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The US-China Tech War and Industrial Policy in the Integrated Circuits Industry: Bridging Gaps or Burning Bridges?

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The integrated circuits (ICs) industry is a cornerstone of modern advanced manufacturing, and its global evolution is likely to shape the technological and innovation capacities of countries in the years to come. Several countries have enacted industrial policies to ensure the supply of ICs and protect national interests. Nevertheless, there is still little understanding of the complexity of the global IC market and the degree of dependency between countries. The aim of this paper is twofold. First, it analyses the key industrial policies adopted by the US and China in the IC industry. Second, it performs an in-depth quantitative study on global and regional IC markets. Social Network Analysis (SNA) is applied to analyse the volume and intensity of global trade of ICs, highlighting the «centrality» of the US and China within international and regional trade networks. The findings reveal that China is far more integrated into global trade networks for ICs than the US, suggesting China's potential for bridging the gaps in its national IC production through international markets, as well as reducing the risks associated with foreign dependence. As for the US, the findings show a weaker global centrality, indicating a greater level of autonomy in its ability to supply ICs for the domestic economy. The paper also proposes a selection of both policy implications, and avenues for future research.

Keywords: Industrial Policy, Integrated Circuits, Resilience, Semiconductors, Social Network Analysis, Chip War.
JEL Classification: L50; L60; O14

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1. INTRODUCTION

The race for integrated circuits (ICs) supremacy – known as *Chip War* (Miller 2022) – is likely to further reshape global value chains (GVCs), global production networks (GPNs) and logistics, as well as jeopardising the technology and innovation capacity of countries. Within this context, the US, China and several European countries, have enacted state interventions to support «specific sectors, technologies or areas of economic activity, such as advanced manufacturing, knowledge-intensive business services or the «green» economy, with the aim of fostering new sources of economic growth» (Warwick 2013, p. 7). These interventions have recently focused on improving national competitiveness in IC production, and reducing foreign dependence. This resurgence of state intervention reflects broader concerns about strategic autonomy in response to supply chain challenges (Molnar *et al.* 2024), and structural transformation capabilities, in the light of global disruptions determined by Covid-19 pandemic, wars and geopolitical tensions. These shocks have exacerbated the vulnerabilities of supply chains and the need for strategic industrial policy frameworks to manage complex transitions (Di Tommaso 2020) and economic resilience [1].

US measures have further promoted the national IC sector while discouraging investments in the Chinese IC industry (*The Economist* 2024) in response to China's highly aggressive industrial policy on semiconductor. Undoubtedly, China has considered chips as fundamental to its future since the country set the National Integrated Circuit Industry Investment Fund in 2014, in order to strengthen research and development (R&D) in the semiconductor industry (Tong and Wan 2023). Since then, increasing attention to the development and competitiveness of the Chinese IC industry has been paid. At the same time, Taiwan has gained a central role: it controls a high share of IC production with potential knock-on effects across the planet (Weil *et al.* 2025). The European Union (EU) still heavily depends on third-country supply for chips (Ciani and Nardo 2022). However, it has started enacting initiatives to safeguard its sovereignty in the IC industry (Hancké and Garcia Calvo 2022), as the release of the European Chips Act (Regulation EU 2023/1781), within the broader economic security strategy (Chimits *et al.* 2024). Questioning about whether China or the US will dominate the semiconductor industry in the years to come is beyond the goal of this paper. Industrial policy initiatives undertaken by those countries could have an im-

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[1] Economic resilience is not simply the capacity of an economy or region to resist, absorb, and recover from shocks. It also means the capacity to adapt and transform in response to evolving conditions, considering a broader array of actors and socio-spatial relations embedded in global contexts (Sutton *et al.* 2023)

portant impact, either promoting the IC industry and trade connections at the global level, or restricting the trade of chips, chip-making technologies and raw materials (Wolf and Kalish 2021). While the grey literature has focused on both the dependency and the concentration of IC manufacturing capacity of countries and firms (e.g., Ciani and Nardo 2022; Kleinhans and Lee 2022), there is still little empirical evidence about national industrial policies in response to the changing IC market (de Graaff 2023).

The aim of this paper is twofold. First, it examines the key industrial policies adopted by the US and China in the IC industry. Second, it presents an in-depth quantitative analysis on the consistency of these policies with respect to the complexity of the global IC market and the degree of dependency between countries, subject to the high specialization of production stages scattered across regions (Cerutti and Nardo 2023). To do this, Social Network Analysis (SNA) is applied to analyse the volume and intensity of global trade of ICs, unveiling the main importers and exporters and the «centrality» of the US and China in international and regional trade networks, and providing a basis for assessing countries' integration and dependencies, the emergence of regional trade communities, and the coherence between industrial policy objectives and countries' observed positions within these networks.

The following research questions are addressed: (1) What are the levels of integration and dependency of China and the US on imports and exports within IC global trade networks? (2) Are there any particularly interconnected or regionalised communities based on trade flows? (3) Are national industrial policies consistent with the positioning of China and the US?

This paper is structured as follows. Section 2 presents the related literature and analytical context, focusing on the IC industry, the «Chip War», and the industrial policies implemented by China and the US within the IC sector. Section 3 describes the data and methodology. Section 4 shows the results. Discussion follows. Section 6 summarises the main findings, and suggests a selection of both policy implications, and avenues for future research.

2. RELEVANT LITERATURE AND CONTEXT OF ANALYSIS

The following subsections provide an overview of the IC industry, highlighting its complexity and global interdependencies. Then, the academic discourse on the «Chip War» is presented, along with a summary of the key industrial policies enacted by China and the US in the IC sector.

2.1. *The integrated circuit industry*

ICs have become the cornerstone of advanced information technology, playing a crucial role in the next-generation of industrial sectors (Li 2021), including telecommunications and renewable energy – driven by digital and green transitions. Several countries try to master both the production and distribution of ICs, and to dominate the semiconductor industry which is one of the most globalised and strategic industries. This means that the race for supremacy in the IC industry can determine important implications for the world economy, trade, and order (Chen and Hsiao 2022).

The IC industry represents one of the most complex industries because of long fabrication cycle times, high levels of stochasticity, and non-linearity in the manufacturing process (Wang and Rivera 2008), compounded by the volatility of the electronic market and the unpredictability of demand (Sun and Rose 2015). The supply chain stretches from chip design, semiconductor manufacturing (also referred to as front-end processes) to test, assembly and packaging (also referred to as back-end processes), before reaching end-user companies, which integrate the chips into their products. Materials, equipment and related services and tools, including electronic design automation tools and functional blocks or IP blocks, enable design and manufacturing (EU Commission 2021). This complex industrial architecture reflects what Cardinale and Scazzieri (2020) characterise as productive interdependencies within modern industrial structures, where systemic conditions emerge from the intricate web of relationships between different stages of production and the interests of various economic actors. Such interdependencies create both opportunities for specialization and efficiency gains, but also vulnerabilities that can cascade through the entire system.

