Research Paper

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Cite this article as: Mousavi, M. A., Pourrostami, N., & Kalhor, Z. (2026). The US-China Value Chain Resilience (2012-2020): Social Networking Analysis (SNA). *Journal of World Sociopolitical Studies*, *10*(1), 157-200. https://doi.org/10.22059/wsps.2025.397892.1539

The US-China Value Chain Resilience (2012-2020): Social Networking Analysis (SNA)*

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(Received: Jul. 04, 2025 Revised: Nov. 15, 2025 Accepted: Nov. 18, 2025)

Abstract

Global supply chains, initially designed to enhance production efficiency and reduce costs through geographically dispersed networks, have evolved into complex global value chains (GVCs) characterized by deep interdependencies among countries and industries. According to Economic Interdependence Theory, higher levels of mutual economic dependence can influence both cooperation and systemic vulnerability, which are often underestimated—especially amid escalating geopolitical tensions. This study examines the resilience of global value chains by analyzing the structural positions of the US and China between 2012 and 2020. Using OECD Inter-Country Input-Output tables and a social network analysis (SNA) framework, it evaluates the network positions of 45 industries across 76 economies (excluding services), through three weighted centrality measures: degree, betweenness, and PageRank. These metrics allow us to (1) measure the degree of bilateral interdependence, (2) evaluate structural resilience to supply disruptions, and (3) uncover network-driven asymmetries in global economic power. Results indicate that China has significantly enhanced its resilience by diversifying industrial connections and expanding its structural centrality, thereby reducing vulnerability to external shocks. In contrast, while the United States remains integral to high-value nodes, its network position is more concentrated, which may expose it to greater risks under conditions of disruption or fragmentation.

Keywords: Resilience, Social Networking Analysis, Supply Chain, Trade, US-China Trade

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* The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in this manuscript.

Journal of **World Sociopolitical Studies**| Vol. 10| No. 1| Winter 2026| pp. 157-200
Web Page: https://wsps.ut.ac.ir//Email: wsps@ut.ac.ir
eISSN: 2588-3127 PrintISSN: 2588-3119

1. Introduction

The global value chain (GVC) framework, emerging in the late 1980s, has fostered economic interdependence by enabling supply chain outsourcing, reducing production costs, and enhancing competitiveness. This specialization in different production stages highlights the significance of intermediate goods, which constitute over 50% of global trade within GVCs. (Ibrahim et al., 2021).

Globalization enhances efficiency, but also heightens systemic risks, as regional disruptions—economic, geopolitical, or environmental—can trigger global instability. The US and China, which account for over 25% of global trade, reinforce their GVC positions through divergent strategies: the US via the *CHIPS and Science Act* to reduce reliance on Chinese technology, and China through its *Dual Circulation* policy to balance domestic and global demand. Meanwhile, shocks like COVID-19, the Russia-Ukraine war, and Brexit have exacerbated supply chain fragility.

Analyzing a country's trade network position, dependencies, and relative standing is key to evaluating its resilience to external shocks and policy changes amid supply chain vulnerability. Supply chain resilience, defined as the capacity to endure disruptions and recover quickly, is critical in mitigating risks from unpredictable events such as natural disasters, economic crises, and pandemics (Mohapatra et al., 2015). It can be measured through robustness (e.g., inventory buffers, diversified sourcing) or responsiveness (e.g., recovery speed) (Han et al., 2020). While GVCs are increasingly analyzed via social network approaches, this study employs network-based resilience metrics, building on Wang et al. (2023) and Hakeem & Suzuki (2015).

This study employs three SNA centrality measures—weighted degree, betweenness, and PageRank centrality—to evaluate national positions within global value chains. These metrics reveal production structures, integration dynamics, systemic resilience to external disruptions, and the interconnectedness of nations. Evaluating network position is critical as it: (1) quantifies industrial interdependence among nations, (2) identifies the most important sectors, and (3) maps strategic inter-industry linkages. These structural analyses provide empirical foundations for assessing national and sectoral resilience capacities within global production networks.

GVC resilience requires two key characteristics: robustness (shock absorption) and flexibility (adaptive reconfiguration to new conditions) (Mohapatra et al., 2015). These can be enhanced through supplier diversification and alternative input sourcing. This analysis is conducted through OECD Inter-Country Input-Output tables (2012–2020). Within this framework, GVCs are modeled as weighted, directed networks, where nodes represent national economies, edges capture bilateral value-added flows, and edge weights quantify the magnitude of value exchange.

The paper is organized as follows: Section 2 reviews resilience and economic network literature. Section 3 details the theory and methodology. Sections 4 and 5 analyze US-China trade and supply chain policies, and Section 6 presents centrality results for both global and US-China bilateral trade networks. Finally, Section 7 summarizes the findings and suggests future research directions.

2. Literature Review

Research on SNA and trade network resilience has been relatively limited. Hakeem and Suzuki (2015) demonstrated that centrality measures (including local and relative centrality) can identify critical nodes within a network. Their analysis of EU trade and investment networks (2007 vs. 2011) reveals structural shifts following the global financial crisis.

Luo et al. (2023) evaluated the trade network vulnerability and global production resilience. Their findings reveal that East Asian economies demonstrated strongest resilience during COVID-19, followed by high-income nations with rapid vaccine deployment, while low-income countries remained vulnerable. Resilient nations moved toward the international trade center (higher centrality value), while less resilient nations become peripheral.

Shahnazi et al. (2023) examined the global oil trade network's structure and resilience to shocks. In their paper, they determined the structure of the network between 178 countries, calculated the stability degree of all countries in oil export and import networks, and developed an index to estimate the effective share of each country. Results showed that countries like China, USA, India, Korea, Germany, and Italy have high instability, reducing the network's resilience. They suggested that centrality in oil exporter countries, such as Saudi Arabia, Russia, and Iraq, can enhance resilience to supply disruptions and shocks. Based on their findings, high centralities could also influence cooperation and coordination, ensuring stable oil supply and reducing price volatility, which could benefit oil-importing countries by creating a more predictable and stable oil market.

In their paper, Wang et al. (2023), explored the way in which expanding the domestic market scale can enhance the resilience of emerging economies in value chains, using hypothetical extraction methods, PageRank algorithm, and the 2005-2019 Comtrade database, thereby promoting gradual economic recovery from unexpected shocks.

Other related studies around centrality measures and the position of countries, especially US and China, in the global trade network are as follows:

Meng et al. (2022), explored the dynamics of US-China relations, focusing specifically on the repercussions of the US-China trade war on the global economy, using GVCs as an analytical framework. The research examines the historical context of US-China relations within GVCs, emphasizing aspects of collaboration, competition, and conflict. By employing trade in value-added measurements, the transition from *hyperglobalization* to *slowbalization* is analyzed, illustrating the evolving interdependence between the US and China across various value-added processes. Special attention is given to the information and communication technology (ICT) sector as a critical battleground in the trade war, investigating the changing roles and influences of both nations within GVCs.

In a study titled *Has the US-China Trade War Caused Trade Decoupling?*, Kim et al. (2021) examined the impact of the US-China trade war on trade decoupling by proposing an analytical framework based on the production function in non-competitive input-output tables. The study focused on the mobile phone trade network and conducted scenario analyses to assess the extent of decoupling post-trade war measures. Findings revealed a significant decline in China's share of total US imports in 2019, but indicated an increase in China's indirect exports to the US. They suggested that China's role in the global trade network has shifted; however further investigations considering the heterogeneity of input-output linkages are recommended to enhance understanding of trade decoupling dynamics.

By using Topic Search Algorithm (HITS), Deguchi et al. (2014) conjugately computed the weighted HITS hub and reference values for each country, to examine the economic hubs and authorities of the World Trade Network (WTN) from 1992 to 2012. They found that the US was the largest economic authority in global trade network from 1992 to 2012. However, US has lost its position as a hub since 2001, and China has now become the largest hub in the WTN. At the same time, China is transforming itself from a 'world factory' to a 'world market'.

