

International Trade Network Analysis

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Abstract

This work exposes the most recent evidence on the international trade network emphasizing key actors, trade behaviour tendencies, and the repercussions of the COVID-19 pandemic. Later, this study provides a descriptive analysis of the network in 2021, focusing on the exploration of significant commercial connections between countries, leaving out noisy trade flows. Among the main findings are: i) most countries maintain close connectivity within the global trade network, regardless of their trading partnerships; ii) bridging roles are predominantly assumed by countries above a certain threshold of edges; iii) the United States, China, and Germany are still the most influential actors within the network; iv) the network is constituted by seven distinct communities with a leading country highly interconnected.

I. Introduction

In recent decades, the landscape of international trade has witnessed significant expansion, largely due to the advance of globalization (Krugman, et al. 2023). At the same time, the examination of international trade networks has emerged as a pivotal area of inquiry within the fields of economics and network analysis. Moreover, COVID-19 pandemic occasioned unexpected and rapid shifts in global commerce, rising confusion and uncertainty. In this context, this study aims to present an updated overview of the international trade network. This work begins by exposing the most recent evidence focusing on key actors, trade behaviour tendencies, and the repercussions of the COVID-19 pandemic on network dynamics.

Further on, based on the latest available data, this study provides a descriptive analysis of the international trade network. While some studies traditionally analyse export volume, our approach focuses on the top five trading partners of each country worldwide. This approach allows to concentrate the analysis on the significant connections between countries, without the noise introduced by extreme export flows.

The analysis reveals five key findings. First, it underscores that most countries maintain close connectivity within the global trade network, regardless of their specific trading partnerships. Second, bridging roles within the network are predominantly assumed by countries above a certain threshold of edges, facilitating trade interactions across various regions. Thirdly, consistent with recent evidence, the United States, China, and Germany maintain as the most influential actors within the international trade network.

Fourth, employing a modularity maximization algorithm, this study identifies seven distinct communities within the network. Each community is spearheaded by a prominent country that serves as the core, facilitating interconnectivity in its respective domain. Finally, the observed trade patterns within the network are compatible with

fundamental principles of reciprocity, mutual trading partnerships, and geographical proximity.

II. Literature Review

Over time, international trade has been dominated by a few countries that capture a significant proportion of global commerce. Gönçer-Demiral and Meltem İnce-Yenilmez (2022) analyse international trade in 2019 and 2020 through the lens of Social Network Analysis (SNA), identifying relationships and structures between countries. They found that the nations with the highest export volumes were (1) China, (2) the US, and (3) Germany. Similarly, Kiyota (2022) applied SNA to international trade in 2020 and identified the same major stakeholders. Smith and Sarabi (2022) explored international trade in 2017 through SNA, using Exponential Random Graph Models (ERGMs) and Gravity Models (GMs) to analyse the trade patterns of countries and predict trade flows. The authors noted that the core actors are North American and Western European countries (excluding Portugal), along with a few nations from South Asia and the Pacific, such as China, Japan, Hong Kong, Singapore, and South Korea, indicating that China, the US, and Germany are central to the contemporary economic order.

The international trade network is characterised by distinct communities and divisions that persist even after global economic disruptions. Several recent studies have highlighted the existence and significance of these communities, groups, and divisions within the international trade network. Antonietti et al. (2022) conducted an analysis using Estrada communicability distance and modularity measures, identifying three prominent international trade communities: i) European countries; ii) the US, Canada, Japan, and Australia; and iii) a distinct northern European group. Notably, their findings illustrate the resilience of these networks, which have persisted despite global shocks like the COVID-19 pandemic. In this tenor, Smith and Sarabi (2022) demonstrated that international trade can be segmented into core and periphery countries, revealing that larger periphery countries tend to specialize in the production of low-technology goods. Furthermore, Herman (2022) corroborated the presence of communities within the international trade network.

