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## **The Impact of Covid-19 Break-Out on the Trade Relations among the G-20's Countries.**

Submitted to Socio-Computing Department, English Section, Faculty of  
Economics and Political Science

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## Abstract

One of the main roles of the G20 is they are withdrawing from ambitious attempts to open world markets in favour of perusing preferential trade arrangements to deliver economic growth and employment and to take incremental steps to reduce margins of preference and continue to gradually eliminate discrimination in international trade. In this research we will form a network analysis shows the 19 countries then apply some metrics on them to be able to understand their relations and how different attributes for countries would affect trade among them to be able to compare trade transaction volume before Covid-19 and during Covid-19.

# *Chapter One:*

# *Introduction*

## **Overview:**

International trade is considered as economic transactions that are made among the world's countries. The items that are commonly traded are: consumer goods, such as clothing; capital goods, such as machinery; and raw materials and food. Or even other transactions involve services, such as travel services and payments for foreign patents; International trade transactions are facilitated by international financial payments, in which the private banking system and the central banks of the trading nations play major and important roles.

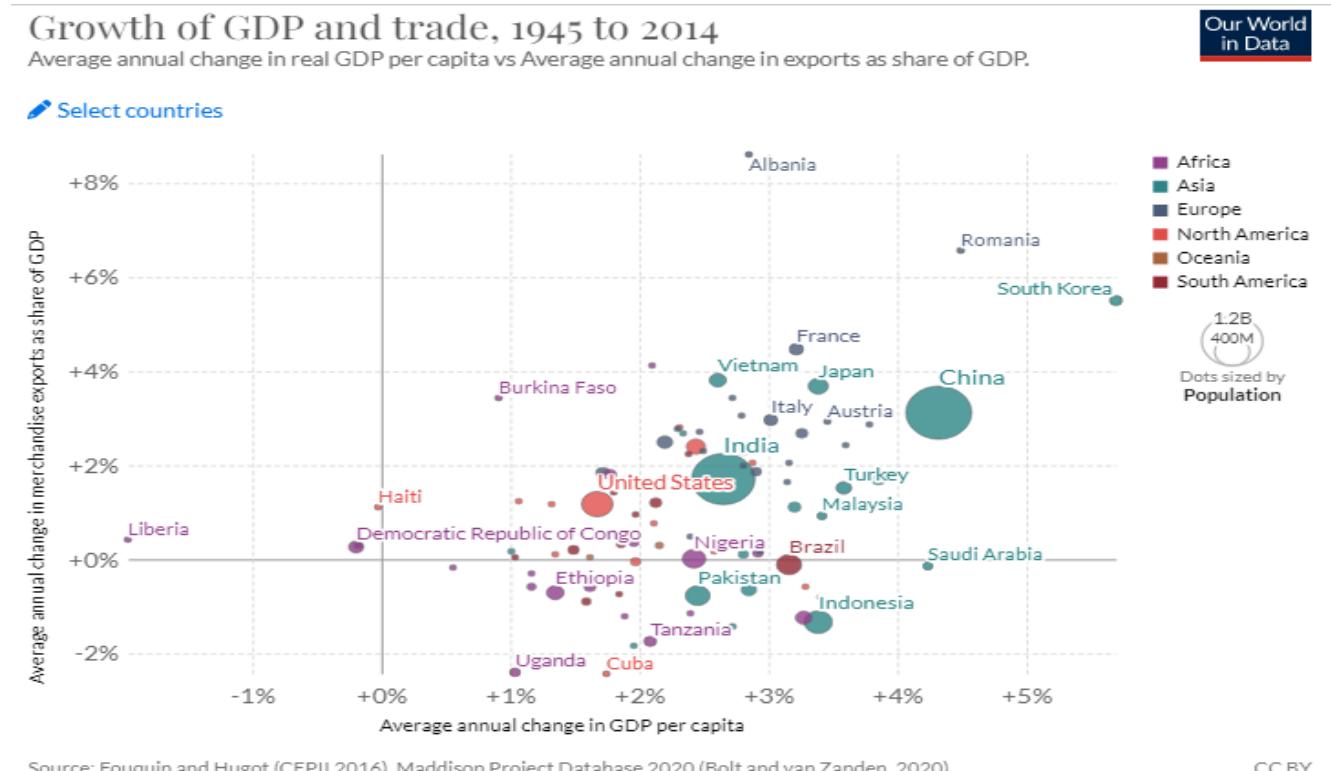
International trade is generally conducted for the purpose of providing any nation with commodities it lacks in exchange for those that it produces in abundance; such transactions, functioning with other economic policies, tend to improve a nation's standard of living.

Thinking about the international trade, we traditionally think about a person or company producing all product elements in their home country and then exporting a final product to a consumer in a different country. However, this type of trade represents about 30% only of goods and services trade nowadays. The majority of trade (70%) is actually in intermediate parts, components, and services that form segments of global value chains (GVCs). The process of producing goods is often spilt across countries, with different elements carried out wherever the necessary skills and materials are available at competitive cost and quality.

## **Trade and Growth:**

Over the last couple of centuries the world economy has experienced sustained positive economic growth, and over the same period, this process of economic growth has been accompanied by even faster growth in global trade. In a similar way, if we look at country-level data from the last half century we find that there is also a correlation between economic growth and trade; countries with higher rates of GDP growth also tend to have higher rates of growth in trade as a share of output.

The following graph shows the average annual change in the real GDP VS the average annual change in exports as a share of GDP between 1945 and 2014.



It is obvious that there is a positive correlation between the average annual change in the real GDP and the average annual change in exports as a share of GDP for most of world's countries.

### Trade as a Complex Phenomenon:

As mentioned before, trade is a fundamental part of economic activity everywhere. Countries exchange not only final products, but also intermediate inputs. This creates a complex network of economic interactions that cover the whole world. The following graph, gives us an insight into the complex nature of trade through plotting the position of cargo ships across the oceans. This graph was created by the London-based data visualization studio Kiln and the UCL Energy Institute.



The links colors represent the ship type

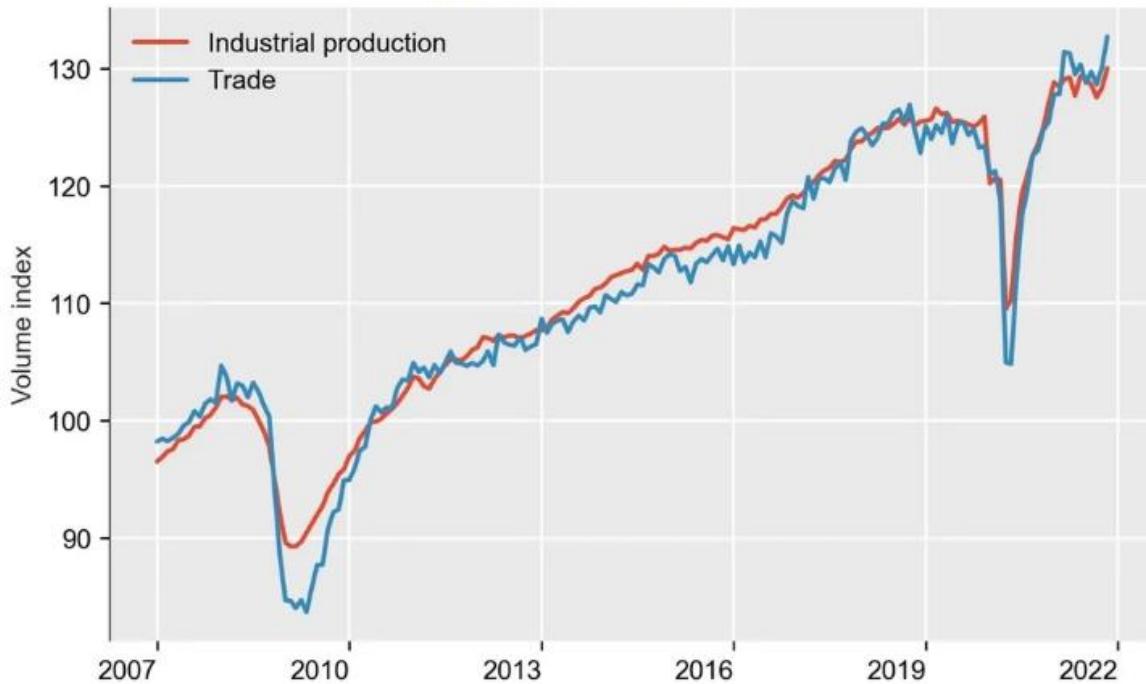
This graph is an example and a proof for trade relations complexity. It shows clearly that if trade relations expressed through networks and not just through numbers and raw data this will be more efficient in understanding this real complex phenomenon.

### Trade and Covid-19:

The year 2020 was marked by some of the largest reductions in trade and output volumes since World War II due to Covid-19 break-out. The declines in both world industrial production and goods trade in the first half of 2020 were of similar depth to those at the trough of the Global Financial Crisis (GFC). However, the volume of global trade has recovered to the pre-pandemic level at an extraordinarily fast pace from around mid-2020 as shown in the following figure.

Figure 1. Volume of world trade and industrial production

Seasonally adjusted (2010=100)



Source: OECD calculations based on CPB World Trade Monitor.

The trade collapse of early 2020 did not hit all products to the same extent and the rising tide did not lift all parts of the global trade system equally either; in 2020, trade in services declined more and has been recovering at a slower pace than goods trade. Not surprisingly, trade in travel and tourism services slumped dramatically but trade in digitally delivered services, such as telecommunication and information technology services, boomed.

In this paper we are going to study the impact of Covid-19 break-out on the G-20's<sup>1</sup> countries trade -G-20 account for more than 75% of the global trade- through comparing their trade in two different time point; 2018 and 2020.

## Project scope

The project aims to detect the most trading country through representing the trade movement of all goods and services in a social network of countries and exports, entities that

<sup>1</sup> G-20 is a 19-country intergovernmental forum along with the European Union (EU). It focuses on major global economic issues such as international financial stability, climate change mitigation, and long-term development. The G-20 brings together the world's major economies. Its members account for more than 80 percent of world GDP, 75 percent of global trade and 60 percent of the world's population.

are majorly responsible in the flowing of trade. Through network analysis we can understand how was the trade relations connected, reaching other countries easily. The major actors responsible for the origin of the flow. The projects surfs database for 2018 and 2020. Through our observation of the formed network we aim to answer several questions:

### **Research questions**

1. How many countries did each country have trade links (exports) with on average?
2. Which country was the most popular in terms of exports?
3. Did the number of the country's export links correlate with its GDP?
4. Which countries had the highest value of exports?
5. What was the value of exports for each country in the network, on average?
6. Which countries had the highest value of imports?
7. Was there any relation between the country's GDP and its imports position?
8. Was there any relations between the country's unemployment rate as a percentage of the GDP and the country's position in terms of exports?
9. Did the number of export relations (country's out-degree) of the country that had the highest unemployment rate affected by this unemployment rate?
10. Which country played the broker role in the trade network?
11. Was there any relation between the country's trade value as a percentage of the country's GDP and trade values (imports and exports)?
12. Did the countries' population size affect their trade values?
13. Was there any relation between real interest rate and inflation rate of country?
14. Was being a country with high final consumption expenditure has a reflect on percentage of trade from GDP?
15. Did Covid-19 affect the number of the exports relations among the G-20's countries?
16. Do we have a new exports leader after Covid-19?
17. Do we have a new imports leader after Covid-19?
18. Is there any change in the "Betweenness" measure after Covid-19?
19. Which country plays the leader rule in terms of the total trade after Covid-19?
20. Did the G-20's countries fall into clusters?
21. Does G-20's communities' memberships changed after Covid-19?
22. Which country can reach other countries faster?
23. Which countries are connected to countries which are, in turn, connected to many others?
24. Which country lies far distance from other countries?

### **Project goals**

1. Discuss which country of those 19 countries was most powerful to know in future which one will have more influence on other countries to take a global decision concerning

trade on making for example new routes between countries to facilitate trade and lower fees or marketing for a certain good or even a technology among them.

2. Study most exporting country which was on the other side have high economy, great industries, and high technology that give it the ability to exports large value of goods to most developed countries.
3. From political point of view if any war happen between one of those countries and other one which country will support it with weapons and goods during its war in terms of the have good trade relation. Or maybe one country try to force another country not to go to war or impose sanctions under the threat of a halt in trade between them as a form of pressure.
4. Comparing trade flow before the pandemic covid\_19 in 2018 and during covid\_19 in 2020 to see if there's any change in the amount of trade or trade movement as an impact of this crisis.

## Methodology

Countries are almost seen as the primary unit of analysis in studying international trade so we use SNA to build trade network as it studies interactions among actors (countries) and assume the independence of observations. we can observe which countries are mostly connected in this team and with high trade flows (exports). See most benefited countries from being included in the network and to study which metrics are more influential in describing data variability which include node attributes.

## Why Social Network Analysis?

Trade relations are complex phenomena, and in order to tackle it, understand it or even get a meaningful results for it we need to use SNA in order to have a nodes that represent the countries and edges that represent the trade relations and then studying the different trade relations among the countries as well as the correlation between some countries' attributes which considered to be a part of the statistical analysis. Throughout this project it will be shown clearly that if trade relations expressed through networks and not just through numbers and raw data this will be more efficient in understanding this real complex phenomenon.

## Collection of data

- a) We obtain data of edges from [comtrade.un.org](http://comtrade.un.org) it was already existing
  1. We choose reporter countries (Source) which are the 19 countries (Argentina, Australia, Brazil, Canada, China, Germany, Republic of Korea, Russian federation, France, India, Indonesia, India, UK, USA, Japan, Mexico, South Africa, Turkey, Saudi Arabia)
  2. Choose partner countries (Target) which are the same 19 countries

b) we obtain data of nodes from (<https://data.worldbank.org/>) that was already existing then we choose some indicators for the same countries that help us in studying trade flow between those countries and be able to compare results of 2018 with 2020, So we choose

- i. GDP (current US\$)
- ii. Population, total
- iii. Unemployment, total (% of total labor force) (national estimate)
- iv. Real interest rate (%)
- v. Inflation, consumer prices (annual %)
- vi. Trade (% of GDP)
- vii. Final consumption expenditure (% of GDP)
- viii. Share of youth not in education, employment or training, total (% of youth population)

c) In our project

1. **Nodes:** represent 19 countries (Argentina, Australia, Brazil, Canada, China, Germany, Republic of Korea, Russian federation, France, India, Indonesia, India, UK, USA, Japan, Mexico, South Africa, Turkey, Saudi Arabia) .
2. **Edges:** represent the value of exports for these countries (amount of goods each country export to the other) equals 342 edges in whole network.
3. Our network is a Trade network between G20 countries with respect to certain indicators
  - i. GDP (current US\$); which signs for Gross Domestic Product which measures the market value of all final goods and services produced in specific time period which is in our case a year and we found that country with highest GDP was USA while South Africa has the lowest one both in 2018 and 2020.
  - ii. Total Population as China has the highest number and Australia has the lowest number of population in both 2018 and 2020.
  - iii. Unemployment (% of total labor force) which is people above a specified age not being in paid employment but currently available for work during the reference period in other words people who are not employed. We observe that Japan has the lowest unemployment percentage in both 2018

and 2020 while South Africa has highest unemployment percentage in 2018.

- iv. Real interest rate (%) which is the rate of interest an investor, saver or lender receives after allowing for inflation. Argentina has the lowest interest rate in 2020 while Russian Federation has the lowest interest rate in 2018.
- v. Inflation which is a general increase in prices of goods and services in economy. Italy has the lowest inflation rate in 2020, Turkey has the highest one in 2020 and 2018 while Japan has the lowest inflation rate in 2018.
- vi. Trade which is the transferred goods and services from one country to another for getting money. The country with highest trade was Germany and lowest one was USA in 2020 and 2018.
- vii. Final consumption expenditure which is national accounts expenditure on goods and services used for the direct satisfaction of individual needs which is recorded in the use of income account. UK has the highest Final consumption expenditure in 2018, China was the lowest one in 2018 and 2020 while Argentina has the highest Final consumption expenditure in 2018.
- viii. Share of youth not in education, employment or training, total (% of youth population) where South Africa has the highest share of youth in both 2018 and 2020.

