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International supply networks: A portrait of global trade patterns in four sectors

Abstract

This paper explores the development of international supply networks in four manufacturing sectors: communication equipment, electrical machinery, motor vehicles, textiles and apparel. The study investigates changes in the trade of intermediate products using descriptive statistics, network metrics and visualization, and econometric methods. The findings of the paper suggest that the evolution of international supply networks towards far-shoring has stagnated since 2015. The paper also reveals some evidence of nearshoring and friend-shoring trends in most recent trade statistics. Developed countries and East Asian economies continue to dominate supply networks, while Latin American and African nations are largely absent.

Key words International trade, Supply networks, Network analysis

United Nations

Contents

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1. Introduction

There is a growing interest in understanding whether global trade is experiencing a shift in its geographic patterns and whether international supply networks are being reorganized to address economic and geopolitical challenges. The interest is due to recent events such as the trade tensions between the United States and China, the COVID-19 pandemic, disruptions in trade logistics, and the war in Ukraine. These events have highlighted the issues associated with excessive reliance on foreign suppliers and have increased the argument for reshaping supply networks to prioritize closer and more dependable suppliers. As a result, there is a growing attention to policies aimed to facilitate nearshoring and friend-shoring to ensure greater supply chain resilience and reliability.

During the last 20 years, the patterns of international trade have been largely driven by decisions taken by firms concerning localization of production activities and choice of suppliers. Such decisions have reflected business strategies which seek to optimize profits by minimizing costs while managing uncertainty (Javalgi et al., 2009; Mukherjee et al., 2013; Tate and Bals, 2017; Ishizaka et al., 2019). Since the early 2000s, improvements in communication technologies, investments in trade infrastructure, and declines in trade costs, have enabled companies to take advantage of production cost differentials across the globe. These factors contributed to a sharp increase in international trade driven by the offshoring of production processes and by the rising integration with low-cost foreign suppliers. This global integration process, however, substantially slowed during the last decade, because of lower marginal benefits and because of a combination of trends such as the convergence of labour costs, technological improvements in automation and robotization, and a rise in trade costs (Piatanesi and Arauzo-Carod, 2019; Antràs, 2020) (Baldwin and Evenett, 2020). This period is generally referred as "slow-balization", a connotation to contrast the hyper-globalization period of the early 2000s.

In recent years, new forces have come into play in further altering global trade patterns. National security, public health and environmental concerns are providing new rationales for trade policymaking. Additionally, increasing awareness of the impact of international trade on income inequalities has resulted in a change in policy priorities in many countries. Moreover, COVID-19 restrictions, recurring supply chain bottlenecks, and an unstable geopolitical background have increased the risks associated with excessive dependence on foreign suppliers. These factors have intensified discussions on whether firms should be improving the resilience of their supply networks by embracing reshoring, nearshoring and friend-shoring strategies. Such strategies will ultimately shape international trade patterns (Baldwin and Lopez-Gonzalez, 2015; Cingolani et al., 2018; McIvor and Bals, 2021).

This paper examines the status and evolution of international supply networks in four manufacturing sectors: communication equipment, electrical machineries, motor vehicles, and textiles and apparel. To identify the changes in the supply network configurations, this paper makes use of descriptive statistics, network metrics and visualization, and econometric methods. Furthermore, the paper explores whether there has been a reversal from far-shoring trends,[1] and whether some of the nearshoring and friend-shoring trends are already manifest in trade statistics. The analysis of this paper identifies international supply networks as revealed by bilateral trade flows of intermediate inputs.

The results of this paper indicate that international supply networks have evolved along many dimensions since 2005. With the exception of communication equipment, supply networks have become more decentralized and diversified. The paper also finds that while far-shoring was a recurring trend in supply networks until 2015, this trend has slowed down, and in some cases reversed, since 2015. However, this paper finds only limited evidence of nearshoring and friend-shoring trends in the most recent trade statistics.

[1] Far-shoring involves moving production capacity and seeking suppliers over very long distances, usually in another continent with the scope of reduce production and input costs. However, far-shoring generally results in higher transport costs.

The remainder of this paper proceeds as follows. Section 2 defines the data utilized in the analysis. Section 3 provides some descriptive statistics and visualizes supply networks. Section 4 analyzes nearshoring and friend-shoring trends. Section 5 concludes.

2. Data and definitions

To illustrate international supply networks, this paper makes use of network analysis (Bastian et al. 2009). Network analysis allows to intuitively summarize trade relationships as networks, rather than describing them as simple bilateral relationships (Borgatti and Li, 2009). This paper also makes use of descriptive statistics and econometric methods to explore nearshoring and friend-shoring trends.

For the analysis of this paper, supply networks are revealed by trade statistics in intermediate inputs. Intermediate inputs are defined according to the United Nations classification on Broad Economic Categories (BEC) at the six-digit level of the Harmonized System (HS) classification.[2] The analysis examines the supply networks of four distinct manufacturing sectors representing diverse supply chains configurations: communication equipment, electrical machineries, motor vehicles, and textiles and apparel. Trade data on the inputs is aggregated to these four sectors using the concordance table between the HS classification and the ISIC classification. Trade data used in the analysis originates from the United Nations Comtrade database and is comprised of bilateral trade flows, with the analysis mostly using data for 2005, 2015, 2019 and 2021.[3]

Trade data is arranged by countries (nodes) and bilateral trade flows (edges). Network metrics and analysis are largely focused on the principal nodes in the supply networks, as identified by their centrality (Borgatti and Everett, 2006). Centrality measures are weighted by the magnitude of bilateral trade flows in order to account for node importance. To simplify exposition and control for bias introduced by smallest trade relationships, the analysis considers only the edges whose magnitudes are larger than 0.1 per cent of global intermediate trade.

Nearshoring and friend-shoring trends are captured by changes in the respective indicators across years. The average geographical distance of the imports of a node sourcing from different suppliers is computed using the bilateral geodesic distance between the node and each of its trading partners, weighted by the value of bilateral trade. A decrease in the average geodesic distance would denote a nearshoring trend.