Countries exhibit trade behaviour tendencies based on certain conditions. First, geographic distance is significant, as nations are more likely to trade with their neighbours due to lower logistical costs. Second, highly developed nations tend to trade with each other and establish specific trading partnerships. Third, trade density between members of the same region varies considerably: European Union (EU) countries exhibit the most intense trade relationships, whereas African nations have the weakest (Gönçer-Demiral and İnce-Yenilmez, 2022; Smith and Sarabi, 2022). Herman's (2021) work using ERGMs and GMs to analyse network relationships in trade from 1995 to 2006 demonstrated that countries tend to engage in reciprocal trade, meaning they are more likely to export to countries from which they import, and vice versa. Additionally, nations are inclined to trade with common third-party trading partners (Herman, 2021).

While COVID-19 may have induced temporary disruptions in the structure of international trade, enduring partnerships and the relative importance of trade have remained, but with potential shifts in trade composition. The COVID-19 pandemic appears to have caused some short-term structural changes within the international trade network. Vidya and Prabheesh (2020) used network analysis measures and artificial neural networks to predict a significant reduction in trade interconnectedness and notable changes in network structure in 2020. Conversely, Kiyota's (2022) investigation into structural breaks and degree centrality behaviour within the international trade network revealed that the influence of key communities, such as the Association of Southeast Asian Nations (ASEAN), remained resilient post-pandemic. However, the author acknowledges the potential for shifts in trade composition, such as changes in economic sectors. Moreover, Gönçer-Demiral and İnce-Yenilmez (2022) highlighted the stability of commercial partnerships and trade patterns one year after the pandemic.

III. Contribution

This investigation holds significant relevance in international trade network analysis. First, our investigation focuses on trade data from 2021, unlike the most recent available studies that utilize data up to 2020. This temporal distinction is particularly crucial in the context of the COVID-19 pandemic, as the global economic landscape has undergone dynamic shifts in response to the pandemic's impact on trade patterns and behaviours. Secondly, while some studies traditionally analyse export volume, our approach examines the top five trading partners of each country worldwide. This methodological approach enables a focus on the relevant connections of countries without the noise introduced by extreme export volumes. Additionally, it facilitates a more targeted analysis by narrowing it down to only meaningful trade flows by country. Therefore, our investigation not only offers a more up-to-date perspective in the light of recent global events but also employs a novel approach to provide deeper insights into the interconnectedness and dynamics of the international trade network.

IV. Data and Methodology

This work relies on trade data sourced from the World Integrated Trade Solution (WITS, 2021), a software platform developed through collaboration between the World Bank, the United Nations Conference on Trade and Development (UNCTAD), and other global organizations. WITS serves as a comprehensive repository of trade-related information. Among the available trade indicators on the WITS platform, we selected the "Export - Trade (US\$ Mil)-Top 5 Export Partner" indicator for 2021. This metric provides the volume of exports, measured in millions of US dollars, between nearly every country and its top five export partners. By focusing on the most substantive trade flows of each country, the chosen indicator offers a comprehensive and objective framework for analysis.

While the structure of the international trade network typically resembles that of a directed network, our analysis treats the trade dynamics as an undirected network to concentrate on trade structures and relationships. We interpret countries as nodes and the existence of a substantial trade relationship between countries as edges.

Specifically, if country j is among the top five export partners of country i , then it is enough for an undirected edge to be formed, and vice versa.

It should be noted that some countries may have fewer than five partners due to data availability issues or unique trading behaviours. Data availability is a common challenge in analysing international relations, as some countries may not accurately report or restrict access to their trade data, particularly in the context of totalitarian or authoritarian regimes (Rothman, 2007). During data cleaning, entries with missing values were removed. Additionally, smaller countries might focus their trade on a limited number of partners.

