# Źródło danych

https://comtrade.un.org/data/ (https://comtrade.un.org/data/)

Analizę przeprowadzono na podstawie danych dotyczących eksportu między Polską i państwami z nią graniczącymi, a pozostałymi krajami. Dane zostały przygotowane przez United Nations (ONZ) i dotyczą roku 2018 zawierając (po wstępnym przetworzeniu przy użyciu programu CSVed) kolejno: państwo eksportujące, państwo importujące, sumaryczny koszt transakcji podany w US\$.

### In [4]:

```
import tabulate
import pandas as pd
fileName = "data.csv"
data = pd.read_csv(fileName, sep = ',', usecols= [0,1,2])
data.head()
```

#### Out[4]:

	Reporter	Partner	Trade Value (US\$)
0	Poland	Afghanistan	9596572
1	Poland	Albania	66487707
2	Poland	Antarctica	499190
3	Poland	Algeria	376354867
4	Poland	American Samoa	2404

# Utworzenie grafu

### In [5]:

## Analiza grafu

#### In [6]:

```
print(f'Liczba wierzchołków: {g.number_of_nodes()}')
print(f'Liczba krawędzi: {g.number_of_edges()}')
print(f'Gęstość: {nx.density(g)}')
print(f'Średnica: {nx.diameter(g)}')
print(f'Liczba węzłów: {g.order()}')
print(f'Rozmiar: {g.size()}')
```

Liczba wierzchołków: 230 Liczba krawędzi: 1570

Gęstość: 0.059616479969622174

Średnica: 3

Liczba węzłów: 230 Rozmiar: 1570

#### In [7]:

```
import matplotlib.pyplot as plt
import warnings
warnings.filterwarnings('ignore')

degree = dict(g.degree(weight='Trade Value (US$)'))
sorted_degree = {r: degree[r] for r in sorted(degree, key=degree.get)}

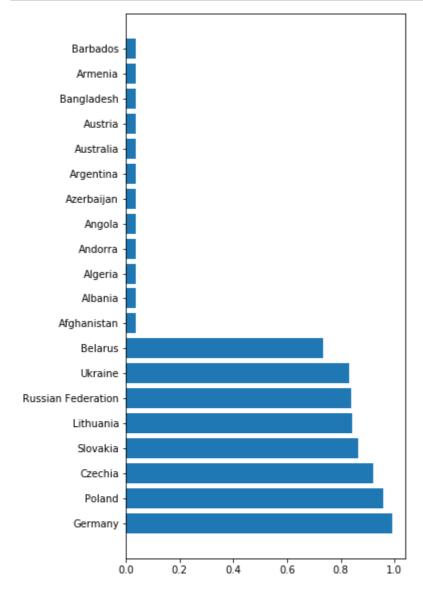
plt.figure(figsize=(5, 10))
plt.barh(list(sorted_degree.keys()), sorted_degree.values())
plt.show()
```

<Figure size 500x1000 with 1 Axes>

Wyznaczamy stopień centralności dla każdego z wierzchołków. Aby wykres był czytelny, pod uwagę wzięto jedynie pierwszych 20 węzłów z największym stopniem. Oczywiście dane opisują eksport z Polski i państw z nią graniczących, dlatego dla nich stopień będzie największy. Widać natomiast, że naszym najbliższym sąsiedztwie niemiecki eksport jest największy, jednak tuż za nimi jest Polska.

#### In [8]:

```
degree_centrality = dict(nx.degree_centrality(g))
sorted_degree_centrality = {r: degree_centrality[r] for r in sorted(degree_centrality,
key=degree_centrality.get, reverse = True)[:20]}
plt.figure(figsize=(5, 10))
plt.barh(list(sorted_degree_centrality.keys()), sorted_degree_centrality.values())
plt.show()
```