While prior studies have extensively examined trade network resilience using various centrality-based approaches, most have focused on sectoral or regional levels rather than country-specific resilience. Among them, only Wang et al. (2023) analyzed resilience at the country level by employing value-added absorption data. However, their approach did not fully capture the dynamics of intermediate goods trade, which plays a crucial role in the propagation of supply chain shocks and trade conflicts.

To address this gap, the present study focuses on the intermediate goods trade between the US and China, using data from the OECD ICIO tables. By applying network centrality metrics, this research introduces a new framework for assessing trade conflicts and evaluating supply chain vulnerabilities, thereby offering a complementary perspective to existing studies on trade network resilience.

3. Theoretical Framework and Methodology

3. 1. Economic Interdependence

Given the research problem, the theory of interdependence has been used for the analysis. The theory of economic interdependence evaluates international relations based on the intensity of exchange and the cost of disrupting ties (Baldwin, 1980; Hirschman, 1945). Economic interdependence also refers to the mutual reliance of trading partners who exchange goods they cannot efficiently produce themselves. Their actions impact one another, making it costly to break the relationship (Mansfield & Pollins, 2003). International trade in goods and services is one of the most important forms of economic interdependence between countries.

According to Baldwin (1980), the concept of interdependence per se has not been clarified in literature (Baldwin, 1980). In international relations, economic interdependence has two meanings. First, countries are interdependent if economic changes in one quickly affect the others, like inflation in France raising prices in Germany. This is called sensitivity interdependence. Second, countries are interdependent if breaking their economic ties would be costly, such as if oil-exporting countries cut off supply to industrial nations. This is called vulnerability interdependence. The main difference lies in the costs countries face if their relationship is disrupted (Lai & Anuar, 2021; Mansfield & Pollins, 2003). Given the focus of this study, the second interpretation of economic interdependence, vulnerability, is employed, as it directly relates to resilience by indicating how trade networks can endure, adapt to, and recover from costly disruptions. In other words, reliance on one another makes breaking the relationship costly, turning interdependence into both a source of cooperation and a potential vulnerability (Bromley, 2004).

Baldwin (1980) argues that the concept of interdependence becomes analytically meaningful only when its disruption entails significant losses. If ending trade relations produces negligible effects—or even advantages—for one party, the relationship cannot be considered true interdependence. Therefore, evaluating interdependence requires not only analyzing the volume of trade, but also assessing the distribution of costs and the availability of substitutes (Baldwin, 1980). In the context of global trade networks, the presence of multiple trading partners can mitigate the impact of disruptions, as countries with diversified economic ties are less vulnerable to the loss of any single partner. Consequently, true interdependence—and its implications for resilience—emerges most clearly when the disruption of key relationships results in substantial and unavoidable costs, highlighting both the cooperative and vulnerable dimensions of economic interconnectedness (Jafari et al., 2024).

These logics are captured in Social Network Analysis (SNA), where a country's position within a network reflects its degree of dependence and influence. In this sense, SNA provides a quantitative operationalization of interdependence theory, which will be discussed in the following section.

3. 2. Data and Building Trade Network[1]

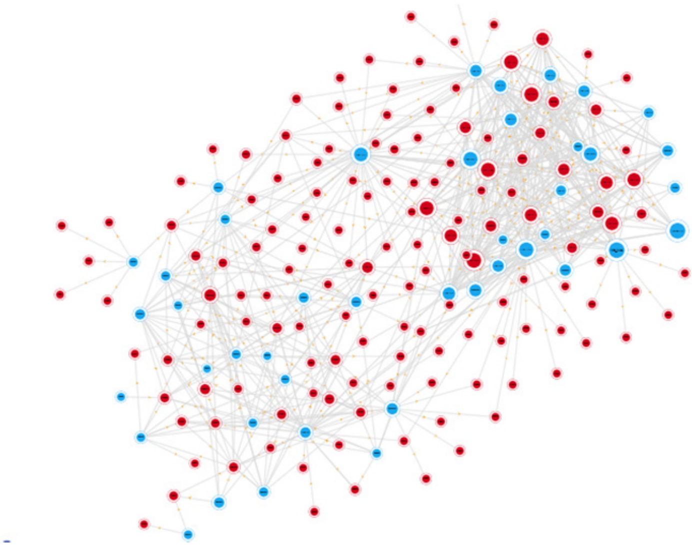
This research assesses the resilience of the US-China supply chain

1. All data supporting the findings of this study are included in the manuscript and its supplementary files

by utilizing OECD ICIO tables from 2012 to 2020. This timeframe includes significant changes, such as China's transition from export-driven trade strategies to a focus on domestic consumption, as well as the intensification of trade disputes with the US, further complicated by the impact of COVID-19. The latest edition of the OECD ICIO, which adheres to the ISIC Revision 4 industry classification, offers extensive data for 76 economies and the Rest of the World from 1995 to 2020.

A network is defined as a directed acyclic graph (DAG) composed of a collection of vertices (nodes), denoted as V, and edges denoted as E, which represent the directed connections between the nodes. It is expressed as G = (V, E), where each edge connects one node to another. In the context of a trade network, each node symbolizes a country or industry, while each edge signifies an economic flow from one country or industry to another. Furthermore, it is possible to assign a weight to each edge to indicate the volume of economic exchange between the two entities. The nodes in this network represent industry-country combinations. These networks utilize trade data from ICIO tables, with edges illustrating trade relationships and weights reflecting the trade volume of intermediate goods. Each edge points toward the importing or demanding country, showing the flow of goods. In the following diagram (Figure 1), the blue icon represents the exporter, while the red icon represents the importer, with a yellow arrow indicating the direction of goods transfer.

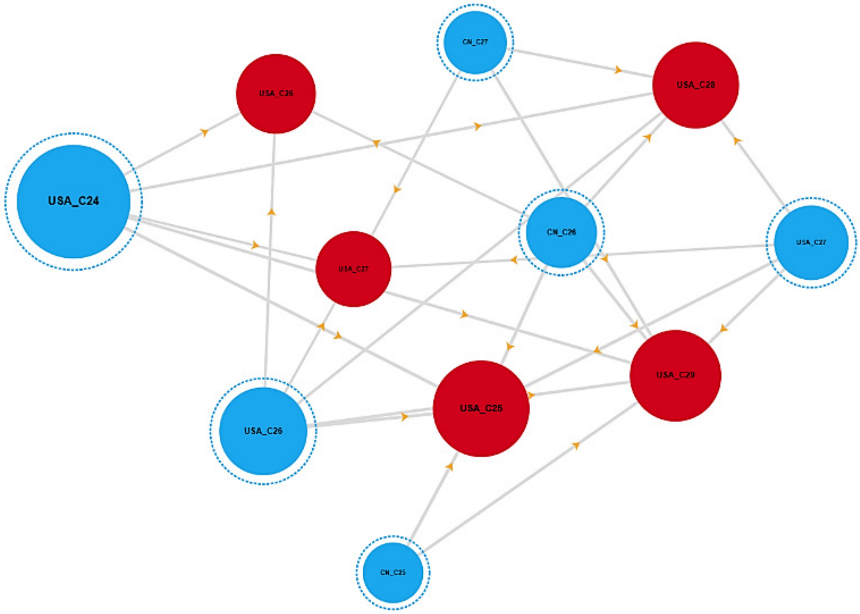
Figure 1. Trade Relations Based on ICIO OECD Table (2020)



Source: Authors

Figure 2 illustrates a segment of the trade network between various US industries and China. For example, the edge from CN_C28 to USA_C29 shows that China's C28 industry serves as the provider/exporter, and the USA_C29 industry is the importer. This edge reflects the flow of goods being transferred from China to the US.

Figure 2. Trade Relations Some US and Chinese Industries



Source: Authors. Based on ICIO and OECD Tables

3. 3. Analyzing Trade Relations with Social Networking Approach and the Concept of Key Centrality Player

Typical tasks in SNA include identifying influential actors via centrality measures, detecting hubs and authorities through link analysis, uncovering communities via detection algorithms, and modeling information diffusion (Tabassum et al., 2018). Recent focus on trade resilience has led to using centrality metrics (e.g., PageRank) to assess countries' robustness through partner diversification.