2.2. *The Chip War*

The literature has emphasised that global value chains (GVCs) have become increasingly fragmented (Durand and Milberg 2020; Grossman and Rossi-Hansberg 2008). According to Muuls *et al.* (2023), economic and financial crises, military and trade conflicts, pandemics, and technological and environmental challenges, have reshaped global supply chains, with a dramatic acceleration in recent years. These dynamics are pronounced in strategic sectors where industrial policy intersects with broader energy transition goals. As Ninni (2023) demonstrated in the context of US and European policies, the semiconductor competition cannot be understood separately from the broader industrial policy frameworks aimed at achieving net-zero emissions and securing strategic autonomy in critical technologies.

The ongoing *Chip War* represents a reaction to these dynamics, as an attempt to mitigate vulnerability and to increase the resilience of the chip supply chains by fostering domestic production capacity and innovation in the industry. However, the goal of expanding chip production at the domestic level is not easy to reach because of the complexity of the semiconductor supply chain, as well as the resources and time needed for building new chip fabrication plants, also known as fabs. Since building these facilities or moving them is very expensive, firms usually do not consider it unless they are sufficiently motivated by subsidies or tax exemptions (Jensen 2022).

Globalisation has pushed companies worldwide to reduce cost by relocating manufacturing to developing countries, resulting in a very competitive product price for customers. However, globalisation has also led to more complex processes and organisational structures, product customization and diversification which in turn increased the level of sophistication, integration, and specialisation of components and services. Thus, the organisation of supply has evolved from linear supply chains into broader and more complex networks (Marchese and Lam 2014). As a result, the geography of the semiconductor GVC continues to be quite unbalanced, with core intellectual property rights, associated with the design of chips, located in the US, South Korea, Taiwan and some European countries (The Netherlands, France, Germany, the UK), and much of the production, assembly and testing of chips is based in Asia, especially in Taiwan and China (Grimes and Du 2022). Cerutti and Nardo (2023) confirm that while the US and several European countries retain leadership in R&D and equipment, the actual manufacturing – both front-end fabrication and back-end assembly – remains consolidated in East Asia. This configuration creates single points of failure in the global trade network. Any natural or man-made event regarding these flows inevitably affects companies that source inputs from or sell products to these areas (Cerutti and Nardo 2023), underscoring a scenario where disruptions in specific Asian hubs cannot be absorbed by other regions (Bonnet *et al.* 2025). Driven by such criticalities and the pursuit of technological sovereignty, the very same trade network has emerged as the major target of state interventions by both China and the US.

2.3. *Industrial policies in China and the US*

Hancké and Garcia Calvo (2022) have provocatively argued that it is a losing strategy producing mature chips at the low end of the market, when very few companies are able to do so in a competitive manner, and in institutional frameworks which increasingly rely on both high-wage and high-skill economies, especially in the case of the EU. In the absence of both competitive and comparative advantages, producing mature chips should be managed by those actors who already make them – even if that means dealing with the single points of failure described above. Nevertheless, since 2021 there has been a massive increase in the number of policies and measures enacted by global major players in order to strengthen both the development and the nationalisation of the chip industry and its value chain.

2.3.1. *China*

China has promoted a series of government initiatives and invested considerable resources to become self-sufficient in chips. The country is a major player in trailing node manufacturing (approximately 50-180 nm) and intermediate node (14-45 nm), with about 25 percent of global capacity – and growing. However, for advanced node manufacturing (10 nm and below), extreme ultraviolet lithography (EUV) remains a crucial bottleneck (Deloitte 2024).

According to Aggarwal and Reddie (2021b), Chinese policies provide an example of new economic statecraft, as China increasingly uses industrial policy to support and expand industries vital to its national defence innovation system. While China has not yet produced any globally leading semiconductor company, it has established a strong presence across nearly every stage of chip production, thanks to important investments in R&D over the last twenty years (Li 2021). As a result, Chinese manufacturing firms have become more and more competitive while being less export-oriented (Hu *et al.* 2023). The identification of strategic sectors within Chinese industrial policy follows established methodological approaches developed over decades of economic planning. As argued by Barbieri *et al.* (2015), China's strategic sector selection process has evolved to incorporate both quantitative indicators of sectoral importance and qualitative assessments of technological potential, creating a systematic framework for prioritizing industrial development efforts.

Although China's semiconductor industry seems resilient even under the increasing pressure and restrictions enacted by the US (Li 2021), Chinese companies are hampered by critical technological bottlenecks (Grimes and Du 2022). As tensions with the US have further grown, China intensified its focus on indigenous technological development to decrease reliance on foreign sources. Table 1 shows this trajectory which has evolved from the initial «Open Door» policy through the «Go Global» strategy to the current emphasis on innovation-driven development and technological self-reliance found in the 14th Five Year Plan (Spigarelli 2018; The State Council of the PRC 2021). More recently, in 2023, China started to take a more assertive policy approach to address the Chip War, coupling industrial support with a legal toolbox of restrictive trade policies and sanctions against foreign entities and critical raw material exports (Cyberspace Administration of China 2023; Ministry of Commerce of the PRC 2023).

2.3.2. *The US*

The US hosts several global leaders in the design of chips and dominates the intellectual property associated with design (Semiconductor Industry Association 2020), accounting for 46 percent of the global trade (Bulfone *et al.* 2024). However, the production, test and assembly of chips have been fragmented and distributed among organisations not based in the country. From the policy-making standpoint, the US has increasingly enacted export controls aimed at preventing any military application of semiconductors, specifically targeting advanced node manufacturing and high-performance computing chips (Deloitte 2024).

The contemporary US approach represents an important departure from historical practices. Tassinari (2014) demonstrated how, during the Washington Consensus era, American rhetoric consistently rejected explicit industrial policy while simultaneously implementing de facto selective interventions through defense procurement and R&D funding. This historical pattern reveals a persistent gap between stated policy principles and actual government practices. Nevertheless, the more recent US strategy is based on restricting China's access to advanced technologies (Li 2021). As detailed in Table 1, this shift began under the Trump administration in 2016 and accelerated during the Biden administration with aggressive trade policies for national security.

In 2023, the discovery of a Kirin chip using SMIC's 7nm process in a Huawei smartphone revealed the technical progress made by the Chinese industry despite restrictions (TechInsights 2023). In response, the Bureau of Industry and Security (2023f) expanded the list of banned chips and manufacturing equipment to thwart US-to-China sales. Simultaneously, the US launched a massive promotion strategy. Investment policies evolved from the 2021 NDAA to the landmark CHIPS and Science Act in 2022. As shown in Table 1, the Act seeks to diversify manufacturing locations, foster innovation through entities like the National Semiconductor Technology Center (NSTC), and improve supply chain resilience (Mazzucato and Rodrik, 2023).

Table 1 summarises the main industrial policies and trade measures enacted by China and the US between 2015 and 2023.