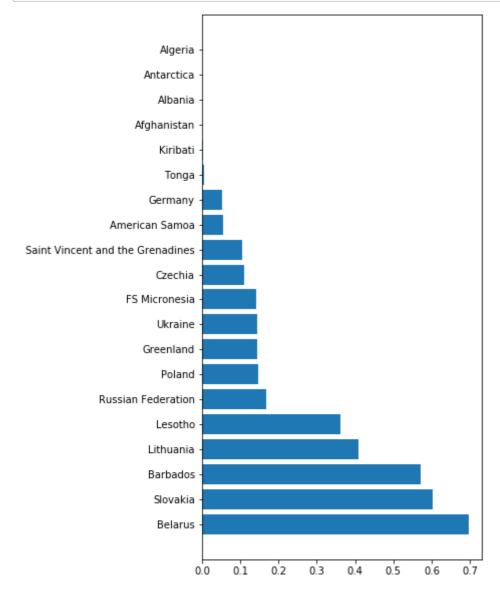


Sprawdzamy jak ważne dla (sieci) eksportu z okolicznego regionu są poszczególne węzły (państwa) za pomocą miary centralności przechodniości.

#### In [9]:

```
betweenness_centrality = dict(nx.betweenness_centrality(g, weight='Trade Value (US$)'))
sorted_betweenness_centrality = {r: betweenness_centrality[r] for r in sorted(betweenne
ss_centrality, key=betweenness_centrality.get, reverse = True)[:20]}

plt.figure(figsize=(5, 10))
plt.barh(list(sorted_betweenness_centrality.keys()), sorted_betweenness_centrality.valu
es())
plt.show()
```



Wyznaczenie współczynnika grupowania, który jest miarą stopnia, w jakim węzły wykazują tendencję do skupiania się

#### In [23]:

```
clustering_coefficient = nx.clustering(g, weight='Trade Value (US$)')
sorted_clustering_coefficient = {r: clustering_coefficient[r] for r in sorted(clusterin
g_coefficient, key=clustering_coefficient.get, reverse = True)[:20]}

plt.figure(figsize=(5, 10))
plt.barh(list(sorted_clustering_coefficient.keys()), sorted_clustering_coefficient.valu
es())
plt.show()
```

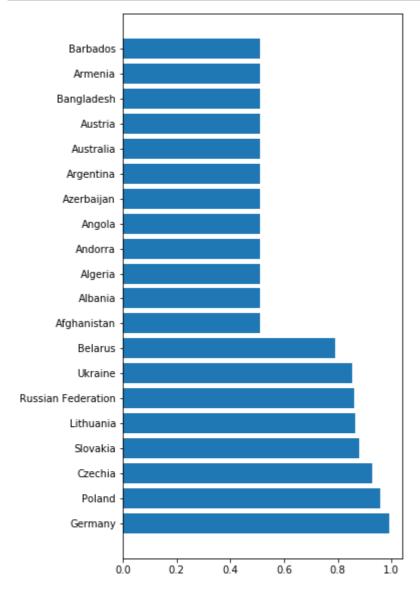


Miara centralności bliskości mówi o tym, jak ważną rolę w grafie odgrywa dany wierzchołek. W tym przypadku mowa o tym, jak ważną rolę pełni w przepływie pieniędzy płynących z okolicznego eksportu. Mierzy się ją jako średnią odległość do wszystkich pozostałych węzłów.

#### In [11]:

```
closeness_centrality = dict(nx.closeness_centrality(g))
sorted_closeness_centrality = {r: closeness_centrality[r] for r in sorted(closeness_centrality, key=closeness_centrality.get, reverse = True)[:20]}

plt.figure(figsize=(5, 10))
plt.barh(list(sorted_closeness_centrality.keys()), sorted_closeness_centrality.values
())
plt.show()
```

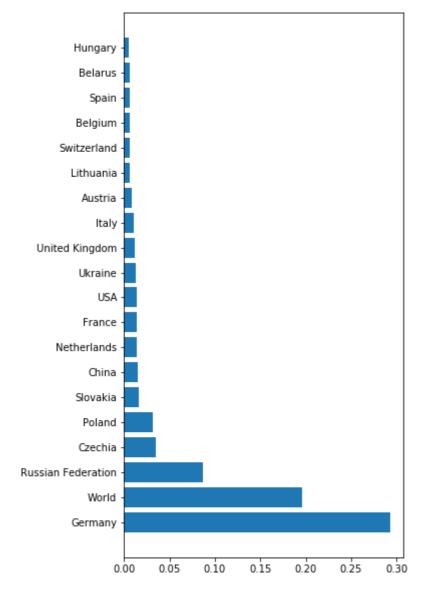


Miara PageRank pzostała zaprojektowana przez założycieli przedsiębiorstwa Google i nazwana nazwiskiem jednego z nich. PageRank jest rozwinięciem znanej od dawna heurystyki, wedle której jakość węzła jest proporcjonalna do liczby węzłów z nim powiązanych.