Friend-shoring is explored using a similar approach, where the political closeness between an importer and its suppliers is calculated based on foreign policy similarity. Foreign policy similarity data is obtained from the Foreign Policy Similarity FPSIM dataset (Häge, 2017), which uses alliance ties (Häge, 2011) and United Nations General Assembly voting patterns (Voeten, 2013).[4] Foreign policy similarity is measured as the average similarity in the voting record of each country pair, corrected for the fact that non-alliance ties are more frequent than alliance ties. An increase in the average political closeness of trade indicates a shift in the importer's import structure towards countries that share similar global views, which is interpreted as a trend towards friend-shoring.

[2] For more details, please see https://unstats.un.org/unsd/trade/classifications/bec.asp. Concordance tables between the BEC, HS and ISIC classification can be found at: https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp

[3] The analysis also aims to investigate recent trends; therefore, while the analysis considers pre-COVID data as of 2019, it does not consider changes that occurred between 2005 and 2015.he analysis also aims to investigate recent trends.

[4] In particular, the index used for the analysis of this paper is Cohen's kappa (Häge, 2017).

3. Networks of international supply chains

While network analysis has long be used in the study of social networks (Galaskiewicz and Wasserman, 1993) it has more recently been applied to explore salient features of international supply networks (Benedictis and Tajoli, 2011; Amador and Cabral, 2017; Amador et al, 2018; Pacini et al., 2021; Gönçer-Demiral and Ince-Yenilmez, 2022). The analysis of supply networks relies on network metrics and visualization (Wasserman and Faust, 1994; Carrington et al., 2005). Network metrics provide useful statistics to compare networks across sectors and time. Network visualization intuitively illustrates network structure and the linkages within a network. Network metrics can be computed at the network level and at the node level. Network level metrics summarize elements of networks such as centralization, density, and complexity. Among these various measures, network centralization is the most informative for supply networks. Centralization provides an indication of the reliance of the network on its most important nodes.[5] Network centralization is standardized by using the percentage value of trade in each edge relative to the entire network. This weighting scheme allows for an easier comparison across sectors and time.

Network analysis also makes use of statistics capturing the significance and characteristics of individual nodes. The most relevant statistic in the study of a supply network is degree centrality. Degree centrality is computed as the number of connections (edges) a node has with other nodes in the network, weighted by the importance of these connections. Concisely, degree centrality provides a measure of relative importance of each individual node for the functioning of a network. As for the network centrality, degree centrality is standardized using the percentage value of trade in each edge relative to the entire network.

Table 1 presents network-level statistics for the four sectors at four different time points. These measures offer insights into the network structure in terms of the relative importance of key nodes or edges. The table begins with the number of nodes and edges required to account for 90 per cent of the trade in each sector.[6] Next, Table 1 reports network centrality. Larger centrality would imply a more centralized network which relies on a more limited number of nodes.

Examining differences across sectors, the supply network of communication equipment shows the highest degree of concentration (as it relies on a small number of suppliers). In 2021, 90 per cent of global trade of intermediate inputs in communication equipment was concentrated across just 35 nodes, and across 158 bilateral linkages (edges). Supply in the motor vehicle sector is also centralized around a small number of nodes, but involves a much higher number of bilateral linkages. On the other hand, the international supply network of textiles and apparel is the most dispersed, requiring 134 nodes and 833 edges to reach 90 per cent of global trade of intermediate inputs in 2021.

Overall, the analysis indicates that the structure of international supply networks varies across sectors and over time, with some networks being more centralized than others. While decentralization trends have been observed in most networks over the period of analysis, there are some exceptions, such as the communication equipment sector which became more centralized over time. Additionally, the trends observed between 2015 and 2021 are more ambiguous, with some sectors showing decentralization and others showing centralization. For example, the network of communication equipment shows a decentralization pattern between 2015 and 2019; and then a centralization pattern between 2019 and 2021. Electrical machinery inverted its trend of 2005-2015 to regain some centralization. On the other hand, the motor vehicle network and the textiles and apparel network continued on their decentralization trend even after 2015.

[5] Network centralization measures whether the functioning of the network is concentrated on a few nodes or evenly distributed across the network. It provides a sense of how much influence or control is held by a small subset of nodes versus being distributed more broadly. Centralization is calculated by comparing the actual distribution of centrality across nodes to the maximum possible distribution of centrality that could exist in a network of the same size and shape. For a in-depth discussion on network metrics, see Opsahl, Agneessens, and Skvoretz (2010).

[6] A larger (smaller) number of nodes or edges implies a more (less) diversified network.

Table 1. Network level statistics

		Communication equipment	Electrical machinery	Motor vehicles	Textiles and apparel
Number of nodes to cover 90% of trade	2005	43	88	56	121
	2015	36	113	59	131
	2019	38	109	64	131
	2021	35	106	66	134
Number of edges to cover 90% of trade	2005	313	723	340	925
	2015	185	877	448	873
	2019	170	896	469	867
	2021	158	822	476	833
Network centralization	2005	2.326	1.136	1.786	0.826
	2015	2.778	0.855	1.639	0.762
	2019	2.632	0.917	1.563	0.761
	2021	2.857	0.943	1.515	0.746

Source: Author's calculations.

Table 2 reports node level statistics in the form of degree centrality for the 15 nodes with highest centrality in 2021. Table 2 complements the statistics of Table 1 by providing an indication of the relative importance of countries for a network at four points in time. Nodes with higher degree centrality are of larger importance for the network.

The supply network of communication equipment is dominated by China, Hong Kong SAR, the Republic of Korea, and Taiwan Province of China, with Malaysia, Viet Nam and Singapore also playing important roles. Between 2005 and 2021, China and Taiwan Province of China strengthened their position in the network, while the United States of America, Japan, Singapore, Philippines, Germany and Mexico became less important. While most changes occurred between 2005 and 2015, some significant changes were noted thereafter, such as the continued increase of Viet Nam's centrality to the network.

Turning to the sector of electrical machinery, the supply network is centred on China, the United States of America, and Germany, with Mexico and Japan also being important nodes. The relative importance of China, the Republic of Korea, Viet Nam, and some East European countries in this network has increased since 2005. On the other hand, most other countries have become less central to the network. China has continued to reinforce its position as the most central node in the international supply network of electrical machinery, even after 2019.