Centrality reflects an actor's network position (Tabassum et al., 2018; De Benedictis & Tajoli, 2011). Highly central actors possess greater influence, facilitating resource access and control over network flows (Freeman, 1978). Highly central GVC sectors drive industrial development and trade competitiveness (Xing et al., 2019).

Centrality measures fall into five main categories: (1) degree, (2) closeness, (3) betweenness, (4) prestige/eigenvector-based centrality (Rusinowska et al., 2011), and (5) PageRank (Zhang et al., 2021). These metrics can be weighted or unweighted. Since trade networks involve financial flows, weighted measures—often termed *strength* in network literature—are essential. Using OECD ICIO data, the study analyzes a directed, weighted economic network. Weighted betweenness centrality (Brandes, 2001) and weighted PageRank (WPR) (Zhang et al., 2021) are applied to identify key US and Chinese industries, alongside PageRank-based resilience metrics (Wang et al., 2023). Our analysis focuses on four centrality metrics—weighted in-degree, weighted out-degree, weighted betweenness, and weighted PageRank. Closeness centrality is excluded because splitting countries disrupts pairwise geodesic distances. Weighted eigenvector centrality is also omitted due to computational constraints in our tool. These metrics are calculated using Python and C++ based on OECD ICIO tables for 45 industries and 76 countries and the Rest of the World (ROW). The extensive data volume in the trade network made calculations time-consuming and revealed software limitations, necessitating biannual calculations to cover the analysis time domain. In addition, this research analyses the resilience of the commodities supply chain, excluding the service sector.

For centrality measures such as Betweenness and PageRank, which rely on the shortest paths within the network, the highest-volume trade paths also correspond to the shortest ones. To avoid negative or fractional values during the process of inverting trade volumes for path calculations, all values were scaled by a factor of 1 million.

3. 3. 1. Degree Centrality

In international trade, a vertex's degree indicates the number of a country's trading partners (De Benedictis & Tajoli, 2011). Degree centrality, reflecting connectivity, can predict trade imbalances (Herman, 2022). In directed networks, degree centrality includes in-degree (incoming nodes) and out-degree (outgoing nodes) (Herman, 2022). In weighted networks, strength is calculated as the total weight of edges connected to a node (Tabassum et al., 2018). Thus, the weighted in-degree is the sum of the weights of incoming edges, and the weighted out-degree is the sum of the weights of outgoing edges.

3. 3. 2. Betweenness Centrality

Another perspective on centrality suggests that a vertex Vi is central if it acts as a crucial link between vertices Vk and Vj (De Benedictis & Tajoli, 2011). Betweenness centrality measures a node's importance in connecting other nodes (Rusinowska et al., 2011). The betweenness centrality index highlights a country's role as a pivotal 'hub' within the trade network (De Benedictis & Tajoli, 2011). It reflects the ability to influence network flows and act as a mediator. Nodes with high betweenness centrality can disrupt operations, peaking when a node is on nearly all shortest paths between other nodes (Xing et al., 2019).

The betweenness centrality index is calculated as follows:

$$C_B(v) = \sum_{\substack{s \neq v \neq t \in V \\ s \neq t}} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

Where σ_{st}, is the number of shortest paths from s to t, and $\sigma_{st}(v)$ is the number of shortest paths from s to t passing though vertex v.

3. 3. 3. PageRank Centrality

Zhang et al. (2022) propose using edge direction, weight, and node-level data in Weighted PageRank (WPR) to better assess centrality in trade networks, reflecting an economy's partner richness and importance. Economies with diverse trading partners can swiftly adapt to GVC disruptions, while those with key partners gain efficiency by connecting to central GVC links. Thus, strong trade networks enhance value chain security and operational resilience. Additionally, Wang et al. (2023) suggest that fostering trade partnerships and upstream-downstream alliances can mitigate protectionism, stabilize domestic markets, and bolster resilience.

Improved trading partner quality fosters specialization and scale, lowering value chain costs and enhancing trade value. Increased bilateral trade volume strengthens relationships. Hence, the PageRank centrality method measures economic resilience; a higher PageRank centrality signifies greater importance in trade relations as well as a stronger capacity to withstand risks like decoupling and supply disruptions (Wang et al., 2023).

The formula is as follows:[1]

$$PR_{PR}(v) = (1 - d)p(v) + d \sum_{u \in \Gamma^{-}(v)} \frac{PR(u)}{d^{+}(u)}$$

Where, $\Gamma^{-}(v)$ are the in-neighbors of v, $d^{+}(u) = \sum_y A_{u,y} w_{u \to y}$ is the sum of the weights of the out-going edges from u, and d is a damping factor.

To put it briefly, the in/out-degree measure indicates the quantity of trading partners and the volume of trade volume. A node, country-industry, with more connections has greater influence in the trade network and affects its resilience (Hakeem & Suzuki, 2015). In addition, fluctuations in this measure, analyzed with other indicators, can provide valuable insights into a country's resilience against external shocks (Luo et al., 2023).

Furthermore, based on the betweenness centrality metric, if there is a node with a higher betweenness, it must have enough stability and strength to increase the resilience in the network (Hakeem & Suzuki, 2015). However, as our study is at country-level, our analysis shows that a country-industry with a higher betweenness centrality can act as a hub and broker that deters threats from other countries in the trade network. Any damage to such a country can destabilize the entire network, posing a threat unless the threatening country has severed ties (Xing et al., 2019). Therefore, it can be argued that a country with strong ties and high betweenness centrality shows greater resilience.

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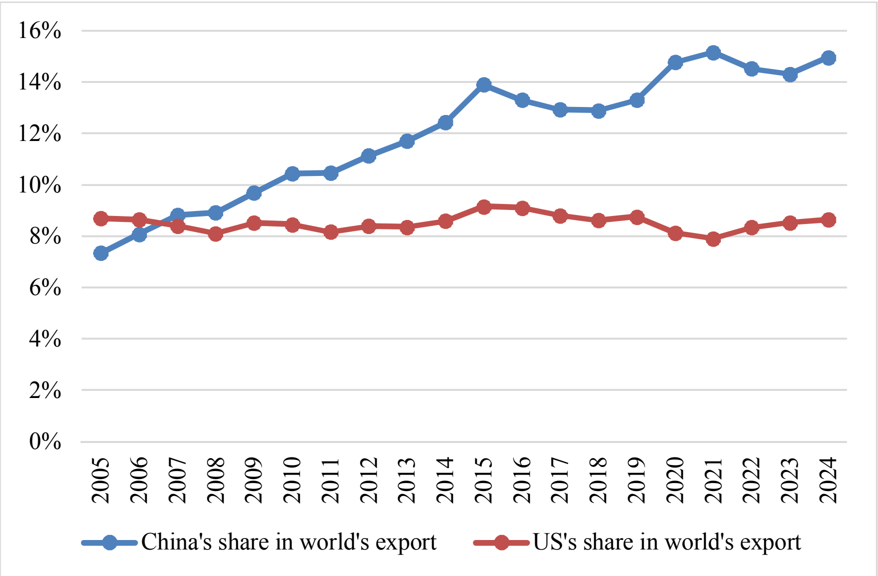
1. See: https://graph-tool.skewed.de/static/doc/autosummary/graph_tool.centrality.pagerank.html#graph_tool.centrality.pagerank

4. US-China Trade Relation

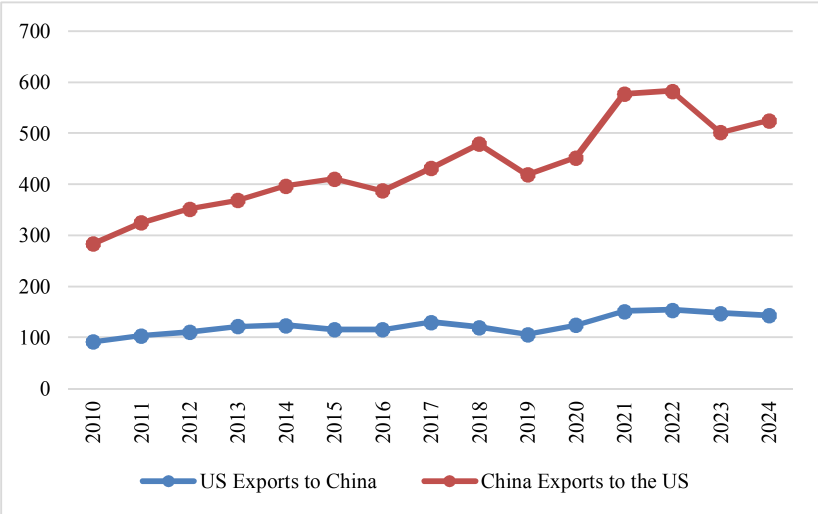
In 2023, the US (8%) and China (14%) account for 22% of global exports, with China's share rising as the US share declines. In 2024, China exported about $524.9 billion to the US (14.7% of its total exports) (Figures 3 and 4) and $291.37 billion to Hong Kong (8.1%). China is the third-largest importer of US goods, importing $144 billion (6.95%), after Canada (16.8%) and Mexico (16.18%) (International Trade Centre, 2024).