#### In [12]:

```
pagerank = dict(nx.pagerank(g, weight='Trade Value (US$)'))
sorted_pagerank = {r: pagerank[r] for r in sorted(pagerank, key=pagerank.get, reverse =
True)[:20]}

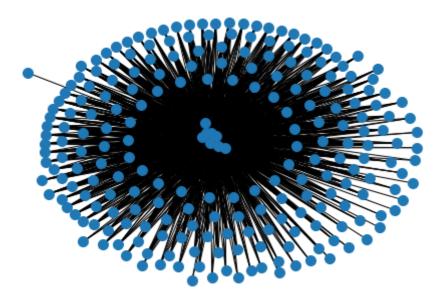
plt.figure(figsize=(5, 10))
plt.barh(list(sorted_pagerank.keys()), sorted_pagerank.values())
plt.show()
```



# Wizualizacja grafu

### In [13]:

nx.draw\_kamada\_kawai(g, node\_size=100, weight='Trade Value (US\$)')

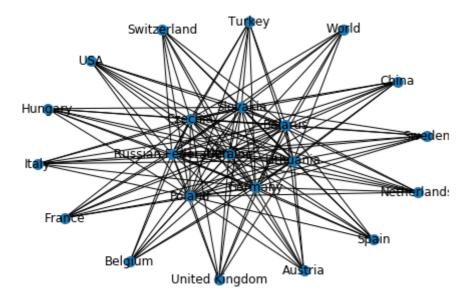


Kraje pełniące najważniejszą rolę w eksporcie z okolicznego regionu (których udział w tym procesie przewyższa średnią).

#### In [24]:

```
degrees = dict(g.degree(weight='Trade Value (US$)')).values()
avg = sum(degrees) / len(degrees)

selected_nodes = {k: v for k, v in dict(g.degree(weight='Trade Value (US$)')).items() i
f v > avg}
subgraph = g.subgraph(selected_nodes)
nx.draw_kamada_kawai(subgraph, node_size=100, with_labels=True, label_color='r', weight
='Trade Value (US$)')
```



Stosunek krawędzi do węzłów - możliwy eksport towarów do pozostałych krajów

#### In [18]:

```
countries = dict(g.degree(weight='Trade Value (US$)')).keys()
countries_ordered = sorted(countries)
datas = []
for key in countries_ordered:
   data = \{\}
    data['Kraj'] = key
    data['Liczba partnerów'] = len(g.edges(key))
    edges = [tuple[1] for tuple in list(g.edges(key))]
    data['Lista partnerów'] = '\n'.join(sorted(edges))
    datas.append(data)
sorted_datas = sorted(datas, key=lambda x:x['Liczba partnerów'], reverse=True)
import tabulate
print("Pierwsze 8 (interesuje nas jedynie Polska i kraje graniczące - pozostałe zawsze
będą mieć liczbę krawędzi <= 8)")
header = ['Kraj', 'Liczba partnerów', 'Lista partnerów']
rows = [x.values() for x in sorted_datas[:8]]
print(tabulate.tabulate(rows, header, "fancy_grid"))
print('...')
```

Pierwsze 8 (interesuje nas jedynie Polska i kraje graniczące - pozostałe zawsze będą mieć liczbę krawędzi <= 8)