*Chapter Two:*

*Descriptive*

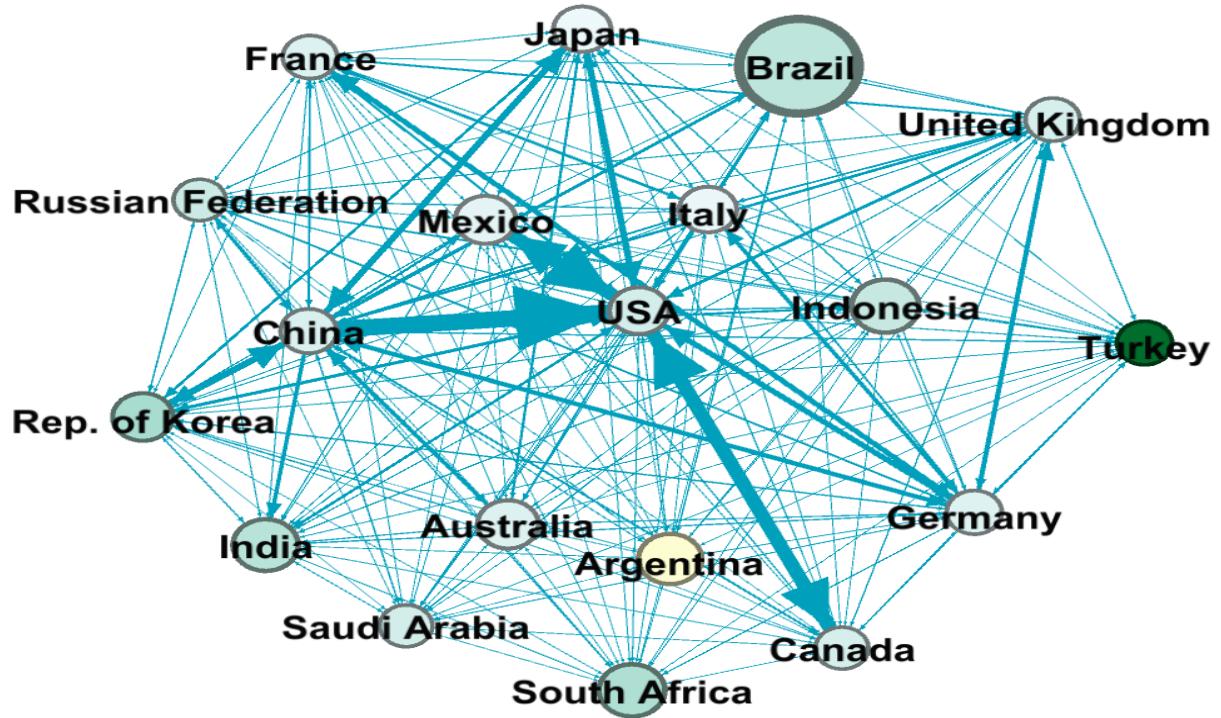
*Analysis*

## 2018 Descriptives:



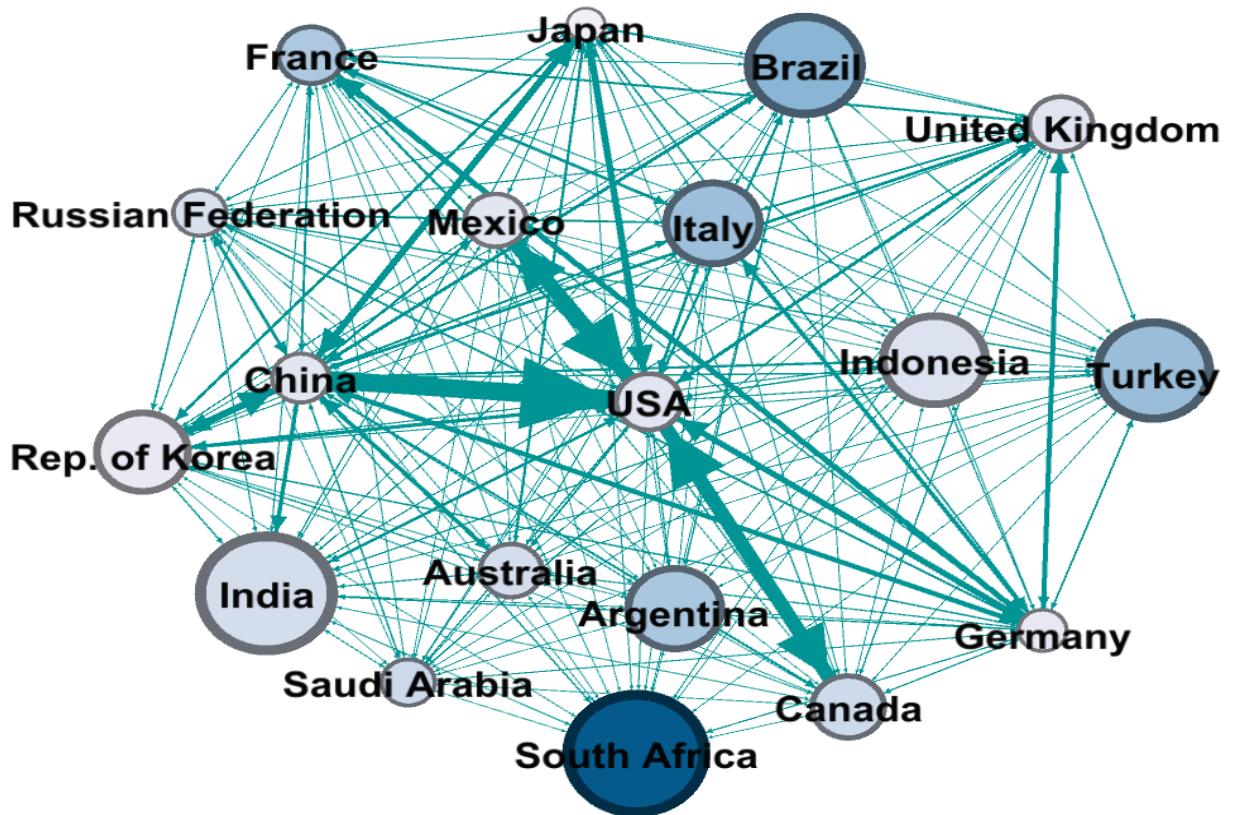
In this network size of the node (country) represents the population while color of the nodes represent the total GDP of country as when the color becomes gradually darker it means it has higher GDP. While the thickness of edges represent that this country has high number of exports (weight) and also as color of edges gets darker it indicates higher weight (exports number). So, from this network shows that

1. China has the highest number of population , followed by India while Australia has the lowest number of population followed by Saudi Arabia. The rest of countries have a close population size.
  2. USA has the highest GDP followed by China, Japan and Japan while Turkey, Saudi Arabia, South Africa and Argentina shows low GDP.
  3. China has the highest number of exports to most countries although it takes the second place in GDP value after USA. There is high flow of exports between china, USA, Mexico and Canada . Italy, Turkey and Argentina has low number of exports.
  4. Most of USA imports come from Canada, Mexico and China which means it depend on those three countries in importing goods.
  5. There is a flow of trade between East Asian countries (China, Japan and Republic of Korea).



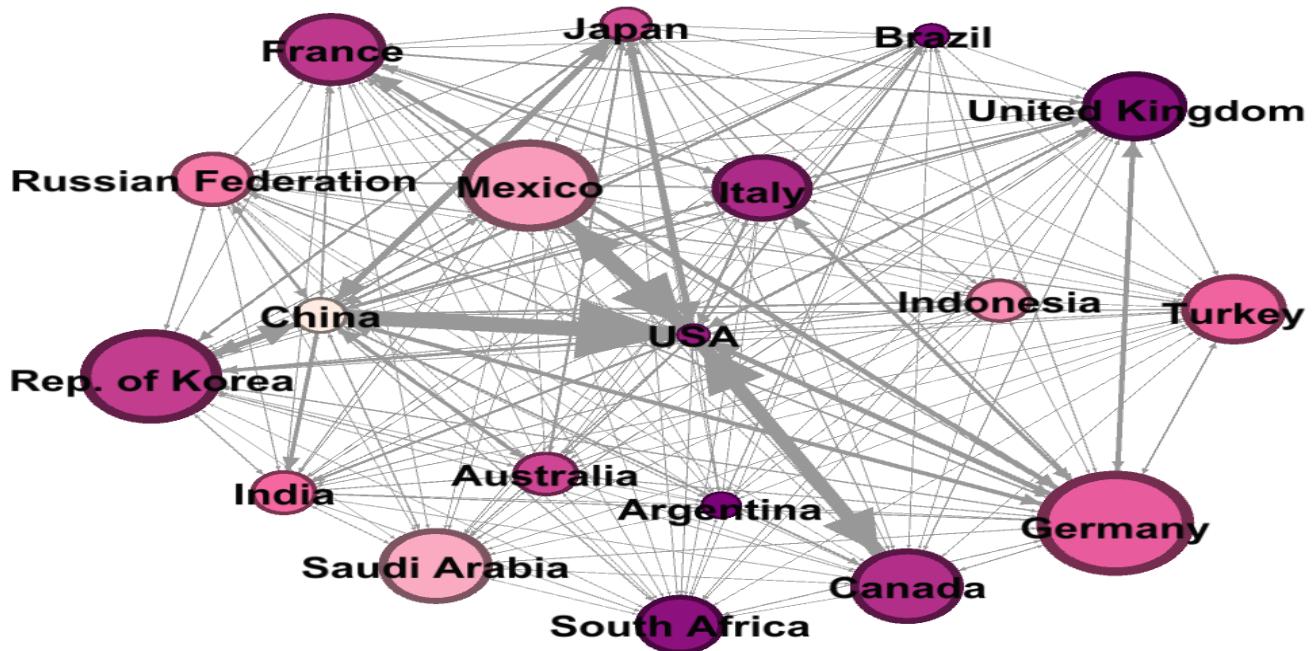
In this graph size of the nodes indicates real interest rate (%) (as the size of country increases the real interest rate increases) while color of nodes (countries) indicates Inflation, consumer prices (annual %) (as the color tone increases it reflects high inflation rate).

1. Turkey has the highest inflation rate followed by Brazil and Republic of Korea.
2. Brazil has the highest real interest rate followed by Indonesia, Republic of Korea, India and South Africa while Italy, China, Mexico and most of remained countries have a moderate interest rate.
3. Argentina has the lowest inflation rate and it has a low interest rate.



In this graph color tone of nodes indicates unemployment, total (% of total labor force) (national estimate) as the color get darker unemployment gets higher while size of the node indicates Share of youth not in education, employment or training, total (% of youth population).

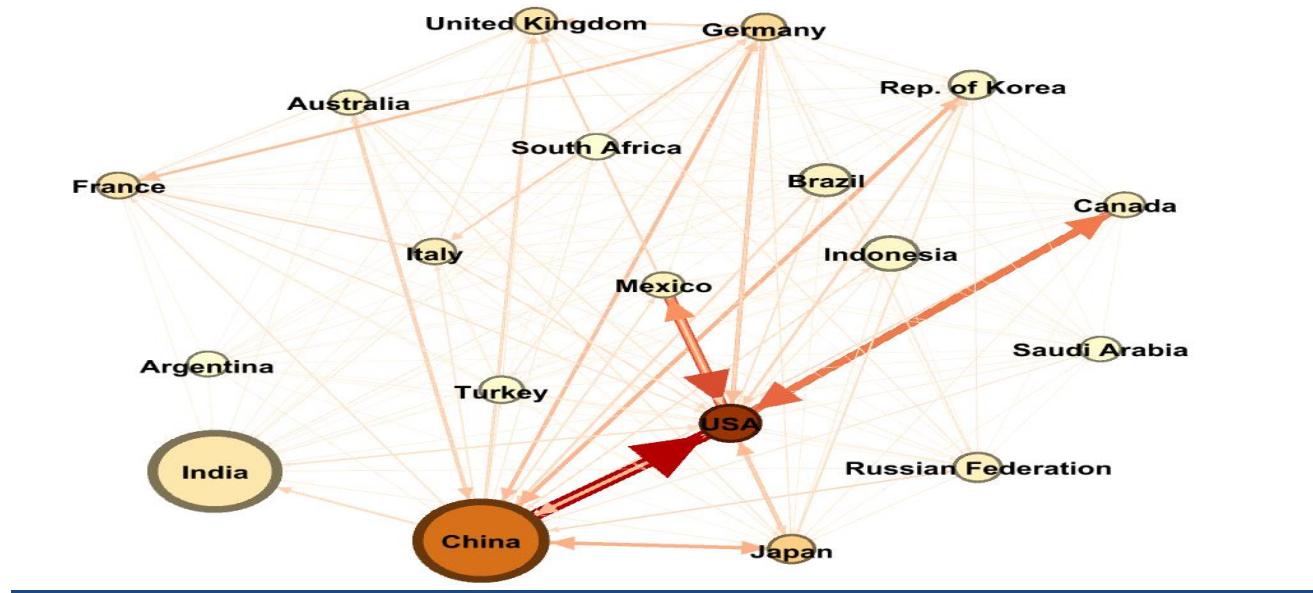
1. South Africa has the highest share of youth and unemployment rate which indicates that it has low job opportunities for youth or has a weak economy which is reflected on her GDP which is low and has a low value of exports and depend on imports too much which means it has low power among G20 countries.
2. Japan has a low share of youth and unemployment rate which is reflected on her GDP as it was high as showed in figure(5) which means it has high power among G20 countries.
3. Brazil and Turkey has high share of youth and unemployment rate that was reflected on GDP that was low.
4. Italy and Argentina has high unemployment rate.
5. India and Indonesia follow South Africa in share of youth from total population.



In this graph color tone of Nodes shows final consumption expenditure (% of GDP) as the color darkens this shows higher final consumption while size of nodes indicates trade (% of GDP).

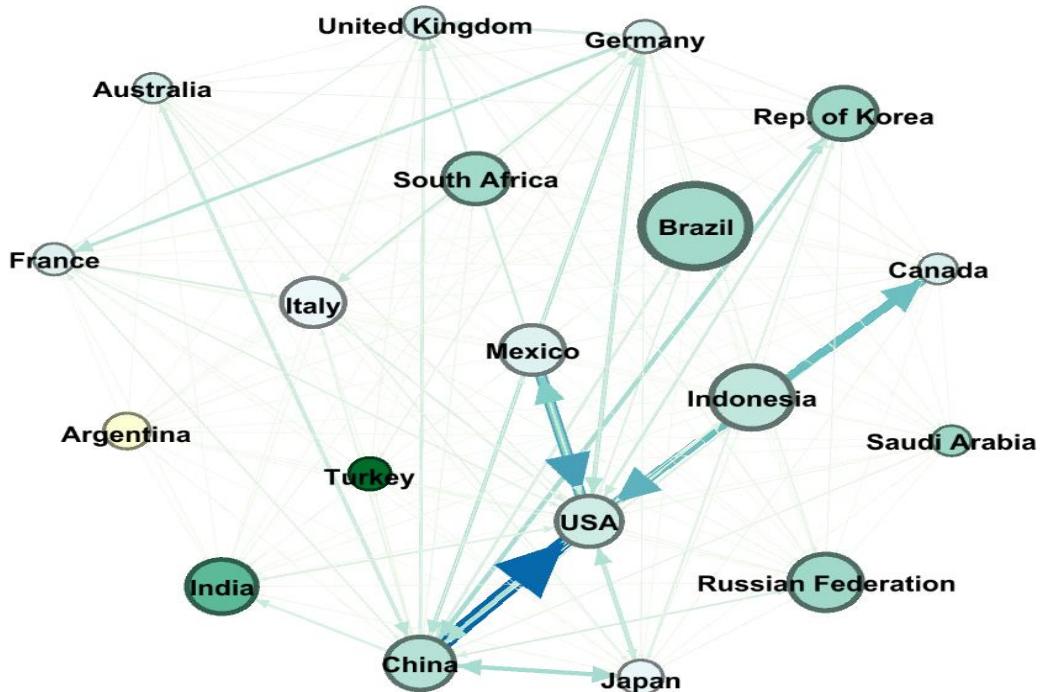
1. UK, South Africa, Brazil and Argentina has a high final consumption that represent high proportion of total GDP and this seems to be right as they have low GDP as they import more than the export.
2. China has the lowest final consumption which indicates that it has high self-sufficiency because it has huge number of exports to all countries and have the second place in order of GDP.
3. In Germany and Republic of Korea trade represent a high percentage of the country's GDP while their final consumption represents a moderate percentage of GDP.
4. In USA trade represent the lowest percentage from its total GDP while it has a high final consumption which indicates that it has its own industries that satisfy self-sufficiency for its population.

## 2020 Descriptives:



In this network size of the node (country) represents the population as a total while color of the nodes represent the total GDP (current US\$) of country as when the color becomes gradually darker it means it has higher GDP. While the thickness of edges represent that this country has high number of exports (weight) and also as color of edges gets darker it indicates higher weight (exports number). So, from this network shows that

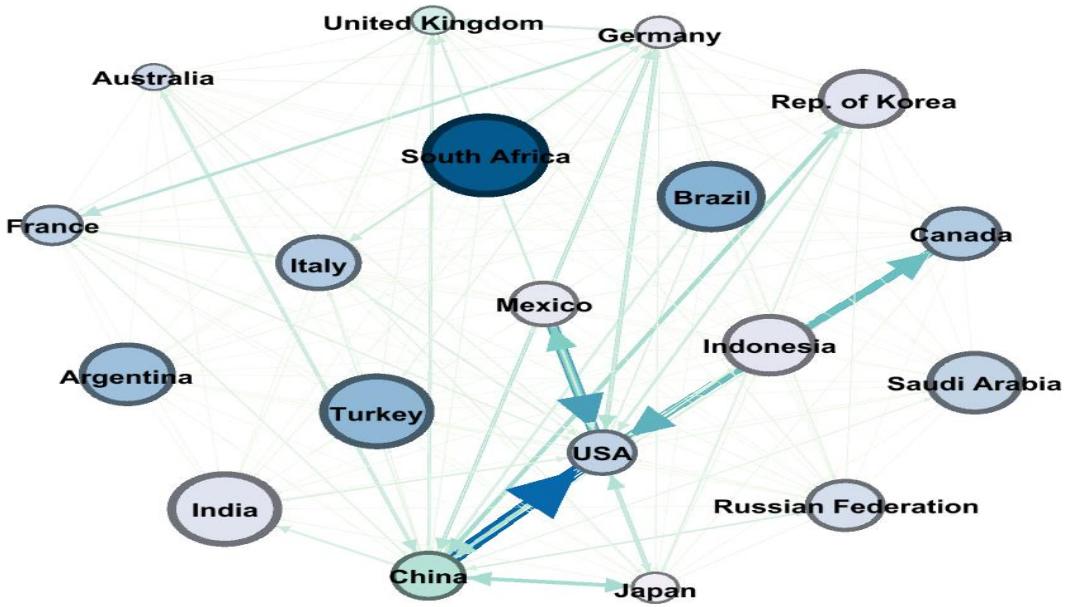
1. China has the highest number of population , followed by India while Australia has the lowest number of population followed by Saudi Arabia. Rest of countries have a close population size.
2. USA has the highest GDP followed by China, Japan and Germany while Turkey and Saudi Arabia shows low GDP.
3. China has the highest number of exports to most countries although it takes the second place in GDP value after USA. There is high flow of exports between china, USA, Mexico and Canada . Italy, Turkey and Argentina has low number of exports.
4. Most of USA imports comes from Canada, Mexico and China which means it depend on those three countries in importing goods.
5. There is a flow of trade between East Asian countries (China, Japan and Republic of Korea).



In this graph size of the nodes indicates real interest rate (%) (as the size of country increases the real interest rate increases) while color of nodes (countries) indicates Inflation, consumer prices (annual %) (as the color tone increases it reflects high inflation rate).

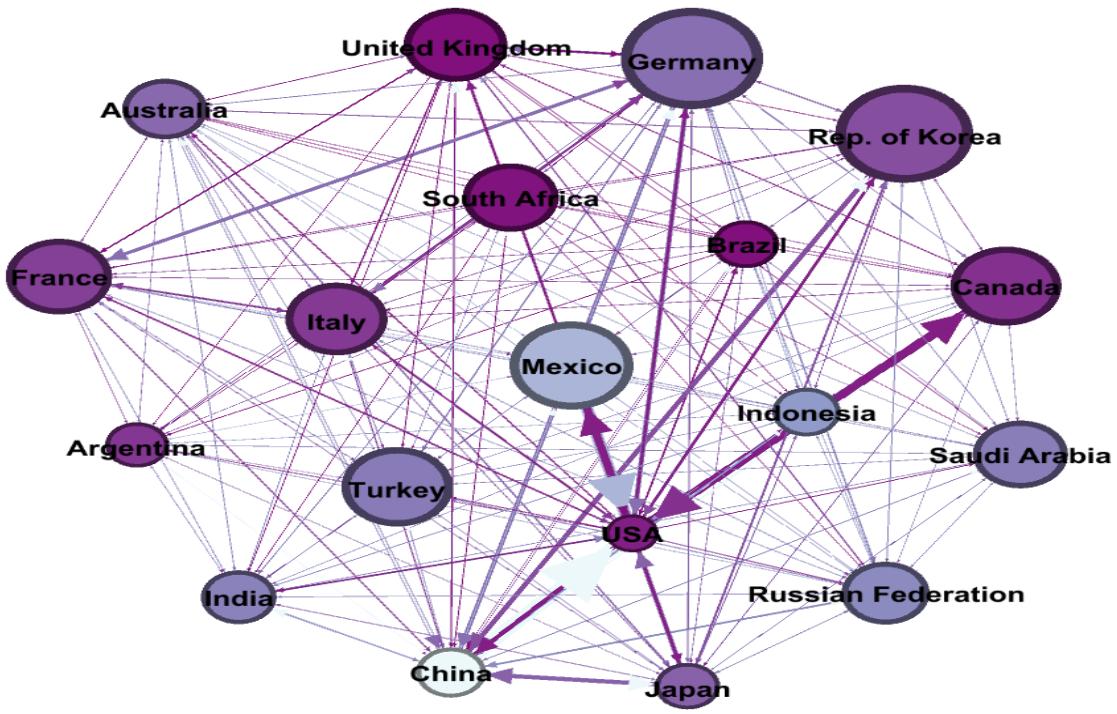
**Note: In economics as inflation rate increases the country increase the real interest rate**

1. Turkey has the highest inflation rate followed by India while Argentina has the lowest inflation rate.
2. Brazil has the highest real interest rate followed by Indonesia, Republic of Korea and South Africa while Germany and France has low interest rate.
3. Argentina has the lowest inflation rate so it has a low interest rate.