The motor vehicles industry supply network as of 2021 is largely concentrated in two countries: Germany and the United States of America. Nodes of lower importance are China, Mexico, and Japan. However, there have been significant changes in the importance of nodes within the motor vehicles supply network over time. Since 2005, Mexico and particularly China have experienced strong increases in centrality. The participation of East European countries in this network has also increased, but their contribution remains limited. Conversely, substantial declines are found in the centrality of Canada and some Western European countries. Most of the changes occurred prior to 2015, with country positions in the network changing to a lesser extent thereafter. The exception is the United Kingdom, whose centrality has more recently declined, likely due to Brexit.[7]

[7] For example, the Society of Motor Manufacturers and Traders reports investment in the UK car industry was estimated as an average of £4bn a year between 2012-2015, but only £1.1bn between 2016-2019.

Table 2. Node level statistics: degree centrality

Communication equipment	2005	2015	2019	2021	Electrical machinery	2005	2015	2019	2021
China	32.0	52.3	53.3	56.3	China	22.5	32.1	32.2	36.0
Taiwan Province of China	18.7	24.8	26.0	28.6	United States of America	28.6	26.2	25.1	23.4
Hong Kong SAR	13.2	21.6	20.9	22.7	Germany	21.9	20.3	20.3	21.0
Republic of Korea	16.5	20.4	18.9	19.5	Mexico	12.2	12.3	12.2	11.1
Malaysia	14.8	12.4	13.8	13.0	Japan	16.0	11.5	10.8	9.9
Viet Nam	0.1	6.3	10.4	11.0	Republic of Korea	5.0	6.6	6.3	6.2
Singapore	15.3	12.1	11.1	9.9	France	9.4	6.8	6.9	6.0
United States of America	20.4	12.6	10.5	8.5	Poland	2.5	3.2	3.9	5.2
Japan	19.5	11.1	9.4	8.3	Italy	6.3	5.0	4.9	5.1
Philippines	8.1	4.2	4.1	3.3	Hong Kong SAR	5.6	4.9	4.5	5.0
Germany	8.3	5.0	4.2	3.2	Viet Nam	0.5	2.6	3.7	4.8
Thailand	4.3	3.7	3.1	3.0	Czechia	3.0	3.8	4.1	4.5
Mexico	5.0	4.1	3.8	3.0	United Kingdom	6.6	4.9	4.5	3.9
India	0.1	1.2	2.1	1.9	Spain	4.2	3.7	3.9	3.6
Netherland	3.1	1.0	1.8	1.6	Hungary	2.2	2.9	3.1	3.4

Motor vehicles	2005	2015	2019	2021	Textiles and apparel	2005	2015	2019	2021
Germany	31.9	29.6	29.4	29.4	China	30.0	44.6	46.2	48.3
United States of America	34.2	31.0	29.6	29.1	Viet Nam	2.6	10.7	13.3	14.7
China	4.7	13.9	13.8	16.8	United States of America	13.7	10.8	10.0	10.2
Mexico	9.4	15.1	16.0	15.4	India	4.5	6.9	7.3	8.6
Japan	13.6	11.8	11.0	10.2	Italy	14.5	9.8	9.3	8.1
France	13.5	8.9	8.9	8.5	Germany	12.0	8.9	8.5	8.0
Canada	15.5	9.1	8.1	6.6	Bangladesh	1.1	5.5	6.2	7.3
Spain	9.6	7.2	7.0	6.5	Türkiye	5.7	6.3	6.1	6.1
Poland	3.7	5.4	6.1	6.3	Republic of Korea	8.7	7.6	6.6	5.5
Italy	6.9	5.5	5.6	5.9	Japan	6.8	5.7	5.7	4.6
Czechia	3.1	5.6	6.0	5.6	Indonesia	3.6	5.3	5.0	4.4
Republic of Korea	2.8	6.0	5.2	5.3	Taiwan Province of China	6.6	5.3	4.5	4.0
United Kingdom	9.6	6.6	6.2	4.7	Hong Kong SAR	13.4	5.7	4.3	3.9
Slovakia	1.4	3.3	3.8	4.1	France	7.0	3.9	3.9	3.6
Hungary	3.9	4.4	4.4	4.0	Cambodia	0.7	2.6	3.1	3.3

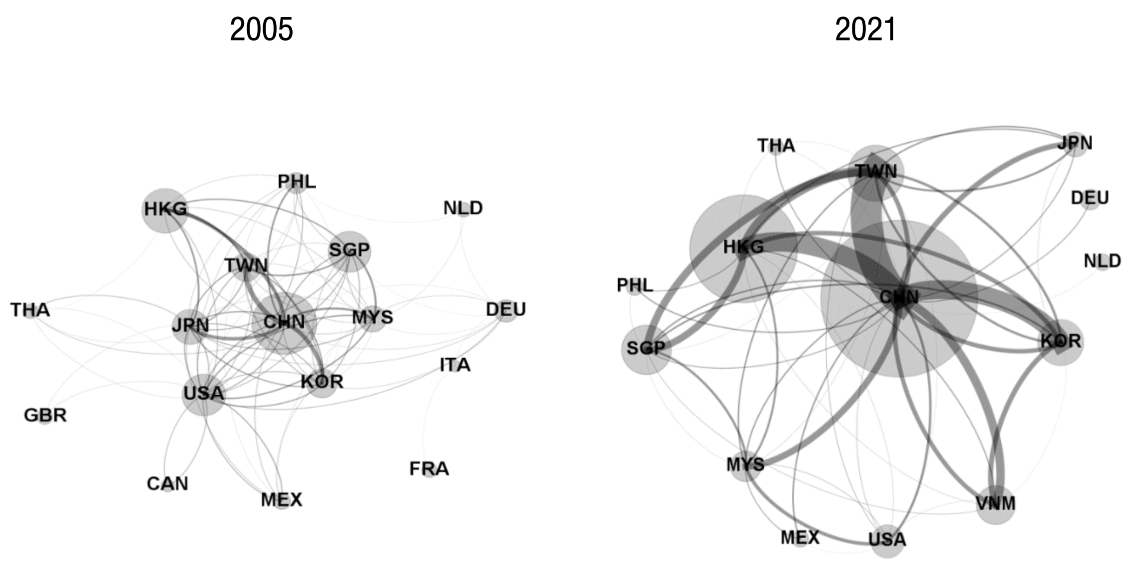
Source: Author's calculations.