Figure 3. China and the US Share in World's Exports



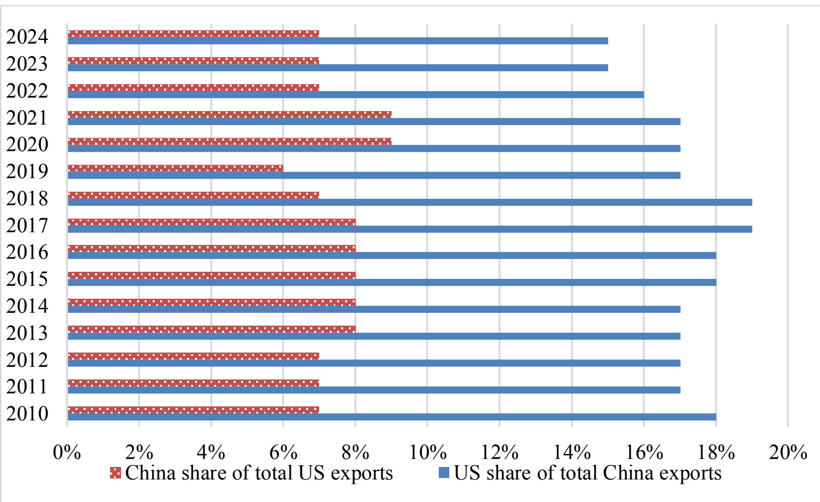
Source: International Trade Centre, 2024

Figure 4. Bilateral Trade Relations of China and the US (in Billion $)



Source: International Trade Centre, 2024

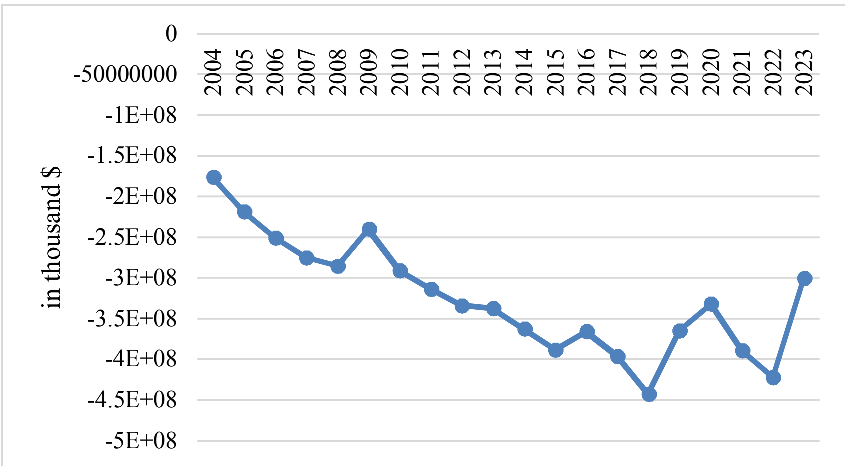
Figure 5. China and the US Share in Their Total Exports



Source: International Trade Centre, 2024

The trade balance shows a deficit favoring China (Figure 6). While policymakers have expressed concerns, particularly during the Trump administration, this imbalance reflects natural GVC dynamics. Countries supplying intermediate goods (such as the US) often run deficits, while downstream producers (such as China) typically show surpluses (Felice & Tajoli, 2021). Recent US policies since 2018 have mitigated the trade deficit, improving the balance from -$421.87 billion in 2022 to -$300.23 billion in 2023.

Figure 6. US Trade Balance with China



Source: Tradmap. org

Traditional trade data's inability to differentiate between final, intermediate, and capital goods creates analytical challenges for GVC studies, particularly for major economies dependent on intermediate imports. China's state-subsidized industrial policies have significantly impacted American companies' competitiveness, leading to strategies like reshoring and friendshoring. These developments occur alongside escalating US-China trade tensions fueled by mutual GVC dependence. Thus, their GVC positions can be assessed through input-output tables and SNA centrality metrics.

5. US-China Supply Chain Policies

In this section, some of the most important considerations, concerns, and policies of the United States and China regarding the supply chain is briefly explained.

5.1. US Supply Chain Policies Against China

The significance of bilateral trade balance was a key aspect of trade policy during Trump's first election campaigns, with China identified as one of the most pressing challenges in this context. Trump and his advisers interpreted the trade deficit as a net reduction in aggregate demand, which diminishes output below capacity and constrains the labor force below full employment (Noland, 2018). Consequently, upon taking office in 2017, Trump implemented mercantilist measures and initiated an investigation by the Office of the US Trade Representative (USTR) under Section 301 of the Trade Act of 1974. This investigation focused on the discriminatory trade practices employed by China, which included: 1. Forced technology transfer requirements; 2. Cyber-enabled actions to illegally acquire US intellectual property and trade secrets; 3. Discriminatory and nonmarket licensing practices; and 4. State-funded strategic acquisition of US assets. These practices were recognized as unfair trade practices by China (Hart & Murrill, 2022).

On April 3, 2019, the Trump administration announced a 25% increase in tariffs on 1,333 goods imported from China, valued at approximately $50 billion. Most of these imported goods consisted of capital and intermediate goods, including machinery, mechanical components, and electronics. Additionally, on June 15, 2018, the US product list policy was revised, increasing the proportion of capital and intermediate goods from 85% to 95% (Kholid, 2022).

New protective measures have emerged in the form of antidumping (AD) actions, countervailing duty (CVD) cases, and occasionally applied global safeguard and national security threat provisions. The assertive approach of the Trump administration is highlighted by its willingness to initiate cases independently, rather than waiting for complaints from businesses or industries, marking a significant departure from previous practices. Key industries that have undergone scrutiny include steel, aluminum, softwood lumber, and solar cells (Noland, 2018).

Noting President Biden's policies and approach regarding supply chains, including the signing of Executive Orders 14005: Made in All of America by All of America's Workers and 14017: America's Supply Chains in 2021, as well as the enactment of the Chips and Science Act in 2022, underscores the significance of supply chain resilience among American politicians.

By signing Executive Order 14017 on February 24, 2021, President Biden mandated year-long reviews of six sectors and a 100-day review of four categories of products in which American manufacturers depend on imports. The report identified four critical supply chains: semiconductor manufacturing and advanced packaging, large-capacity batteries, critical minerals and materials, and pharmaceuticals and active pharmaceutical ingredients.

Based on the 100-Day Reviews report published by the White House, the U.S. share of global semiconductor production has declined from 37% in 1990 to 12% today, and it is projected to decrease further without a comprehensive US strategy to support the industry. Global demand for electric vehicle (EV) batteries is expected to grow from approximately 747 gigawatt-hours (GWh) in 2020 to 2,492 GWh by 2025. In the absence of policy intervention, US production capacity is anticipated to increase to only 224 GWh during that period, while US annual demand for passenger EVs is expected to exceed that capacity. Furthermore, global demand for lithium and graphite-two of the most critical materials for electric vehicle batteries is estimated to increase by more than 4,000% by 2040 in a scenario where the world meets its climate goals, with graphite projected to grow nearly 2,500%. Additionally, China was estimated to control 55% of global rare earth mining capacity in 2020 and 85% of rare earth refining.