In this graph color tone of nodes indicates unemployment, total (% of total labor force) (national estimate) as the color get darker unemployment gets higher while size of the node indicates Share of youth not in education, employment or training, total (% of youth population).

1. South Africa has the highest share of youth and unemployment rate which indicates that it has low job opportunities for youth or has a weak economy which is reflected on her GDP which is low and has a low value of exports which means it has low power among G20 countries.
2. Japan has a low share of youth and unemployment rate which is reflected on her GDP as it was high as showed in figure(1) which means it has high power among G20 countries.
3. Brazil, Turkey and Argentina has high share of youth and unemployment rate that was reflected on GDP that was low.

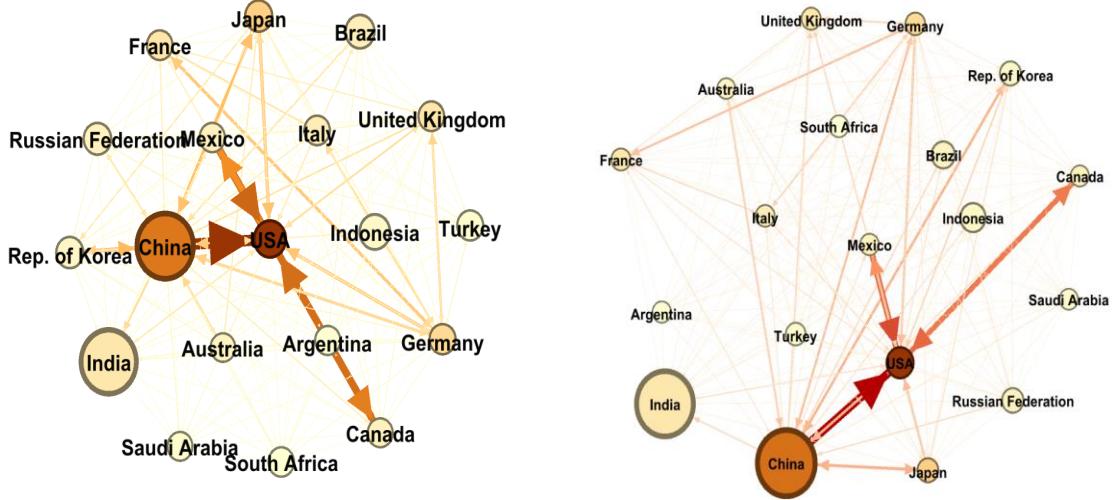


In this graph color tone of Nodes shows final consumption expenditure (% of GDP) as the color darkens this shows higher final consumption while size of nodes indicates trade (% of GDP).

1. UK, South Africa, Brazil has a high final consumption that represent high proportion of total GDP and this seems to be right as they have low GDP as they import more than they export. Trade also represent a moderate percentage from their whole GDP.
2. China has the lowest final consumption which indicates that it has high self-sufficiency because it has huge number of exports to all countries and has the second place in order of GDP.
3. In Germany and Republic of Korea trade represent a high percentage of the country's GDP while their final consumption represents moderate percentage.

### **Comparison:**

#### Comparing 2018 with 2020

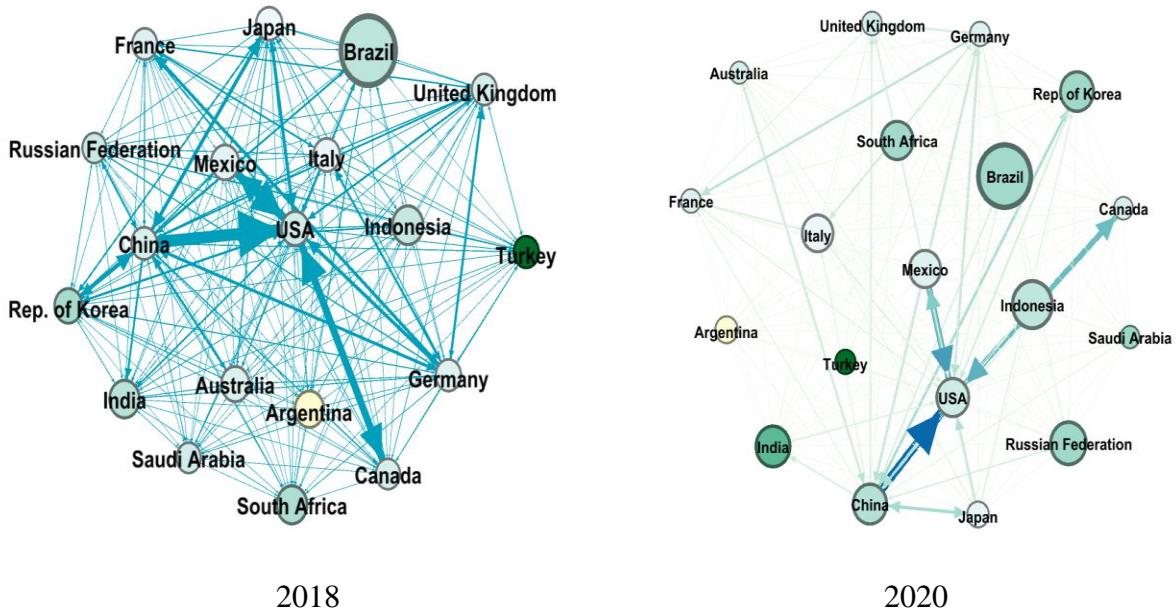


2018

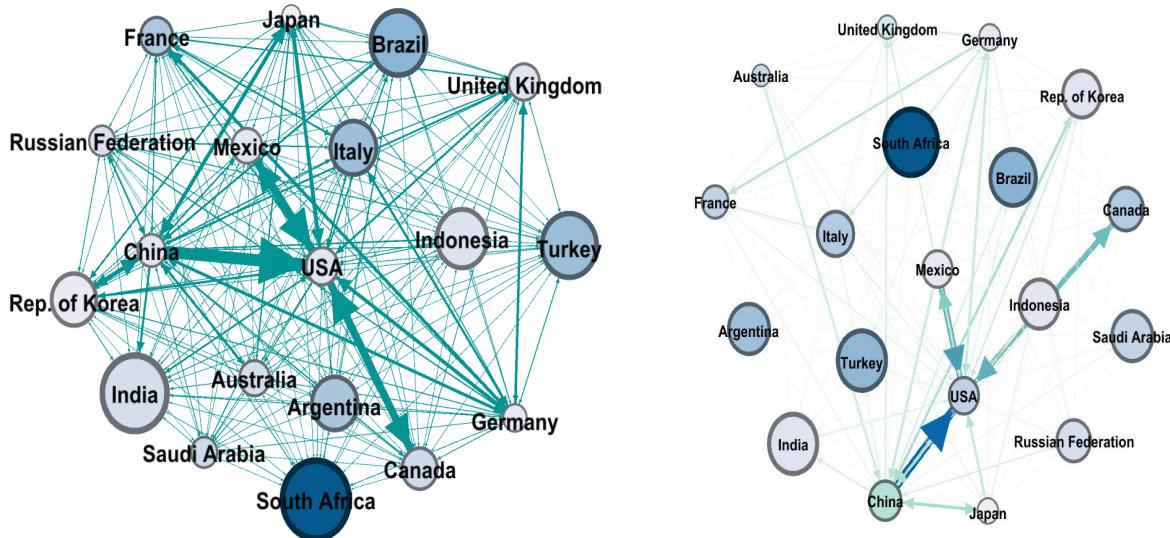
2020

According to population China and India still have the largest total population in 2018 & 2020.

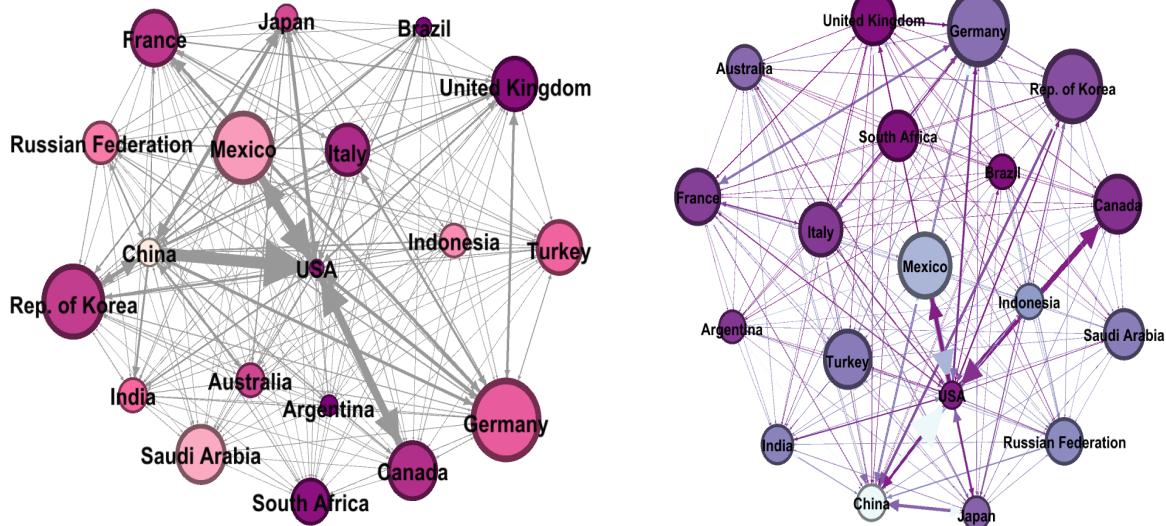
1. USA still has the highest GDP followed by china in 2018 and 2020.
2. China still have the highest value of exports.
3. Turkey still have high inflation rate but in 2018 it is followed by India while in 2020 it's followed by Brazil.



1. Japan has the lowest inflation rate in both 2018 while Italy has the lowest inflation rate in 2020.
  2. Brazil still have the highest interest rate followed by Indonesia in both years 2018 and 2020.



1. South Africa still have the highest share of youth and unemployment rate while Japan still has a low share of youth and unemployment rate.
  2. India, Brazil and Turkey take second place in highest share of youth after South Africa in 2020 and 2018.
  3. Brazil, Turkey and Argentina takes the second place in highest unemployment rate after South Africa in 2020 while Brazil, Turkey and Italy takes the second place in highest unemployment rate after South Africa in 2018.



1. Argentina has the highest final consumption expenditure in 2018 followed by Brazil and UK while in 2020 UK has the highest final consumption expenditure followed by Brazil and South Africa.
2. China has the lowest final consumption expenditure in both 2018 and 2020.
3. Germany has the highest amount of trade in both 2018 and 2020 followed by Republic of Korea and Mexico.
4. USA has the lowest amount of trade in both 2018 and 2020.

*Chapter Three:*

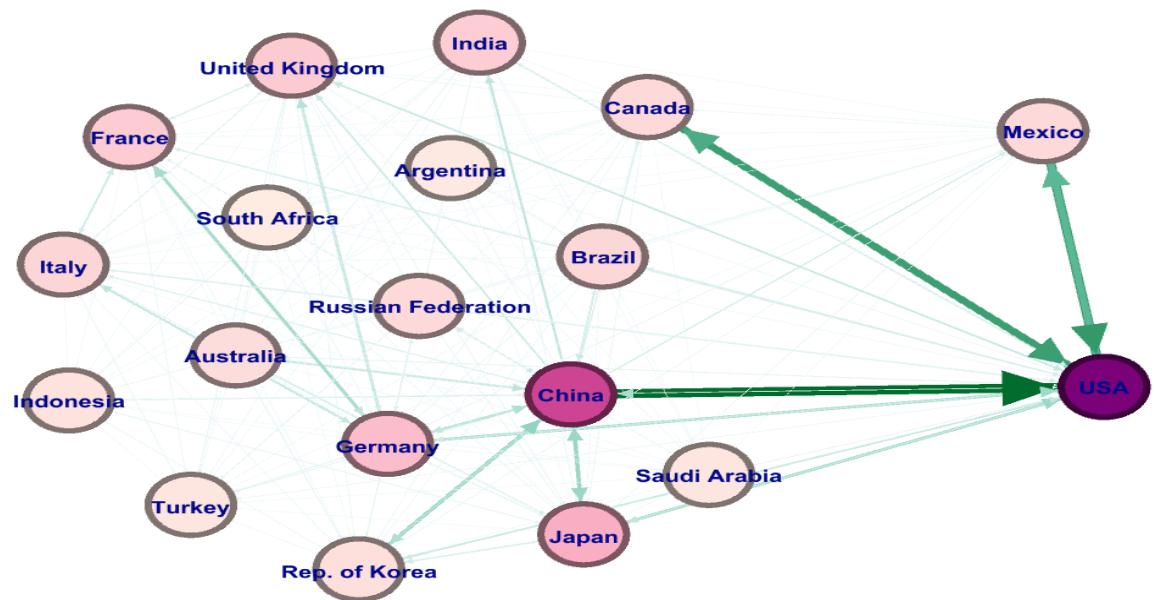
*G20's 2018*

*Trade Network*

*Analysis*

## 2018's Networks Analysis:

1. In 2018, how many countries did each country have trade links (exports) with on average?
2. In 2018, which country was the most popular in terms of exports?
3. In 2018, did the number of the country's export links correlate with its GDP?



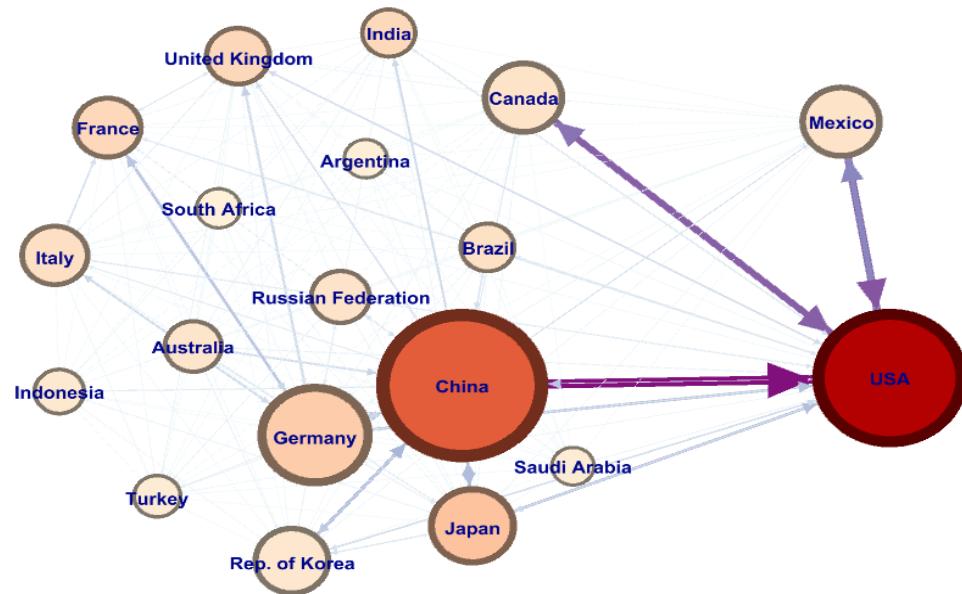
### Graph properties:

Node size reflects the out-degree, edges color reflects the value of the exports and the node color represents the GDP of the country.

From the previous graph, it seems like that all the G-20's countries have the same nodes sizes (all countries have the same popularity) meaning that the number of exports relations between them is the same; each country exports to the other 18 countries, this can give us an impression of how these countries are connected.

However, by looking at the colors and the thickness of edges we can find out that China is the leading country in terms of exports values. USA has the largest GDP and at the same time it can be considered as the leading country in terms of imports; Although USA exports with a moderate high value to both Canada and Mexico, however its imports are relatively larger than its exports. We can deduce that the country's GDP does not affect the country's out-degree (correlation=0).

4. In 2018, which countries had the highest value of exports?
5. In 2018, what was the value of exports for each country in the network, on average?
6. In 2018, was there any relation between the country's GDP and its exports values?

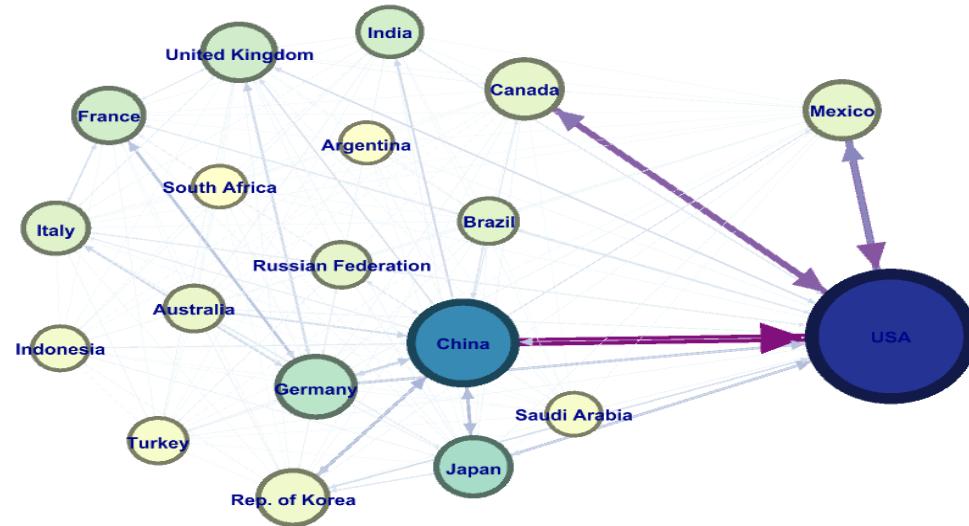


#### Graph properties:

Node size reflects the weighted out-degree, edges color reflects the value of the exports and the node color represents GDP.

It seems like on average, each country in the network has trade relations of value 350955537608.105. And it is clear that China occupies the first place in the exports, followed by USA and Germany respectively. It seems like the relation between the GDP and the exports values (weighted out-degree) goes in the same direction; i.e., for example China has the leadership in the export values and has a relatively high GDP as well and most of the G-20's countries have from low to moderate GDP and from low to moderate weighted out-degree as well.

7. In 2018, which countries had the highest value of imports?
8. In 2018, was there any relation between the country's GDP and its imports position?