The network analytical framework employs several methods and metrics to uncover hidden structures and patterns within networks. Degree centrality quantifies the significance of a node based on its connected edges (Newman, 2018), indicative of a country's trade flow volume in this context. Closeness centrality assesses a node's proximity to the rest of the network using geodesic distances or the shortest paths, reflecting a country's connectivity within the trade network (Newman, 2018).

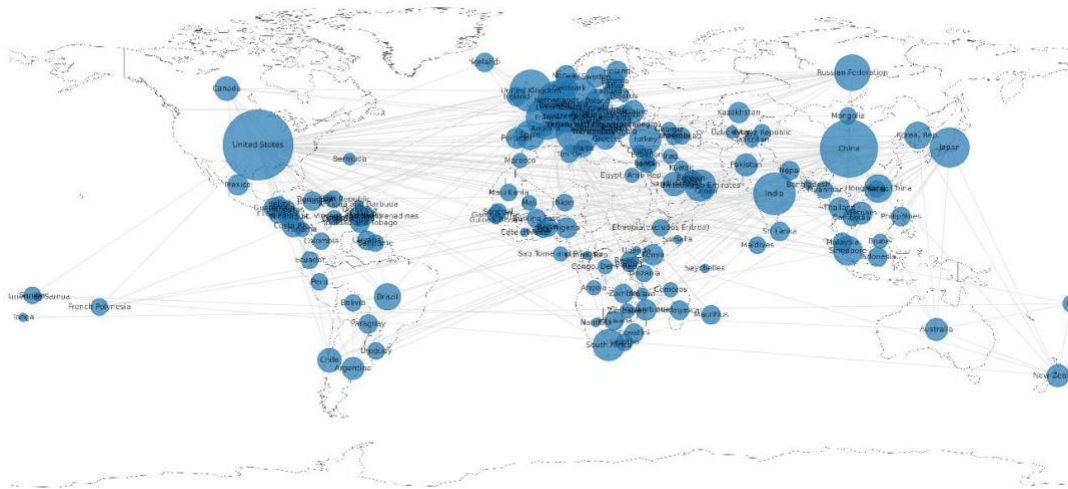
Moreover, betweenness centrality identifies nodes that serve as crucial connectors for others by comparing the number of shortest paths between a specific pair of nodes passing through a particular node to the shortest paths between the same pair of nodes (Newman, 2018). Thus, a higher betweenness centrality level suggests that a node acts as a bridge, forming part of numerous shortest paths of other nodes. This is the same to say that a country with high betweenness centrality degree plays the role of a hub in the international trade network.

The network analysis framework also incorporates an efficient clustering method, the Louvain algorithm, which maximizes modularity to detect robust community structures. Modularity measures the density of edges within communities compared to those between communities (Newman, 2018). The Louvain algorithm iteratively groups nodes into communities, enhancing the identification of key trading regions or groups within the international trade network.

V. Analysis

In the following sections, we present an analysis of the international trade network. As previously mentioned, in this network, countries act as nodes while edges signify the existence of trading relationships between them. The network (Figure 1) comprises 160 nodes and 518 edges, averaging 3.2 edges per node. Although the concept of planarity is pertinent in physical transportation networks, such as railways, it holds little significance in this context. Because edges solely represent monetary exchanges, their visual intersection is inconsequential.