Based on this report and the US' reliance on China for semiconductors, the CHIPS and Science Act was signed into law by President Biden in August 2022 to strengthen US supply chains. This legislation offers subsidies and tax incentives to encourage the revival of advanced semiconductor production on American soil. Two months later, the Biden administration imposed extensive restrictions on the export of chips and chip-making technology to China, aiming to undermine that country's capacity to manufacture the same class of integrated circuits.

In brief, from 2018 to 2024, there was a policy evolution from trade balance focus to tech competition; supply chain security became more important than pure trade metrics, China remains primary strategic competitor, and semiconductor industry has become central to economic security strategy.

5. 2. China's Supply Chain Policies Against US

Since the launch of a campaign by Trump to contain China in trade, high technology, and the economy, China has also adopted strategies to undermine Trump's intentions and alleviate the pressure from his administration. To shift the situation in its favor, China employed three tools: narrative, supply chain, and military (Xiying, 2021).

Under its supply chain policy, China adopted three strategies: first, promoting innovation through increased capital investment to strengthen weak links in the supply chains, develop core technologies, and prevent being constrained by the US. The establishment of the National Integrated Circuit Industry Investment Fund (NICIIF) in 2014 aimed to provide financial support for enterprises and attract social capital to the integrated circuit industry (Xiying, 2021).

Secondly, China's ambitious technology-related industrial policies, aim to secure a superior position in a wide range of technologies, especially advanced technologies in the world while also dominating the domestic market by obtaining technology from US and foreign firms (Sutter & Casey, 2022). In addition, China 'seeks to reduce its dependence on technologies from other countries and move up the value chain, advancing from low-cost manufacturing to become a global innovation power in science and technology' (Office of the US Trade Representative, 2018). To achieve this aim, a large number of industrial policies have been issued by China's Communist Party, such as National Medium- and Long-Term Science and Technology Development Plan Outline (2006-2020) (MLP), the State Council Decision on Accelerating and Cultivating the Development of Strategic Emerging Industries

(SEI Decision), and Notice on Issuing 'Made in China 2025' (Made in China 2025 Notice).

The third strategy employed by China to enhance its capabilities against the US was to learn the relevant US laws and regulations to establish an American-style sanctions system. This initiative led to the creation of the Unreliable Entities List (UEL) in May 2019 (Xiying, 2021). Under this framework, foreign entities or individuals that boycott or sever supplies to Chinese companies for non-commercial reasons, causing significant harm to these companies, may be included on the UEL. Those listed face restrictions or prohibitions on engaging in China-related import or export activities and investments. However, the Ministry of Commerce (MOFCOM) has clarified that US companies are not specifically targeted by the UEL, and that there is no intention to single out any particular countries or entities (Sheng & Xu, 2020).

It appears that, in response to Trump's pressure for a trade and technology war against China, the Chinese leadership has adopted a dual circulation strategy to bolster the country's growth. This strategy serves as a means to protect the domestic market from external shocks by eliminating bottlenecks in both natural resources and technology. As a result, vertical integration of production can occur, enabling self-reliance through the expansive domestic market and leading to a reduction in imports of high-end inputs (García & Ramirez, 2021). Overall, this strategy aligns with China's goal of achieving self-sufficiency in resources and technology, leveraging its large domestic market.

In brief, China's response combines state-led industrial policy, legal countermeasures, and economic insulation to resist US pressure while pursuing long-term tech dominance. The Dual

Circulation model underscores Beijing's shift toward self-sufficiency amid escalating US-China rivalry (Xiying, 2021; Sutter & Casey, 2022; USTR, 2018; García & Ramirez, 2021).

6. Results and Discussion

This section presents an analysis of centrality metrics in two parts: 1) Global Trade Network Positioning: A comparative assessment of China's and the US' structural roles in the global trade network; and 2) Bilateral Trade Interdependence: An evaluation of mutual dependence in the US-China trade relationship using centrality measures. The industry and country codes referenced in the analysis are shown in Table 1.

Table 1. Industry and Country Codes[1]

Code	Industry
A01_02	Agriculture, hunting, forestry
A03	Fishing and aquaculture
B05_06	Mining and quarrying, energy producing products
B07_08	Mining and quarrying, non-energy producing products
B09	Mining support service activities
C10T12	Food products, beverages and tobacco
C13T15	Textiles, textile products, leather and footwear
C16	Wood and products of wood and cork
C17_18	Paper products and printing
C19	Coke and refined petroleum products
C20	Chemical and chemical products
C21	Pharmaceuticals, medicinal chemical and botanical products
C22	Rubber and plastics products

1. OECD ICIO tables

Code	Industry
C23	Other non-metallic mineral products
C24	Basic metals
C25	Fabricated metal products
C26	Computer, electronic and optical equipment
C27	Electrical equipment
C28	Machinery and equipment, nec
C29	Motor vehicles, trailers and semi-trailers
C30	Other transport equipment
C31T33	Manufacturing nec; repair and installation of machinery and equipment
	Country
CN	China
USA	The US

Source: OECD ICIO Tables

6.1. The US-China Global Trade Network Positioning

The out-degree index is recognized as a measure of influence in SNA literature (Tabassum et al., 2018). The industry with the highest weighted out-degree dominates global exports. Figure 7 shows basic metals as the top intermediate goods exported by China. Global producers argue that China's steel and aluminum subsidies distort prices and violate WTO rules, harming fair competition (McBride, 2018).

Following C24, sectors A01T02, C20, C26, and C13T15 rank among the most highly exported intermediate goods from China. Notably, C26 has demonstrated an upward trend in export volume. In contrast, there has been no significant change in the export of chemical products (C20) and other non-metallic minerals, likely due to recent export restrictions imposed by the Chinese government on products such as rare earths.

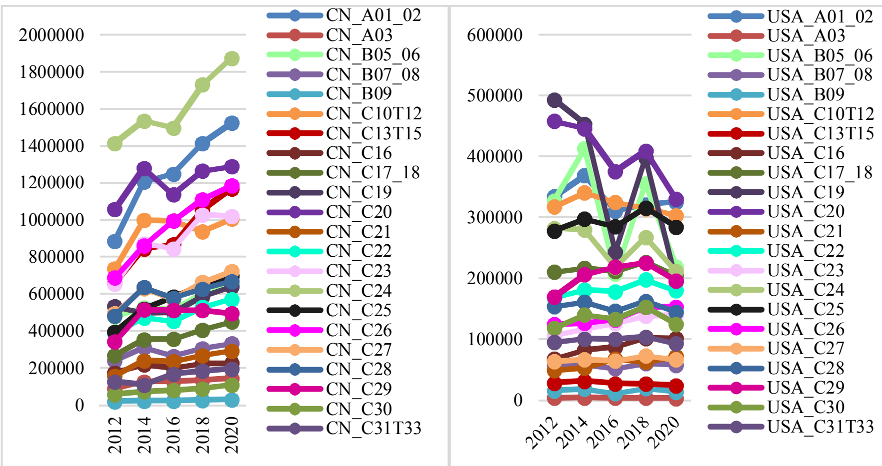
Figure 7 shows declining or stable weighted out-degree centrality index across for most US sectors, reflecting recent protectionist policies. Only sectors C26, C23 (particularly due to the strategic importance of rare earth materials), C16, and C21 have experienced slight increases. Industry C21 has also demonstrated growth, especially during the COVID-19 pandemic. Additionally, B05_06 fluctuations reflect shifting energy policies. The results reveal China's growing GVC dominance through higher intermediate goods exports over the US.

In network analysis, in-degree centrality indicates support, positioning China as a key partner in basic metals (C24), food products (C10T12), and computer, electronic, and optical equipment (C26) (see Figure 8). According to Liu (2023), Figure 8 illustrates that China has the highest imports of food products (CN_C10T12), raising concerns about food security due to supply chain disruptions in 2023. In contrast, the weighted in-degree centrality for the US has largely remained stable across most American industries, except for C19 and C20. This indicates that America's dependence on imported intermediate goods has not significantly changed in comparison to China.