The supply network of the textiles and apparel sector has been rather dispersed, with China being the most important node, particularly since 2015. In 2021, Viet Nam is a distant second, and the United States of America is third. The network includes several developing countries such as India, Bangladesh, Indonesia, Türkiye, and Cambodia. Importantly, many developing countries have seen their importance in this network increase, particularly Viet Nam, India, Bangladesh, and Cambodia. In contrast, the importance of more established economies in this supply network has declined since 2005. This decline in importance is evident not only for some Western European economies (Italy, Germany, and France) but also for other advanced economies such as Japan, the Republic of Korea, and Hong Kong SAR.

The structure of supply networks can be captured more easily through network visualization. By representing the nodes as points and the edges as lines, it becomes possible to see how the various economies are connected and how they are positioned within the network. This can help identify clusters of economies that are closely connected to each other, as well as hubs or gateways that play a key role in connecting different parts of the network. Network visualization can also be useful for identifying the most important trade connections between economies and for visualizing changes in the network over time.[8]

Figure 1 visualizes the communication supply network in 2005 and 2021. Overall, between 2005 and 2021 this supply network has grown noticeably in size while further centralizing around China. China's importance in this network is largely due to the very strong linkages with Hong Kong SAR, the Republic of Korea, and Taiwan Province of China. Moreover, the trade of smaller and more distant nodes has also reoriented towards China, as in the example of Mexico and Germany. Finally, the rise of Viet Nam as an important node in this network has been driven by its trade links with China, and to some extent with the Republic of Korea.

Figure 1. Communication equipment supply network in 2005 and 2021



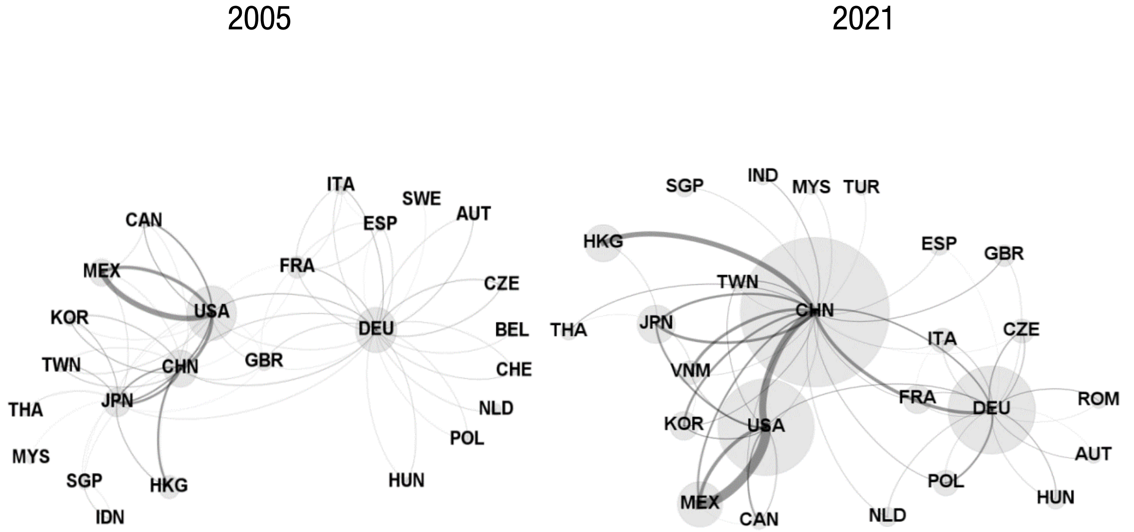
Source: Author's elaboration using Gephi 0.97.

Note: Countries codes follow the ISO 3166 classification. The sizes of nodes and the thicknesses of edges are representative of the magnitude of trade and are comparable across time. Nodes with less than 1 per cent of total trade and edges accounting for less than 0.1 per cent of trade are omitted from the visualization.

The electrical machinery supply network has undergone substantial changes since 2005, both in relation to its size and structure (Figure 2). In 2005, this network was still largely bipolar, with the North American network configured around the United States of America, and the European network centred on Germany. The network comprising East Asian economies was less organized, with Japan as its central node. China acted as a link between the more developed East Asian economies and the United States of America. As of 2021, the network has become tripolar, with China taking a central stage and forming its own supply network reliant on other Asian economies. China continues to maintain and has further developed linkages with the other two regional networks.

[8] To avoid clutter, the visualization of the network is filtered by removing nodes of marginal importance (those with less than 1 per cent of total trade). Similarly, edges that account for less than 0.1 per cent of trade are removed from the visualization. Visualization is performed by Gephi v0.97, using the Yifan-Hu algorithm (Hu, 2011). The sizes of nodes and the thicknesses of edges are representative of the magnitude of trade and are comparable across time.

Figure 2. Electrical machinery supply network in 2005 and 2021



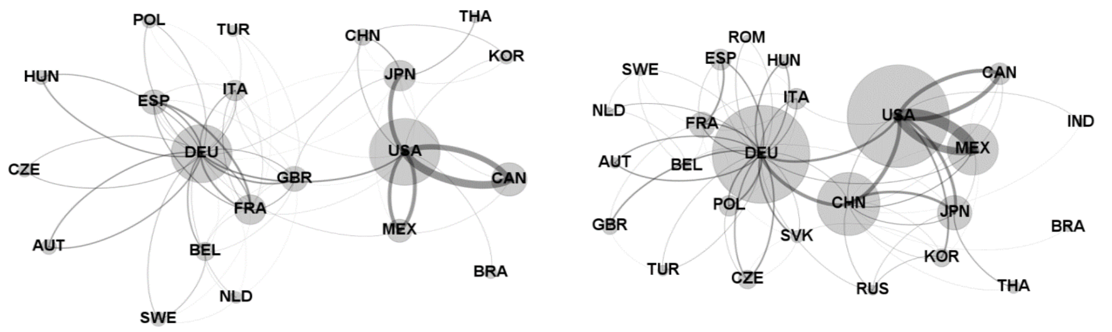
Source: Author's elaboration using Gephi 0.97.