Figure 1. International Trade Network, 2021

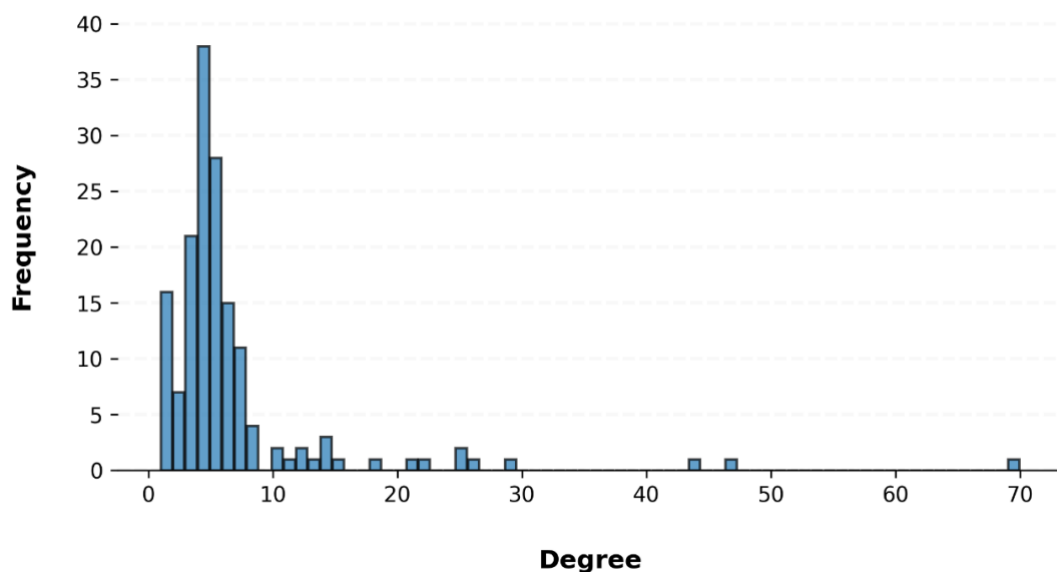


Source: Own elaboration based on WITS (2021).

Furthermore, it is important to note that the network is fully connected, meaning there is a path between any pair of countries. Consistent with the findings of Gönçer-Demiral and İnce-Yenilmez (2022) and Kiyota (2022), our analysis identifies the US, China, and Germany as prominent actors within the international trade landscape. These countries demonstrate the highest number of edges, reflecting their crucial roles in global commerce.

Figure 2 illustrates the distribution of the number of trading relationships per country. From the graph, it is evident that most countries in the network possess a degree centrality ranging between 1 and 9. As we mentioned before, despite the selected trading indicator, some countries exhibit fewer than five edges in our dataset due to data availability and reliability limitations. Nevertheless, the commercial connections drawn provide valuable insights into the composition and patterns of the international trade network.

Figure 2. Distribution of nodes' degrees



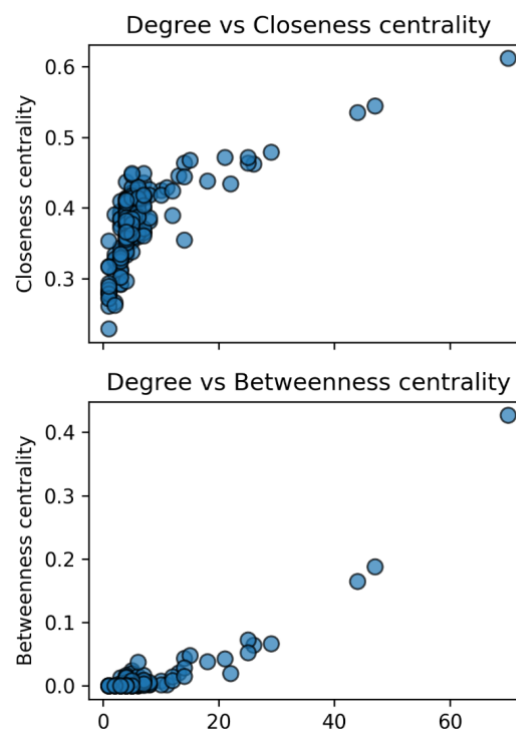
Source: Own elaboration based on WITS (2021).

As will be seen later, modularity analysis indicates that there are trade communities (countries with strong commercial relationships) led by the countries with the highest degree centrality (the US, China, and Germany). Additionally, there is a discernible division of countries based on the number of edges they possess in the network. The majority of countries have fewer than 9 edges, followed by those with 10-30 edges, and only three countries have more than 30 edges (the main actors already mentioned).

