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Assessing the global value chain trade structure of the EU, RCEP and TPP through trade network analysis

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Abstract: Using network analysis, the study examines the trade structure of the three largest trade blocs, the European Union (EU), the Regional Comprehensive Economic Partnership (RCEP) and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP). The use of intermediate goods exports data from the OECD TIVA database to assess the trade flow among member countries. It employs centrality measures such as centrality degree, eigenvector, betweenness, and closeness to identify the complex network flow of trade and the extent of trade concentration to countries within each bloc. The results reveal that the EU and RCEP supply chains are dominated by Germany and China, respectively. However, other countries are also acting as a central hub in the EU bloc. Similarly, the CPTPP supply chain is governed by nations such as South Korea, Japan, and Canada. Overall, the EU and RCEP have a dense trade network where countries have deep integration for efficient trade flow. In contrast, in CPTPP, the developed countries have higher participation, and the underdeveloped countries have less participation in trade flow. The findings provide important implications that high dependence on the central hub potentially poses the vulnerability of external/ internal shock in regional trade partnerships. Furthermore, high-quality standards favour developed nations and hinder underdeveloped nations' participation in regional trade partnerships.

Keywords: intermediate goods, global value chain, network analysis, centrality

Introduction

Over the last two decades, trade policies aimed at reducing transportation costs and trade barriers to encourage global integration have revolutionised information technology and open economic policies. Consequently, this creates a more fragmented process for producing the final product among different economies' firms through various manufacturing and support service activities (Ponte et al., 2019). These activities are called Global Value Chains (GVCs) (Guo et al., 2023). GVCs have become the backbone of modern trade, investment, and production. In 2016, global value chains accounted for over 85% of international trade (Sampath & Vallejo, 2018) that cross international borders multiple times before produced goods are consumed. This fragmentation of production enables countries within the global

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economy to specialise based on special nodes of the production process in order to gain entry to the global market. GVCs are often described as the "central nervous system" and "backbone" of the world economy (Carpa & Zarzoso, 2022). The global trading system has significantly evolved over the last few decades due to liberalization, technological advances, and the emergence of mega-regional trade agreements. Among the major regional trade frameworks shaping 21st-century economic integration in the Asia-Pacific region are regional trade agreements, the Regional Comprehensive Economic Partnership (RCEP), and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP). Although both aim to strengthen regional economic integration, their goals, organizational structures, and geopolitical foundations are highlighted by their histories, negotiating procedures, and membership paths.

The CPTPP traces its origins to 2005, when it was first launched as the Trans-Pacific Strategic Economic Partnership by four founding countries: Brunei, Chile, New Zealand, and Singapore. The United States became a participant in the agreement in 2018. Then, the framework agreement went through lengthy negotiations between 2010 and 2015 until, finally, it was signed in February 2016 by 12 countries, including Australia, Canada, Japan, Malaysia, Mexico, Peru, the United States, and Vietnam. In January 2017, the US formally exited the agreement following a decision by President Donald Trump, stating it would cost American jobs and favour bilateral trade agreements. So, the remaining 11 countries updated the agreement and signed the CPTPP in March 2018, in Santiago, Chile. The CPTPP has 12 members, including the United Kingdom, which joined in 2023 but is not an original member. On the other hand, RCEP was suggested by ASEAN in 2011 to combine ASEAN's existing FTAs with six key partners- Australia, China, India, Japan, New Zealand, and South Korea into a single agreement. Negotiations began in 2012 and lasted almost ten years. Due to the COVID-19 pandemic, the RCEP was signed virtually in November 2020 and came into effect in January 2022 without India, which withdrew in 2019 due to concerns about market access, particularly with China, and insufficient protections for its domestic sectors. Another significant regional bloc is the European Union (EU), which was formally established with the Maastricht Treaty in 1993 with its original six members- Belgium, France, West Germany (now unified Germany), Italy, Luxembourg, and the Netherlands- intended to lay the foundation for deeper economic and political integration. Since then, the EU has experienced several rounds of enlargement and evolved into a Union of 27 member states. The UK is currently the only country to have left the EU, after the 2016 Brexit referendum, with its leaving on 31 January 2020 being largely influenced by the desires of national sovereignty, immigration control, and displeasure with EU regulation and financial commitments. The relationship between trade agreements and the Global Value Chain (GVC), or production network trade, has been explored in numerous studies in recent years. Trade agreements significantly facilitate offshoring activities. In other words, countries

that are members of trade agreements are more likely to engage in cross-border production sharing, which is crucial for GVCs. Therefore, trade agreements have a considerably strong effect on trade related to GVC among the participating countries (Orefice & Rocha, 2014; Blyde et al., 2015; Ruta, 2017; Laget et al., 2020). It is important to understand the GVC trade structure in which RCEP, CPTPP, and EU are embedded; these are not only the world's largest and technologically most dynamic regional agreements, but each will also be central in restructuring production networks, in building trade resilience, and in determining opportunities for technological upgrading by members. Despite the increasing relevance of these trade blocs, existing academic work has generally analysed RCEP, CPTPP, and the EU separately. A few studies acknowledge their respective ability to change global trade patterns. While the existing studies provide insight into possible arrangements, comparative analysis is notable regarding their role in the global value chain. Addressing this gap, the current study investigates the trade relations located within these blocs, through the structural properties of their GVC trade network from 2011 to 2022 using network analysis. This study is one of the first studies of RCEP, CPTPP, and the EU jointly from a GVC network perspective, contributing fresh insights about how these trade blocs differ with respect to their connectivity, integration, and positioning in the global production system. By applying network analysis, the paper captures structural properties such as centrality and connectedness, reflecting both the advantage but also the vulnerability of member countries within the changing GVC landscape. To achieve this objective, the remainder of the paper is organised into the following sections: Section 2 discusses the literature review related to research, Section 3 discusses the methodology, Section 4 presents the results and discussion, and Section 5 concludes the research.