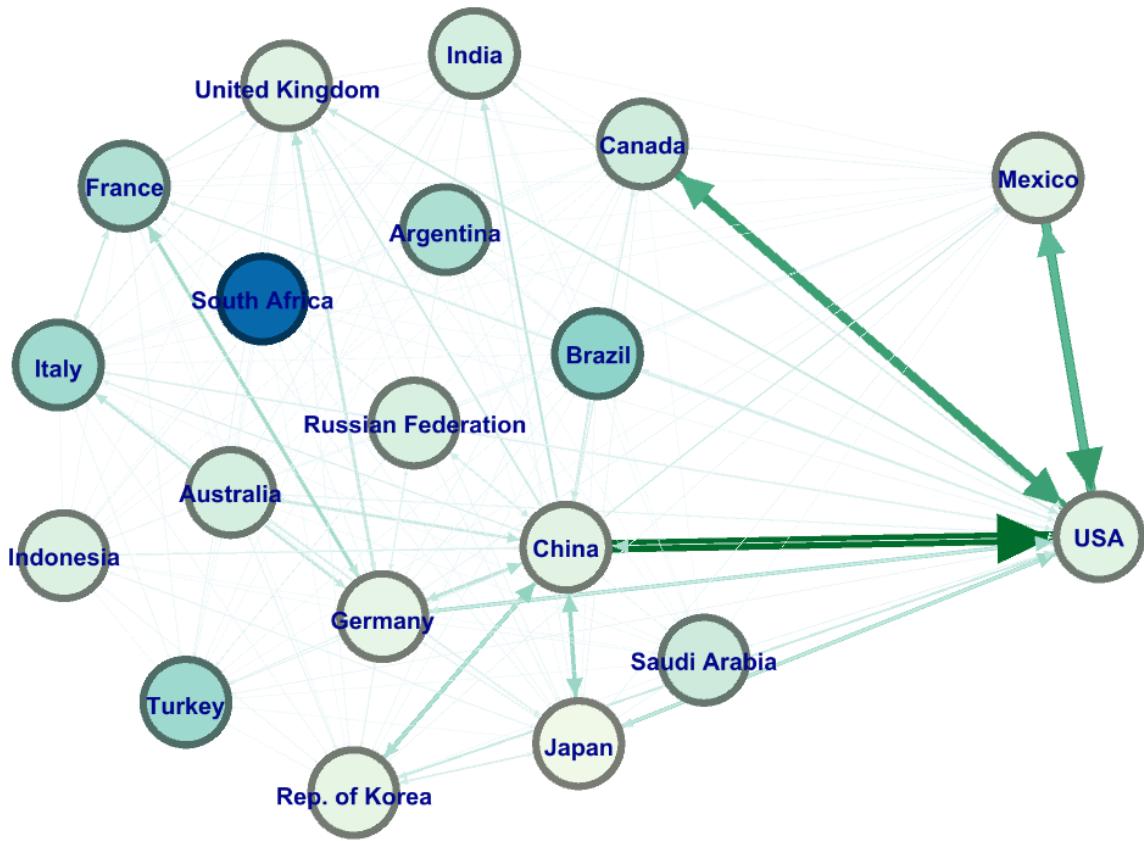


**Graph properties:**

Node size reflects the weighted in-degree, edges color reflects the value of the exports and the node color represents GDP.

It seems like USA occupies the first place in the imports, followed by China and Germany respectively. It seems like the relation between the GDP and the weighted in-degree goes in the same direction; i.e., for example USA has the leadership in terms of the GDP value and imports as well, followed by China that occupies the second place in both imports and GDP, South Africa has a very low GDP and Imports as well... etc.

9. In 2018, was there any relations between the country's unemployment rate as a percentage of the GDP and the country's position in terms of exports?
10. In 2018, did the number of export relations (country's out-degree) of the country that had the highest unemployment rate affected by this unemployment rate?



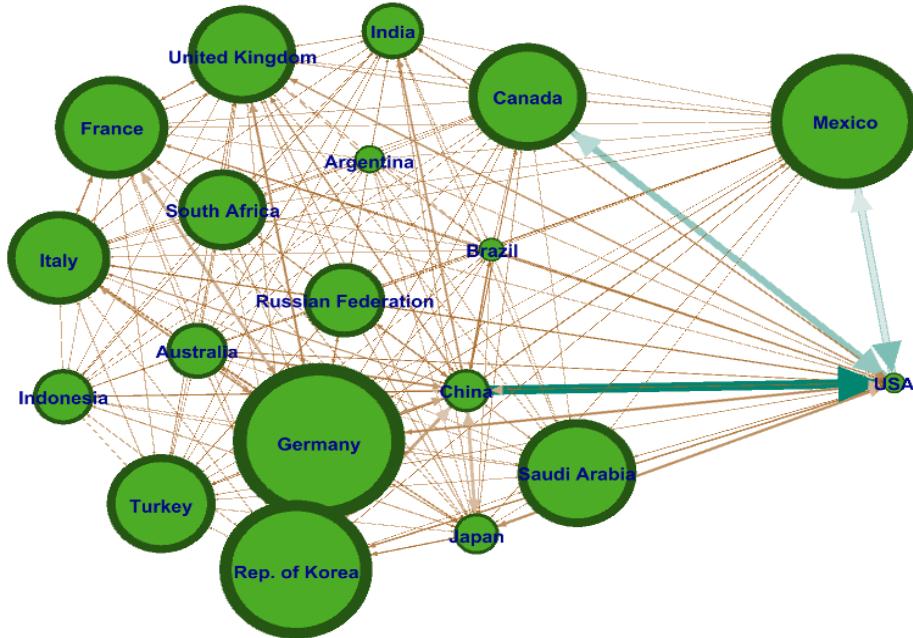
**Graph properties:**

Node size reflects the out-degree, edges color reflects the value of the exports and the node color represents the estimated the unemployment as a percentage of total labor force.

NOW, we can get an insight about why China was the leading forces in terms of exports; China has a very low percentage of unemployed people, and the helped in producing and exporting more than the others do (and that might be the reason, as the labor force has a positive impact on the production level of any factor, company, or even country).

In addition, having a low percentage of the employment helped USA to have the highest value of the GDP. Although, South Africa out-degree is the same as the reset of the G-20's counties, however the value of its exports seems to be very low and that might be due to its high unemployment rate (South Africa has the highest unemployment value among all the 19 countries).

11. In 2018, which country played the broker role in the trade network?

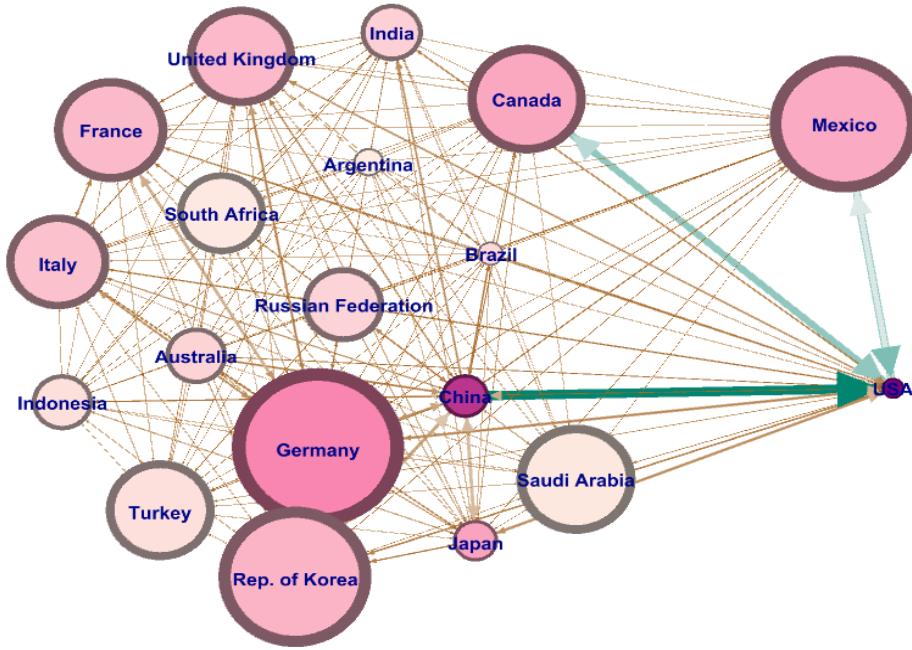


**Graph properties:**

Node size reflects trade as a percentage of the country's GDP, edges color reflects the value of the exports and the node color represents betweenness centrality.

It seems like; none of the G-20's countries play the broker rule in this network. And that was expected from the beginning since all of the G-20's countries are connected together in a way or another through the trade relationships, so no need for a broker among them.

12. In 2018, was there any relation between the country's trade value as a percentage of the country's GDP and trade values (imports and exports)?

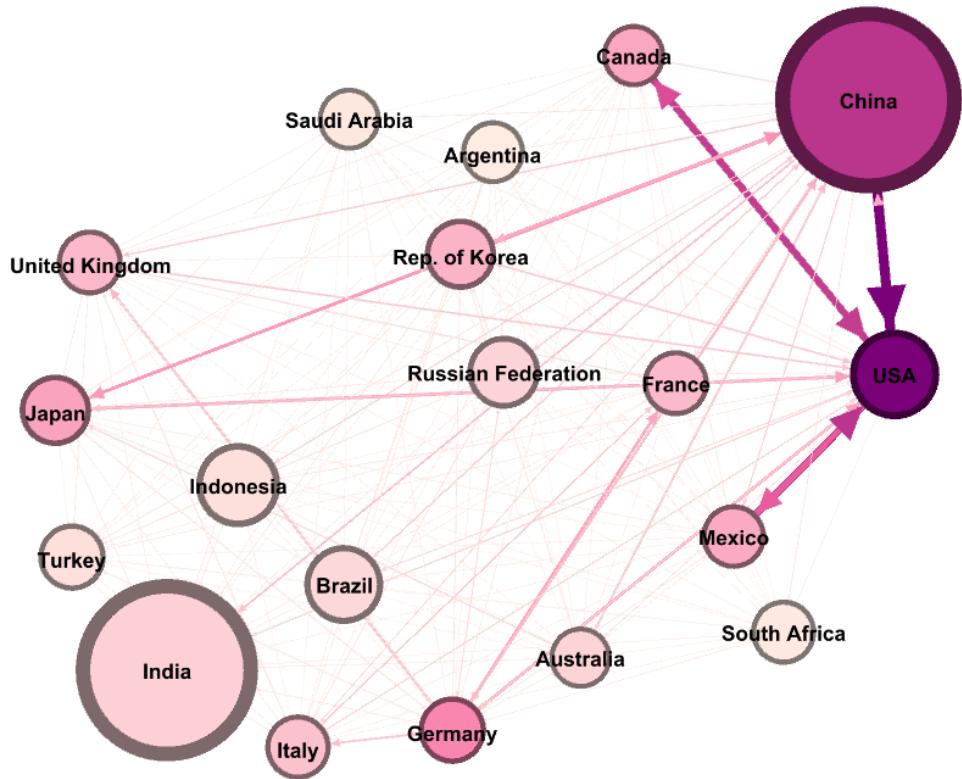


**Graph properties:**

Node size reflects trade as a percentage of the country's GDP, edges color reflects the value of the exports and the node color represents weighted degree.

It is well known that the trade as a percentage of the country's GDP is calculated by dividing the aggregate value of imports and exports over a period by the gross domestic product for the same period. It seems like, we have Germany occupies the first place on it followed by Korea although they are not the leaders in terms of the total trade values (weighted degrees). Hence, there was not any relation between the country's trade value as a percentage of the country's GDP and trade values (imports and exports). It seems like USA occupies the first place followed by China in the total trade values.

13. In 2018, did the countries' population size affect their trade values?

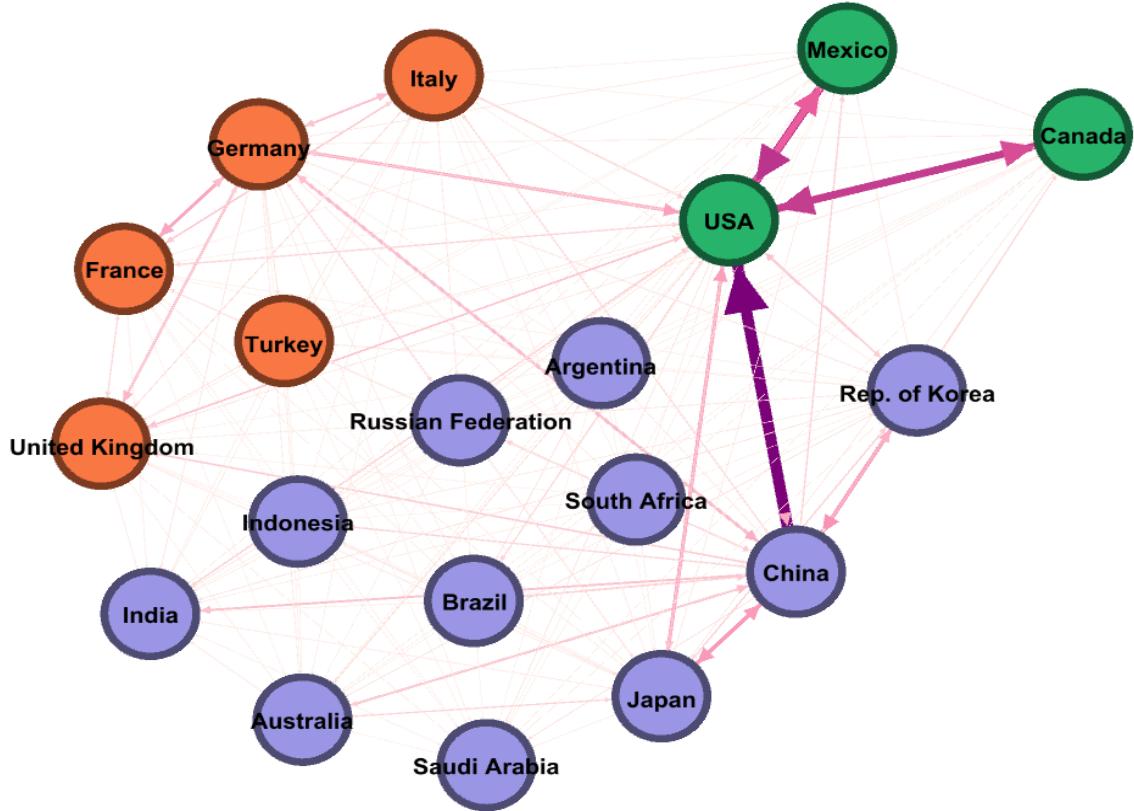


**Graph properties:**

Node size reflects population, edges color reflects the value of the exports and the node color represents weighted degree.

It seems like China has the largest population size and it occupies the second place in the total trade values. Although, USA is the third largest population among the G-20's populations it occupies the first place in the total trade values. India has the second largest population size however; it is not a strong influencer in term of the total trade values.

14. In 2018, do the G-20's countries fall into clusters?



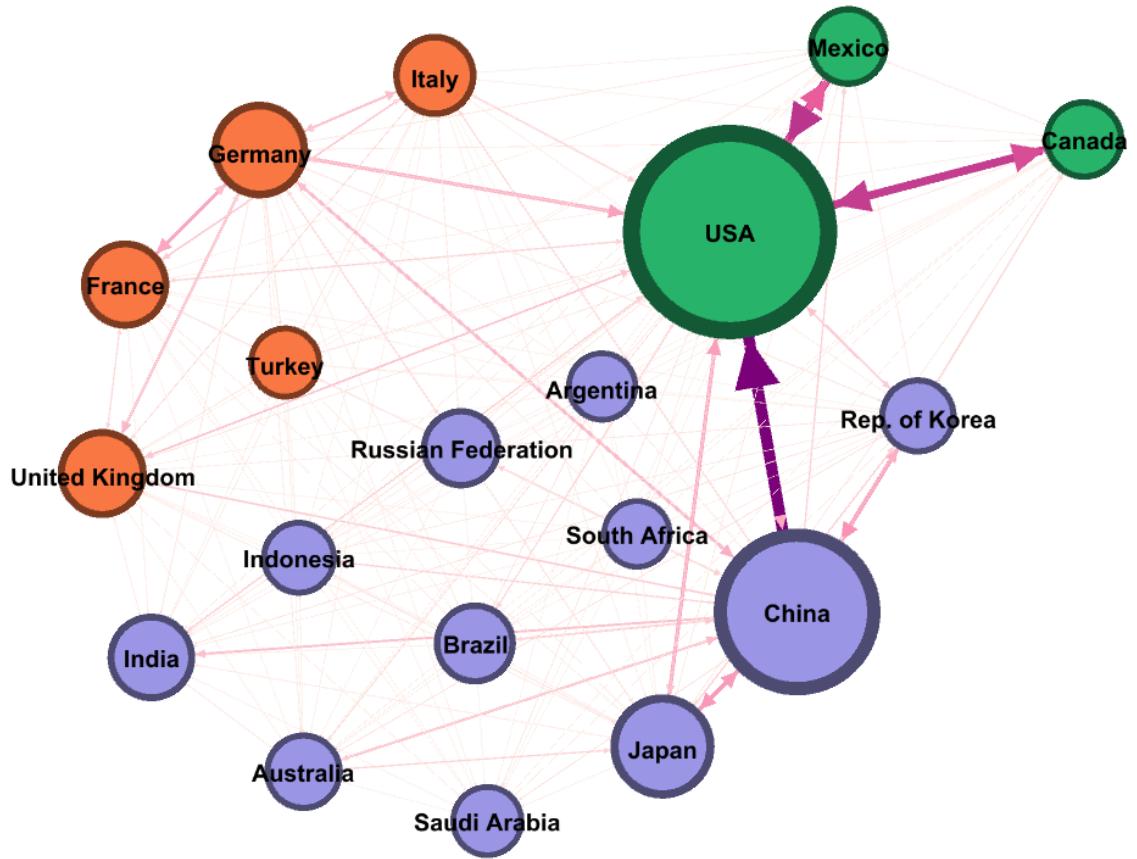
Node colors represent the community

It seems like the G-20's countries formed three different clusters/communities. As shown by graph, USA, Canada and Mexico formed a community (**community 1**) meaning that the trade relations among them are dense while the trade relations with other countries are sparse. Italy, Germany, France, Turkey and UK formed another community (**community 2**). Korea, China, Japan, KSA, Australia, India, Indonesia, Brazil, South Africa, Argentina, and Russia formed the third community (**community 3**).