Furthermore, based on total weighted out-degree centrality, the exports of intermediate goods increased from $10,358,551.45 million in 2012 to $15, 302, 555.08 million in 2020, reflecting an approximate growth of 48%. In contrast, total weighted in-degree centrality shows that China's imports of intermediate goods rose from $9,919,013 million to $14,450,859 million during the same period, representing a growth of approximately 46%. Both categories demonstrate that while China's exports of intermediate goods have increased, its imports have also risen at a comparable rate. This suggests that China is maintaining its position both upstream and downstream in the value chain.

For the US, the weighted in-degree declined from $4,312,158.04 million in 2012 to $3,745,418.16 million in 2020, representing a decrease of 13%. Similarly, the weighted out-degree fell from $3,922,300.16 million to $3,443,323.88 million in 2020. This trend indicates that the US is no longer a significant source of support or influence in the GVC.

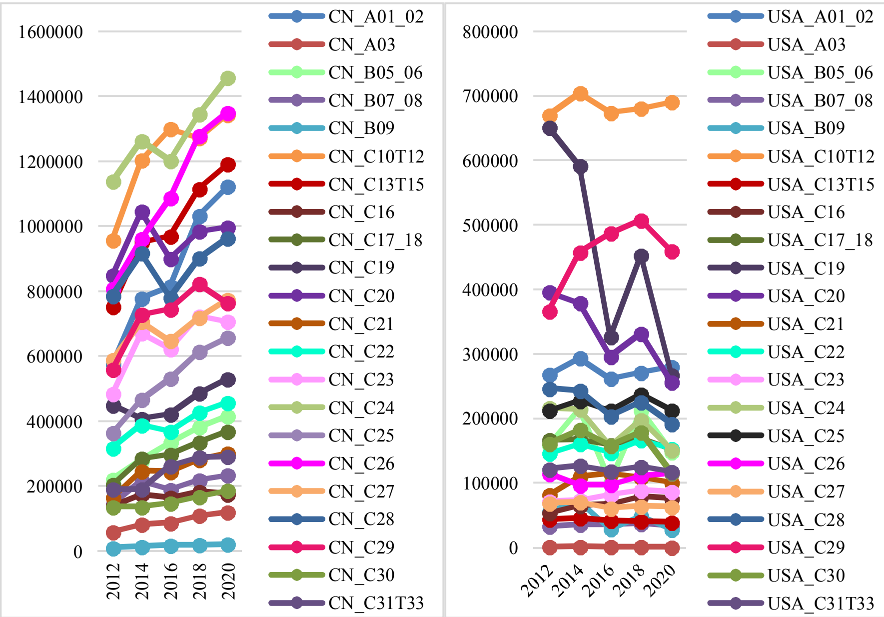
Figure 7. Weighted-Out Degree for China (left) and the US (right), in Million Dollars



Source: Authors

The difference between total weighted out-degree centrality and weighted in-degree centrality reflects the trade balance of countries. In recent years, The US imports more intermediate goods than it exports, but this gap is shrinking, from $389,857.88 million in 2012 to $302,094.28 million in 2020. Meanwhile, during the same period, China’s trade balance for intermediate goods has remained positive and this gap is growing, highlighting China’s influence in the value chain.

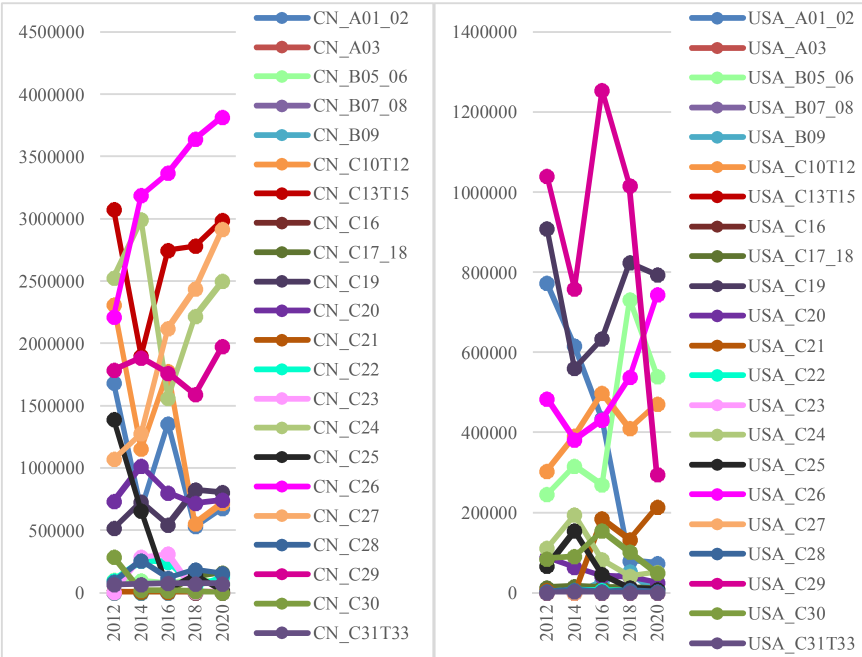
Figure 8. Weighted-In Degree for China and the US, in Million Dollars



Source: Author

As mentioned, the betweenness centrality index indicates a country's key role in the trade network. (De Benedictis & Tajoli, 2011). Figure 9 validates US concerns about China's dominance in tech products, C26 and C27. In 2020, China had the highest weighted betweenness centrality value at 3,819,133, while the second highest score of 3,028,189 was for mining and energy products from the rest of the world. This highlights China's role as a hub in the GVC. However, America's betweenness centrality value for the C26 significantly increased during the period under review. Nonetheless, despite the value increasing to 744,726 in 2020 for the US, it remains lower than that of China. Meanwhile, the US' C29 industry has lost its position as a hub.

Figure 9. Weighted Betweenness Centrality of China and the US

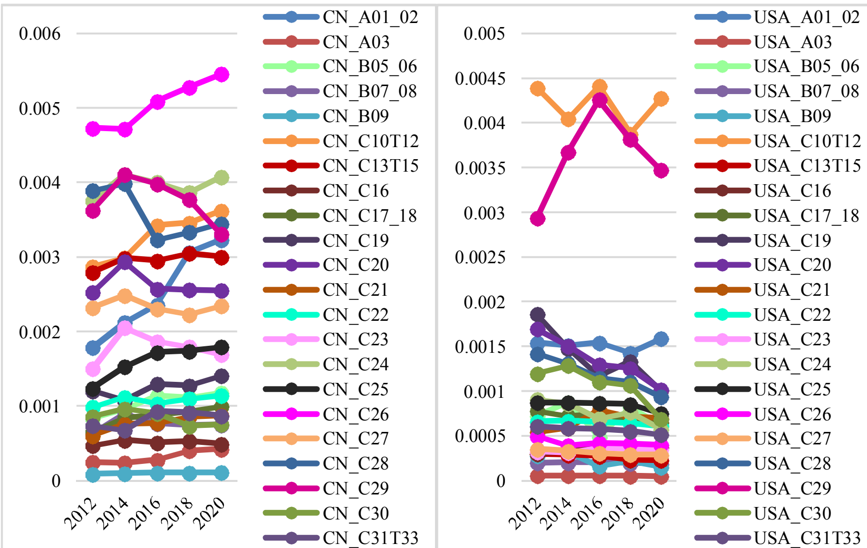


Source: Author

Another key centrality measure, PageRank, further highlights the global importance of China's sector C26 (Figure 10). PageRank evaluates node significance in networks and measures the influence of trading partners in global trade (Zhang et al., 2022). Economies with diverse trading partners gain resilience, mitigating disruptions in global value chains (Wang et al., 2023).

The average value of PageRank centrality for intermediate goods was 0.0016 in 2012 and 0.002 in 2020, and most of the Chinese intermediate good's industries are above the average, indicating that a significant position in GVC and its trading partners is important. Therefore, any disruption in trade, especially for C26, C24, and C10T12, which have risen in rank, may strengthen these industries' resilience through alternative options.

Figure 10. Weighted PageRank Centrality of China and the US



Source: Author

For the US, the average value of PageRank centrality was 0.00107 in 2012, which declined slightly to 0.0009 in 2020. Only five American industries producing intermediate goods are above this average, indicating that the US does not hold a significant position in GVCs of intermediate goods. In addition, in comparison to China, only two industries (C29 and C10T12) have better rankings. Consequently, for other industries, the lack of significant trading partners means that any disruption could be detrimental to trade flow, except for those with higher betweenness centrality values, as this serves as a protective factor (C10T12, C29, and C28).