2. Literature review

In recent years, RCEP and CPTPP have become two of the world's most important regional trade blocs in the Asia-Pacific, with the European Union often serving as a benchmark for such regional integration efforts. RCEP is the world's largest free trade agreement by population and GDP. It accounts for 30% of the global GDP, approximately $38 trillion in terms of GDP, and covers over 2.2 billion people, or approximately 30% of the world population. The CPTPP member countries comprise an estimated 10-15% of the world's GDP, around $ 12.1 trillion, and cover 6.5% of the world's population. Tariffs were eliminated on about 95% of the goods traded with member states, thus giving preferential access to the member markets. Alongside these Asia-Pacific regional blocs, the European Union (EU) is a super-national political and economic union, an ultimate form of regional integration. The EU consisted of about 5.5% of the world population in 2023, and in 2024, the EU generated a GDP of nearly US$19.4 trillion, approximately one-sixth of the global GDP. It is also the leading global exporter of manufacturing goods and

services, comprising around 14% of world merchandise trade (European Commission, 2024). RCEP is significantly higher in terms of GDP and population covered than CPTPP and the EU, which makes it the largest trading bloc in history. Both agreements and the EU are essential in defining the paths for the GVCs and intraregional economic integration. While RCEP can be more broadly geographic with extensive economic coverage, CPTPP is usually viewed as a deeper trade agreement, with some of the more concrete commitments in labour rights, environment, intellectual property, dispute resolution, and state-owned enterprises (Xu et al., 2024). On the other side, the EU has a single market guaranteeing the movement of goods, services, investment, and common policies for trade, agriculture, environment, people, and regional development, reinforcing its integration (European Commission, 2024). The EU provides a frame of reference for comparisons with developing regional trade blocs such as RCEP and CPTPP, which remain focused on trade liberalization rather than deep institutional and political integration.

The CPTPP must also be seen as more facilitating for high-standard, rules-based GVC integration in developing value chains, because countries can improve their predictability. In contrast, RCEP's strength lies in its inclusivity and broad coverage of developing Asia, creating opportunities for development in the lower segment of the GVC and also in a start-up capacity for intra-regional trade (Kimura et al., 2022). Itakura & Lee (2019) contend that CPTPP stimulates higher sectoral growth in industries with increased GVC intensities because of stringent non-tariff and regulatory disciplines. Similarly, Park et al. (2021) demonstrate that RCEP will create income gains that are nearly twice the income gains from CPTPP due to its large market size, as well as the higher degree of integration among its members. The combined rules of origin and trade facilitation in RCEP are expected to deepen value chains in East Asia and allow the greater state of GVCs for participating countries. Desierto (2018) provides additional details on significant qualitative differences between the two agreements. She highlights that the investment framework under RCEP is more accepting of developmental asymmetries, while prioritizing some regulatory space for developing economies. She also notes that the provision in CPTPP on investor-state-dispute settlement, transparency, and regulatory coherence creates a more disciplined environment, while, more demanding, legal certainty is essential for high-value GVC participation. RCEP's rules of origin and cumulative benefits also favour intra-regional sourcing from RCEP members and may reduce the expanded contracts using US markets because of global trade tensions (Zreik, 2024). Due to RCEP's reductions in tariffs, GVC participation and positioning are increased, particularly in Korea, Japan, and ASEAN countries, with long-run effects being larger than the short-term effects (Wen et al., 2022). The economically advanced ASEAN economies like Singapore and Vietnam, which supported adopting CPTPP as they were able to receive first-mover

advantages for setting trade norms, while other ASEAN economies indicated a preference for RCEP's more flexible approach (Wu, 2020).

Both agreements have different aspects, but many researchers like Li & Li (2022), Kong et al. (2025), Uppatum & Chaisrisawatsuk (2024) argue that both RCEP and CPTPP had individually a statistically insignificant effect on trade flows, while the interaction effect of dual membership will significantly increase bilateral trade. Such a contribution of their findings indicates several aspects of developments in supply chain and supports the notion that the two agreements are complementary to each other, and overlapping membership could also enhance GVC. In this context, the EU is one of the most integrated regional blocs across the global economy, with the global value chain central to its production and trade systems. Evidence suggests that GVCs in the EU expanded strongly since the 1970s, driven by trade liberalization and technological development, which continued the trend of fragmentation within the EU (Škabić, 2019). EU members are heavily integrated into the global value chain and backward linkages, which is indicative of heavy reliance on imported intermediates. The level of GVC participation varies between EU member states, with more developed countries capturing more value added or less developed members staying trapped in downstream activities (Božić & Botrić, 2017). Luxembourg and Slovakia show the highest level of participation, while Croatia shows the lowest (Škabić, 2017). In 2015, nearly 20 million jobs, or about 8.6% of total EU employment, were tied to intra-EU intermediate trade, with especially high shares in manufacturing and business services, highlighting how significant GVC participation is to employment and the economy (Fritsch & Matthes, 2020). EU trade agreements exhibit a unique normative aspect, but sustainability provisions differ with partner countries' GVC engagement, as deeply engaged import-dependent firms often resist the incorporation of standards that would raise costs. Accordingly, while the EU may be viewed as a normative power, it can be shown that the EU applies its normative values-based approach to trade selectively according to interests that coincide with domestic policy (Poletti et al., 2021). Standards also play a key role: European standards and international standards operate to reduce information asymmetries and facilitate trade inside and outside the Single Market by placing a time burden on importers and an on-cost for engagement to source, reinforcing the EU's position as a regulated GVC integration hub (Blind et al., 2018). In the recent past, EU policy has geared towards supply chain resilience and strategic autonomy, especially in relation to critical raw materials and vulnerabilities stemming from a post-COVID world (Amighini et al., 2023). The free trade agreement between the EU significantly increased intra-regional trade. Countries with an association agreement traded on average about 14% more than without one. Overall, the trade effect within the EU was much larger than most regional agreements, indicating the substantial depth of institutional and economic integration for the EU (Caporale et al., 2008). With the involvement in regional trade agreements, the depth of agreements is also important. Orefice &

Rocha (2014) demonstrate that a one-unit increase in the depth of a trade agreement leads to an approximately 12-point increase in the trade of production networks. Similarly, free trade agreements have a positive effect of 9.4%, while deeper integration agreements have a 12.7% positive effect on production fragmentation (Blyde et al., 2015). Laget et al. (2020) also demonstrate that the depth of preferential trade agreements increases the domestic value added of intermediaries by 0.38% for each additional policy area included in the agreement. The effects of agreements depend on the development level of the participating countries. Thus, the benefits of trade agreements are not uniform and vary according to the economic context defined by the participating countries.

3. Methodology

This study employs a network analysis framework to examine the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), Regional Comprehensive Economic Partnership (RCEP) and European Union, focusing on the structural properties of its GVC trade network. The Network Analysis provides insights about the relationship between nodes, which helps to understand the complex structure of a group of people, a country, and others (Hevey, 2018).