**BUT, THE QUESTION IS WHY? WHY THESE COUNTRIES FORM COMMUNITIES AMONG EACH OTHER?**

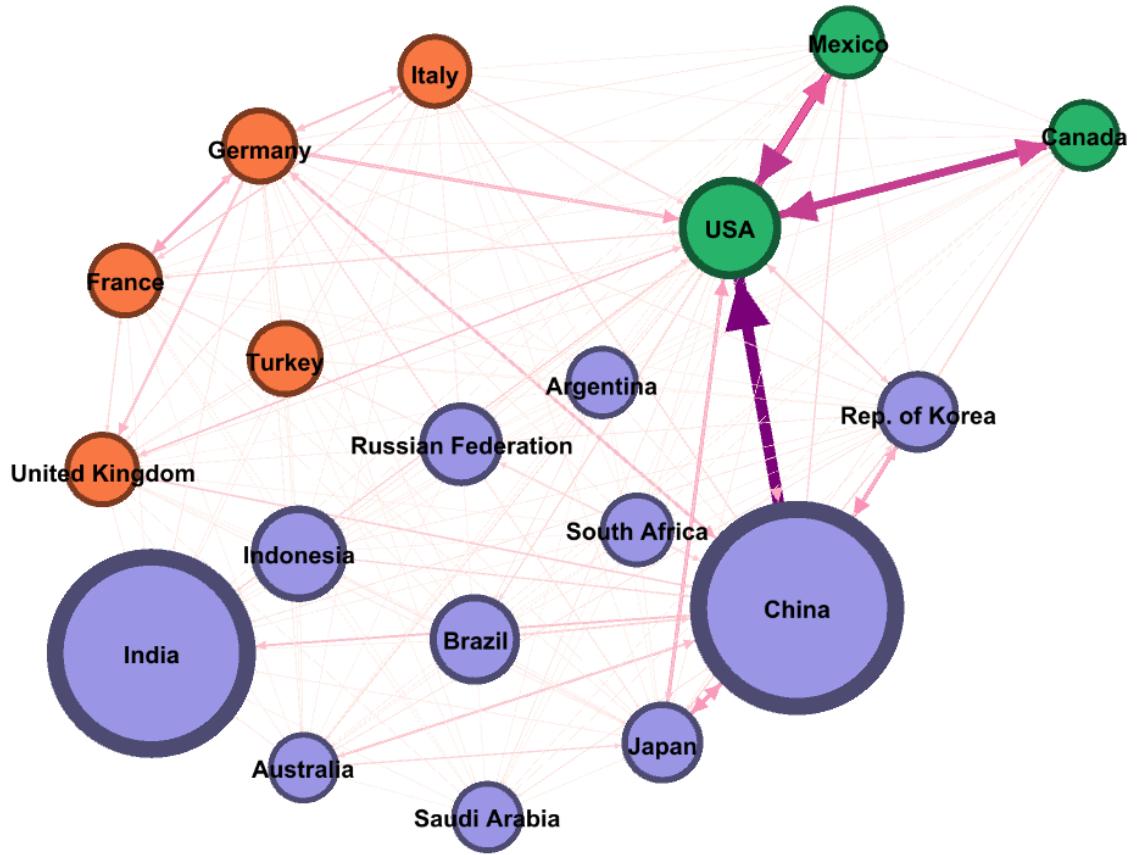
In a try to understand the reason behind such separation we made four different scenarios as follows:

- Make the code color represents the community, node size represents the GDP, and the edge color represents the trade value.



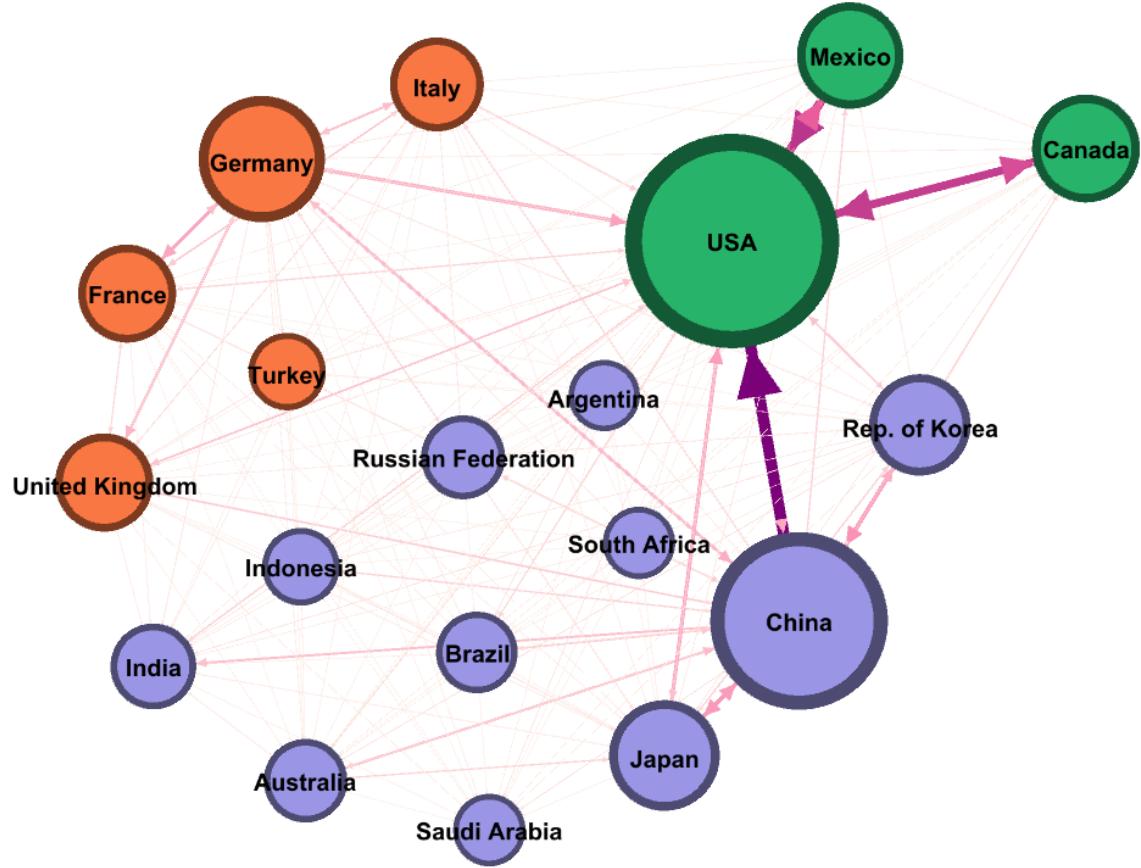
As it appears, (community 2) have similar but not identical GDP. In (community 3) all the countries have similar but not identical GDP except China that has the highest GDP among community 3 countries. For (community 1) it looks like Mexico and Canada have a similar GDP however, USA does not. Hence, as a general conclusion we can say that there might be a weak positive correlation between the Countries' GDP and the communities idea.

- b) Make the code color represents the community, node size represents the Population size, and the edge color represents the trade value.



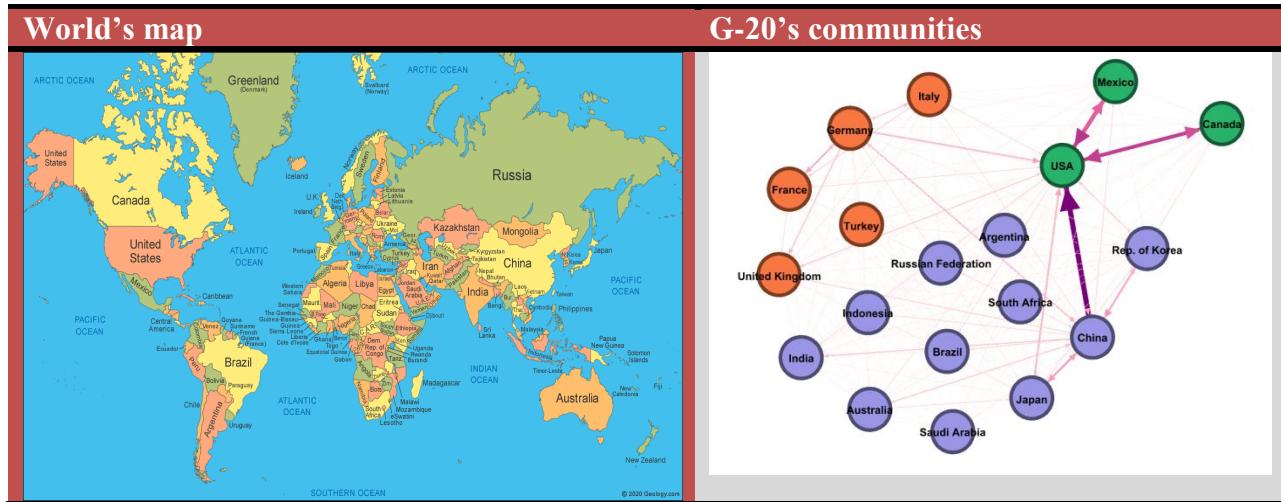
As it appears, (community 2)'s countries have a very similar population size. In (community 3) all the countries have similar but not identical population size except China and India. For (community 1) it looks all the three countries have similar population sizes. Hence, as a general conclusion we can say that there might be a moderate positive correlation between the Country's population size and the communities idea.

- c) Make the code color represents the community, node size represents the weighted degree, and the edge color represents the trade value.



As it appears there is no relation between the communities idea and the countries' trade position; since, USA and China are the most influential countries in terms of trade, however, each of them belong to a different communities.

- d) Determine the relation based on the geographical location of the countries.



It seems like all (**community 1**)'s countries belongs to the same geographical location and the same applies for (**community 2**)'s countries. However, it is not the same for (**community 3**)'s countries; meaning that not all its countries belong to the same geographical location i.e., Brazil and Argentina belong to South America, South Africa lies in Africa...etc.

Hence, as appeared from our analysis it seems like the idea of the clusters is affected heavily by the geographical location and the population size.

*Chapter Four:*

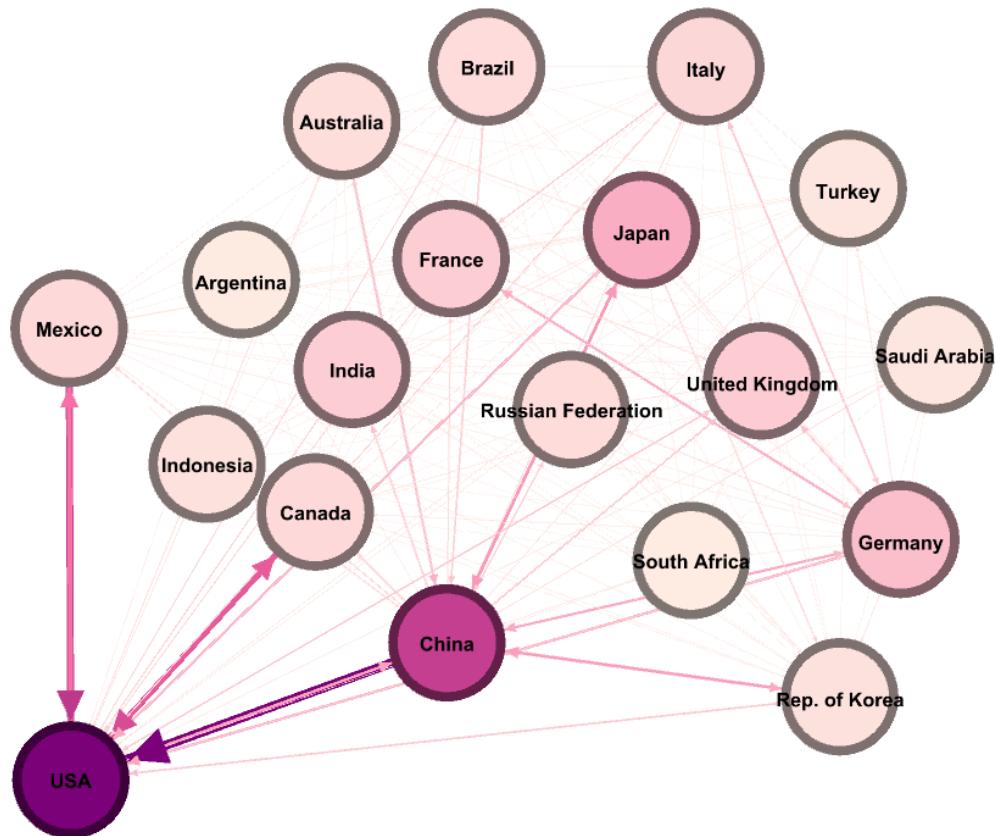
*G20's 2020*

*Trade Network*

*Analysis*

## 2020's Networks Analysis:

1. In 2020, how many countries did each country have trade links (exports) with on average?
2. In 2020, which country was the most popular in terms of exports?
3. In 2020, did the number of the country's export links correlate with its GDP?



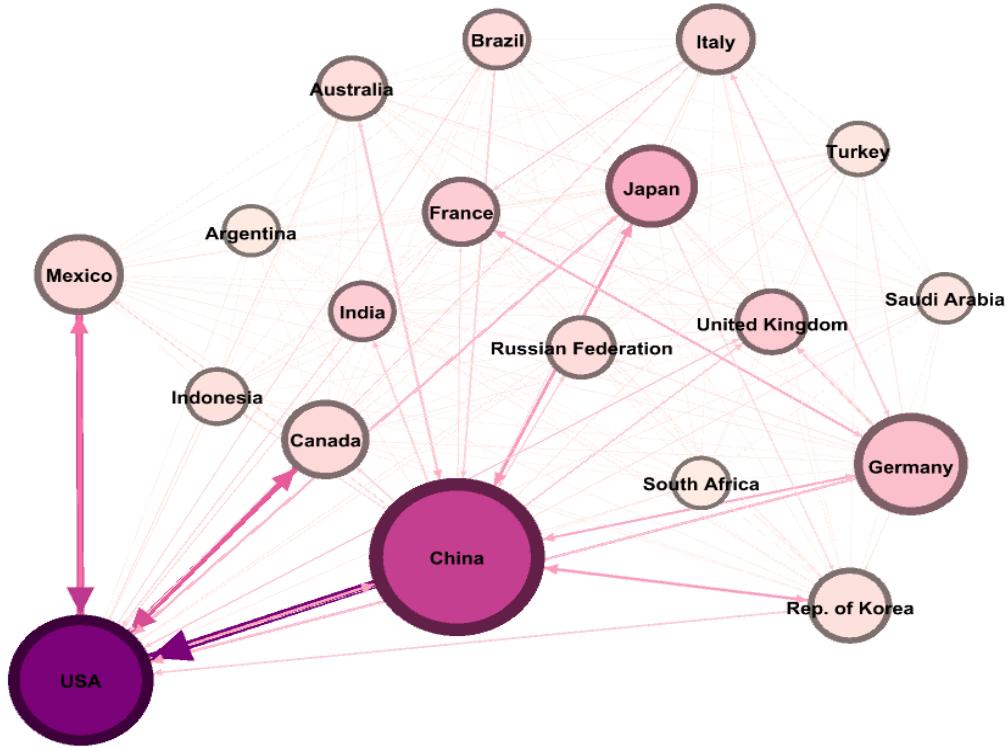
### Graph properties:

Node size reflects the out-degree, edges color reflects the value of the exports and the node color represents the GDP of the country.

From the previous graph, it seems like that all the G-20's countries have the same nodes sizes (all countries have the same popularity) meaning that the number of exports relations between them is the same; each country exports to the other 18 countries, this can give us an impression of how these countries are connected.

However, by looking at the colors and the thickness of edges we can find out that China is the leading country in terms of exports values. USA has the largest GDP and at the same time it can be considered as the leading country in terms of imports; Although USA exports with a moderate high value to both Canada and Mexico, however its imports are relatively larger than its exports. We can deduce that the country's GDP does not affect the country's out-degree (correlation=0).

4. In 2020, which countries had the highest value of exports?
5. In 2020, what was the value of exports for each country in the network, on average?
6. In 2020, was there any relation between the country's GDP and its exports values?

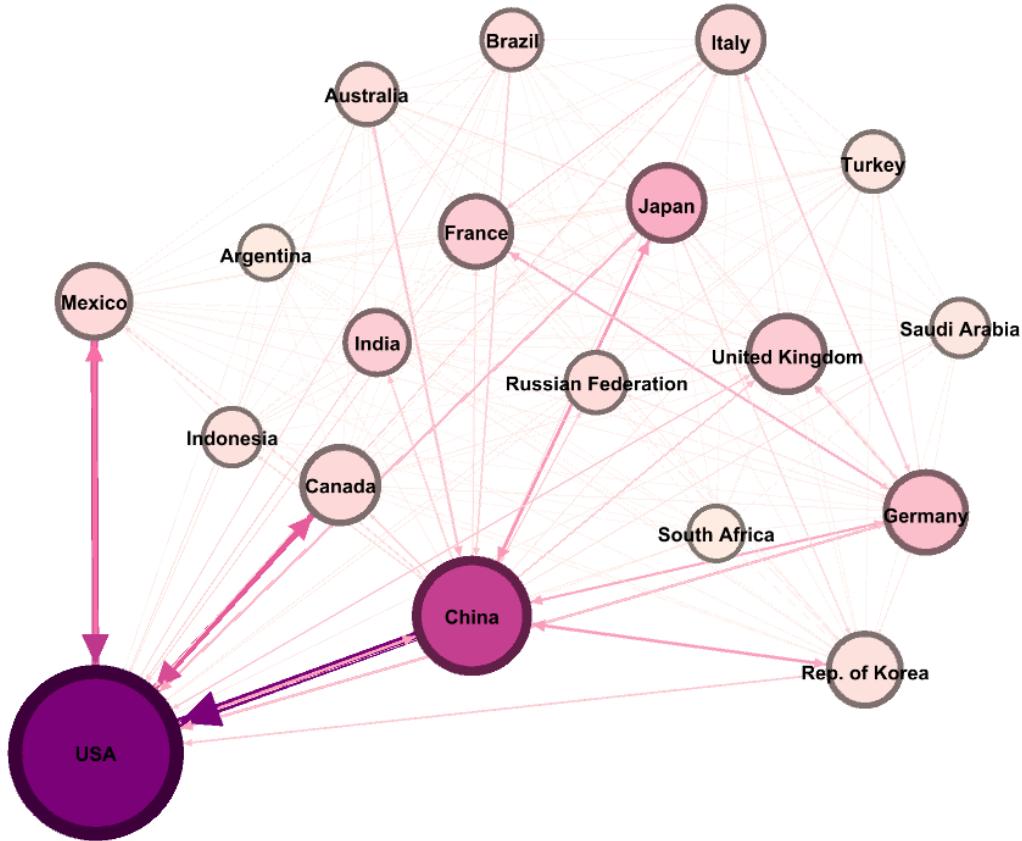


**Graph properties:**

Node size reflects the weighted out-degree, edges color reflects the value of the exports and the node color represents GDP.

It seems like on average, each country in the network has trade relations of value 317120321075.947. And it is clear that China occupies the first place in the exports, followed by USA and Germany respectively. It seems like the relation between the GDP and the exports values (weighted out-degree) goes in the same direction; i.e., for example China has the leader position in the export values and has a relatively high GDP as well and most of the G-20's countries have from low to moderate GDP and from low to moderate weighted out-degree as well.

7. In 2020, which countries had the highest value of imports?
8. In 2020, was there any relation between the country's GDP and its imports position?