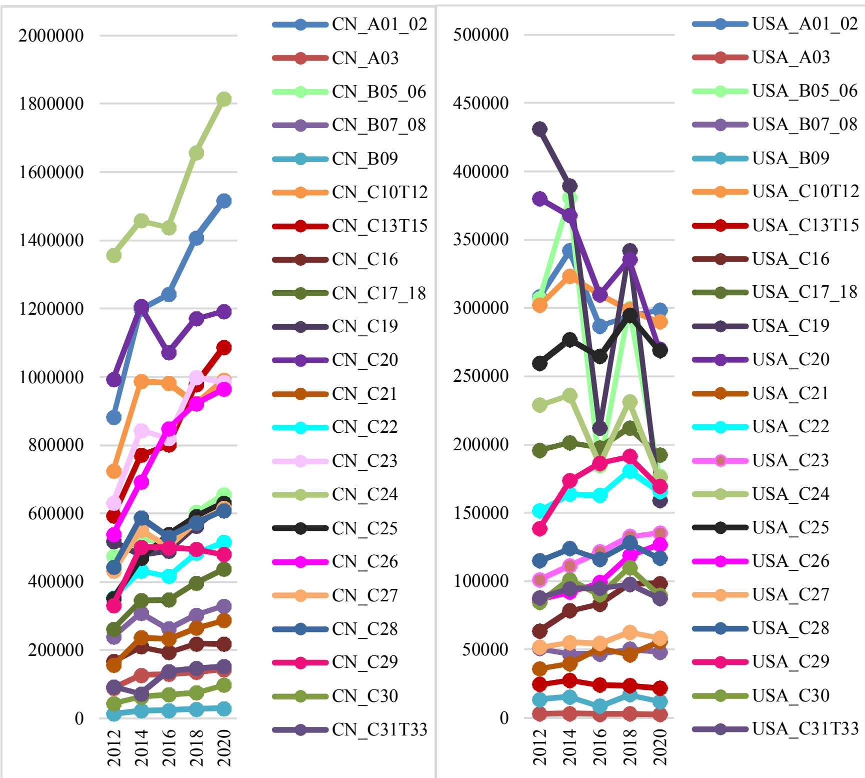
Comparing Figures 7 and 10 indicates that industries maintaining stable or increasing PageRank rankings (e.g., China's A01-02, C10T12, and C26) consistently demonstrate strong out-degree centrality, conversely, declining centrality correlates with reduced trade influence (e.g., US' C10T12, C20, C29; China's C23). Furthermore, a high rank in Betweenness centrality has also contributed to the strengthening and increase in trade volume (C26 for US).

6. 2. The US-China Bilateral Trade Interdependence

The following analysis examines the evolution of centrality measures during the study period through the establishment of a bilateral trade network between the US and China. Figure 11 illustrates the weighted out-degree, a measure of influence, revealing that most American industries have undergone negative growth, signaling a decline in their trade influence with China. In contrast, China's trends show a consistent upward trajectory. Among American industries, only C26 and C21 display positive growth slopes. Additionally, industries C25 and C29 have seen a modest rise since 2012, yet their values remain largely unchanged compared to 2014, suggesting a relatively stable US position in most sectors. The pronounced fluctuations in the energy sector (B05_06, and C19) further highlight the impact of shifting US political policies during this period.

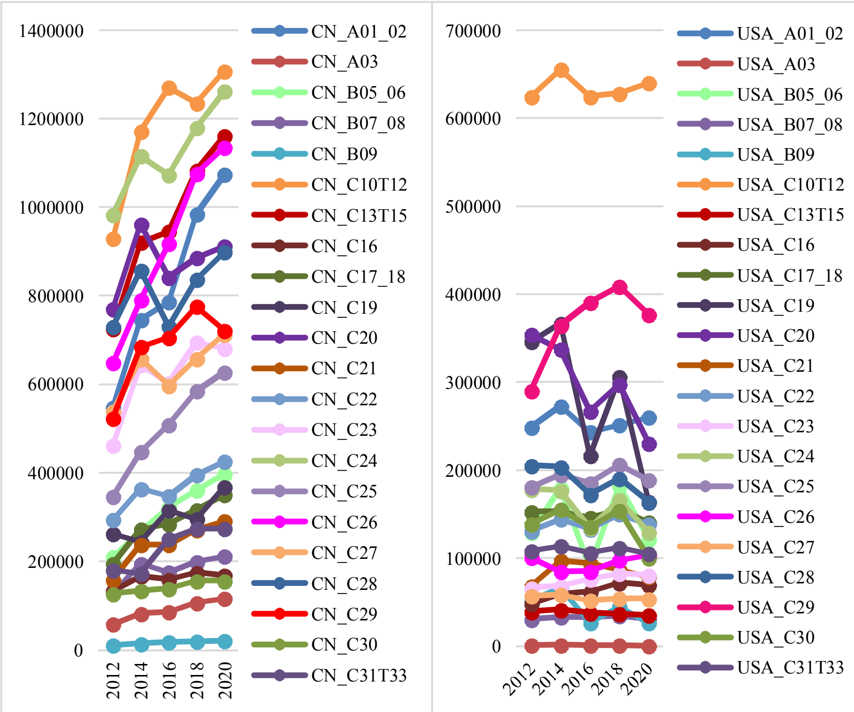
Figure 12 shows that the weighted in-degree for China has an upward trend, indicating a movement toward the upstream of the value chain. Additionally, Figure 12 also shows that Chinese industries, including C10T12, C24, C13T15, C26, and A01_02, have significantly increased their imports from American industries during the period under review, indicating that Chinese industries have been more supportive than their American counterparts.

Figure 11. Weighted Out-Degree for China to US (left) and the US to China (right)



Source: Author

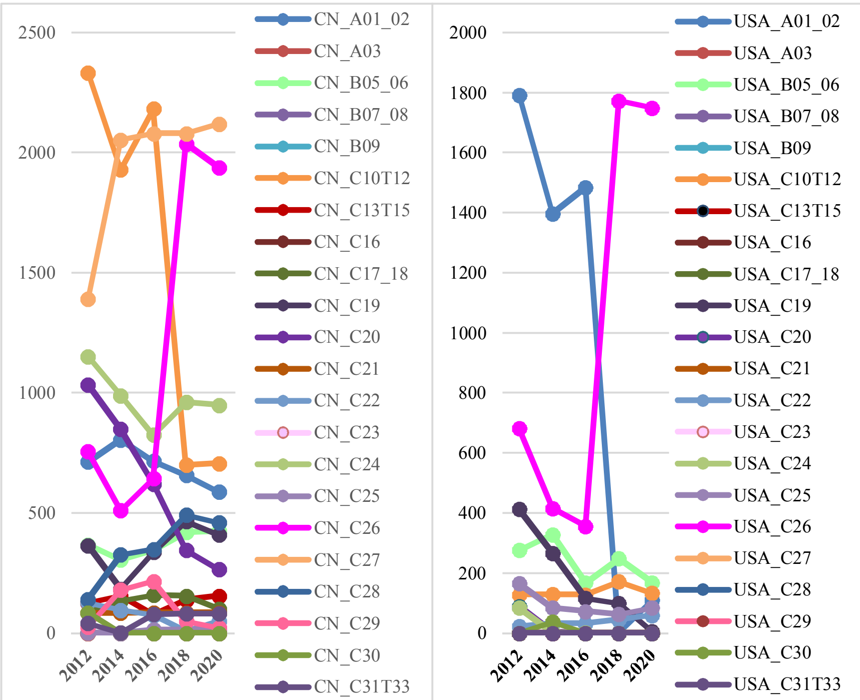
Figure 12. Weighted In-Degree for China from US (left) and the US China (right)



Source: Author

Based on weighted betweenness centrality (Figure 13), only one US industry (C26) is identified as a pivotal hub, whereas China has multiple pivotal hubs in its trade relations with the US, including C27, C26, C24, C10T12, and A01-02. This highlights the dominant role of Chinese industries in bilateral trade. Notably, C26 has seen a sharp rise in both the US and China since 2016, reinforcing its importance as a key intermediary. This dynamism creates potential deterrence effects, making major policy shifts—such as decoupling or reshoring—difficult to implement, at least in the short term. Even after 2018, amid the trade war and the COVID-19 pandemic, only a slight decline was observed. A similar pattern is evident for China's C27 industry.