Note: Countries codes follow the ISO 3166 classification. The sizes of nodes and the thicknesses of edges are representative of the magnitude of trade and are comparable across time. Nodes with less than 1 per cent of total trade and edges accounting for less than 0.1 per cent of trade are omitted from the visualization.

Figure 3 visualizes the configuration of the motor vehicle supply network in 2005 and 2021. As of 2005, this network was distinctively bipolar, with the United States of America and Germany being its central nodes. European countries were closely integrated around Germany, and to some extent France. Similarly, Canada, Mexico and Japan were integrated in the North American supply network. As of 2021, this network remains bipolar, but with the difference that China has achieved a more prominent role both within the North American and the European Network. Of importance is also the rising role of Mexico within the North American network, largely to the expense of Canada. The European network remains closely integrated, with Germany reinforcing its importance as its central node.

Figure 3. Motor vehicle supply network in 2005 and 2021

2005 2021



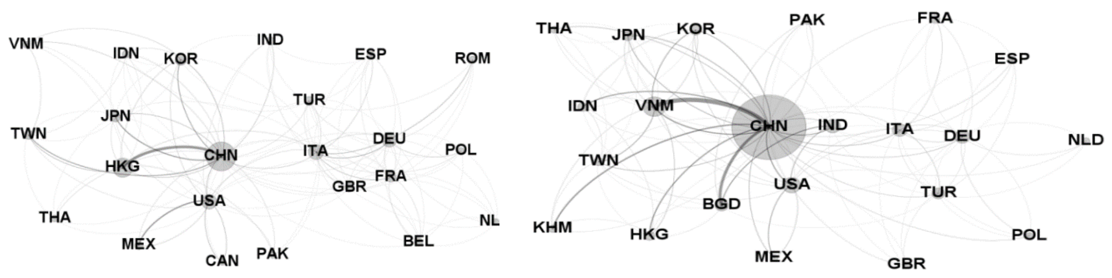
Source: Author's elaboration using Gephi 0.97.

Note: Countries codes follow the ISO 3166 classification. The sizes of nodes and the thicknesses of edges are representative of the magnitude of trade and are comparable across time. Nodes with less than 1 per cent of total trade and edges accounting for less than 0.1 per cent of trade are omitted from the visualization.

The structure of the textiles and apparel supply network is markedly different from the previous three networks (Figure 4). In 2005, the network was very dispersed, with no clear centre, but still with a number of relatively important nodes (China, Hong Kong SAR, Italy, Germany, and the United States of America). As of 2021 the network remains largely decentralized, but with China now taking a prominent position. The supply network also sees the emergence of Bangladesh, Cambodia, India, Pakistan and Viet Nam as important nodes, but largely because of their links with China.

Figure 4. Textile and apparel supply network in 2005 and 2021

2005 2021



Source: Author's elaboration using Gephi 0.97.

Note: Countries codes follow the ISO 3166 classification. The sizes of nodes and the thicknesses of edges are representative of the magnitude of trade and are comparable across time. Nodes with less than 1 per cent of total trade and edges accounting for less than 0.1 per cent of trade are omitted from the visualization.

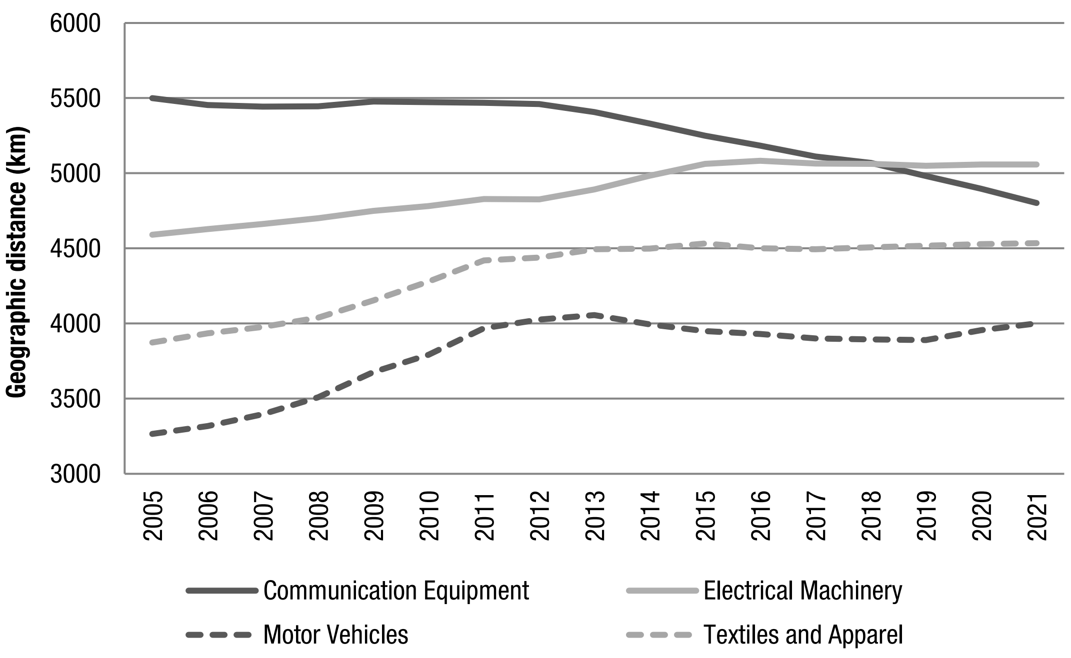
4. Nearshoring and Friend-shoring

This section explores nearshoring and friend-shoring trends.[9] Nearshoring and friend-shoring trends are first simply illustrated by calculating the average geographic distance and political closeness index across time, and then the trends are explored econometrically. Figure 5 plots the evolution of the average geographical distance in the four networks from 2005 to 2021. This average is weighted by the value of each bilateral trade relationship.[10]

Figure 5 shows a clear far-shoring trend for three supply networks (motor vehicles, electrical machinery and textiles and apparel) until about 2015. By contrast, the geographic distance of trade in the communication equipment supply network remained stable until about 2013. After 2013, the communication equipment supply network shows a clear near-shoring trend. As for the other three networks, they do not manifest any significant trends after 2015, neither far- nor near-shoring.