Table 1. Description of variables used

Dataset/Source	Variables used	Coverage	Explanation
OECD-Tiva Database	Gross exports of intermediate goods (bilateral flow)	2010-2022	Captures cross-border trade in intermediate goods, which reflects inputs required in fragmented production in GVCs
CPTPP member countries	Gross exports of intermediate goods (bilateral flow)	2010-2022	Allows for mapping of CPTPP trade network structure.
RCEP member countries	Gross exports of intermediate goods (bilateral flow)	2010-2022	Captures the mapping of RCEP trade network structure
EU member countries (Including UK)	Gross exports of intermediate goods (bilateral flow)	2010-2022	Captures the mapping of EU trade network structure

Source: authors' representation

In the GVC, the goods cross borders several times, and value addition takes place at each stage. Trade in intermediate goods serves as an important indicator for country participation in the production activities within the global value chain. The trade in intermediate goods helps to understand which economy dominates the trade in selected blocs. Therefore, we have used the trade of intermediate goods, and the

data have been taken from the OECD-TIVA database for the time period from 2010 to 2022. The following table 1 provides details of the variables.

To identify the influential countries in both blocs, we have used different centrality degrees as follows:

Degree centrality

Degree centrality represents the number of connections of a country; in other words, it provides insight into the number of countries that trade with a country. We have used the directed network method, in which two measures have been used: In-degree centrality and Out-degree centrality (Benedictis, et al., 2014). c_{hj} represent a trade matrix, where *h* indicates the row of exporting countries and j indicates the column of importing countries. In Equation 1, $Cen^{N}_{D_{(in)}}$ represents In-degree centrality, $\sum_{h\neq j}^{N(t)} c_{hj}$ represent the total no. of countries from which country j is importing. N represents the total no. of nodes (meaning the total number of countries), and we normalized the degree using $N-1$ by excluding the country itself to calculate the degree.

$$Cen^{N}_{D_{(in)}} = \frac{\sum_{h\neq j}^{N(t)} c_{hj}}{N-1} \quad (1)$$

Similarly, we normalised Out-degree centrality given in equation 2, where $\sum_{h\neq j}^{N(t)} c_{jh}$ represent the total no. of countries a country j exports to.

$$Cen^{N}_{D_{(out)}} = \frac{\sum_{h\neq j}^{N(t)} c_{jh}}{N-1} \quad (2)$$

The degree ranges from 0 to 1, and a degree of 1 means a country is directly connected with others in the trade network.

Betweenness centrality

Betweenness centrality measures how often a country acts as an intermediary in trade between other member countries. In the standard formulation of centrality calculation of node *j* is

$$C_B(j) = \sum_{s\neq t\neq j} \frac{\sigma_{st}(j)}{\sigma_{st}} \quad (3)$$

Where σ_{st} is the total number of shortest trade routes between nodes *s* and *t*, and $\sigma_{st}(j)$. The total number of trade routes going through node *j*. $s \neq t \neq j$ ensures the condition that *s*, *t*, and *j* are distinct nodes, excluding the path where *j* is the source or target.

In our analysis, we use trade value to measure the paths between two countries. Which means the higher the trade value, the shorter the path between two countries

or vice versa. We have used a normalised equation to measure betweenness centrality as given in equation 4.

$$C_B(j) = \frac{1}{(N-1)(N-2)} \sum_{s \neq t \neq j} \frac{\sigma_{st}(j)}{\sigma_{st}} \quad (4)$$

Eigenvector centrality

Eigenvector centrality measures a country's importance in a network based on its connection to other highly influential nodes. In trade terms, the degree helps us to understand a country's influence in the trade network based on its links with other highly important countries. The eigenvector centrality of the country depends on the summation of the centrality degrees of its partner countries. In our analysis, we extend this by using a weighted directed trade matrix, where trade value represents the strength of a country's connection with central, highly influential countries. This helps to understand the intensity of the country's connection with the bridge of the trade network. The equation for eigenvector centrality is:

$$C_E(j) = \frac{1}{\lambda} \sum_{i=1}^{N} A_{ij} x_i \quad (5)$$

$C_E(j)$ represents the eigenvector centrality of country *j*,
A_{ij} trade weight from country *i* to *j*
N is the total number of countries
λ The largest eigenvalue of the weighted adjacency matrix

Closeness centrality

Closeness centrality tells how close a country is to others by the shortest possible length. In our analysis, we use trade value to measure the distance between two countries. We use the inverse of trade value; therefore, the higher the trade value between two countries, the shorter the path between them or vice versa. For calculating closeness centrality, we use the equation as follows:

$$C_c(i) = \frac{N-1}{\sum_{j \neq i} d(i,j)} \quad (6)$$

Where N is the number of countries and $N-1$ represents the number of other countries excluding country *i* itself. $\sum_{j \neq i} d(i,j)$ indicates the sum of the shortest trade path from country *i* to every other country *j*. Here, d(i,j) is the shortest trade route from i to j, measured using the inverse of trade value. The calculation of raw closeness centrality depends on network size and the distance between two countries. In our weighted trade network, a few countries have large trade flows that affect the

probable results. To address this, we normalised the raw closeness score using min-max scaling, as given in the equation:

$$C_c^N(i) = \frac{C_c(i) - C_c^{min}}{C_c^{max} - C_c^{min}} \quad (7)$$

$C_c(i)$ is the raw centrality of country i (from equation 6)
C_c^{min} is the minimum closeness centrality value across all countries in the network
C_c^{max} is the maximum closeness centrality value across all countries in the network
The normalised closeness centrality gives values in the 0 to 1 range for easier comparison and interpretation.
Since some members are common between the trade blocs, such as Australia, Singapore, Vietnam, Brunei, Malaysia, and New Zealand, for the implementation of the above said methodology, the exclusion of these members is not possible, and this is the limitation of the study.

4. Results and discussion

4.1. Trade network metrics of RCEP

Table 2 presents the intermediate contract in total exports for RCEP member countries from 2010 to 2022. Countries like Brunei and Australia have a higher intermediate content in their total exports. This indicates their specialization in resource-based intermediate exports. All other countries show both stability and slight increases in the share of intermediate exports over time, implying a rising role in the value chain. China's exports included 50% intermediate goods exports, and remained consistent over the decade.

Countries like Vietnam, Thailand, and the Philippines hover in the 50–60% range, reflecting their midstream role, often acting as locations for final assembly or as part of second-tier suppliers. Vietnam, in particular, shows a gradual rise in this ratio, indicating a deepening engagement in global production networks. This is consistent with Vietnam's improving eigenvector and closeness centrality in the network results, showing its growing centrality in regional trade. In contrast, Cambodia has a lower share of intermediate goods exports in its gross exports, accounting for around 35 per cent over the decade.