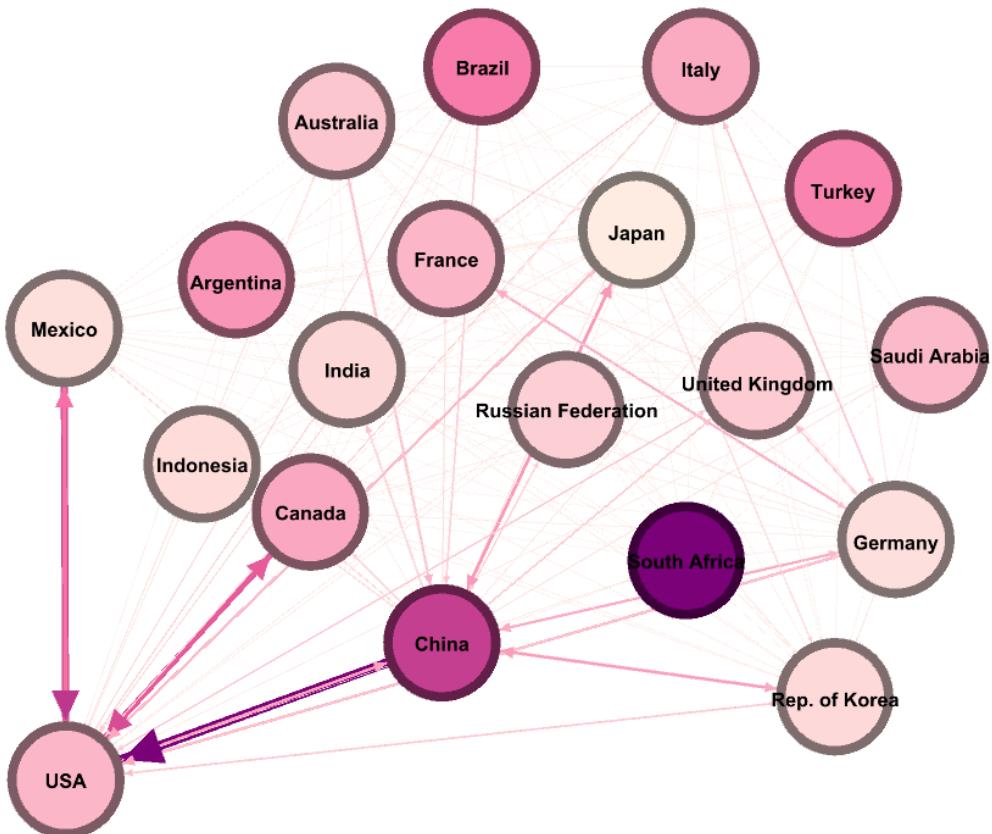


**Graph properties:**

Node size reflects the weighted in-degree, edges color reflects the value of the exports and the node color represents GDP.

It seems like USA occupies the first place in the imports, followed by China. It seems like the relation between the GDP and the weighted in-degree goes in the same direction; i.e., for example USA has the leadership in terms of the GDP value and imports as well, followed by China that occupies the second position in both imports and GDP, South Africa has a very low GDP and Imports as well... etc.

9. In 2020, was there any relations between the country's unemployment rate as a percentage of the GDP and the country's position in terms of exports?
10. In 2020, did the number of export relations (country's out-degree) of the country that had the highest unemployment rate affected by this unemployment rate?



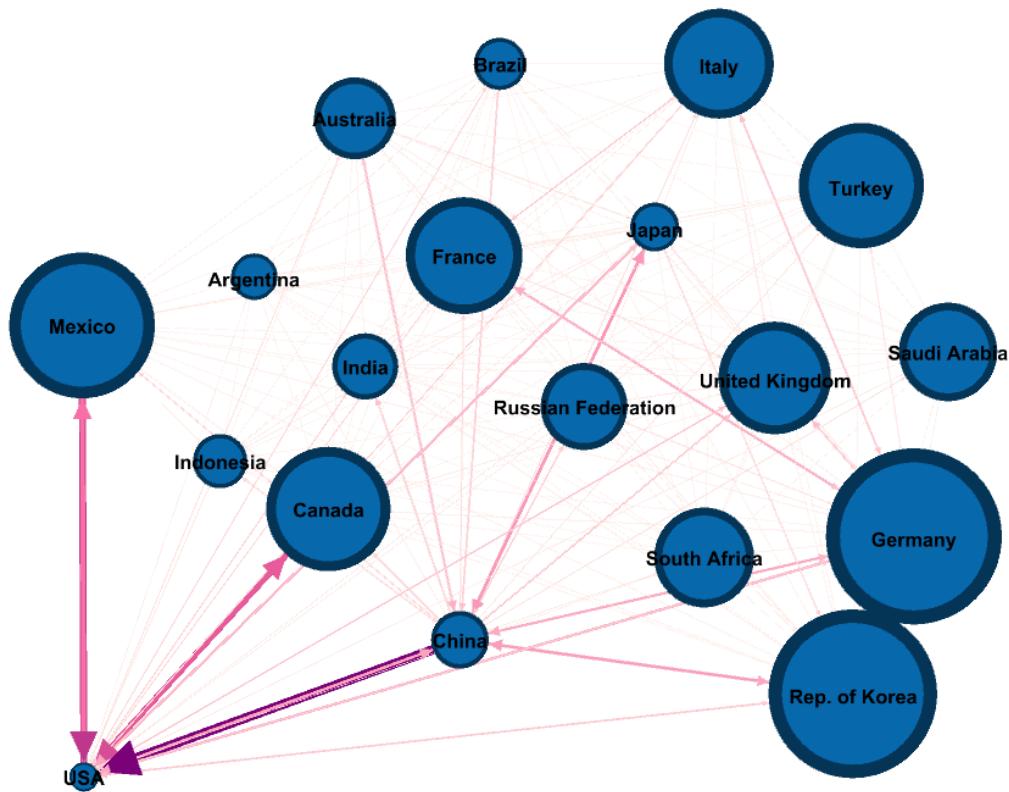
**Graph properties:**

Node size reflects the out-degree, edges color reflects the value of the exports and the node color represents the estimated the unemployment as a percentage of total labor force.

Although, China has a relatively high unemployment rate (higher of 2020's value), however it can still holds its first place in terms of exports values.

In addition, having a relatively low percentage of the employment helped USA to have the highest value of the GDP. Although, South Africa out-degree is the same as the reset of the G-20's counties, however the value of its exports seems to be very low and that might be due to its high unemployment rate (South Africa has the highest unemployment value among all the 19 countries).

11. In 2020, which country played the broker role in the trade network?

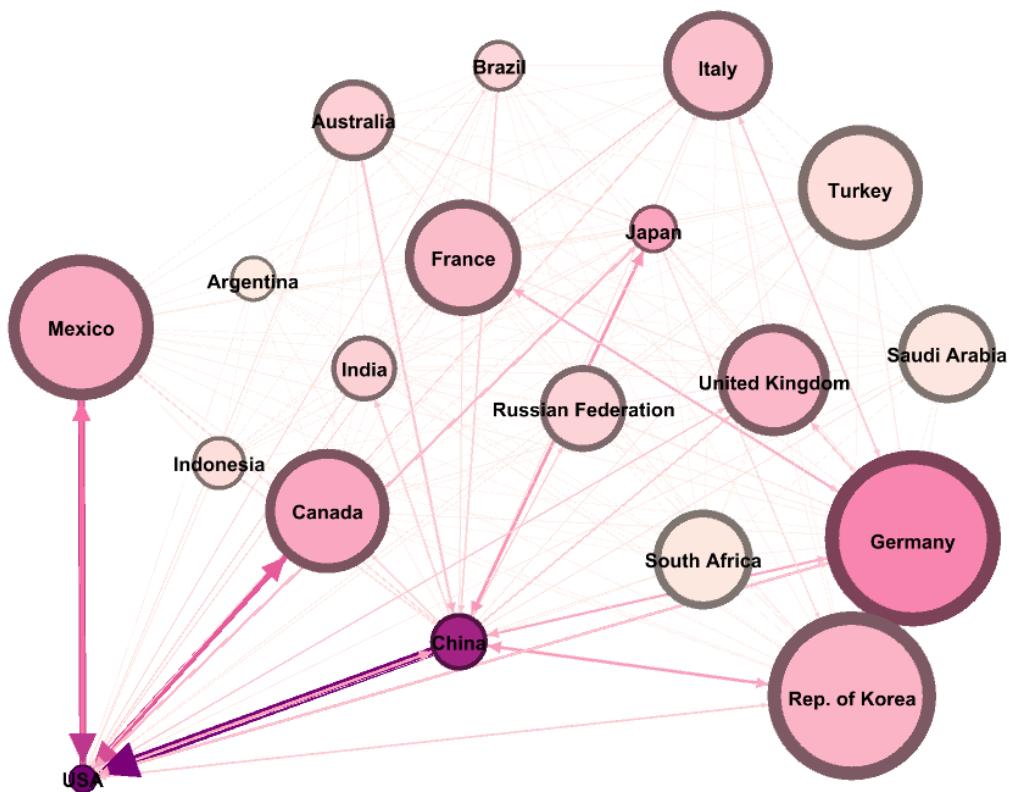


**Graph properties:**

Node size reflects trade a percentage of the country's GDP, edges color reflects the value of the exports and the node color represents betweenness centrality.

It seems like; none of the G-20's countries play the broker rule in this network. And that was expected from the beginning since all of the G-20's countries are connected together in a way or another through the trade relationships, so no need for a broker among them.

12. In 2020, was there any relation between the country's trade value as a percentage of the country's GDP and trade values (imports and exports)?



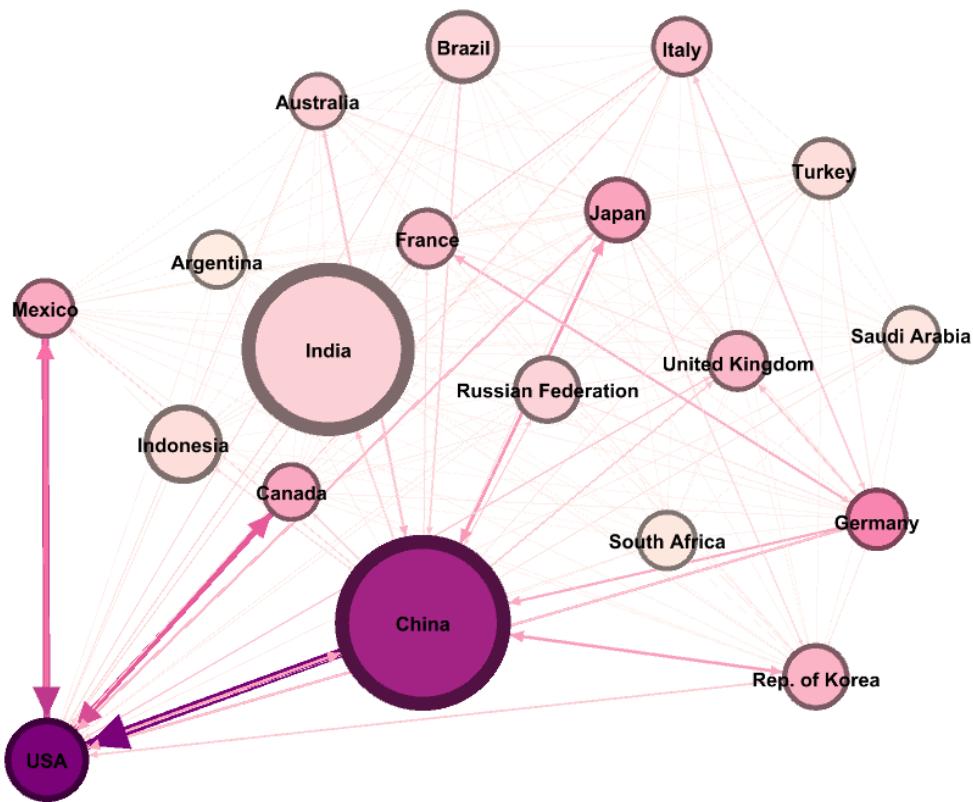
**Graph properties:**

Node size reflects trade as a percentage of the country's GDP, edges color reflects the value of the exports and the node color represents weighted degree.

It seems like that, Germany occupies the first place in the trade as a percentage of the country's GDP followed by Korea although they are not the leaders in terms of the total trade values (weighted degrees). Hence, there was not any relation between the country's trade value as a

percentage of the country's GDP and trade values (imports and exports). It seems like USA occupies the first place followed by China in the total trade values.

13. In 2020, did the countries' population size affect their trade values?

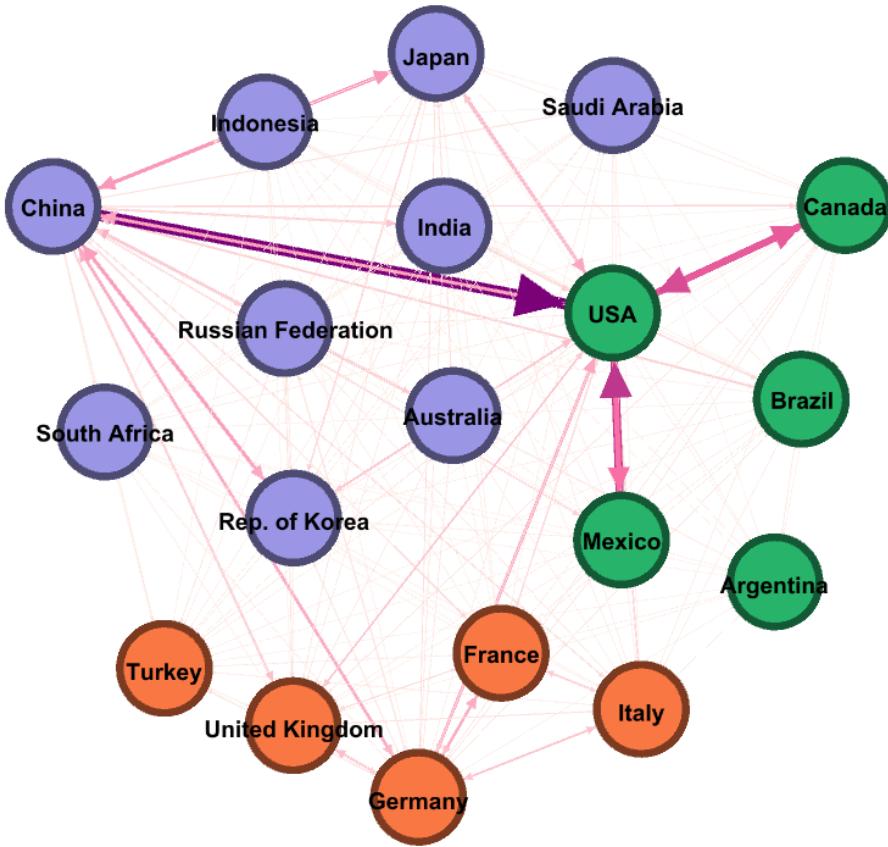


**Graph properties:**

Node size reflects population, edges color reflects the value of the exports and the node color represents weighted degree.

It seems like China has the largest population size and it occupies the second place in the total trade values. Although, USA is the third largest population among the G-20's populations it occupies the first place in the total trade values. India has the second largest population size however; it is not a strong influencer in term of the total trade values.

14. In 2020, do the G-20's countries fall into clusters?



Node colors represent the community

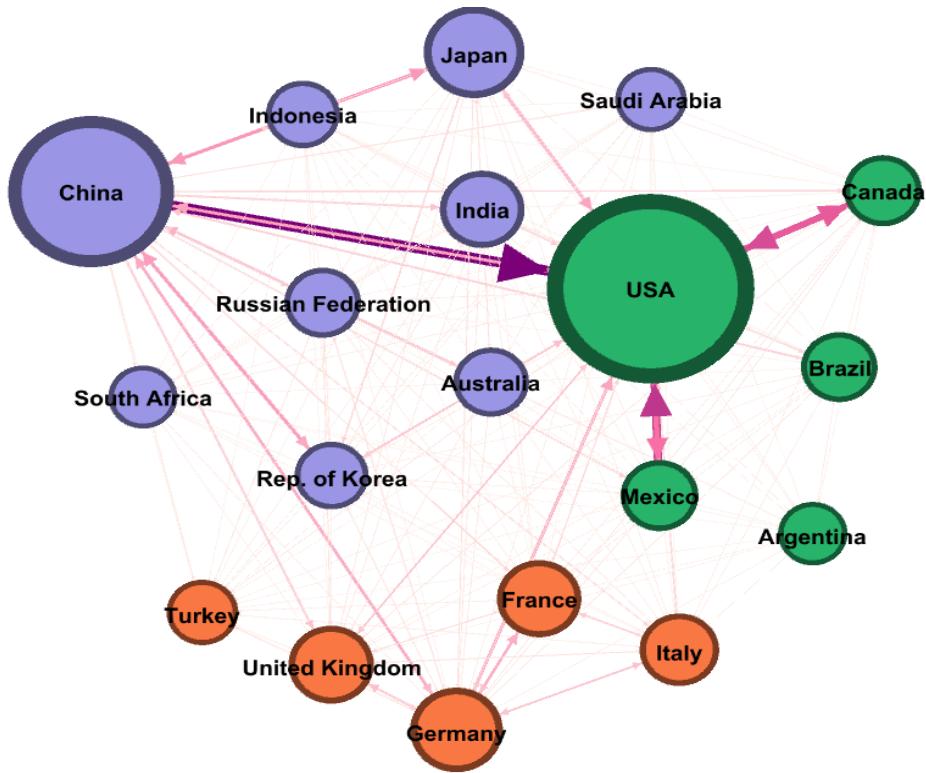
It seems like the G-20's countries formed three different clusters/communities. As shown by graph, USA, Canada, Brazil, Argentina and Mexico formed a community (**community 1**) meaning that the trade relations among them are dense while the trade relations with other countries are sparse. Italy, Germany, France, Turkey and UK formed another community (**community 2**). Korea, China, Japan, KSA, Australia, India, Indonesia, South Africa, and Russia formed the third community (**community 3**).

As it appears in 2020, there were some changes in the memberships of some countries in community 1 and 3. However, (community 2)'s members did not change.

**THE QUESTION NOW IS WHY? WHY THESE COUNTRIES FORM COMMUNITIES AMONG EACH OTHER?**

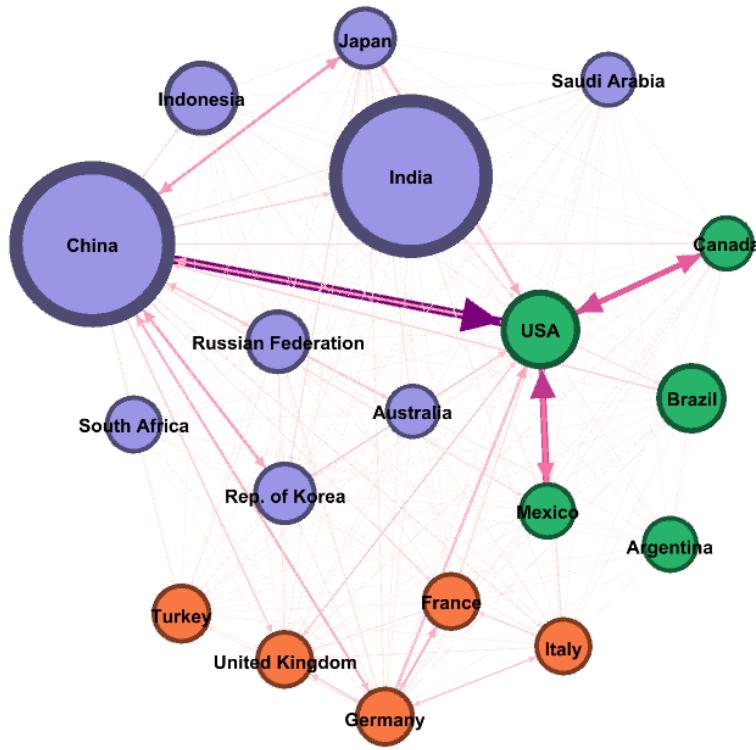
In a try to understand the reason behind such separation we made four different scenarios as follows:

- a) Make the code color represents the community, node size represents the GDP, and the edge color represents the trade value.