Kraj	Liczba partnerów	Lista partnerów
Germany	227	†   Afghanistan
		Albania
		Algeria
		American Samoa
		Andorra
		Angola
		Anguilla
		Antarctica
		Antigua and Barbuda
		Argentina
		Armenia
		Aruba
		Australia
		Austria
		Azerbaijan
		Bahamas
		Bangladesh
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	Bouvet Island
	Br. Virgin Isds
	Brazil
	Brunei Darussalam
	Bulgaria
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	Burkina Faso
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	Cabo Verde
I	Cambodia
	Cameroon
	Canada
I	Cayman Isds
I	Central African Rep.
I	Chad
I	Chile
I	China
I	Christmas Isds
	Colombia
I	Comoros
	Congo
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		1	Uruguay
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		Burkina Faso
		Cabo Verde
	1	Cambodia
	1	Cameroon
	1	Canada
	1	Cayman Isds

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	Congo
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	Cyprus
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	Côte d'Ivoire
1	Dem. Rep. of the Congo
1	Denmark
	Djibouti
	Dominica
	Dominican Rep.
	Ecuador
	Egypt
	El Salvador
	Equatorial Guinea
	Eritrea
	Estonia
	Eswatini
	Ethiopia
	FS Micronesia
	Faeroe Isds
	Falkland Isds (Malvinas)

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	Fiji
	Finland
	Fr. South Antarctic Terr.
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	French Polynesia
	Gabon
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		State of Palestine
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		Trinidad and Tobago
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	l l	Guyana
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	I I	Hungary
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	Japan
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	Kazakhstan
	Kenya
	Kuwait
	Kyrgyzstan
	Lao People's Dem. Rep.
	Latvia
	Lebanon
	Lesotho
	Liberia
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	Luxembourg
	Madagascar
	Malawi
	Malaysia
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		Oman
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		Papua New Guinea
		Paraguay
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		Russian Federation
		Rwanda

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	1	Saint Barthélemy
	1	Saint Kitts and Nevis
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	Uruguay
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	Zambia
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Russian Federation	192   Afghanistan
	Albania
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	Australia
	Austria

12.2020	U		Untitled
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	1	Faeroe Isds
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	Bolivia (Plurinational State o
f)   	Bosnia Herzegovina
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	Brazil
	Brunei Darussalam
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	Burkina Faso
	Burundi
	Cabo Verde

02.2020		Untitled
		Cambodia
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		Canada
		Central African Rep.
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	1	Dem. People's Rep. of Korea
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72.2020		Ontitica
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	I	Marshall Isds
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	I	Mauritius
	I	Mexico
	I	Mongolia
	I	Montenegro
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	I	Mozambique
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		Netherlands
	I	New Caledonia

02.2020 I		Untitled
		New Zealand
	1	Nicaragua
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		North Macedonia
		Norway
		Oman
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		Paraguay
		Peru
		Philippines
		Poland
		Portugal
		Qatar
		Rep. of Korea
		Rep. of Moldova
		Romania
	1	Russian Federation
		Rwanda
		Saint Kitts and Nevis
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		Singapore
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	1	Switzerland
	1	Syria
	1	Tajikistan
	1	Thailand
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			Austria
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72.2020			Office
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Rwanda
San Marino
Saudi Arabia
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Sierra Leone
Singapore
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Slovenia
South Africa
South Sudan
Spain
Sri Lanka
State of Palestine
Sudan
Sweden

02.2020	1	Untitled
		Switzerland
		Syria
		Tajikistan
		Thailand
		Togo
		Trinidad and Tobago
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	l I	Uganda
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## Pytania biznesowe

## 1. Który z krajów jest największym eksporterem w okolicznym dla Polski regionie?

Wcześniejsza analiza wykazała, że największą liczbę partnerów oraz największe zyski z eksportu zarabiają Niemcy

## 2. Jakie 6 krajów pełnią najważniejszą rolę w przepływie towarów z okolicznego regionu (Polski i państw z nią graniczących)?

Są to: USA, Wlk. Bryt. Francja, Holandia, Włochy. Ich udział 3-krotnie przewyższa średnią.

## 3. Rola którego z krajów biorących udział w przepływie pieniędzy wygenerowanych z okolicznego eksportu jest największa?

Odpowiedź na to pytanie dostarcza nam miara centralności przechodniości (betweenness centrality), która opisuje wpływ konkretnego wierzchołka na dyfuzję informacji w grafie. Tym krajem jest Białoruś.