TAB. 1. *Main industrial policies and trade measures enacted by China and the US (2015-2023)*

Country	Year	Policy/Measure	Objective/Key provisions
China	2015	Made in China 2025	National strategic plan aiming at making China dominant in global high-tech manufacturing (The State Council of the PRC 2015)
	2020	Policies for Promoting High-Quality Growth	Measures to support the IC and software industries (The State Council of the PRC 2020)
	2021	14th Five-Year Plan (2021-2025)	Focus on indigenous technological development to decrease reliance on foreign sources (The State Council of the PRC 2021)
	2021	Law on Science and Technology Progress	Develops and strengthens technological domains identified as priorities in the 14th FYP (The Standing Committee of the NPC 2021)
	2023	Cybersecurity Review Office Actions	Sanctions limiting/interrupting exports or access to the Chinese market for foreign firms (e.g., Micron Technology) (Cyberspace Administration of China 2023)
	2023	Export Control on Critical Minerals	Blocking the export of graphite, essential for EV batteries (Ministry of Commerce of the PRC 2023)
	2023	Bilateral Cooperation Agreements	Strengthening supply chain cooperation with South Korea (Cao *et al.* 2023) and expanding trade networks in Latin America (Jennings 2023)
US	2016	Early Export Controls (Trump Admin.)	Initial export control measures and bans enacted against Chinese companies (Li 2021)
	2021	2021 NDAA	Authorized the «CHIPS program» for semiconductor manufacturing and R&D (US Dept. of Commerce 2022a)
	2022	CHIPS and Science Act	Appropriated $ 50 billion for the CHIPS program ($ 11 bn for R&D), creating the NSTC, NAPMP, and Manufacturing USA institutes (United States Congress 2022)
	Oct. 2022	BIS Export Controls (New Ruling)	Controls on advanced computing, semiconductor manufacturing, and supply chain items (Bureau of Industry and Security 2022a)
	Oct. 2022	Unverified List Expansion	Inclusion of 31 additional companies and modification of their treatment (Bureau of Industry and Security 2022b)
	Nov. 2023	Expansion of Banned Chips & Equipment	Further restrictions on manufacturing equipment and advanced AI chips ((Bureau of Industry and Security 2023c, 2023d, 2023e) to prevent military applications

Notes: In January 2023, a new rule made an initial update to the controls to more effectively achieve the policy objectives identified in previous regulations by adding the same controls implemented on China in that rule to Macau (Bureau of Industry and Security 2023a).

The Bureau of Industry and Security conducted a public briefing on two interim final rules (1 and 2) released on October 17, 2023, and published in the Federal Register on October 19, 2023, and one final rule (3) published on October 18, 2023.

Source: Authors' elaboration based on various sources.

3. DATA AND METHODOLOGY

We analyse the volume and intensity of IC global trade to capture the «centrality» of the US and China within international and regional trade networks.

Indeed, countries that export the final goods capture the largest share of value-added gains from participating in global value chains (Meng and Ye 2022). From this perspective, chip exports provide insights into a country's competitiveness in the semiconductor industry, while imports indicate its dependence on foreign technology.

We apply Social Network Analysis (SNA) to the trade flows of imports and exports between 226 countries, using data from the UN Comtrade database for 2021 (De Benedictis and Tajoli 2011; Iapadre and Tajoli 2014; Serrano and Boguna 2003) [2]. This approach establishes a theoretical and methodological framework for understanding trade networks and evaluating the position of different actors within them (Domenech and Davies 2011). Centrality reflects the importance of a node within the overall network. Specifically, we use degree centrality as an indicator, which measures the number of connections (intensity) associated with a given node, or country. The greater the number of direct connections, the more significant the country's position in the network.

Given the directionality of connections, which indicates «who gives what to whom,» degree centrality is divided into in-degree and out-degree. The in-degree of node *i* measures the value imported from other countries, while the out-degree of node *i* reflects the value exported from node *i* to other countries (Hanneman and Riddle, 2005). Subsequently, we calculate the weighted out-degree and in-degree of node *i* to account for the quantity (volume) of flows exchanged. The weighted out-degree ($E_{out,i}$) and the in-degree ($E_{in,i}$) are respectively calculated as follows:

$$E_{out,i} = \frac{\sum_{j=1}^{n} x_{ij}}{n-1} \tag{1}$$

$$E_{in,i} = \frac{\sum_{j=1}^{n} x_{ij}}{n-1} \tag{2}$$

Where *n* represents the number of countries in the network, *xij* is the value from node *i* to node *j*, and *xji* is the value from node *j* to node *i*. Unweighted and weighted networks provide different insights. Therefore, using both indicators ensures more accurate information on the network's structure (De Andrade and Rêgo 2018; Schiavo *et al.* 2009). Next, to assess the centrality of China and the US in various regional areas, we calculate centrality indices for six geographical regions: Oceania, North America, Latin America,

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[2] The dataset is available at: https://data.mendeley.com/datasets/7y642csd76/1.

Asia, Europe, and Africa. For this purpose, we create six adjacency matrices that reflect regional exchanges. Additionally, beyond the direct relationships within each geographic area, we also include direct relationships with the US and China in each regional area (disaggregated for China, Hong Kong SAR, «Other Asia, nes», and Macao SAR). This approach excludes exchanges between countries that are not part of the region; for example, exchanges between the US, China, and Hong Kong in Oceania.

Furthermore, to understand the bilateral net position of each country, we construct a net export matrix, representing the difference between exports and imports for each pair of countries, with all negative symmetric values considered zero. Using this matrix, we recalculate the weighted degree of centrality. This approach helps to measure the extent to which a country's ICs needs are met by domestic production. In this sense, it can be interpreted as an indicator of national autonomy (although it does not capture dependency on intermediate goods).

Finally, we apply the modularity method for community detection, a system property that measures the extent to which networks can be divided into separate communities or clusters (Kharrazi *et al.* 2020; Newman 2006), based on the relationship between internal and external connections within subsystems. This measure is often used to identify and characterize groups of highly interconnected nodes. Additionally, it helps to identify clusters of countries connected within the semiconductor industry, providing a clearer understanding of global geopolitical dynamics. In the following figures, different colours in the networks represent distinct, highly interconnected communities.

4. RESULTS

Our analysis intends to capture the relevance of China and the US in the industry, both at a global level and in different macro geographical areas. Our centrality indicator considers as the main variable import or export flows. From this perspective, the centrality of a single country is not assessed in terms of chip quality, innovation or performance, but only in terms of how much a country is able to export and import in the sector and the variety of its relations (*i.e.* the number of countries involved in its network).

4.1. *IC bilateral trade*

Before analysing the details of the countries' centrality in terms of imports and exports as separate trade flows, we consider the trade balance of the sector for each country.

TAB. 2. *Electronic Integrated Circuits: import and export flows of China and the US (USD)*

Year 2021	Export	Import	Net Export
China	134,170,025,999	351,047,228,669	*–216,877,202,670*
US	47,216,106,877	26,561,242,911	*20,654,863,966*

Source: Authors' elaboration.

The metrics presented in Figure 1 and Figure 2, depicted by the size of the nodes, illustrate the centrality in relation to the magnitude of the surplus (weighted outdegree) and the magnitude of the deficit (weighted indegree) in the balance of payments in the IC sector[3]. The figures show the centrality of «Other Asia, nes (not elsewhere specified)» which includes Taiwan, home to the world's biggest foundry company, Taiwan Semiconductor Manufacturing Company (TSMC) which accounted for more than 50 percent of global market share and 56 percent of global foundry revenue in 2018 (Grimes and Du 2022). Still in Figure 1, Singapore accounts for a major portion of the network in terms of node size, hosting 12 percent of the Outsourced Assembly and Test (OSAT) (Semiconductor Industry Association 2016). Singapore has a strategic position for such a step in the value chain (Duhalde and Liu 2018). It is also worth noting that South Korea is home to Samsung Electronics, the dominant player in the dynamic random-access memory (DRAM) market, similar to how Intel leads the microprocessor market in the US. Both DRAM and microprocessors are types of ICs, and their market dominance highlights the oligopolistic structure of the semiconductor industry, which has seen significant consolidation in recent years.