Now that we have outlined general information about the international trade network, including the number of nodes, edges, the distribution of edges per node, and the overall network structure, we aim to explore how degree centrality correlates with the positioning of countries and their strategic roles. Two metrics that can provide insights into this relationship are closeness and betweenness centralities.

Figure 3 illustrates the interaction between these metrics and degree centrality. The upper graph exhibits a logarithmic shape, indicating a positive relationship with a decreasing slope. This suggests that countries with a smaller number of edges (e.g., those with fewer than 9) still exhibit relatively high closeness centrality. As international trade has expanded globally, facilitated by reduced logistical and communication costs and increased global interconnectedness, this implies that most countries are closely connected to the global network, regardless of the number of their trading partnerships. This observation aligns with the trend towards globalization experienced in recent decades (Krugman et al., 2023).

Figure 3. Relationship between centrality measures

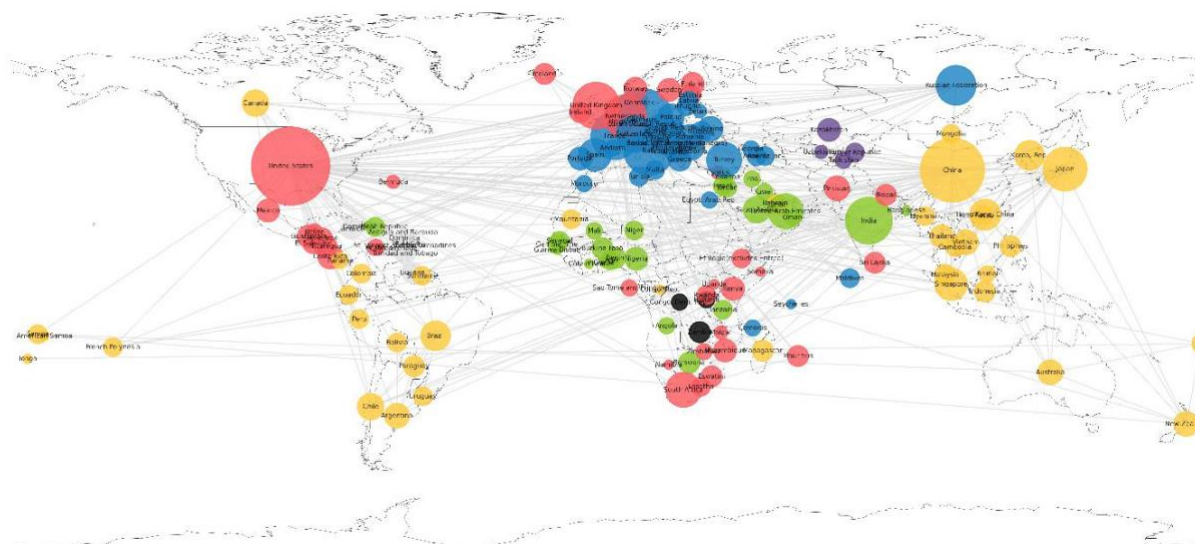


Source: Own elaboration based on WITS (2021).

In contrast, the lower graph exhibits an exponential pattern, suggesting that only countries with a certain threshold of edges play significant bridging roles in the network. Specifically, having around 15 edges appears to be the cutoff for increased significance in the international trade sphere. As expected, both graphs highlight the US, China, and Germany (the nodes with the highest degree) as the most central and influential actors in the network.

We have now outlined the general properties of the network and the relationship between the number of edges and the countries' significance within the network. To conclude this description, we examine the presence of communities within the network using modularity maximization following the Louvain algorithm. This optimization process aims to identify groups of nodes that are more densely connected to each other compared to nodes in other parts of the network. Figure 4 illustrates the communities detected through modularity maximization, represented by different colours.

Figure 4. Communities within the international trade network



Source: Own elaboration based on WITS (2021).