The degree of centrality represents the total number of direct trade links of a country, which is segregated into two degrees. The in-degree centrality indicates how many countries a nation sources intermediate goods from, while the out-degree centrality reflects the number of countries it exports intermediate goods to. In the RCEP bloc, most countries, such as China, Japan, South Korea, Thailand, and Australia, have a centrality degree of 2 (1 for import and 1 for export), suggesting a well-connected network structure in the RCEP bloc. However, countries like Laos,

Brunei, and Cambodia have around 0.90 In-Out centrality degree, reflecting these countries' importing and exporting to 90 percent of countries in the trade network and the missing links with all countries.

Table 2. Share of intermediate goods in gross exports of RCEP countries (%)

Year/ Country	2010	2015	2020	2021	2022
Australia	71.53	71.21	77.88	83.07	82.94
Japan	54.57	56.12	57.58	57.73	57.59
Korea	55.96	59.71	61.71	62.05	62.36
New Zealand	42.05	41.30	46.43	48.93	49.06
Brunei	71.11	84.79	85.42	83.58	86.19
Cambodia	27.63	38.39	43.43	46.72	51.37
China	46.30	46.35	49.07	49.88	50.94
Indonesia	66.83	61.25	62.32	66.02	68.74
Laos	56.11	57.25	64.17	66.31	69.61
Malaysia	61.00	60.13	62.90	64.86	65.28
Myanmar	60.74	57.52	57.56	58.58	61.14
Philippines	56.47	60.60	62.55	61.04	61.83
Thailand	47.38	44.45	50.22	52.43	50.38
Viet Nam	45.17	45.64	48.18	49.62	47.71

Source: OECD-Tiva Database

This analysis reveals that most countries in the RCEP bloc are engaged in the production and supply of intermediate goods to each other and are well-connected in the supply chain. In contrast, countries such as Brunei, Laos, and Myanmar have a high participation in the supply of intermediate goods. This implies that RCEP improves regional productivity and trade in intermediate products (Park et al., 2021)

The betweenness centrality is a crucial measure of a country's role as a connector or bridge in the trade network. In the trade of intermediate goods, it helps to understand the processing centre, connecting different parts of the value chain. In the RCEP trade network, China stands out prominently as a connector with a betweenness degree value of 0.89, far higher than any other RCEP country; this indicates that 89 percent of the shortest paths of the RCEP trade network pass through China. These findings suggest that China acts as a centre hub, influencing trade flows and value chains in the RCEP bloc as represented in figure B in appendix. (Wei & Yu, 2021). On the other hand, countries including Brunei, Indonesia, and Malaysia have a betweenness of 0, implying these countries are peripheral in the bloc and connect with other countries through China (the Central hub) eigenvector Centrality.

The eigenvector centrality shows the importance of a country and its connection with other influential countries in the trade network. In RCEP, China has the highest degree of 0.73, followed by South Korea (0.42), Japan (0.41), and Vietnam (0.21). These countries are deeply embedded and have a high influence on

the regional trade network. In contrast, countries like Brunei (0.002), Laos (0.003), and Cambodia (0.013) have a low degree, revealing that these countries are less connected to influential countries in the RCEP trade network. This metric provides insights that China, South Korea, and Japan have a strategic position in the RCEP trade network and have influence over the trade flow in this bloc as represented in figure A in appendix.

Table 3. Centrality degree of the trade network of the RCEP Bloc

Country	Degree Centrality	In-Degree	Out-Degree	Betweenness	Eigenvector	Closeness (Normalized)
Australia	2	1	1	0.071	0.13	0.85
Brunei	1.71	0.92	0.78	0	0.00	0
Cambodia	1.85	0.92	0.92	0	0.01	0.51
China	2	1	1	0.89	0.70	1
Indonesia	2	1	1	0	0.14	0.85
Japan	2	1	1	0.082	0.40	0.96
Laos	1.64	0.78	0.85	0	0.00	0.24
Malaysia	2	1	1	0	0.12	0.82
Myanmar	1.93	0.92	1	0	0.01	0.37
New Zealand	1.85	0.92	0.92	0	0.01	0.40
Philippines	2	1	1	0	0.06	0.69
Singapore	2	1	1	0.071	0.15	0.83
South Korea	2	1	1	0	0.42	0.95
Thailand	2	1	1	0.071	0.19	0.89
Vietnam	2	1	1	0.071	0.20	0.92

Source: authors' calculations

The closeness centrality reflects how close a country is to all other countries in the network; therefore, in our analysis, it means how efficiently a country can source or supply intermediate components to the rest of the RCEP bloc countries. High closeness is an advantage for supply chain responsiveness in a trade network. In our analysis, China ranks at the top (1.0), followed by Japan (0.96), South Korea (0.95), Vietnam (0.92), and Thailand (0.89). These metrics reveal that these countries are well-positioned in the regional value chain, and have high intermediate goods trade between them. Brunei, which has a closeness degree of 0, reflecting an isolated nation in the trade network, has lower trade with other partners. Other countries such as Laos (0.24), Myanmar (0.37), and New Zealand (0.40) also lag in closeness, reflecting lower trade flows of intermediate goods in the RCEP trade network. Overall, it reflects that the large countries such as China, Japan, and South Korea have high trade flows with other members in the RCEP trade network.

4.2. Trade network metrics of CPTPP

Table 4 illustrates the percentage share of intermediate goods exports in gross exports for CPTPP countries over the period 2010 to 2020. Several CPTPP countries, such as Brunei, Chile, Peru, and Australia, show a high share of more than 70 per cent, signifying their key position in supplying intermediate goods. Malaysia, Singapore, and Japan also hold moderate shares in supplying intermediate export shares of around 58–66 per cent. Vietnam and Mexico maintain a consistent share of 50 per cent in intermediate exports. Canada and New Zealand show a moderate share ranging between 50 and 60 per cent. Canada is an important trading partner in the North American region. Overall, the data shows that CPTPP countries have a deep engagement in the trade of intermediate goods exports in the world. Therefore, some countries can easily play a role as a supplier of intermediate goods in this bloc.

