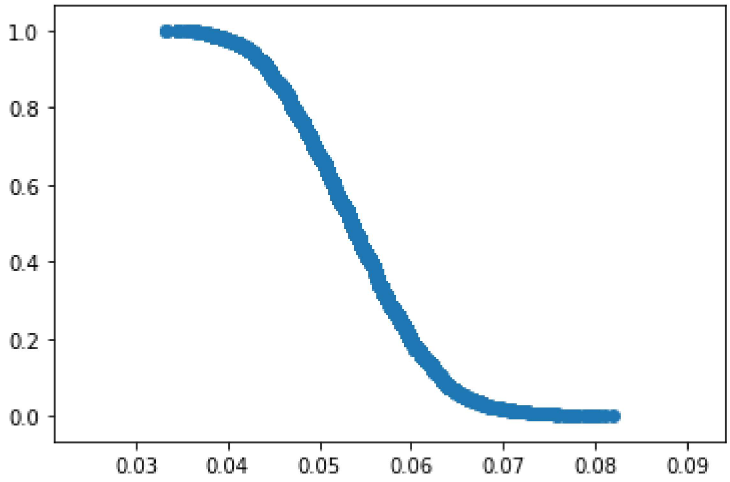
In [87]:

```
close = np.array(list(nx.closeness_centrality(G).values()))
print('Máximo:', close.max())
print('Mínimo:', close.min())
print('Média:', close.mean())
print('Mediana:', median(close))
print('Desvio padrão:', close.std())
```

```
Máximo: 0.08182330142114155
Mínimo: 0.033368458025992274
Média: 0.05367887533707091
Mediana: 0.05346031058925383
Desvio padrão: 0.007378657435766654
```

In [88]:

```
x, f = np.unique(close, return_counts=True)
cdf = f.cumsum()/f.sum()
ccdf = 1-cdf
plt.scatter(x,ccdf)
plt.show()
```



In [89]:

```
#nx.draw_circular(G, node_color=close, cmap=plt.cm.Blues, with_labels=True)
```

5.4) Auto-Vetor

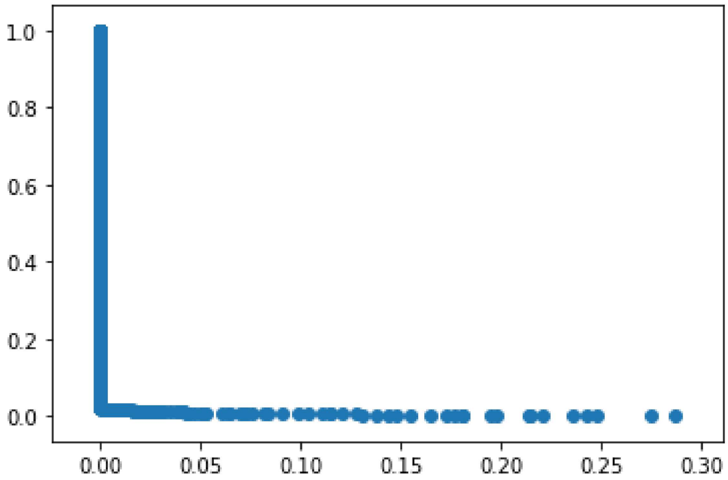
In [90]:

```
ev = np.array(list(nx.eigenvector_centrality(G).values()))
print('Máximo:', ev.max())
print('Mínimo:', ev.min())
print('Média:', ev.mean())
print('Mediana:', median(ev))
print('Desvio padrão:', ev.std())
```

```
Máximo: 0.2865344997425942
Mínimo: 2.5844534949806683e-13
Média: 0.0013748720743855974
Mediana: 6.487236204115351e-09
Desvio padrão: 0.014159728362837043
```

In [91]:

```
x, f = np.unique(ev, return_counts=True)
cdf = f.cumsum()/f.sum()
ccdf = 1-cdf
plt.scatter(x,ccdf)
plt.show()
```



In [92]:

```
#nx.draw_circular(G, node_color=ev, cmap=plt.cm.Blues, with_labels=True)
```