As mentioned earlier, the US, China, and Germany are the most prominent countries within the international trade network. As depicted on the map, these key actors belong to distinct trade communities. Our analysis reveals the presence of seven communities, each with a noticeable country acting as a core, leading the community in terms of interconnectivity. Table 1 summarizes the four main communities according to their number of members. Notably, India emerges as an economic middle power playing a key role within its commercial community.

With only minor discrepancies, this categorization aligns in general with the communities identified by Antonietti et al. (2022) and Herman (2022). While our results regarding communities' cores are consistent with those of Antonietti et al. (2022), our group divisions are marginally different and higher in number. This is mostly due to the generalized lack of data after the COVID-19 pandemic in 2020, which is one of the major analysis limitations that Antonietti et al. (2022) experienced. Herman (2022) identifies the

same four main communities with their leaders. Moreover, as can be seen in Figure 4, the commercial patterns and groupings in our network support the idea of countries trading based on the principle of reciprocity, mutual trading partners and geographical closeness. Therefore, the COVID-19 pandemic had no significant effect on the trading structure. It appears that if any change has taken place, it was too small or short-lasting. However, this finding may change if further analysis is conducted on international trade by sectorial composition.

VI. Limitations and advice on further research

It is pertinent to acknowledge certain limitations encountered in the elaboration of this study. As mentioned earlier, data availability and reliability in international relations is a significant issue. The utilized data was not an exception as some countries had unreported partners, which had an impact, even though small, on the structure of the trade network. This is an ongoing issue in the field of international relations that must be resolved by academia in conjunction with public and private organizations to advance the development of meaningful quantitative analysis within the discipline.

Furthermore, the span of this work is constrained due to the omission of longitudinal and sector-specific trade patterns analysis. Broadening the scope to include these dimensions could provide a deeper understanding of the network by analyzing the structure and changes of trade flow through time, as well as the commercial divisions according to the productive sectors or other revealing classifications. Moreover, a methodological framework based on directed and weighted networks may reveal unseen trade patterns, structures, and communities as it analyses trade flows more profoundly. Consequently, we acknowledge the potential for further exploration in these areas with other methodologies, anticipating that such investigations may find alternative conclusions.

VII. Conclusion

Most recent studies and evidence on international networks indicates four main elements. First, historically a small group of countries has had significant influence over global trade, capturing a substantial share of international commerce. Second, this dominance persists despite fluctuations in the global economy, with distinct communities and divisions remaining prevalent within the international trade network. Third, evidence suggests that countries exhibit different trade behaviour tendencies influenced by several factors and conditions. These tendencies shape their trading patterns and interactions in the international trade scene. Fourth, although the COVID-19 pandemic shock caused temporary disruptions in trade structures, long lasting partnerships and relative trade relevance have remained. However, there is evidence of potential shifts in trade composition, related to the exchange flows of different types of goods and services.

This work aims to shed light on the configuration of the international trade network based on the latest available data, contributing to the comprehension of the post pandemic commercial scenario. Furthermore, unlike previous studies that primarily focus on trade

volume, this research emphasizes the significance of meaningful trade flows between countries, regardless of the volume of trade. This provides an analytical framework that resembles more closely the real dynamics of international trade, where countries prioritize trade with specific partners.

Our analysis of the international trade network in 2021 suggests four main findings. First, regardless of their trading partnerships, most countries are closely connected within the global network. Second, significant bridging roles are primarily played by countries above a certain threshold of edges. Third, consistent with recent studies, the US, China, and Germany are the most influential actors and cores in the international trade network. Thus, the COVID-19 pandemic did not have a profound impact on the trade structure, despite some short-lasting effects. Fourth, based on modularity maximization criteria, seven distinct communities were identified, each led by a prominent country that serves as commercial center, driving interconnectivity in its respective community. Finally, the observed trade patterns are compatible with the principles of reciprocity, mutual trading partnerships, and geographical closeness.

VIII. References

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