Table 4. Share of Intermediate goods in Gross Exports of CPTPP countries (in percentage)

Year/Country	2010	2015	2020	2021	2022
Australia	71.53	71.21	77.88	83.07	82.94
Canada	63.97	61.17	60.84	64.43	66.05
Chile	72.75	73.25	78.61	81.91	80.51
Japan	54.57	56.12	57.58	57.73	57.59
Mexico	46.77	40.65	40.38	40.87	41.65
New Zealand	42.05	41.30	46.43	48.93	49.06
Brunei	71.11	84.79	85.42	83.58	86.19
Malaysia	61.00	60.13	62.90	64.86	65.28
Peru	76.55	71.86	79.23	78.67	77.26
Singapore	60.28	60.78	59.71	57.81	57.60
Viet Nam	45.17	45.64	48.18	49.62	47.71

Source: OECD-Tiva Database

The degree of centrality measures the trade connections of countries in the bloc. Most countries in the CPTPP, such as Japan, Singapore, Malaysia, Canada, Australia, and New Zealand, have a centrality degree of 2.0, showing their engagement in import-export of intermediate goods in the trade network, and representing a cohesive trade network where major economies serve as well-connected participants (Xu et al., 2024). Countries like Mexico (1.9), Chile and Peru (1.8), and Brunei (1.5) have a slightly low degree, implying a few missing trade links with other countries' trade networks.

For further analysis, we reflect on the In and Out centrality degree. Most countries, including Japan, Singapore, Malaysia, Canada, and Australia, have a degree of 1.0 in both, indicating the suppliers and recipients of intermediate goods. However, Mexico has a slight export dominance, with an out-degree of 1.0 above an in-degree of 0.9, suggesting its participation in supplying intermediate goods in the

bloc. Despite small variations, the overall metric shows mutual interdependence and a distributed trade network of the CPTPP bloc.

Betweenness centrality indicates which country acts as a bridge between others in the trade network, which means goods will cross-bridge the country border at least once during trade. In CPTPP network, Japan ‘s high betweenness centrality (0.84) indicates that it functions as key bridge in the movement of intermediate goods trade flow in the bloc, which reflects its trade governance and rule-setting in the CPTPP bloc (Wu, 2020). It is followed by Australia (0.2), Singapore (0.1), Mexico (0.089), and Canada (0.078) also have non-zero betweenness degrees, indicating these economies occasionally act as bridging nodes with the bloc trade network, although their intermediary roles are relatively small compared to Japan. Their positions may reflect Australia and Singapore’s role in South-East Asia, and Mexico and Canada’s intermediary role in the North American region. All other countries, including Brunei, Chile, Peru, Malaysia, Vietnam, and New Zealand, have zero betweenness, indicating these countries neither facilitate nor control trade routes between other countries. This suggests that a concentration of trade control is in the hands of a few central players indicated in figure D in appendix.

Table 5. Centrality degree of the trade network of the CPTPP bloc

Country	Degree Centrality	In-Degree	Out-Degree	Betweenness	Eigenvector	Closeness
Australia	2	1	1	0.2	0.27	0.58
Brunei	1.5	0.8	0.7	0	0.01	0
Canada	2	1	1	0.078	0.22	0.60
Chile	1.8	0.9	0.9	0	0.02	0.07
Japan	2	1	1	0.84	0.64	1
Malaysia	2	1	1	0	0.35	0.67
Mexico	1.9	0.9	1	0.09	0.23	0.65
New Zealand	2	1	1	0	0.05	0.26
Peru	1.8	0.9	0.9	0	0.01	0.03
Singapore	2	1	1	0.1	0.46	0.81
Viet Nam	2	1	1	0	0.24	0.58

Source: authors’ calculations

Eigenvector centrality reflects which country has influence on its trade partners, in other words, which node dominates in a network. Japan (0.64) has the highest degree, confirming its role as a main hub that connects to other major economies in the CPTPP bloc. If followed by Singapore (0.46) and Malaysia (0.35), it indicates its strategic position in the CPTPP intermediate goods network from the Southeast region, while countries like Mexico (0.23) and Canada (0.22) reflect its influential node in North American production chains. In contrast, Brunei, Peru, Chile, Vietnam, and New Zealand have low eigenvector degree, indicating lower connection with highly central economies and lower dominance in the trade network. This metric reveals Japan, Singapore, and Malaysia have a central economy in the

south-east region, while Mexico and Canada have a main node in the North American region represented in figure C in appendix.

Closeness centrality measures how efficiently a country can reach others in the trade network, which means countries are close in trade terms. Japan ranks highest (1.0), showing its main leadership and easy accessibility with other nations in the regional production chain. Singapore, Malaysia, Mexico, and Canada have degrees greater than 0.6, demonstrating their close integration, suggesting an efficient trade flow in the CPTPP trade network. In contrast, New Zealand, Chile, and Peru have a lower degree, showing their weaker trade connectivity with others in terms of intermediate goods trade. These results emphasize that most of the CPTPP countries are highly accessible to other nations and reflect an easy flows of intermediate goods trade.

4.3. Trade network metrics of EU

Table 6 illustrates the percentage share of intermediate goods exports in gross exports for EU countries over the period 2010 to 2022, including the UK. Member countries such as Belgium and Finland have consistently shown the highest participation in the export of intermediate goods, above 60 per cent. In 2022, both countries reached their highest, around 64 per cent. In contrast, Croatia and Malta have a lower share of intermediate goods exports, around 40 per cent. Major economies of the group, such as Germany, France, and Italy, have a consistent upward trend and account for around 50 per cent of the export of intermediaries. Similarly, the share of the UK remains close to 50 per cent and has not changed after Brexit.

Table 7 provides the centrality measure of the EU bloc. Degree centrality measures trade connections of countries in the bloc. All countries in the EU bloc have centrality degree 2.0 (in-degree 1 and out-degree 1), revealing a well-connected trade network of the bloc. This reveals that each country is both a source and destination in trade flow. This measure provides foundation connection between the countries in the given bloc, while further insight is provided by other centralities such as betweenness, eigenvector and closeness.

The betweenness centrality provides the important insight of which hub plays an intermediary role in the given network. In Table 7 Germany exhibits the highest betweenness centrality (0.90), clearly playing a dominant role in the EU bloc. Other countries such as Finland, France, Greece, Poland, Spain and Sweden also have moderate degree which reveal their intermediary role after Germany, as highlighted in figure F in appendix. Similarly, the United Kingdom has served as an important bridge EU trad network. However, its withdrawal does not affect the bloc's trade flow, since Germany remained the central node for connecting other countries in the trade flow.