Figure 5 illustrates a distinct far-shoring trend for three supply networks (motor vehicles, electrical machinery, and textiles and apparel) until approximately 2015. After 2015, neither far- nor near-shoring trends are evident in the three networks. In contrast, far-shoring was absent until around 2013 in the communication equipment sector, after which a clear near-shoring trend emerged.

Figure 5. Average geographical distance of supply networks



Source: Author's calculations. Geographic distance is computed as weighted average where weights are the values of bilateral trade.

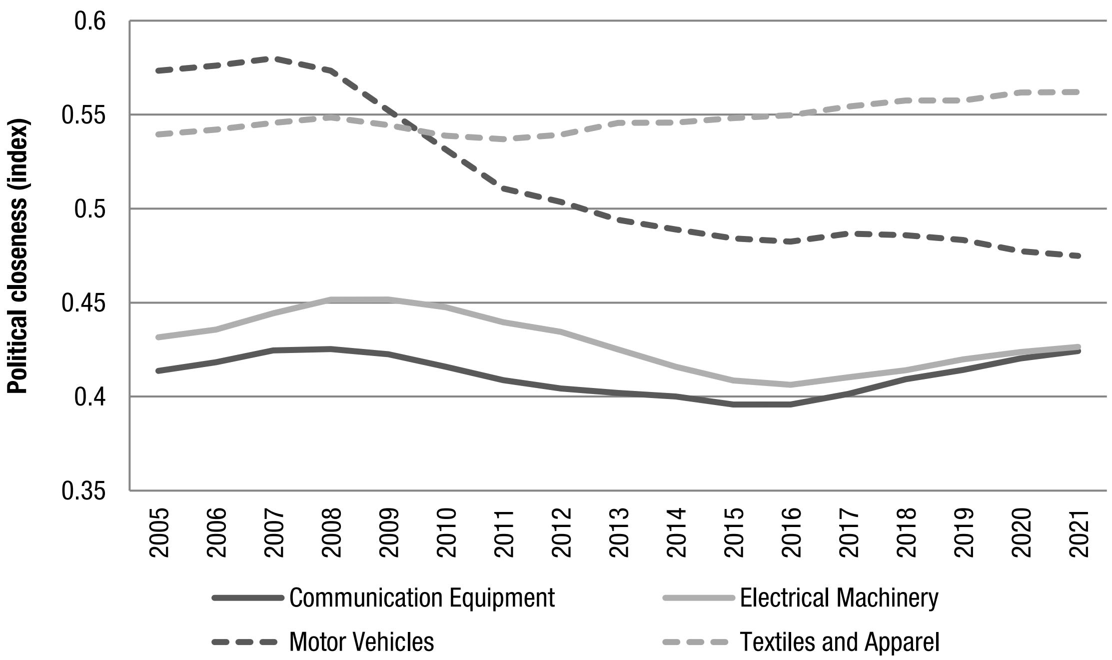
[9] Note that an increase in the centralization of networks discussed above does not necessarily imply nearshoring trends, as the two concepts are different. Network centralization measures the importance of the nodes within a network, without considering the geographical location of these nodes. An increase in a network's centralization implies a decline in the number of important nodes of a network. On the other hand, nearshoring trends capture changes in the geographical distance between nodes and suppliers.

[10] The interpretation of the statistics in Figure 5 is as follows. In the example of motor vehicles, the average distance of the bilateral trade flows between the nodes of the network went from about 3300 kilometres in 2005 to about 4000 kilometres in 2021.

Of interest is also the average geographic distance of the four networks. The trade of intermediate products in the motor vehicles network has constantly been at lower distances relative to other networks. This is consistent with what is observed in the network visualization graphs which suggested a more regional structure for this network. Trade in the textiles and apparel supply network is generally subject to larger distances. Distances have been even larger in the electrical machinery and the communication equipment supply networks. The latter network had the largest geographical distance until 2019, to then be surpassed in 2021 by the electrical machinery supply network.

Figure 6 illustrates the trends in relation to the political closeness variable. This variable captures the average political distance of the bilateral trade within a network. An increase in this variable indicates that trade patterns have shifted to favour politically closer trading partners. Figure 6 shows a clear trend opposite to friend-shoring in the motor vehicle sector, albeit from the relatively highest initial level of friend-shoring, indicating that trade in this network has progressively moved toward trading partners with different political views. The trends in the other networks have been relatively more muted. However, all three networks appear to follow a slight friend-shoring trend starting from 2015. Comparing across sectors, trade in the textiles and apparel supply network appears to be relatively more reliant on trade between countries with similar political views. On the other hand, trade in the electrical machinery and in the communication equipment sectors occurs between countries that are more divergent in terms of political closeness.

Figure 6. Average political closeness of supply networks



Source: Author's calculations. Political closeness computed as weighted average of the foreign policy similarity index where weights are the values of bilateral trade.

To further explore the presence of nearshoring and friend-shoring trends, this paper employs a simple econometric approach which includes fixed effects as controls for node and supplier characteristics. This approach adds to the results of the descriptive analysis by controlling for changes in the centrality of nodes. This adds to the analysis investigating possible nearshoring and friend-shoring trends regardless of how the nodes have evolved within the network. [11]

[11] Nearshoring and friend-shoring trends are investigated separately to maintain consistency with their own definitions. Still, results are robust also by estimating the two variables in the same equation.