According to the UN Comtrade Data referred to 2021, China is characterised by a negative net export worth approximately US$ 217 billion. On the contrary, the US has a positive net export worth about US$ 21 billion (Table 2). The direct net export of chips from the US to China in 2021 has been about US$ 10,8 billion. This further analysis reveals that, beyond the importance of the countries in terms of influence on the trade flows, the US appears much more significant than China in terms of production of chips.

Figure 1 represents the out-degree, which is the weighted degree of the net value exported based on bilateral trade. Labels and nodes reflect each country's centrality in terms of net exports, specifically highlighting which countries maintain a trade surplus relative to others. The communities identified by different colours illustrate clusters of countries that are highly interconnected in terms of their net exports and imports. This means that within each colour community, countries tend to share stronger trade relations, pos-

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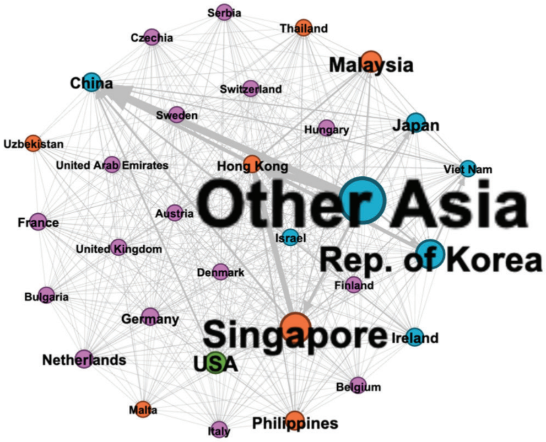
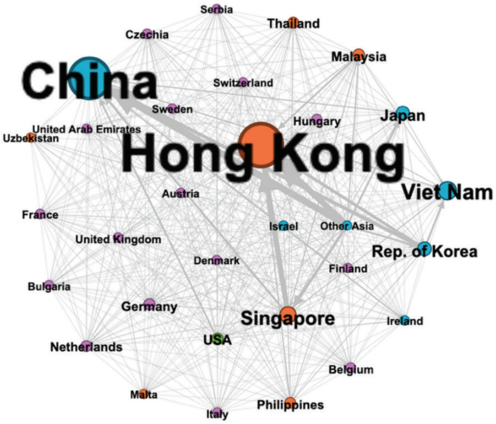
[3] In the Appendix A, it is possible to view the entire network for the two indices (Figure A12 and Figure A13).

FIG. 1. *Outdegree weighted centrality by bilateral trade*



Source: Authors' elaboration.

FIG. 2. *Indegree weighted centrality by bilateral trade*



Source: Authors' elaboration

sibly reflecting regional trade agreements, geographical proximity, or similar economic structures. The «Blue community» consists of major Asian economies such as China, Japan, Republic of Korea, and others. These countries tend to dominate the trade network, suggesting their high levels of competitiveness in terms of net exports. Their size and central position indicate a strong export surplus across multiple countries. The US stands out in the «Green community», suggesting a unique trade position where it balances its relationships with multiple regions. Its centrality shows its trade surplus with several countries. The figure also highlights how «Other Asia, nes» acts as a central hub in this network, connecting various countries across the globe, which may signal the region's role as a trade bridge.

Figure 2 illustrates the in-degree, which represents the weighted degree of the net value imported based on bilateral trade. Labels and node sizes reflect each country's centrality in terms of net imports, i.e., which countries have the largest trade deficit relative to others. The different colour-coded communities reflect clusters of countries that are particularly interconnected in terms of their net imports and exports. These communities may reveal trade dependencies or regional trade relationships. In the «Blue community» (China, Japan, Rep. of Korea, etc.), China has one of the largest node sizes, signifying its high level of net imports from other countries. This underscores the complexity of global trade dynamics, where even dominant exporters like China exhibit significant levels of imports. Hong Kong stands out as the most significant node in the Orange community, indicating its pivotal role as a trade hub with large net imports. The US (Green community) is depicted as a smaller node, suggesting that in this network, the US plays a more balanced role with regards to its net imports relative to other global players.

4.2. *Import and export centrality at the global level*

This section evaluates the centrality of analysed countries in terms of both import and export at the global level. The results for the global network based on the centrality indicator are displayed in Table 3. The values are sorted in ascending order by the Export centrality index (out-degree_weight) for the best 21 countries of the ranking. The centrality indicators capture the value imported or exported by each country, allowing us to capture the relevance of China and the US.

Specifically, the Import centrality index indicates the countries that are more important in terms of imported ICs from all countries; while the Export centrality index indicates the countries that are more important in terms of exported ICs to all countries. Centrality indicators capture the number of countries with which the goods are traded, while weighted centrality indicators measure the volume of the trade.

The Asian countries are the most central countries in terms of export flows. China is the third best country according to the Export centrality index and the first one for what concerns the Import centrality index. In this respect, the relevance of China is higher compared to that of the US which is placed 7th in the Export centrality index ranking. However, the US has a slightly more developed trade network compared to China in terms of the number of countries involved in export (172 vs. 162) and import (94 vs. 70)

TAB. 3. *Centrality of a country compared to all other countries (2021)*

Countr	Outdegree_weight	Outdegree	Indegree_weight	Indegree
China, Hong Kong SAR	203,545,000,000	121	214,030,000,000	72
Other Asia, nes	155,918,000,000	116	0	0
China	134,170,000,000	162	351,047,000,000	70
Singapore	101,531,000,000	128	52,811,658,713	60
Rep. of Korea	99,216,990,732	88	49,912,639,054	60
Malaysia	55,008,151,022	89	36,701,153,051	58
US	47,216,106,877	172	26,561,242,911	94
Japan	24,818,986,496	73	24,757,808,590	61
Philippines	22,733,006,370	86	14,057,126,581	52
Germany	14,638,794,592	170	15,394,325,927	76
Viet Nam	14,055,637,938	58	45,838,193,907	50
Netherlands	13,360,494,815	167	9,318,174,200	78
Ireland	11,146,658,234	85	3,039,068,324	60
Thailand	7,875,455,176	111	12,854,107,725	55
France	7,207,792,156	153	4,330,265,250	72
Israel	3,660,832,967	121	2,886,911,214	55
Mexico	3,486,450,856	42	15,575,933,965	66
Belgium	2,036,582,616	132	3,255,320,669	58
United Kingdom	1,663,937,794	152	2,785,678,979	71
Czechia	1,514,892,638	129	3,458,329,461	62
Italy	1,450,711,324	135	1,897,933,148	70

Source: Authors' elaboration.

flows. As regards European countries, Belgium, France, Netherlands, and Germany are among the most important economies according to the Export centrality index.