Table 6. Share of intermediate goods in gross exports of EU countries (%)

Year/Country	2010	2015	2020	2021	2022
Austria	55.71	55.91	56.87	58.69	57.09
Belgium	64.52	64.98	62.38	63.29	63.89
Czechia	51.96	52.98	53.58	54.83	54.62
Denmark	55.16	53.35	52.51	52.19	53.56
Estonia	56.78	55.44	59.69	60.59	60.57
Finland	59.14	63.62	62.66	64.31	64.74
France	50.11	51.82	53.40	53.92	53.90
Germany	53.48	53.82	55.03	56.11	56.61
Greece	48.80	45.04	56.34	52.13	51.60
Hungary	49.91	52.12	53.16	53.50	52.80
Ireland	51.70	53.36	57.86	57.01	57.76
Italy	47.33	46.83	49.01	50.29	49.15
Latvia	60.06	58.11	59.85	61.58	61.02
Lithuania	56.16	55.70	58.35	57.83	59.07
Luxembourg	66.18	64.76	60.88	48.91	55.96
Netherlands	58.60	57.10	58.06	58.72	60.31
Poland	53.53	55.15	55.45	56.69	57.13
Portugal	49.45	46.73	50.84	51.19	48.76
Slovakia	52.18	52.75	51.83	52.55	51.69
Slovenia	51.84	56.13	58.08	59.10	59.75
Spain	48.51	48.47	52.16	52.36	51.62
Sweden	56.33	57.06	57.32	57.55	58.63
UK	57.64	57.15	60.03	58.57	58.29
Bulgaria	52.71	55.38	57.12	56.33	56.50
Croatia	38.24	39.13	44.23	38.81	37.90
Cyprus	48.01	50.44	57.78	53.07	57.38
Malta	43.50	40.97	41.24	42.33	47.69
Romania	53.88	56.09	56.82	56.49	56.60

Source: OECD Tiva Database

Germany has the highest eigenvector centrality (0.54) highlighting its strong connections with other central countries. France, Italy, the United Kingdom, the Netherlands, Belgium, Austria, Ireland, Luxembourg, and Czechia form a second tier of influential countries, suggesting that they are well-integrated with other important players. In contrast, the countries such as Cyprus, Latvia, Malta and Lithuania have negligible eigenvector centrality, which means weak integration in the bloc. This reveals that most of the member countries have connected with influential countries, particularly the dominating country central economies represented in figure E in appendix. In other words, it reveals the core-peripheral structure of the bloc, in which a small group of western economies are at the centre of trade network.

Table 7. Centrality degree of the trade network of the EU bloc

Country	Degree centrality	In-Degree	Out-Degree	Betweenness	Eigenvector	Closeness (Normalized)
Austria	2	1	1	0.00	0.15	0.91
Belgium	2	1	1	0.00	0.23	0.87
Bulgaria	2	1	1	0.00	0.01	0.22
Croatia	2	1	1	0.00	0.01	0.19
Cyprus	2	1	1	0.00	0.01	0.02
Czechia	2	1	1	0.00	0.12	0.86
Denmark	2	1	1	0.00	0.09	0.77
Estonia	2	1	1	0.00	0.01	0.07
Finland	2	1	1	0.07	0.05	0.65
France	2	1	1	0.01	0.45	0.96
Germany	2	1	1	0.90	0.54	1.00
Greece	2	1	1	0.04	0.03	0.42
Hungary	2	1	1	0.00	0.09	0.82
Ireland	2	1	1	0.00	0.16	0.80
Italy	2	1	1	0.04	0.32	0.94
Latvia	2	1	1	0.00	0.00	0.00
Lithuania	2	1	1	0.04	0.01	0.21
Luxembourg	2	1	1	0.00	0.12	0.83
Malta	2	1	1	0.00	0.01	0.20
Netherlands	2	1	1	0.00	0.24	0.90
Poland	2	1	1	0.07	0.17	0.89
Portugal	2	1	1	0.00	0.06	0.71
Romania	2	1	1	0.00	0.05	0.64
Slovakia	2	1	1	0.00	0.05	0.70
Slovenia	2	1	1	0.00	0.02	0.33
Spain	2	1	1	0.07	0.21	0.87
Sweden	2	1	1	0.00	0.10	0.78

Source: authors' calculations

The closeness centrality helps to understand the easy accessibility of a country in the trade network. In the bloc, Germany emerges as the most central economy (centrality degree 1) underscoring its superior accessibility and integration with other nations. Other countries such as France, Italy, Netherlands, Austria, Spain and Belgium are also an easily accessible hub in the bloc trade network. Conversely, the countries such as Cyprus, Lithuania, Malta, Bulgaria, and Croatia are peripheral in the trade network, reflecting difficulty in the flow of intermediate goods trade. These findings demonstrate that western countries or large EU economies enjoy easy accessibility in trade network, while small countries are isolated.

Table 8 summarizes the average value of network centrality metrics (centrality, betweenness, eigenvector, and closeness) to compare the connectivity pattern of the selected trade blocs.

Table 8. Centrality degree of CPTPP, RCEP and EU Bloc (average)

Degree	CPTPP	RCEP	EU
Degree Centrality	1.91	1.93	2
In-Degree	0.95	0.97	1
Out-Degree	0.95	0.97	1
Betweenness	0.12	0.08	0.05
Eigenvector	0.23	0.17	0.13
Closeness	0.48	0.69	0.62

Source: authors' calculations

EU has a higher centrality degree, indicating a slightly dense and greater number of direct trade connections for member countries; all the countries are connected to each other. However, the picture shifts in case of betweenness and eigenvector centrality.

The CPTPP have the highest betweenness (0.12) and eigenvector centrality (0.23), followed by the RCEP bloc. This reveals that the CPTPP bloc countries are less connected, and at the same time, a few economies are dominating the bloc. Therefore, in this bloc, any shock to the dominant countries could affect the intermediate trade network of the bloc. In contrast, the low centrality of the EU reflects its less vulnerability to shocks in the value chain. In the case of closeness centrality, the RCEP bloc has a higher degree, followed by the EU, which reveals the easy accessibility and rapid intermediate goods trade flow in the network. The comparative analysis of network centralities of RCEP, CPTPP and EU draws an implication that the CPTPP and RCEP blocs are less connected and under the dominance of a few member countries, pose a higher risk to trade shocks. On the other hand, the EU bloc demonstrates significant resilience to trade shocks due to its well-connected nature and the absence of single or/few countries' dominance. The well-distributed network means that the bloc has less reliance on a single hub and mitigates the risk of disruption from trade shocks.