The empirical specification of the equation investigating nearshoring trends takes the form:

$$\Delta Pct_{ij} = \beta_1 \ln(geographic\ distance_{ij}) + \omega_i + \varphi_j + \varepsilon_{ij}$$

For friend-shoring the estimating equation is identical but for the relevant variable:

$$\Delta Pct_{ij} = \beta_2(political\ closeness_{ij}) + \omega_i + \varphi_j + \varepsilon_{ij}$$

The subscript *i* denotes the node and *j* the supplier. In the equations, ΔP_{ij} corresponds to the change in the percentage of imports of node *i* coming from supplier *j* between period *t* and *t*-1. This is formally defined as: $\Delta Pct_{ij} = \frac{imp_{ij}^{t}}{\sum_j imp_{ij}^{t}} - \frac{imp_{ij}^{t-1}}{\sum_j imp_{ij}^{t-1}}$ where *imp* denotes the imports of node *i* from supplier *j*. Therefore, a negative ΔPct_{ij} implies a decline in the reliance of node *i* from suppliers in country *j*, relative to the other suppliers. Vice-versa, positive ΔPct_{ij} implies that country *j* has increased its relative importance as a supplier of node *i*. The specification introduces fixed effects controlling for changes in nodes' (ω_i) and suppliers' (φ_j) characteristics. The fixed effects control for any event occurring in a particular node or supplier, for example due to of an economic crisis or other country-specific events which may result in a lower capacity to serve as a node or supplier in a network.[12] In this specification a negative sign on the coefficient β_1 would indicate nearshoring trends, as nodes would rely on geographically closer suppliers. On the other hand, a far-shoring trend would be denoted by a positive β_1. In the case of trade favouring suppliers in politically closer countries, a positive coefficient β_2 would indicate a friend-shoring trend. [13] The estimations are performed using different time periods so to better identify trends.[14]

Table 3 presents the results of the econometric analysis, which are generally consistent with the descriptive statistics discussed earlier. Far-shoring trends are observed in all four networks from 2005 to 2015. However, there are some discrepancies between the econometric results and the trends illustrated in Figure 5, particularly for the motor vehicle and communication equipment networks. The econometric analysis reveals that the motor vehicle network has experienced far-shoring trends throughout the entire period of analysis, which is not evident from Figure 5. Additionally, the econometric estimation does not detect a nearshoring trend in the communication equipment network after 2015. This result suggests that the nearshoring trend in the communication equipment supply network has been mostly driven by changes in the centrality of nodes, rather than a decline in the geographical distance of the suppliers of specific nodes. In other words, trade in this network has increased relatively more in relation to nodes that were already relying on geographically closer suppliers, rather than being a consequence of nodes reorienting imports to favour geographically closer suppliers.

Regarding friend-shoring trends, the econometric estimations are generally consistent with the descriptive statistics, indicating a trend towards friend-shoring since 2015. Specifically, the econometric results indicate a friend-shoring trend in the communication and textiles and apparel sectors after 2015. Similarly, the pre-

12 As the analysis does not investigate the possible causes of these trends, it abstains from introducing time-variant trade costs or other policy covariates, and simply focuses on the identification of possible trends. Moreover the inclusion of policy variables affecting trade costs (e.g. tariffs) would confound the analysis as these policies are often instruments for the trends.

13 While nearshoring can happen jointly with friend-shoring, the two concepts are distinct. For this reason the regressions are estimated separately for each of the variables. Estimating the regressions by including both geographical distance and political closeness provide similar results.

14 The econometric analysis omits the observations related to nodes of less than 1 per cent of sectoral trade and of bilateral trade flows accounting for less than 0.1 per cent of sectoral trade. In doing so, the analysis seeks to explore the trends only for the most meaningful nodes and on the basis of bilateral trade of some significance.

2015 trends against friend-shoring in the electrical machinery and motor vehicle sectors have disappeared after 2015.

Table 3. Nearshoring and friend-shoring trends: econometric estimates

	Communication equipment	Electrical machinery	Motor vehicles	Textiles and apparel
Geographical distance (log km)				
2005-2021	0.0018	0.0032***	0.0079***	0.0067***
2005-2015	0.0039**	0.0066***	0.0071***	0.0045***
2015-2021	-0.0009	0.0016**	0.0036***	-0.0012
2019-2021	-0.0006	-0.0002	0.0018***	-0.0001
Political Closeness Index				
2005-2021	-0.0204***	-0.0042	-0.0094*	0.0009
2005-2015	-0.0256***	-0.0118**	-0.0063*	-0.0034
2015-2021	0.0078*	-0.0021	-0.0034	0.0030*
2019-2021	0.0071***	-0.0024	-0.0021	0.00218*
Observations	345	274	359	400
R-Squared	0.305	0.414	0.291	0.295

Source: Author's calculations.

Note: all specifications include node and suppliers fixed effects. The level of significance is: *** p<0.01, ** p<0.05, * p<0.1. Number of observations and R-Squared statistics are averages across the estimations.

5. Summary and conclusions

This paper analyzes the evolution the international supply networks of four sectors: communication equipment, electrical machinery, motor vehicles, and textiles and apparel. The findings of this paper rely on network metrics and visualization, descriptive statistics, and econometric analysis. Overall, the results of this paper indicate that supply networks have substantially evolved since 2005, with most of the changes occurring during the period from 2005 to 2015. A general trend in all four networks during this period has been far-shoring and the growth of global value chains. Since 2015, the evolution of the networks has slowed down and followed diverse trends. The analysis also points to substantial differences in the structure of the four supply networks and in their evolution during the period of analysis.

The communication equipment supply network exhibits a high degree of reliance on a limited number of nodes, with China always being the dominant one, particularly since 2015. More generally, this network is predominantly characterized by East Asian economies. As of 2021, the network is heavily reliant on the economies of China, Hong Kong SAR, and Taiwan Province of China. Apart from these three, Viet Nam is the only economy whose significance in the network has significantly increased, particularly after 2015. The communication equipment network shows some signs of nearshoring and friend-shoring since 2015.

The electrical machinery supply network has gone through substantial changes since 2005. In 2005, this network was still largely bipolar, with the North American network configured around the United States of America, and the European network centred around Germany. As of 2021, this network has become tripolar, with China taking a central stage and forming its own supply network reliant on other Asian economies. China, the Republic of Korea, Viet Nam, and some of the East European countries have seen their relative importance increase since 2005. The electrical machinery supply network has been characterized by a far-shoring trend, even after 2015. This network shows some very limited friend-shoring patterns since 2015.