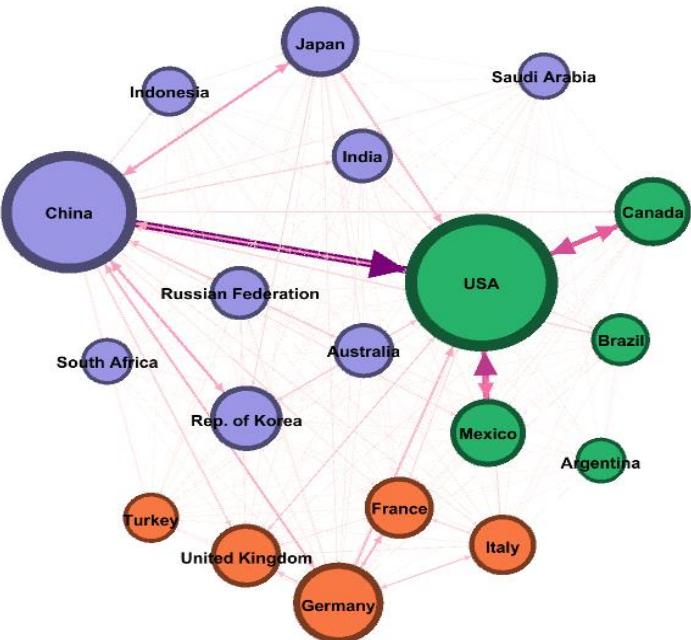
As it appears, (community 2) have similar but not identical GDP. In (community 3) all the countries have similar but not identical GDP except China that has the highest GDP among (community 3)'s countries. For (community 1) it looks like again all the countries have similar GDP except USA. Hence, as a general conclusion we can say that there might be a weak positive correlation between the Countries' GDP and the communities idea.

- b) Make the code color represents the community, node size represents the Population size, and the edge color represents the trade value.



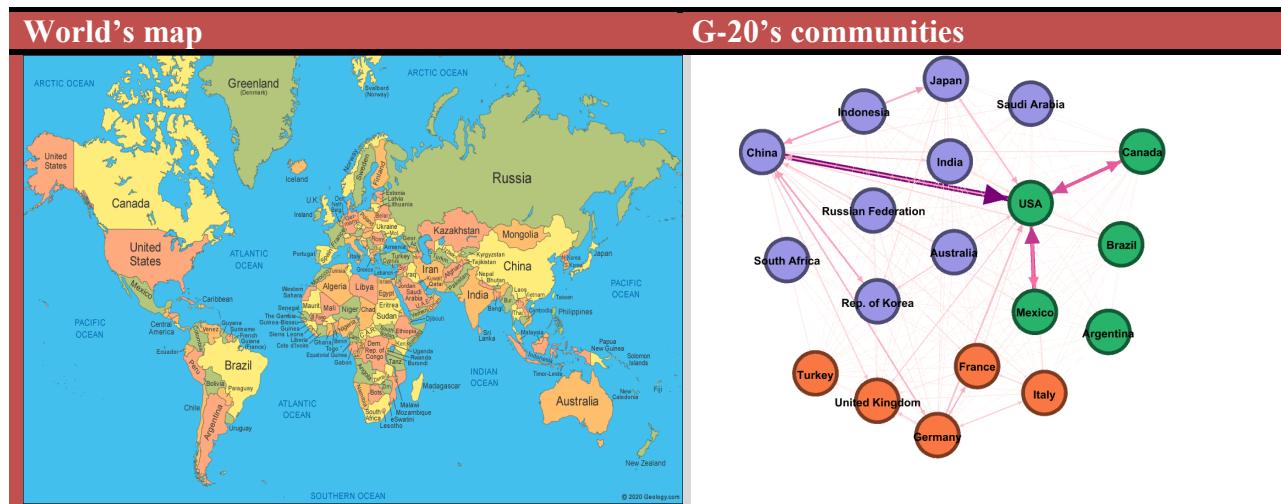
As it appears, (community 2)'s countries have a very similar population size. In (community 3) all the countries have similar but not identical population size except China and India. For (community 1) it looks like all the countries have a similar not identical population sizes. Hence, as a general conclusion we can say that there might be a moderate positive correlation between the country's population size and the communities idea.

- c) Make the code color represents the community, node size represents the weighted degree, and the edge color represents the trade value.



As it appears there is no relation between the communities idea and the countries' trade position; since, USA and China are the most influential countries in terms of trade, however, each of them belong to a different communities.

- d) Determine the relation based on the geographical location of the countries.



It seems like all (**community 2**)'s countries belongs to the same geographical location. And, for (**community 1**)'s countries it seems like all its counties belong to near geographical locations (South/South America). And for (**community 3**)'s countries it is not the same; meaning that not all its countries belong to the same geographical location i.e., South Africa lies in Africa...etc.

Hence, as appeared from our analysis it seems like the idea of the clusters is affected heavily by the geographical location and the population size.

*Chapter Five:*

*2018 & 2020*

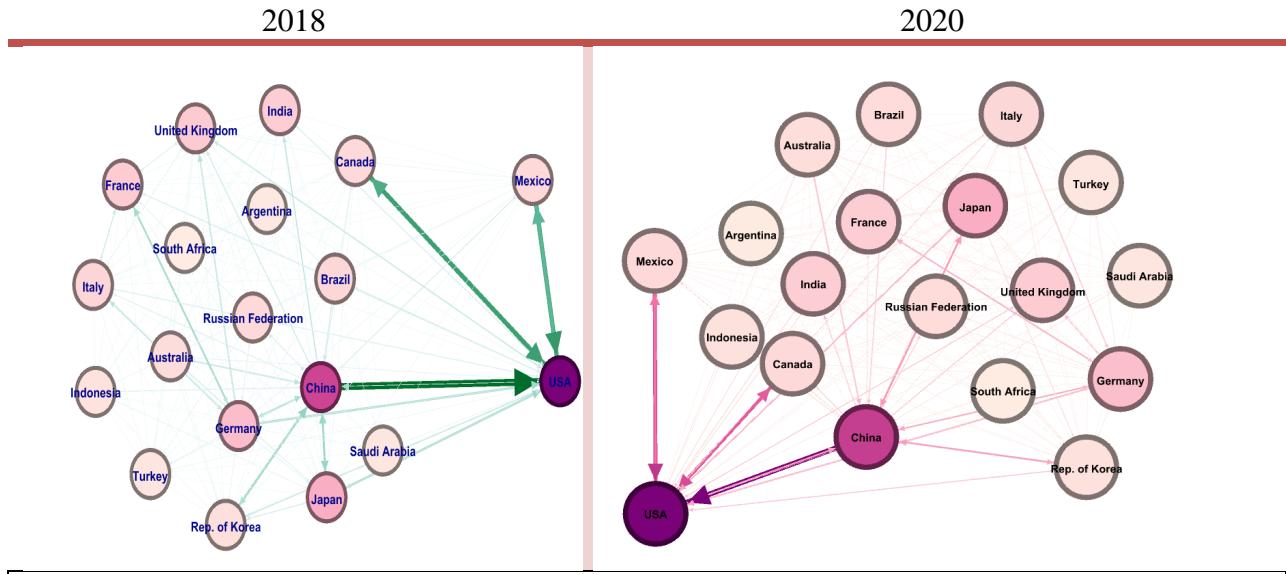
*Combined*

*Analysis and*

*Comparisons*

## Comparisons:

- Does Covid-19 affect the number of the exports relations among the G-20's countries?

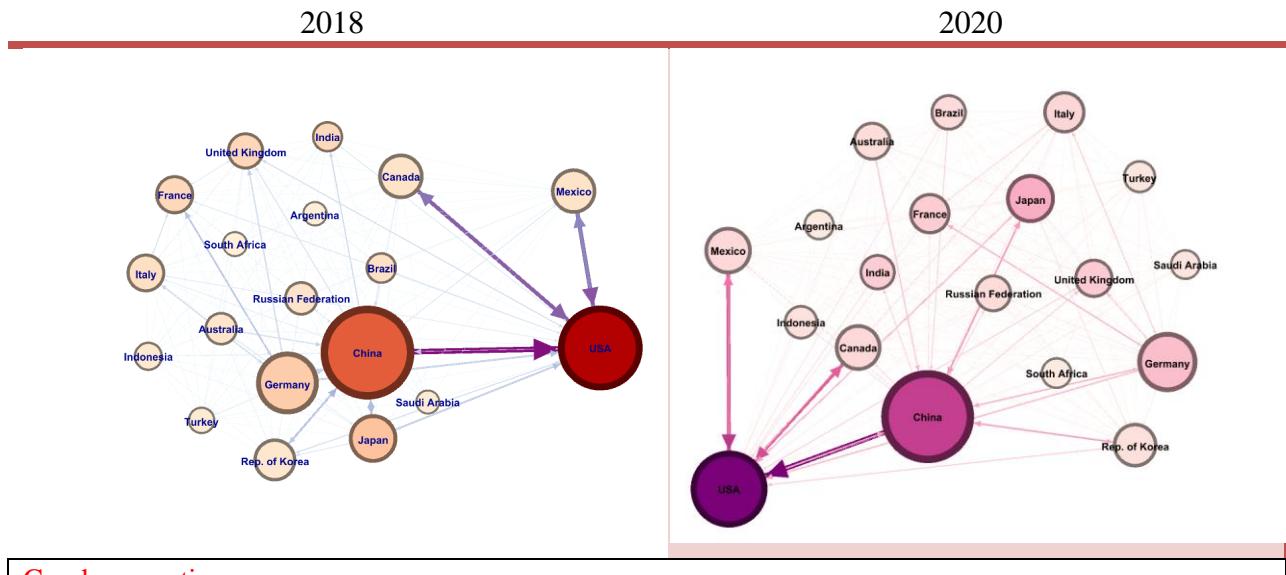


### Graph properties:

Node size reflects the out-degree, edges color reflects the value of the exports and the node color represents the GDP of the country.

It seems like Covid-19 had no impact on the number of the exports relations; all the G-20's countries have the same nodes sizes before and after Covid-19.

- Do we have a new exports leader after Covid-19?

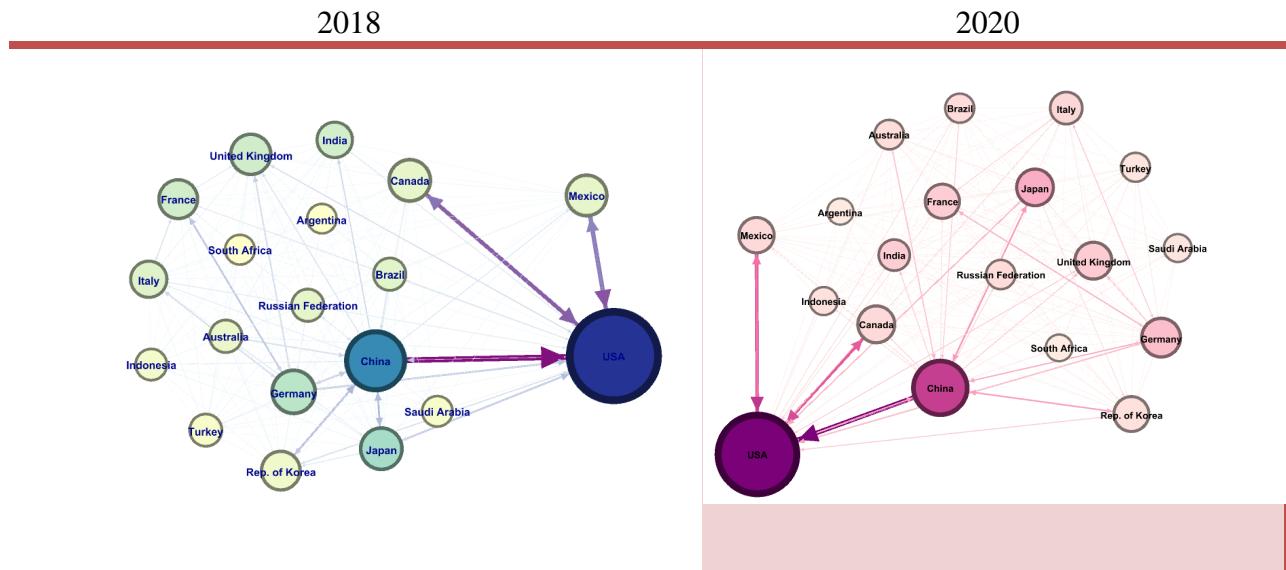


### Graph properties:

Node size reflects the weighted out-degree, edges color reflects the value of the exports and the node color represents GDP.

It does not seem like we have any new leader in terms of exports; China is still occupying its position.

### 3. Do we have a new imports leader after Covid-19?



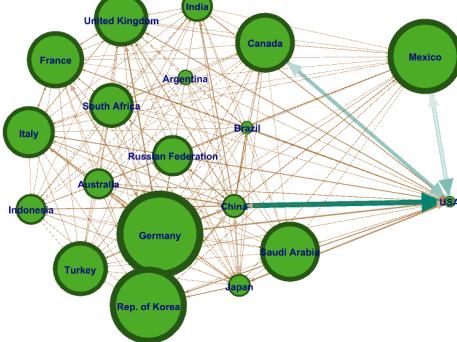
#### Graph properties:

Node size reflects the weighted in-degree, edges color reflects the value of the exports and the node color represents GDP.

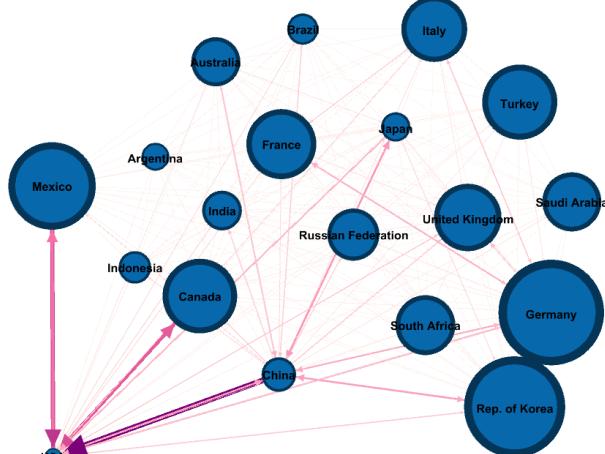
It does not seem like we have any new leader in terms of imports; USA is still occupying its position.

### 4. Is there any change in the betweenness measure after Covid-19?

2018



2020



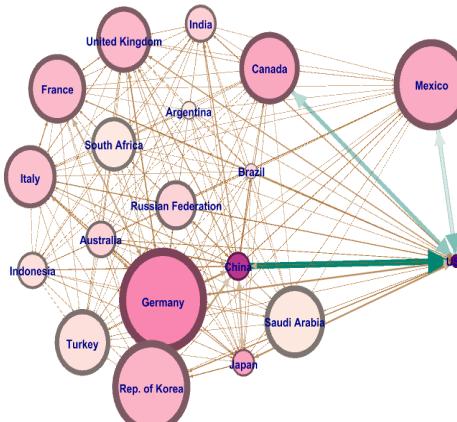
**Graph properties:**

Node size reflects trade as a percentage of the country's GDP, edges color reflects the value of the exports and the node color represents betweenness centrality.

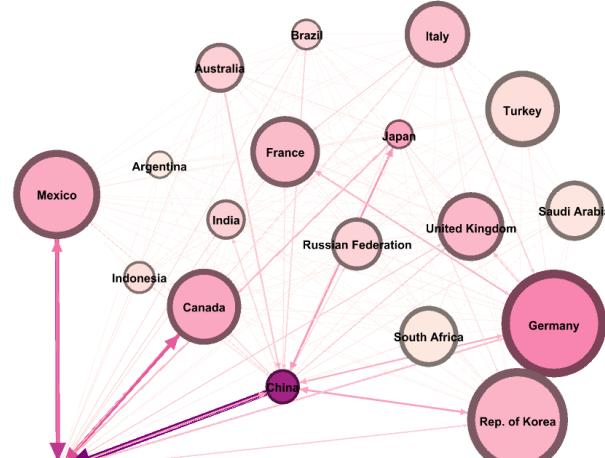
No actually it seems like; none of the G-20's countries played the broker rule even after Covid-19.

5. Which country plays the leader rule in terms of the total trade after Covid-19?

2018



2020



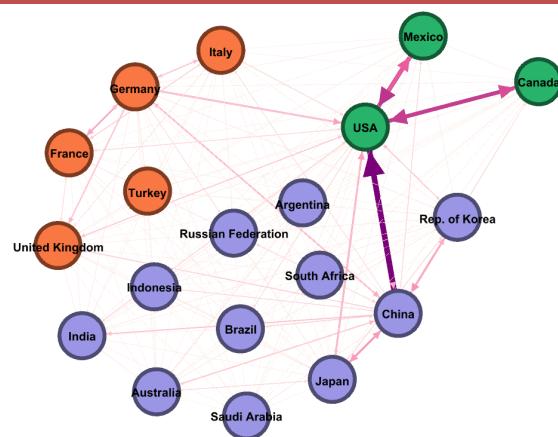
**Graph properties:**

Node size reflects trade as a percentage of the country's GDP, edges color reflects the value of the exports and the node color represents weighted degree.

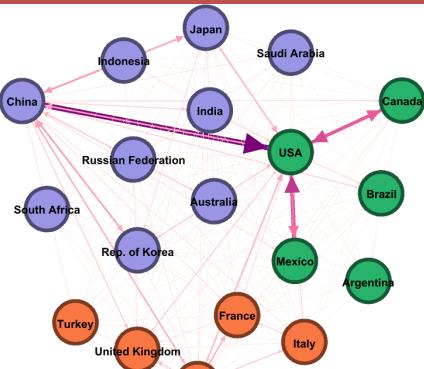
USA is still the total trade leader after Covid-19.