Conclusion

This study analysed the network structure of intermediate goods trade among countries in the RCEP, CPTPP and EU blocs, using various centrality measures to understand the importance and position of countries in the value chain. In the RCEP bloc, China has a dominating position and acts as a central hub in the trade network. It is followed by Japan and South Korea, which have moderate dominance in the RCEP trade network. However, China plays a dominant role in RCEP intermediate goods trade, making it a critical node in this trade network. Any disruption in this node can disrupt production across RCEP economies. Similarly, in the CPTPP bloc, countries such as Japan, Singapore, and Canada act as a central hub and have a huge influence on the production network. The supply chain in this bloc is not affected by a disruption in a single country. At the macro level, the trade network of the CPTPP bloc is centred

around a few nations and is less efficient in the trade flow of intermediate goods. This scenario is observed because the CPTPP bloc has a major focus on high labour standards, product quality, and intellectual property rights, and these countries comply with these standards (Narayanan & Sharma, 2016). However, it is difficult to comply with standards for underdeveloped nations such as Brunei, Chile, Peru, and Malaysia, while favouring developed nations (Narayanan et al., 2015).

In the EU bloc, Germany has a dominant role in the intermediate goods trade network. Along with Germany, other countries such as France, Italy, Spain, Finland and the UK also act as a central hub in the trade network. The well-distributed trade flow reflects its resilience to disruption to the value chain due to the disruption in a single hub.

In conclusion, the EU bloc demonstrates the efficient flow of intermediate goods trade, with a deeply integrated trade structure. The balance distribution of influence within a trade network is crucial for the stability and prosperity of all small member nations. Therefore, minimizing disruption risk at the central note in RCEP bloc would enable member nations to leverage its comparative advantage such as lower labour costs, product quality, IPR standards and favourable tariff regimes to enhance its participation in the regional and global value chain.

Similarly, in the CPTPP bloc, lowering the stringent requirement of high Labour, product quality, and IPR standards by large member countries could improve its integration into the GVC trade network.

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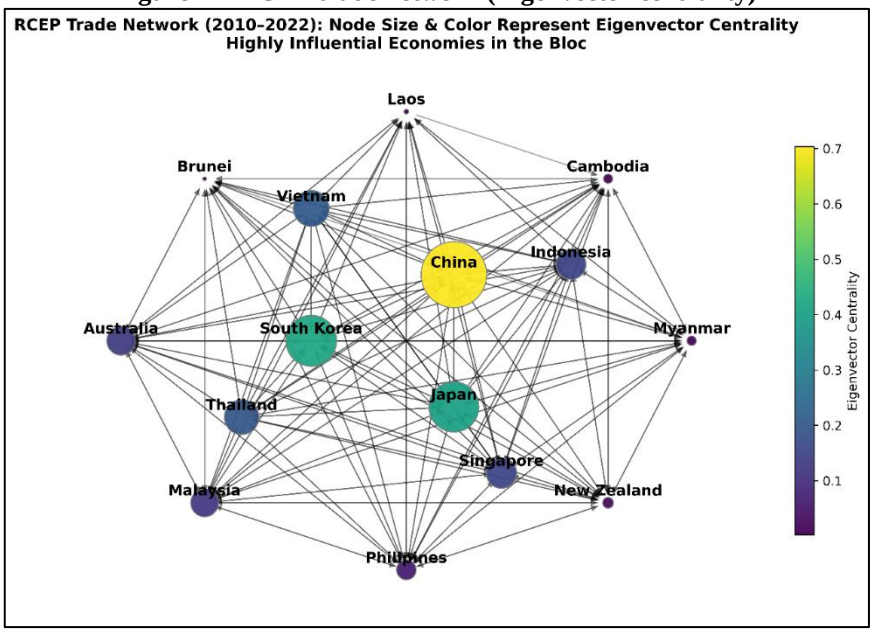
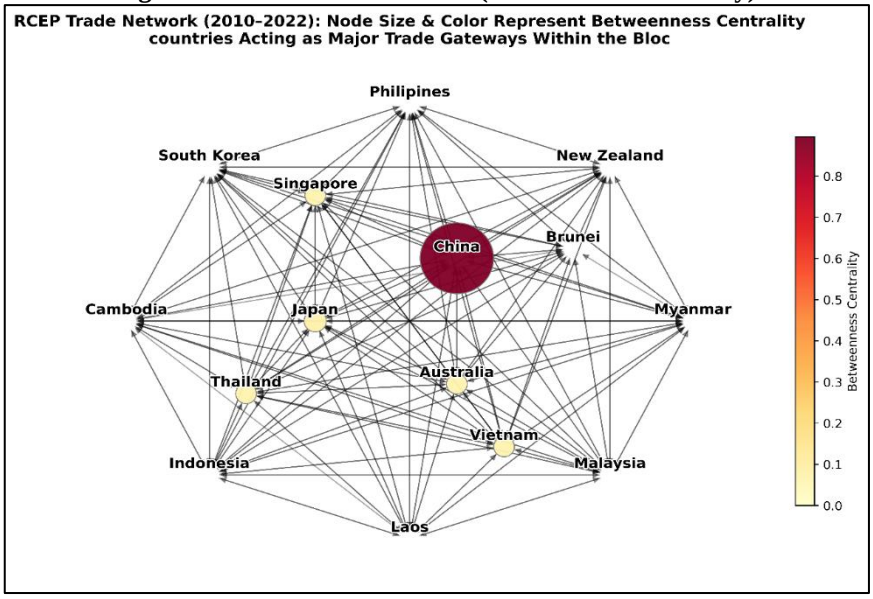
Appendix

Figure A - RCEP trade network (Eigenvector centrality)