5.6) PageRank

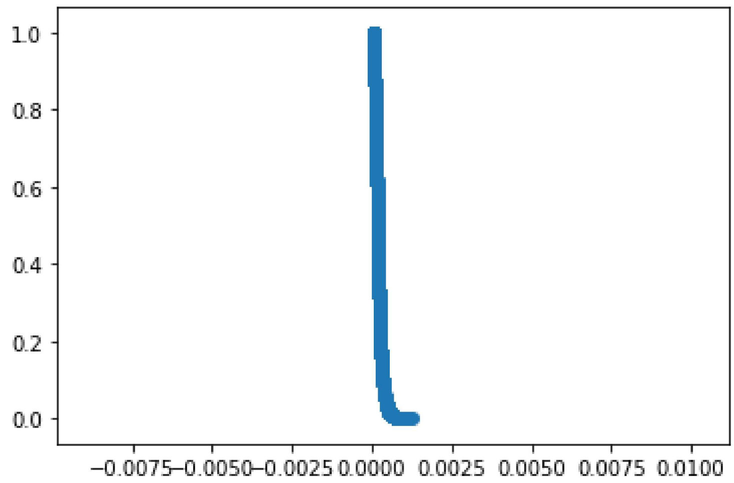
In [93]:

```
pr = np.array(list(nx.pagerank(G, alpha=0.9).values()))
print('Máximo:', pr.max())
print('Mínimo:', pr.min())
print('Média:', pr.mean())
print('Mediana:', median(pr))
print('Desvio padrão:', pr.std())
```

```
Máximo: 0.0012619217986757857
Mínimo: 5.514453821082074 5e-05
Média: 0.0002023881805302 57
Mediana: 0.00017454400746322047
Desvio padrão: 0.00011315279016893226
```

In [94]:

```
x, f = np.unique(pr, return_counts=True)
cdf = f.cumsum()/f.sum()
ccdf = 1-cdf
plt.scatter(x,ccdf)
#plt.xscale('log')
#plt.yscale('log')
plt.show()
```



In [95]:

```
#nx.draw_circular(G, node_color=pr, cmap=plt.cm.Blues, with_labels=True)
```

5) Similaridade

5.1) Jaccard

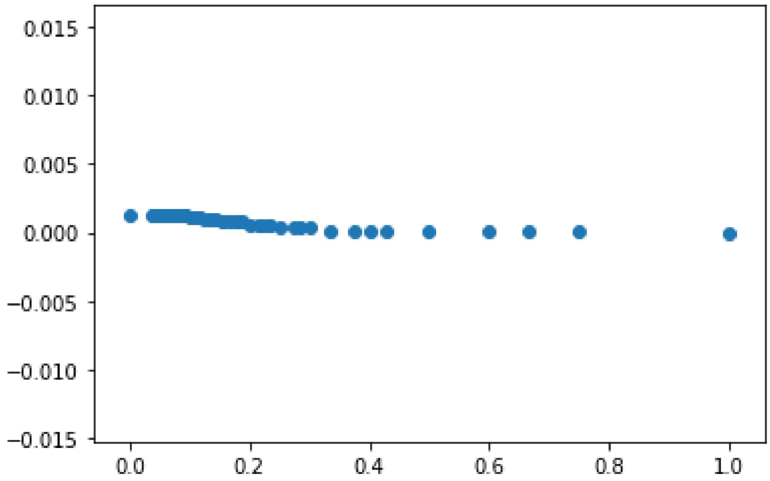
In [96]:

```
jaccard = np.array([p for (u, v, p) in nx.jaccard_coefficient(G)])
print('Máximo:', jaccard.max())
print('Mínimo:', jaccard.min())
print('Média:', jaccard.mean())
print('Mediana:', median(jaccard))
print('Desvio padrão:', jaccard.std())
```

```
Máximo: 1.0
Mínimo: 0.0
Média: 0.0003192309409136126
Mediana: 0.0
Desvio padrão: 0.010867012863508618
```

In [97]:

```
x, f = np.unique(jaccard, return_counts=True)
cdf = f.cumsum()/f.sum()
ccdf = 1-cdf
plt.scatter(x,ccdf)
#plt.xscale('log')
#plt.yscale('log')
plt.show()
```