Figure 13. Weighted Betweenness for China (left) and the US (right)

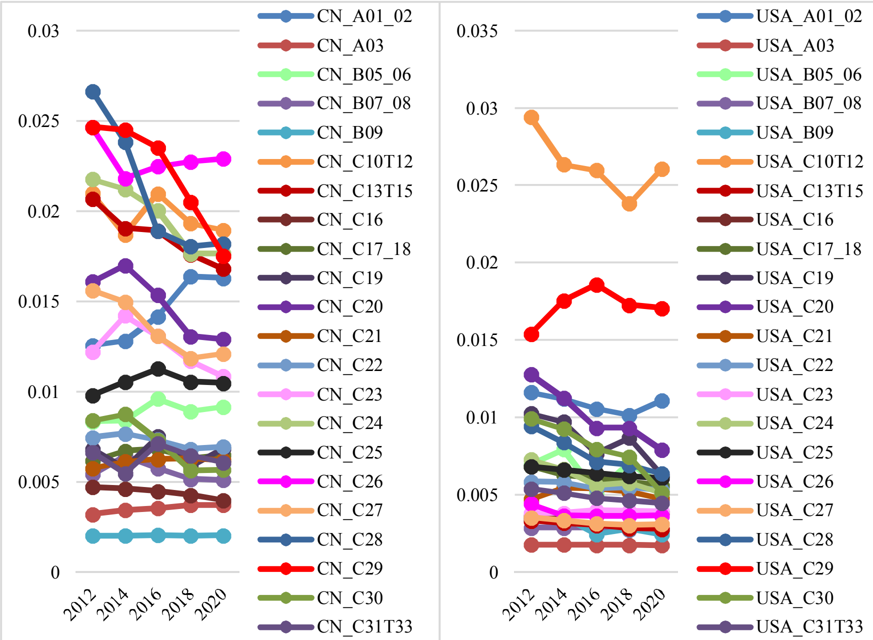


Source: Author

The weighted PageRank centrality index (Figure 14) in China, when compared to that of the US, clearly indicates that a significant number of Chinese industries hold superior rankings. Furthermore, the diversity of Chinese industries with higher PageRank scores in China-US trade is more pronounced. In fact, the PageRank status of the two countries suggests that the resilience of Chinese industries surpasses that of American industries. This is further evidenced by previous centrality measures, which demonstrate that China possesses greater support and influence than the US. Since many companies operating in China are American, the presence of such resilience can also delay the exit of these American firms. In a study conducted by Cohen et al. (2022), empirical evidence suggests that following the escalation of tensions between the US and China and the imposition of tariffs, the closure and relocation of factories from China to the US has rarely occurred. Instead, companies have adopted alternative strategies, one of which is diversification of sourcing, or what is commonly referred to as 'China Plus one', i.e. employing alternate sources positioned overseas to serve other markets, and using sources based in China to mainly serve the expanding Chinese and Asian markets (Cohen et al., 2022).

However, many Chinese industries are experiencing a decline, which may indicate that the number of major American industries that previously engaged in significant trade with China is decreasing. This trend could overshadow the long-term vulnerabilities of Chinese industries in bilateral trade with the US. To examine the effects of external shocks, it is necessary to employ models such as diffusion to enhance this analysis by assessing the extent of changes, which is beyond the scope of this article.

Figure 14. Weighted PageRank Centrality for China to US (left) and US to China (right)



Source: Author

The status of China and the US was first examined by constructing an international trade network using weighted degree, betweenness, and PageRank centrality measures. Our analysis revealed that China currently has greater influence and support in intermediate goods, as indicated by the weighted degree centrality. While the US position has been declining, it is noteworthy that the trade deficit in these goods has improved. In terms of the betweenness index, the diversity of Chinese industries that are advancing is greater than that of the US, indicating that China is becoming a hub for a wider range of industries. Conversely, the US

Journal of WORLD SOCIOPOLITICAL STUDIES | Vol. 10 | No. 1 | Winter 2026

has only improved its status in industry C26. The weighted PageRank centrality, as a proxy for resilience, shows that a larger number of Chinese industries have higher values compared to their US counterparts. This, combined with the more favorable status of the weighted betweenness centrality, enhances the resilience of Chinese industries against external shocks. In contrast, US resilience is lower due to the comparatively low value of the PageRank index. It is important to note, however, that given the low degree centrality, US domestic industries currently experience less conflict with other industries globally.

The analysis then established a bilateral trade network between the US and China to assess the degree of interdependence and resilience between the two nations. Findings indicate that based on the weighted degree centrality, China holds a more advantageous position in terms of influence and support compared to American industries. Conversely, when examining the weighted intermediate index, two industries— C27 and C26 from China, along with industry C26 from the US—have played a significant intermediary role in recent years, while other industries have experienced a decline in their positions (for instance, C10T12, C20, and C24 from China, as well as CA01-02 from the US).

In terms of the weighted PageRank centrality, a greater number of industries in China demonstrate higher resilience compared to those in the US. However, only two industries, C10 and C29, are more favorable in the US regarding the significance of trading partners and resilience. However, the trend of this index has been either declining or remaining flat for many industries, which implicitly indicates a loss of crucial trading partners. Consequently, this has led to a reduction in the resilience of industries in both countries, particularly in China. The only industries currently in a favorable and growing position are industry C26 in China and industry C10 in the US.

7. Conclusion

This article evaluates the positions of China and the US within the GVC and their bilateral trade. It analyzes their resilience through social network criteria, an aspect that has been largely neglected in previous research works on their relationship and trade conflicts. This article assesses resilience using PageRank Centrality and other social network indicators.

The reports from the World Trade Organization indicate that while deep trade connections can increase the vulnerability to external shocks, they can also enhance resilience. Consequently, an increase in trade relations between countries may diminish the impact of self-sufficiency or re-shoring on national resilience. To bolster resilience, it is essential to foster greater trade cooperation among nations (World Trade Organization, 2021). Therefore, in trade, the greater the importance and diversity of partnerships, the higher the potential for resilience and the lower the impact of shocks.

Diversifying the supplier or seller base can enhance resilience to shocks, but challenges arise from information asymmetries and high entry costs. While interconnected economies can promote resilience, they may also lead to increased specialization and reduced substitutability, which can amplify contagion in the system. In order to examine this issue more closely, it is necessary to conduct a detailed evaluation of the industries that demonstrates greater resilience in response to various events, which require further study. Thus, it is recommended that the level of vulnerability and resilience in certain industries—where centrality indicators are particularly significant—be examined more closely through scenario design and methods such as diffusion analysis.

The initial survey demonstrating the resilience of both countries indicates that China has established more connections with the industries of other countries in the global trade of intermediate goods, compared to the US. The presence of a greater number of industries with a higher PageRank, which signifies the existence of increasingly significant trading partners, enhances China's resilience while reducing its vulnerability. From this perspective, any disruption initiated by the US, along with pressure on other trading partners to decrease trade with China, poses significant challenges. With close ties, such disruptions will have detrimental effects on both the US and other trading partners. This dynamic highlights the theory of economic interdependence, which posits that extensive trade linkages increase the costs of conflict and make economic coercion less effective. Conversely, while the US retains influence in high-value sectors, its network concentration exposes it to asymmetric risks under conditions of disruption. These results demonstrate that the resilience and fragility of supply chains are not only economic phenomena, but also network-dependent outcomes, fully consistent with the theoretical framework of economic interdependence

Although the bilateral trade network features only one trade partner, making it challenging to accurately assess resilience, preliminary analysis suggests that China is generally in a more favorable position. Additionally, other findings indicate that, at least in the short term, China has not experienced significant impacts from external shocks. However, the decline in the PageRank index suggests that the decoupling of the two countries is increasingly likely in the coming years.

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