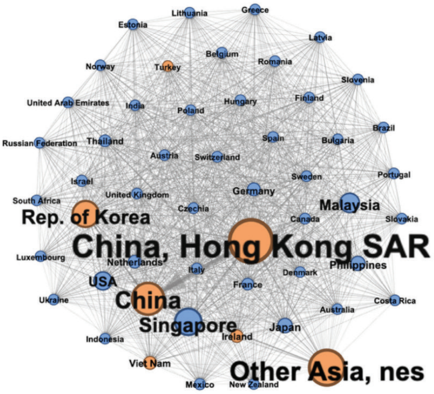
Figure 3 and Figure 4 show respectively the network of import and export of a country with respect to each of the other countries. The size of the nodes and labels are weighted for the Import centrality index («in-degree») and the Export centrality index («out-degree») (values of Table 3). In the Appendix A, we offer references for both the weighted and unweighted centrality indexes (Figures A14, A15, A16, A17). China's node is larger than that of the US, both in the Indegree and out-degree graph. The relevance of Hong Kong is quite interesting, as almost all its exports are directed to China. According to the UN Comtrade Data, in 2021 Hong Kong exported 181 billions of ICs to China, and only 21 billion in the rest of the world. The empirical analysis does not combine Hong Kong SAR and China so that we can uncover information regarding their roles. China's relevance emerges even without Hong Kong.

Specifically, in Figure 3 the size of the labels and nodes reflects the total value imported from the rest of the world: China stands out as a major importer globally, with its node and label size dominating the network. The first, highly connected community includes countries such as China, Hong Kong, Vietnam, Ireland, Republic of Korea, Turkey, and «Other Asia, nes.» These countries form a densely connected cluster, indicating strong trade

FIG .3. *The country's position in the world network based on the indegree centrality index*

Source: Authors' elaboration.

FIG. 4. *The country's position in the network based on the outdegree centrality index*



Source: Authors' elaboration.

ties and significant import activities between them. The close proximity and interconnections suggest mutual trade dependencies and possibly shared supply chains. Figure 3 represents a reduced version of the entire network, which consists of 226 countries. It focuses on highlighting the most significant relationships and central actors in global import activities. For a comprehensive view of the entire network and to grasp the broader trade dynamics, refer to the Appendix A, where Figures A12 and A13 illustrate the complete network structure.

The communities identified in Figure 4 remain the same as in the previous figures, as these communities are calculated using trade relationships in both imports and exports values. In this case, however, the size of the nodes and labels reflects the volume of exports each country sends to the world. For example, Hong Kong is shown as a major exporter, which highlights its significant role in global trade. In terms of export concentration, the arrows are consistent across the in-degree and out-degree graphs and indicate the direction of trade. For instance, Hong Kong's exports are heavily concentrated toward China, showcasing a strong trade reliance. By contrast, «Other Asia, nes» has a more diversified set of trade relationships, exporting to multiple countries rather than focusing primarily on one trade partner.

4.3. *Regional analysis*

As for the second step of this analysis, we present the networks of each geographical area in order to understand the centrality of China and the US in each area. The figures indicate the Export and Import centrality index value of a country compared to all other countries of that area. The US, China, Hong Kong SAR, Macao, and «Other Asia, nes» are always included even when they are not part of the area considered. This allows us to evaluate their specific role within the area analysed. The size of the nodes and the label are weighted, respectively, for the Indegree and Outdegree values.

The figures exclude trade between countries that are not part of the specified geographical area. For example, regarding Europe, the analysis includes trade flows from the US, China, Macao, and other Asian countries only when they are trading with Europe. Trade flows between China, Hong Kong SAR, Macao, and the US are excluded, as they are not part of that area. As concerns North America, we have not included trades between China, Hong Kong SAR and Macao but those with the US, because it is part of the area analysed. The tables are all sorted in ascending order by the Export centrality index («out-degree_weight»).

The following subsections report the most interesting results which have been obtained for Asia, North and Central America, Europe, and Africa.

4.3.1. *Asia*

China and Hong Kong SAR play a crucial role as importers of ICs in Asia. Notably, China occupies a central position in the region, importing from all regional players and absorbing a significant portion of Hong Kong SAR's exports. In contrast, Hong Kong SAR predominantly imports from Other Asia

Fig. 5. *The centrality of China and the US in Asia (weighted indegree)*

Source: Authors' elaboration.

and the Republic of Korea but exports almost exclusively to China (Figure 5). Given the size of the node and the label, China is also important in terms of Export centrality index, along with Malaysia, Singapore, Republic of Korea, «Other Asia, nes.» The US operates in Asia in terms of export but it appears not particularly important compared to the other big players. In Figure 5, the labels and node sizes represent imports, with Hong Kong and China remaining the most central countries, consistent with previous visualisations. Both are part of the same community, which also includes Vietnam and the Republic of Korea. This highlights the strong interdependence of these players in regional trade. A broader second community is formed by «Other Asia, nes», Singapore, Malaysia, and the US, showing relevant regional trade connections between these states.

Then, in Figure 6, the labels and node sizes represent exports. Hong Kong SAR, China, and the Republic of Korea are all big players within the same community, indicating both their centrality and interconnectedness in the region. Also, the strong link between China and Hong Kong SAR is confirmed by the edge size showcasing the huge import directed from the latter to the former. «Other Asia, nes» along with Singapore and Malaysia lead within the second community where the US is also part of. Overall, both the in-degree and out-degree measures in Asia show a more prominent role of China compared to the US. This centrality within the network is due to its political and geographical proximity, and to the many relationships China has historically built in the region particularly through its Go Global strategy (Bellabona and Spigarelli 2007) and the Belt and Road Initiative (Sampaolo *et al.* 2021). However, perhaps the most interesting point that emerges is that

FIG. 6. *The centrality of China and the US in Asia (weighted outdegree)*

Source: Authors' elaboration.

China does not appear to export to the US, whereas the opposite is true, with the US exporting ICs to China as per the retrieved data.

4.3.2. *North and Central America* (NCA)

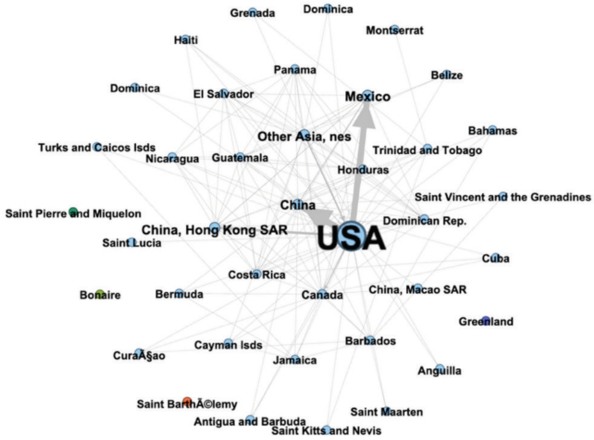
China and Mexico play a major role as importers of electronic ICs in North and Central America since these countries especially import from the US (Figure 7). Indeed, the US dominates the region in terms of export. In Figure 7, the labels and node sizes represent imports. It clearly emerges that China, Hong Kong, and Mexico are dependent on imports from the US, while the US itself imports from «Other Asia, nes» and Hong Kong. This observation highlights the dependency of key economies like China, Hong Kong, and Mexico on the US for imports, reflecting the strong demand for American produced, although outsourced, ICs in the region. At the same time, the US maintains significant import connections with both «Other Asia, nes» and Hong Kong, underlining the mutual interdependence in global trade. This points to a highly interconnected network where even major exporters, such as China, are heavily reliant on external markets like the US for certain imports, while the US diversifies its supply chains across many regions.