#### 6. Does G-20's communities' memberships changed after Covid-19?

**2018**



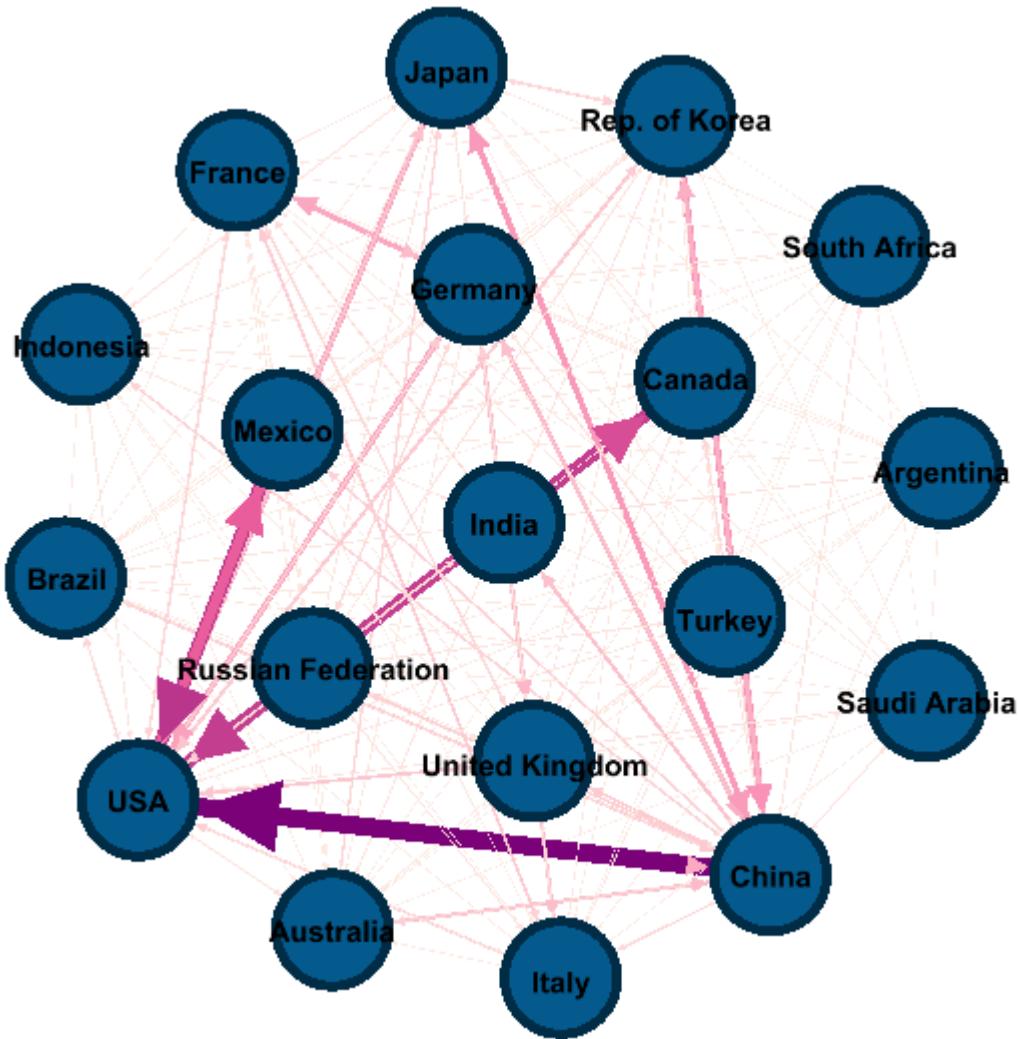
**2020**



It seems like the G-20's countries formed three different clusters/communities before and after Covid-19. As it appears in 2020, there were some changes in the memberships of some countries between **community 1 and 3**; Brazil and Argentina left **(community 3)** to joint **(community 1)** meaning that the trade relations among them and USA, Canada and Mexico became strong although it was sparse in 2018. However, **(community 2)**'s membership didn't change after Covid-19.

## Combined Analysis:

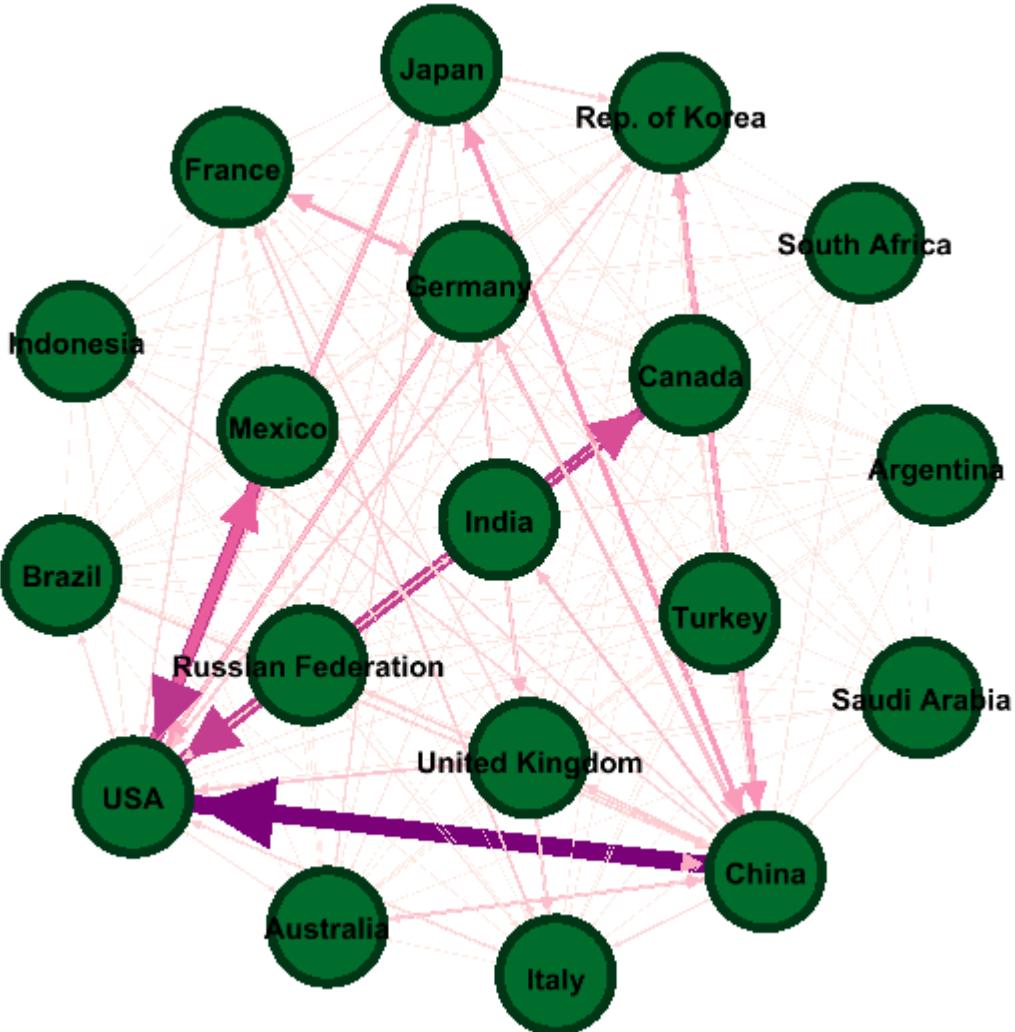
7. In 2018 and 2020, which country can reach other countries faster?



Nodes colors represent the closeness centrality

It seems like all the G-20's countries can reach each other with the same speed and Covid-19 break-out had no impact on this fact.

8. Which countries are connected to many other countries which are, in turn, connected to many others?



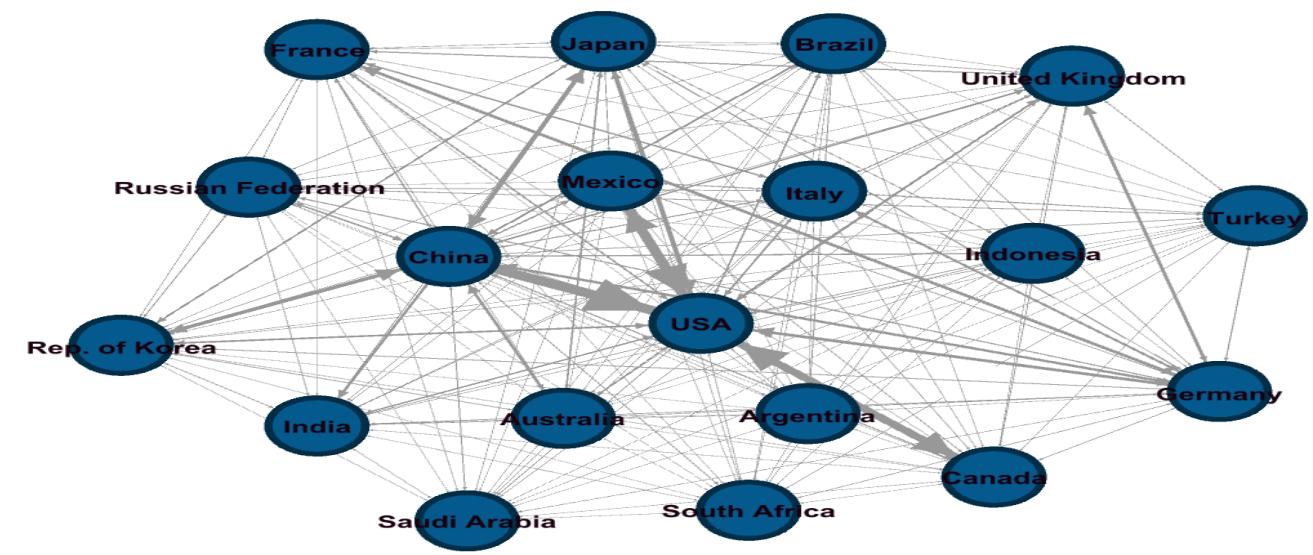
Nodes colors represent the Eigen-vector centrality

As all of the G-20's countries are connected together, we found that the Eigen-vector centrality equal to one for all countries, and that was expected. Covid-19 break-out had no impact on this fact.

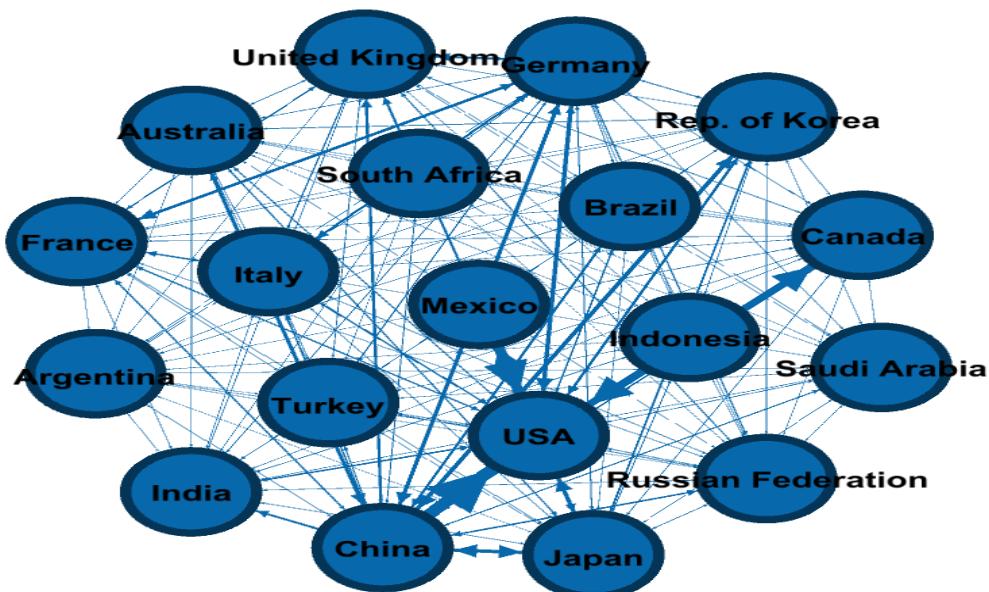
### Graph density

It is found that our graph is a complete graph as all its Nodes are connected to each other as the graph density equals to 1 which means that 100% of the all possible trade flow was found between G20 countries in 2018 & 2020.(all countries are completely linked with each other)

## Clustering coefficient



In this graph colour of nodes represents clustering coefficient while size of nodes represents closeness, we can observe that average clustering coefficient was equal to 1 (all nodes has the same colour tone) which means that for each node all its neighbours are connected and there's a strong trade between countries. This was also observed from equal size of nodes that indicates that closeness was also equal to 1 which confirms the result of clustering coefficient that all nodes are linked, close to each other and make cluster with all its partners in 2018.



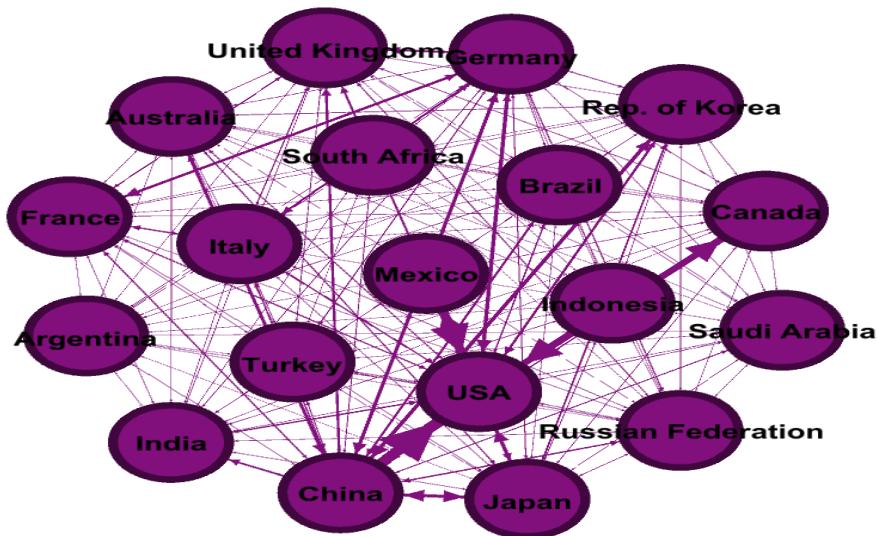
This graph colour tone of nodes represents clustering coefficient while size represent closeness in 2020 and if we compare it with graph of 2018 we will find that they are the same.

## Path length

In 2020 and 2018 average path length was equal to 1 which means that each country (node) can reach other 18 countries through only one step which indicates the strong link between those 19 countries and how their trade relationship is strong and powerful.

## Eccentricity

We observe that eccentricity was equal to 1 which means that distance between a node(country) and the node furthest from it is 1 that reflects that countries are actually close to each other , also this appears in other metrics like closeness and average path length.



In this graph color tone indicates the Eccentricity that reflects all has same value and distance between them.

*Chapter Six:*

*Conclusion and  
Main Findings*

## **Insights from Networks Analysis (The Main Findings)**

In the previous chapters, we were able to find clear answers for our research question through networks analysis. Networks analysis helped in understanding that China and USA play a very influential role in the trade relation among all the 19 countries. Also it helped in understanding how well our network is connected (all the countries are linked together through the trade relations). We were able to confirm that although all the countries trade with each other, however, the idea of clusters or communities did not disappear since we had three communities in the network.

We were able to accept or reject a certain hypothesis through different visualizations by different colors and attributes. For example, when we assumed that there is a relation between the countries' GDP and the countries' position in terms of exports, we found that there is no relation between the countries' GDP and the exports values (weighted out-degree) through the visualization and the network analysis.

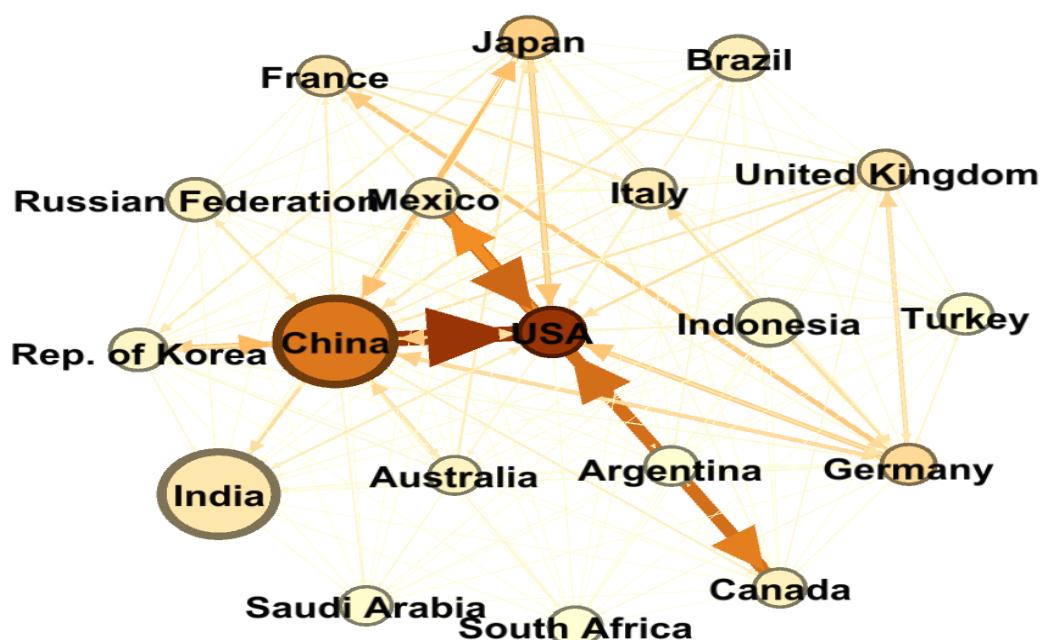
Through the comparisons we made we found out that Covid-19 did not change the trade relations among the G-20's countries;

- All the countries were connected together before and after Covid-19 and hence no need for a broker among them and hence, all the G-20's countries were able to reach each other with the same speed.
- The United States of America managed to retain its first position in the trade (total trade / imports) even through Covid-19 break-out.
- China's position didn't change after Covid-19 break-out; China is still the G-20's exports leader.
- USA's GDP was the highest among all the G-20's countries even after Covid-19 break-out.
- Before and after Covid-19 break-out the average path length was equal to 1 which means that each country (node) can reach other 18 countries through only one step which indicates the strong link between those 19 countries and how their trade relationship is strong and powerful.
- Before and after Covid-19 break-out South Africa ranked as the first in the unemployment rate.
- Before and after Covid-19 break-out the country's GDP does not affect the number of the country's export links (country's out-degree) (correlation=0).
- Before and after Covid-19 break-out the relation between the GDP and the exports values (weighted out-degree) goes in the same direction i.e., for example China has the leadership in the export values and has a relatively high GDP as well.
- Before and after Covid-19 break-out the relation between the GDP and the imports values (weighted in-degree) goes in the same direction; i.e., for example USA has the leadership in terms of the GDP value and imports as well,

- Before and after Covid-19 break-out there was not any relation between the country's trade value as a percentage of the country's GDP and trade values (imports and exports)
- After Covid-19 break-out the trade network was as connected as before.

However, although it seems like the G-20's countries formed three different clusters/communities before and after Covid-19. After Covid-19 break-out, there were some changes in the memberships of some countries between **community 1 and 3**; Brazil and Argentina left **(community 3)** to joint **(community 1)** meaning that the trade relations among them and USA, Canada and Mexico became strong although it was sparse in 2018. However, **(community 2)**'s membership didn't change after Covid-19.

## Visualization




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Through visualization we were able to understand the trade relations among the G-20's countries and how these relations were not affected by Covid-19 break-out although we thought that these relationships would be significantly and prominently affected by the spread of Covid-19. Changing the nodes colors and sizes and the edges colors helped in the analysis of the trade in order to provide a clear answers for even something statistical like the correlation between different attributes in a single time point or even over time.

## **Application of Social Network Analysis into Other Similar Topics**

Social networks are everywhere and research aiming at analyzing and understanding these structures is growing year by year. Our analysis cases study of G-20's trade relations was only a sample of networks analysis but the world is full of real situations that can be modeled and analyzed through SNA for example, Network of alliances between countries where nodes represent the countries and edges represent the alliances, another example in which networks analysis will be helpful is the network of wars among the world's countries where nodes represent countries and edges represent the existence of the war in which we can see how intense the wars in our world and how the world became an arena for conflicts and disputes, not an arena of peace and cooperation as it should be .

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