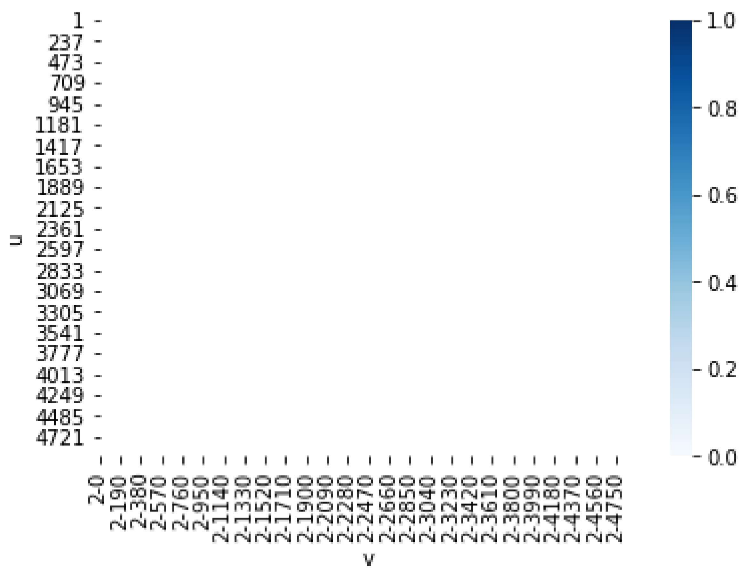


In [98]:

```
mapa = [[u,v, p] for (u, v, p) in nx.jaccard_coefficient(G)]

import pandas as pd
df = pd.DataFrame(mapa)
df.set_index([0,1],inplace=True)
df_m = df.unstack(level=0)

import seaborn as sns
ax = sns.heatmap(df_m, cmap=plt.cm.Blues)
locs, labels = plt.xticks()
#plt.xticks(locs,range(1,33,2))
plt.xlabel('v')
plt.ylabel('u')
plt.show()
```



5.2) Adamic/Adar

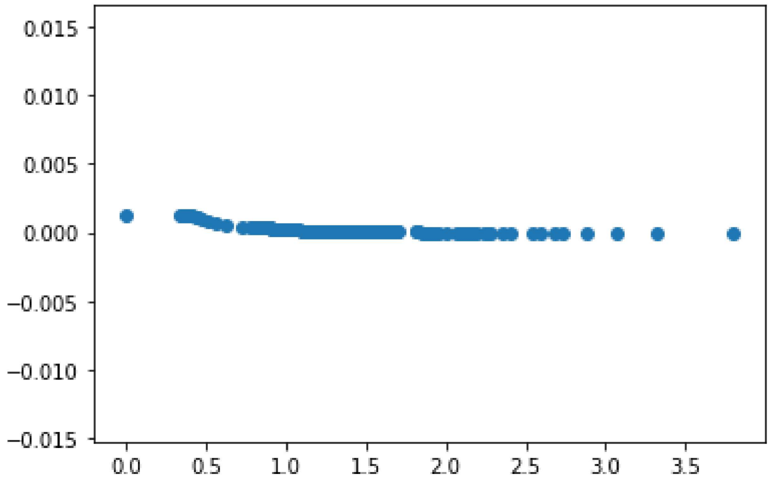
In [99]:

```
adamic = np.array([p for (u, v, p) in nx.adamic_adar_index(G)])
print('Máximo:', adamic.max())
print('Mínimo:', adamic.min())
print('Média:', adamic.mean())
print('Mediana:', median(adamic))
print('Desvio padrão:', adamic.std())
```

```
Máximo: 3.7956293084047643
Mínimo: 0.0
Média: 0.0009516694695484576
Mediana: 0.0
Desvio padrão: 0.029036748421469256
```

In [100]:

```
x, f = np.unique(adamic, return_counts=True)
cdf = f.cumsum()/f.sum()
ccdf = 1-cdf
plt.scatter(x,ccdf)
plt.show()
```



In [101]:

```
#pairs = dict([((u,v), p) for (u, v, p) in nx.adamic_adar_index(G)])
mapa = [[u,v, p] for (u, v, p) in nx.adamic_adar_index(G)]

import pandas as pd
df = pd.DataFrame(mapa)
df.set_index([0,1],inplace=True)
df_m = df.unstack(level=0)

import seaborn as sns
ax = sns.heatmap(df_m, cmap=plt.cm.Blues)
locs, labels = plt.xticks()
#plt.xticks(locs,range(1,34,2))
plt.xlabel('v')
plt.ylabel('u')
plt.show()
```