Then, the visualisation of Figure 8 emphasises the dominant role of the US as a leading exporter in the region. The size of the country's node suggests its strong presence in regional trade, with numerous countries depending on its exports. This reflects the country's economic power and influence, as it supplies a wide range of ICs to other nations, reinforcing its leadership in the global IC market.

FIG. 7. *The centrality of China and the US in NCA (weighted indegree)*

Source: Authors' elaboration

FIG. 8. *The centrality of China and the US in NCA (weighted outdegree)*



Source: Authors' elaboration.

4.3.3. *Europe*

In Figure 9, the labels and node sizes represent imports. Germany and China are the most central, with China being particularly prominent due to significant imports from Ireland. An interesting aspect is the presence of three distinct trade communities: one exclusive to China and Ireland, another connecting France, Belgium, Malta, and China Macao SAR, and finally, a third group of European countries that are connected to both the US and Hong Kong. This visualisation highlights Germany and China as major importers in the global trade network, with China standing out due to its substantial

FIG. 9. *The centrality of China and the US in Europe (weighted indegree)*

Source: Authors' elaboration.

FIG. 10. *The centrality of China and the US in Europe (weighted outdegree)*

Source: Authors' elaboration.

imports from Ireland, possibly linked to highly innovative driver sectors like pharmaceuticals or electronics.

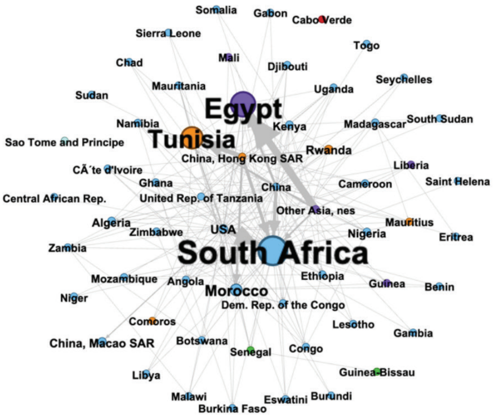
Then, in Figure 10, the labels and node sizes represent exports. Interestingly, within Europe, the most central country in terms of exports is The Netherlands due to the presence of NXP, a worldwide microcontroller chip company that has an important involvement in the Chinese market (Grimes and Du 2022). Germany is also central in terms of export, considering the presence of Global Foundries, and Infineon. Interestingly, Ireland has a highly concentrated export relationship with China suggesting specialisation in high-demand ICs and, to a lesser extent, the US. This opens up a political theme, regarding dependency. European countries export heavily to China, and thus, the export of the entire region depends on such IC demand from China. Ireland represents a key player in IC trade as a historical hub for leading semiconductor companies with manufacturing and distribution operations tied to both China and the US, including Qualcomm, Analog Devices, Cadence, Synopsys, Siemens Mentor Graphics, Infineon, OnSemi, ARM, Meta, Qorvo and Renesas (Silicon Republic 2023). As indicated by the European Chips Act, this may suggest further room for the development of the IC industry, by exploiting the opportunities offered by the domestic market, such as demand for cutting-edge electronics in various industries – including telecommunications, automotive, and renewable energy – driven by digital and green transitions.

4.3.3. *Africa: A contested area?*

An interesting analysis of regional trade networks is that with Africa. Figure 11 reveals three major regional importers: South Africa, Tunisia, and Egypt, corresponding to three distinct trade communities (along with some smaller ones). In the first community, the US and China compete for dominance in the South African and broader African markets. The second community shows a privileged relationship between Egypt in particular, Mali, Guinea, Liberia, with «Other Asia, nes». Lastly, Tunisia primarily imports from Hong Kong, the latter having less intensive trade relations also with Rwanda and Mauritius.

The trade relationships with African nations are particularly interesting. The division into three trade communities – centered on South Africa, Tunisia, and Egypt – reflects regional dynamics in African markets. The competition between the US and China for influence in South Africa and broader African trade highlights the continent's growing importance as a global trade partner. The second community, linking «Other Asia, nes» with Egypt and other African nations like Mali, Guinea, and Liberia, shows a developing but important trade relationship. Lastly, Hong Kong's relatively concentrated exports to Tunisia, Rwanda, and Mauritius suggest targeted regional trade patterns.

FIG. 11. *The centrality of China and the* US *in Africa (weighted indegree)*



Source: Authors' elaboration.

FIG. 12. *The centrality of China and the* US *in Africa (weighted outdegree)*

Source: Authors' elaboration.

5. DISCUSSION

The discussion of the results is organised around the three research questions of the paper.

5.1. *What are the levels of integration and dependency of China and the* US *on imports and exports within* IC *global trade networks?*

The results revealed that China and the US are among the most central countries in the export network in the chip sector. In particular, China is more central than the US, both in terms of imports and exports, globally and in each of the macro-areas considered. This centrality is an indication of China's significant role, both in terms of competitiveness (on the supply side) and global demand (or dependence) in the chip sector. Economic integration with the rest of the world could allow China to control and influence a substantial portion of the international chip market, as well as lead to increased efficiency, specialisation, and access to resources that may not be easily available domestically. However, when analysing the bilateral trade balance of the sector, a different picture emerges. The US records a trade surplus while China shows a trade deficit. These findings suggest that China depends greatly on other countries for chip procurement, while the US seems to be less dependent.

5.2. *Are there any particularly interconnected or regionalised communities based on trade flows?*

The high centrality and connectivity of China extend across multiple regions of the world, highlighting the presence of dense and highly interconnected trade communities. This connectivity is reinforced by the diversification potential of global and regional value chains, as well as by China's participation in regional trade-investment agreements, such as the Regional Comprehensive Economic Partnership (RCEP) (Baldwin and Evenett 2020; Kelsey 2022; Kimura *et al.* 2022). In this context, China's role is strengthened not only by its export capacity but also by the sheer size of its semiconductor-consuming domestic market. These features contribute to the formation of tightly interlinked trade networks characterised by strong productive interdependencies. The results suggest that regionalisation processes in the IC sector operate within, rather than against, a deeply integrated global trade structure, making any rapid disentanglement of trade flows particularly challenging.

5.3. *Are national industrial policies consistent with the positioning of China and the US?*

The evidence provided by our study facilitates framing the analysis by considering the impact of recent industrial policies enacted by key players, starting from the Made in China 2025 plan and the US Chips Act. The analysis of net export flows reveals that it seems unlikely, at least in the short-medium run, that China will be able to achieve independence from foreign suppliers in this strategic sector, with China's IC production falling well short of «Made in China 2025» targets of 70 percent self-sufficiency by 2025 (Solid State Technology 2019). At the same time, the plan of the US Chips Act seems very far away, in terms of decoupling and pushing the reshoring of American companies from China while attracting foreign companies to expand capacity and enhance the US chip industry. Some key aspects should be considered. The US faces a shortage of skilled labour (Sainato 2023), along with concerns about subsidy criteria raised by major companies such as TSMC (Blanchard and Kao 2023; Gordon 2023).