As of 2021, the motor vehicle supply network remains largely bipolar, centred on Europe and the United States of America. However, China has been playing an increasingly important role in this network. In relation to the European pole, the participation of East European countries in such network has increased with their contribution largely linked to Germany. United Kingdom's importance in this network has very recently declined, likely because of Brexit. With regard to the North American pole, Mexico's importance in the motor vehicle supply network has also increased, while the importance of Canada has decreased. This network shows a clear far-shoring trend, even during the most recent years. The motor vehicle supply network does not show any evidence of friend-shoring trends.

The international supply network of the textiles and apparel sector has remained relatively decentralized. As of 2021, its main poles are China and Viet Nam. Since 2005 this supply network has evolved to include Bangladesh, Cambodia, India, and Pakistan as important nodes, but largely due to their links with China. By contrast, the importance of many high-income countries has declined since 2005. This network shows far-shoring trends, especially up to 2015, and no signs of nearshoring after 2015. This network appears to have been experiencing some friend-shoring trends since 2015.

Overall, the findings of this paper suggest that international supply networks' have generally become more decentralized during the last few years. However, many of the networks remain dominated by a limited number of countries, with suppliers in developed economies and East Asian countries maintaining dominance in many of the networks. This paper also finds some limited evidence of nearshoring and friend-shoring trends in the most recent trade statistics. This is not a surprise, as the reorganization of supply chains may take years to fully emerge. A meaningful alteration to current global trade patterns would require locating new reliable suppliers and creating the necessary trade infrastructure supporting such reorganization. In this regard, it is possible that the limited evidence revealed by the analysis could indicate the beginnings of more generalized changes yet to come.

Another general finding of the paper that while developed countries and East Asian economies continue to dominate supply networks, Latin American and African nations remain largely absent, at least in relation to the trade of intermediate inputs. The opportunities created by changes in the structure of international supply networks will be dependent on technological upgrading and reduction in trade costs. Investment and partnership to facilitate the adoption of technologies, investments in trade infrastructure, and improving transparency and cooperation in trade related regulations therefore remain of paramount importance for the integration of developing economies into supply networks. Moreover, governments willing to facilitate the integration of their firms into supply networks should consider ways to increase predictability in the trade policy environment, both their own and that of their trading partners. Consequently, any reshaping of international supply networks might very possibly result in a stronger interest in forming trade agreements and in expanding existing ones.

References

Amador J, Cabral S, Mastrandrea R and Ruzzenenti F (2018). Who's who in global value chains? A weighted network approach. *Open Economies Review* 29(5):1039–1059.

Amador J and Cabral S (2017). Networks of Value-added Trade. *The World Economy*, 40: 1291-1313.

Antràs P (2020). Conceptual Aspects of Global Value Chains. *World Bank Economic Review* 34 (3): 551-574.

Baldwin R E and Evenett S J (eds) (2020). *COVID-19 and Trade Policy: Why Turning Inward Won't Work*, a VoxEU.org eBook, CEPR Press.

Baldwin R and Lopez-Gonzalez J (2015). Supply-chain trade: A portrait of global patterns and several testable hypotheses. *The World Economy* 38(11):1682–1721

Bastian M, Heymann S and Jacomy M (2009). Gephi: An Open Source Software for Exploring and Manipulating Networks. *Proceedings of the International AAAI Conference on Web and Social Media*, 3(1): 361-362.

Benedictis L D and Tajoli L (2011). The world trade network. *The World Economy*, 34(8):1417–1454.

Borgatti S P and Everett M G (2006). A Graph-Theoretic Perspective on Centrality. *Social Networks*, 28: 466-484.

Borgatti SP and Li X (2009). On Social Network Analysis in a supply chain context. *Journal of Supply Chain Management,* 45: 5-22.

Carrington P J, Scott J, and Wasserman S (2005). *Models and methods in social network analysis*. Cambridge university press.

Cingolani I, Iapadre L andTajoli L (2018) International production networks and the world trade structure. *International Economics*, 153: 11-33.

Galaskiewicz J and Wasserman S (1993). Social Network Analysis: Concepts, Methodology, and Directions for the 1990s. *Sociological Methods & Research*, 22(1), 3–22.

Gönçer-Demiral D and İnce-Yenilmez M (2022). Network analysis of international export pattern. *Social Network Analysis and Mining*, 12:156.

Häge F M (2017). Chance-Corrected Measures of Foreign Policy Similarity (FPSIM Version 2). *Harvard Dataverse, V2*.

Häge F M (2011). Choice or Circumstance? Adjusting Measures of Foreign Policy Similarity for Chance Agreement. Political Analysis,19, 3: 287-305.

Hu Y (2011). Algorithms for Visualizing Large Networks. Combinatorial Scientific Computing, 5, 10.1201.

Ishizaka A, Bhattacharya A, Gunasekaran A, Dekkers R and Vijay Pereira (2019). Outsourcing and offshoring decision making. International Journal of Production Research, 57(13): 4187-4193.

Javalgi R G, Dixit A and Scherer R F (2009). Outsourcing to Emerging Markets: Theoretical Perspectives and Policy Implications. Journal of International Management, 15 (2): 156–168.

McIvor R and Bals L (2021). A Multi-theory Framework for Understanding the Reshoring Decision. *International Business Review*, 30(6).

Mukherjee D, Ajai S G and Datta A (2013). "Creating Value Through Offshore Outsourcing: An Integrative Framework. *Journal of International Management*, 19 (4): 377–389.

Opsahl T, Agneessens F and Skvoretz J (2010). Node Centrality in Weighted Networks: Generalizing Degree and Shortest Paths. *Social Networks*, 32(3): 245–251.

Pacini H, Shi G, Sanches-Pereira A and da Filho A (2021). Network Analysis of International Trade in Plastic Scrap. *Sustainable Production and Consumption*, 27:203–216.

Piatanesi B and Arauzo-Carod JM (2019). Backshoring and nearshoring: An overview. *Growth and Change*, 50(3): 806-823.

Tate W L and Bals L (2017). Outsourcing/Offshoring Insights: Going Beyond Reshoring to Rightshoring. *International Journal of Physical Distribution & Logistics Management*, 47 (2/3): 106–113.

Voeten E (2013). *Data and Analyses of Voting in the United States General Assembly,* in Bob Reinalda (ed.). Routledge Handbook of International Organization (London: Routledge).

Wasserman S and Faust K (1994). Social network analysis: Methods and applications.