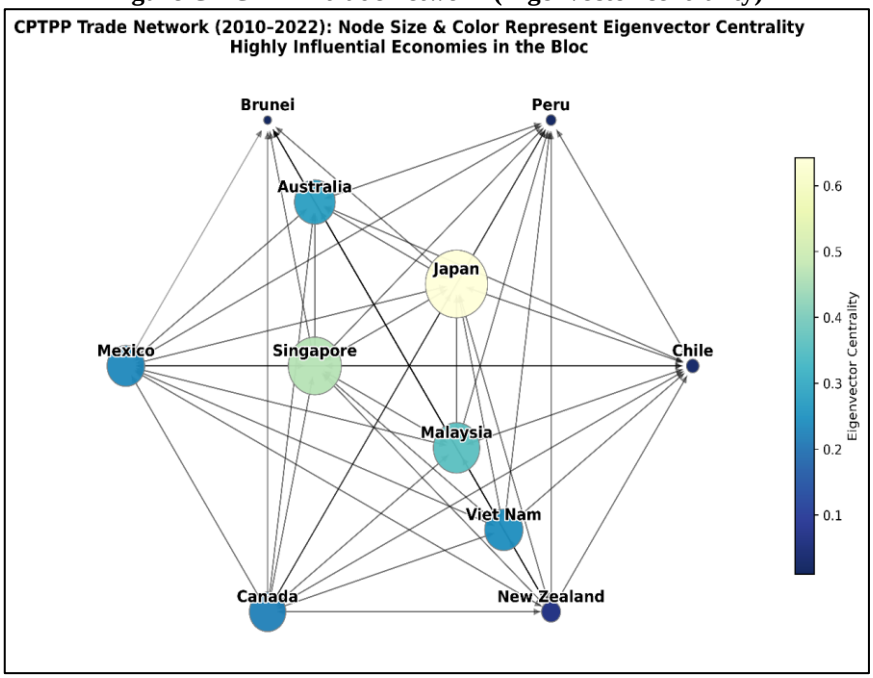
Source: Constructed from Table 3

Figure B- RCEP trade network (Betweenness centrality)



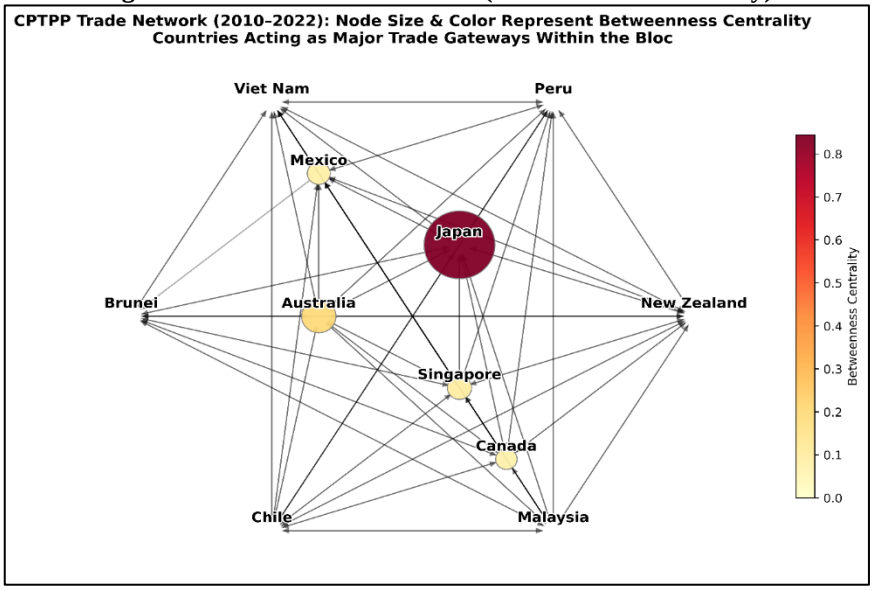
Source: Constructed from Table 3

Figure C - CPTPP trade network (Eigenvector centrality)



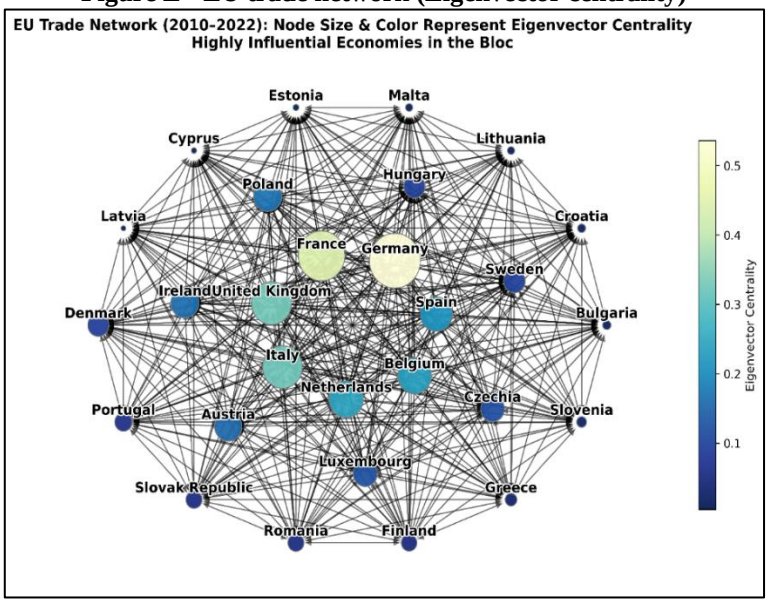
Source: Constructed from Table 5

Figure D - CPTPP trade network (Betweeenness centrality)



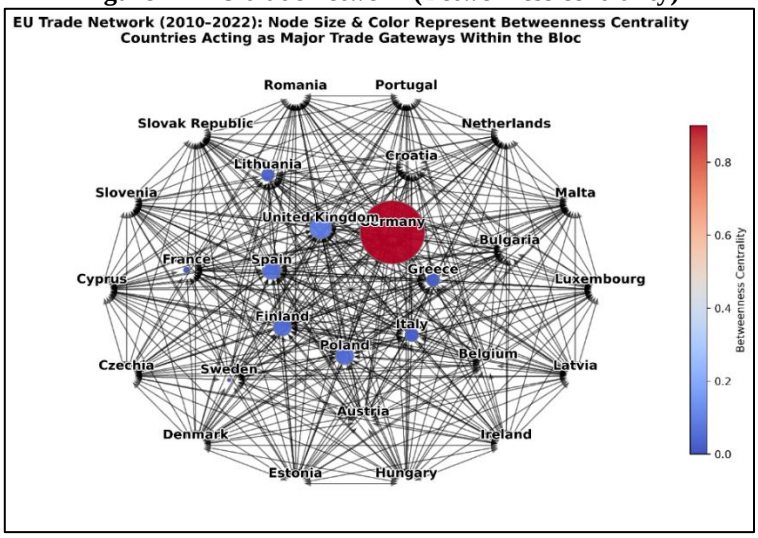
Source: Constructed from Table 5

Figure E - EU trade network (Eigenvector centrality)



Source: Constructed from Table 6

Figure F - EU trade network (Betwenness centrality)



Source: Constructed from Table 6

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