More broadly, the findings suggest that policymakers may have underestimated the complexity of the global semiconductor supply chain, as well as the time and capital required to develop domestic chip fabrication plants and innovation capacity. The political economy factors underlying these policy challenges extend beyond simple market considerations. As Aggarwal and Aggarwal (2023) emphasise, the success of industrial policies depends critically on how governments navigate international constraints, manage domestic stakeholder interests, and maintain coherent long-term strategic visions amid changing technological and geopolitical conditions. This complexity is also indicative of deeper structural characteristics of modern industrial systems. Cardinale and Scazzieri (2020) argue that productive interdependencies create systemic conditions where the interests of different economic actors become intertwined in ways that resist simple policy interventions. The IC industry exemplifies these dynamics, where attempts to reshape supply chains should contend with deeply embedded patterns of specialisation and technological complementarity. In this regard, our findings highlight a potentially misleading narrative in industrial policy, driven by an unrealistic ambition to disentangle the intricate trade networks within the chip sector. This tension reflects the broader dilemma identified by Aggarwal and Aggarwal (2023) between national security objectives and the efficiency gains derived from international specialisation and technological cooperation.

6. CONCLUSION, POLICY IMPLICATIONS AND AVENUES FOR FUTURE RESEARCH

This paper has analysed the key industrial policies implemented by the US and China in the IC industry. Furthermore, it has presented an in-depth quantitative analysis on global and regional IC markets. To do this, SNA has been applied to scrutinise the volume and intensity of IC global trade, highlighting the «centrality» of the US and China within international and regional trade networks.

When investigating the extent of integration and dependency of China and the US concerning imports and exports within the global IC trade networks, our findings revealed that China is far more integrated into global trade networks for microchips than the US. On one hand, this suggests a potential for China to bridge the gaps in its national IC production through international markets, along with diminishing the risks associated with foreign dependence. On the other hand, the relatively weaker global centrality of the US suggests a greater level of autonomy in its ability to supply microchips for its domestic economy.

As for the emergence of particularly interconnected or regionalised communities based on trade flows, Asian countries such as China, Malaysia, Republic of Korea, Singapore, Hong Kong SAR and «other Asia nes» are the most central ones in terms of export flows. Regarding Europe, the most connected countries are Belgium, France, Ireland, Germany and the Netherlands. ICs are frequently exported and imported, by several countries. As ICs are considered final goods, this pattern arises because countries import specific ICs to support certain domestic industries, while simultaneously they manufacture and export other types of ICs.

In examining the consistency of US and China industrial policies with their respective positions, the results indicate a strong alignment between China's trade relations in integrated circuits and its geopolitical stance. China is emerging as a key force across various regions, either directly or through its trade partners, by continuing to rely heavily on strategic alliances and cultivating a network of dependencies among its trading partners. Whereas, the US appears to be quite distant in terms of decoupling and encouraging the reshoring of American companies from China, while also attracting foreign companies to expand capacity and bolster the US chip industry.

Based on the results obtained from the analysis, we suggest a selection of diverse industrial strategies for the IC industry in the two countries. Developing effective industrial policies in these contexts necessitates frameworks that recognise both the opportunities and constraints posed by global interdependencies. According to Di Tommaso (2020), smart and resilient strategies should strike a balance between economic sustainability and strategic autonomy while addressing the governance challenges highlighted by both economic theory and policy practice. This indicates that future industrial policy strategies in the IC industry should transcend the simple dichotomy of protectionism versus liberalisation, moving instead toward more sophisticated approaches capable of managing complex structural changes. While the US might consider burning the international bridges China has built, the Chinese government could continue designing and implementing policies aimed at enhancing global trade relations to ensure a steady IC supply for its domestic market. For China, the long-term development of a competitive national IC industry could materialise as a result of the government's *dual circulation strategy*.

As a final consideration, the methodological strategy adopted and the data used, may explain some of its limitations, which should be addressed through further studies. First, the quantitative analysis should be enriched by considering trade flows in the IC sector, and additional variables such as the quality, sophistication and innovation level of imported and exported products, as well as ownership structures and their actual production level.

Furthermore, we have examined centrality indicators that account for indirect connections, such as closeness and betweenness centralities. Given that the trade of ICs exclusively involves final goods, these indicators might not have captured other important economic characteristics of the IC market. Thus, this study could be enhanced through the analysis of the dynamic properties and structure of the network. In particular, it would be interesting to examine the evolution of the IC market in terms of processes related to regionalisation or globalisation.

Comparing the 2021 situation with more recent data is essential to assess the impact and effectiveness of the industrial policies enacted by China and the US. We have outlined the starting point for a future comparison, to be conducted when data becomes available. Changes in the centrality index and trade balance levels will provide insights into the adjustments in the positions of the two countries following the implementation of more intensive industrial policy measures. Future analyses could also delve deeper into the relationship between China and Hong Kong SAR, which raises the broader question of domestic production versus importation for export purposes. As for Europe, it would be interesting to explore whether and how trade flows have shifted in response to recent US policies.

Acknowledgment

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Appendix A

(Eq. A1) Weighted out-degree

$$E_{out,i} = \frac{\sum_{j=1}^{n} x_{ij}}{n-1}$$

(Eq. A2) Weighted in-degree

$$E_{in,i} = \frac{\sum_{j=1}^{n} x_{ij}}{n-1}$$

Tab. A1. *Electronic integrated circuits: Import and export flows of China and the US*

Year 2021	Export (USD)	Import (USD)	Net Export (USD)
China	134,170,025,999	351,047,228,669	*–216,877,202,670*
US	47,216,106,877	26,561,242,911	*20,654,863,966*

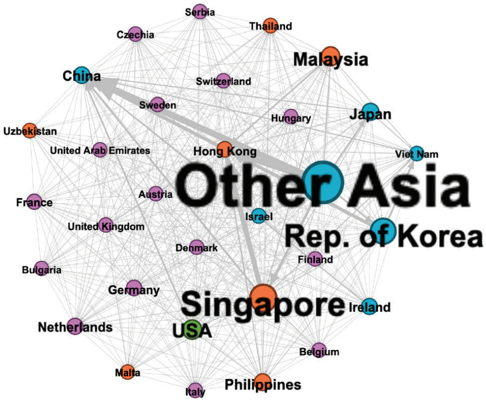
Source: Authors' elaboration.

Tab. A2. *Centrality of a country compared to all other countries (2021)*

Data sorted by Outdegree	Export centrality index	N. of countries to which the country exports	Import centrality index	N. of countries the country imports from
Country	Outdegree_weight	outdegree	Indegree_weight	Indegree
Italy	1,450,711,324	135	1,897,933,148	70
Czechia	1,514,892,638	129	3,458,329,461	62
United Kingdom	1,663,937,794	152	2,785,678,979	71
Belgium	2,036,582,616	132	3,255,320,669	58
Mexico	3,486,450,856	42	15,575,933,965	66
Israel	3,660,832,967	121	2,886,911,214	55
France	7,207,792,156	153	4,330,265,250	72
Thailand	7,875,455,176	111	12,854,107,725	55
Ireland	11,146,658,234	85	3,039,068,324	60
Netherlands	13,360,494,815	167	9,318,174,200	78
Viet Nam	14,055,637,938	58	45,838,193,907	50
Germany	14,638,794,592	170	15,394,325,927	76
Philippines	22,733,006,370	86	14,057,126,581	52
Japan	24,818,986,496	73	24,757,808,590	61
US	*47,216,106,877*	*172*	*26,561,242,911*	*94*
Malaysia	55,008,151,022	89	36,701,153,051	58
Rep. of Korea	99,216,990,732	88	49,912,639,054	60
Singapore	101,531,000,000	128	52,811,658,713	60
China	*134,170,000,000*	*162*	*351,047,000,000*	*70*
Other Asia, nes	155,918,000,000	116	0	0
China, Hong Kong SAR	203,545,000,000	121	214,030,000,000	72

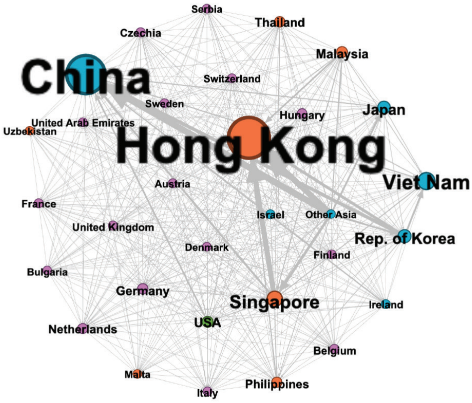
Source: Authors' elaboration.

FIG. A1. *Outdegree weighted centrality by bilateral trade*



Source: Authors' elaboration.

FIG. A2. *Indegree weighted centrality by bilateral trade*

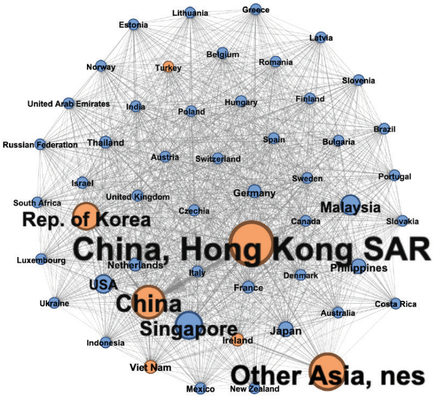


Source: Authors' elaboration.

FIG. A3. *The country's position in the world network based on the indegree centrality index*

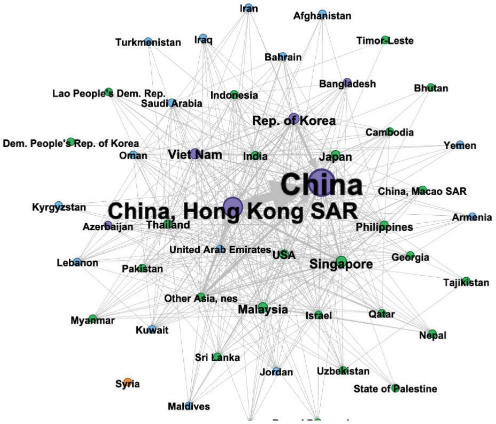
Source: Authors' elaboration.

FIG. A4. *The country's position in the world network based on the outdegree centrality index*



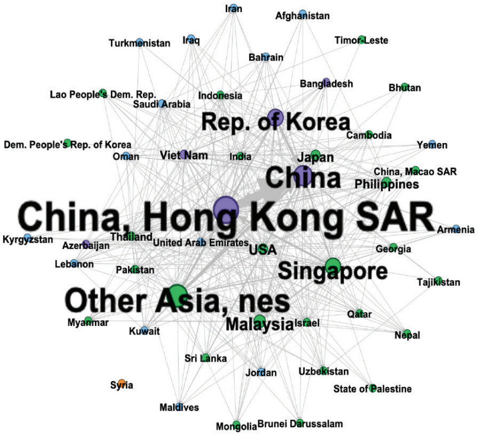
Source: Authors' elaboration.

FIG. A5. *The centrality of China and the* US *in Asia (weighted indegree)*



Source: Authors' elaboration.

FIG. A6. *The centrality of China and the* US *in Asia (weighted outdegree)*

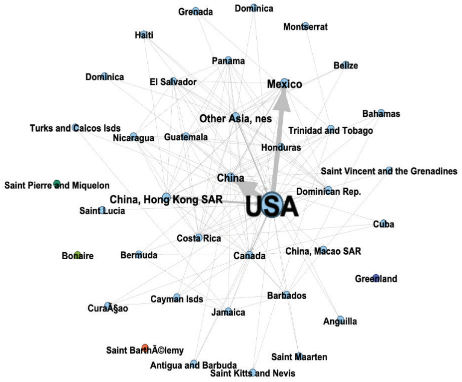


Source: Authors' elaboration.

Fig. A7. *The centrality of China and the* US *in* NCA *(weighted indegree)*

Source: Authors' elaboration.

Fig. A8. *The centrality of China and the* US *in* NCA *(weighted outdegree)*



Source: Authors' elaboration.

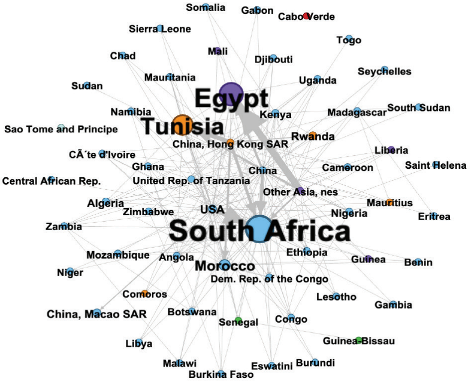
Fig. A9. *The centrality of China and the* US *in Europe (weighted indegree)*

Source: Authors' elaboration.

FIG. A10. *The centrality of China and the* US *in Europe (weighted outdegree)*

Source: Authors' elaboration.

FIG. A11. *The centrality of China and the* US *in Africa (weighted indegree)*

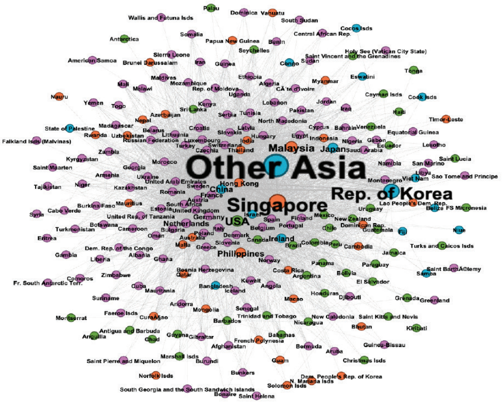


Source: Authors' elaboration.

FIG.A12. *The centrality of China and the* US *in Africa (weighted outdegree)*

Source: Authors' elaboration.

FIG. A13. *The full* IC *world network of net bilateral trade based on the weighted degree centrality (both outdegree and indegree)*



Source: Authors' elaboration.

FIG. A14. *The full* IC *world network based on weighted outdegree centrality*

Source: Authors' elaboration.

FIG. A15. *The full* IC *world network based on the weighted indegree centrality.*

Source: Authors' elaboration.

FIG. A16. *The full* IC *world network based on the outdegree centrality*

Source: Authors' elaboration.

FIG. A17. *The full* IC *world network based on the indegree centrality*

Source: Authors' elaboration.

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