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GINA Economic
Methodological Notes
HCSS Datalab

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GINA Economic in short

The Geopolitical Interactive Network Analysis (GINA) Economic dashboard, developed by the HCSS Datalab in cooperation with Strategic Analysts, applies network science to explore global patterns of economic interdependence. It focuses on how cross-border investment positions and merchandise trade flows connect states through enduring relationships of ownership and exchange, providing a structured, data-driven view of the economic dimension of international relations.

Drawing on the IMF's Direct Investment Positions by Counterpart Economy dataset and international merchandise trade statistics from UN Comtrade, GINA Economic translates position and transaction data into two network layers: an investment network and a trade network. The investment layer visualizes bilateral foreign direct investment positions as directed and weighted ties that capture how capital and ownership links are distributed across economies. The trade layer represents bilateral flows of goods, aggregated into Harmonized System commodity sections, highlighting major corridors of exchange, regional clusters and concentrated dependencies in critical goods.

The dashboard allows users to explore these networks through interactive maps, node-link diagrams and summary graphs across different time frames, commodity groups and subsets of actors. By placing investment and trade side by side within a shared network-science framework, GINA Economic helps users investigate how patterns of ownership and material exchange overlap, diverge or evolve, and how these patterns relate to broader geopolitical developments.

While GINA Economic is built on a consistent and transparent methodological foundation, its insights are constrained by the quality, coverage and design of the underlying open-source datasets. Reporting asymmetries, confidentiality rules, differences in valuation and the stock-based nature of foreign direct investment positions limit full comparability across countries and time periods. Aggregation choices and the current focus on visual and exploratory analysis also simplify complex dynamics. As such, the dashboard is intended as a conservative but robust analytical baseline for examining how trade and investment shape the structure of global economic networks.

1. Introduction

The current geopolitical landscape is shaped not only by diplomatic signalling and military posturing, but also by deep and evolving patterns of economic interdependence. Cross-border capital positions and trade flows structure how states access markets, technologies and critical resources, and they shape both vulnerabilities and leverage in international affairs. To systematically explore these economic dimensions of interstate relations, analytical tools are needed that move beyond individual indicators and instead map how states are embedded in wider systems of ownership and exchange. The Hague Centre for Strategic Studies (HCSS) has developed the GINA Series, an initiative of the HCSS Datalab in collaboration with Strategic Analysts, to apply network science frameworks to multiple dimensions of international relations. Drawing on bespoke HCSS- and publicly available datasets as shown figure 1, GINA examines patterns, interdependencies and power dynamics between states across four domains: Diplomatic, Military, Economic and Information. The present methodological note provides the conceptual and technical foundations for GINA Economic and offers transparency in the construction of its dashboard.

Figure 1 - GINA Suite overview

GINA Economic focuses on how international investment and trade connect states through enduring cross-border relationships. By combining the International Monetary Fund's Direct Investment Positions by Counterpart Economy (DIP) dataset with international merchandise trade statistics from UN Comtrade, the dashboard translates position and transaction data into network structures that represent capital integration and goods exchange between economies. Users can explore these networks through interactive maps, node-link diagrams and summary graphs across different time frames, commodity groups and subsets of actors. While GINA Economic is grounded in a shared methodological logic with the wider series, it tailors that logic to the specific characteristics of investment positions and trade flows, highlighting how patterns of ownership and material exchange underpin broader geopolitical dynamics.

International investment constitutes a key channel through which firms and states build long-term economic linkages across borders. By establishing lasting equity stakes, intra-group debt relationships and reinvested earnings, investors embed decision-making structures and capital within foreign jurisdictions. These positions reflect strategic choices about where to locate production, how to finance operations and which markets to prioritise. They can create durable forms of influence and exposure that persist even when political or security relationships change. At the same time, investment positions are responsive to structural conditions, situational shocks and relational factors such as regional production networks or treaty frameworks. GINA Economic captures these relationships through an investment layer that visualises bilateral FDI positions as directed and weighted ties, enabling users to examine how ownership structures and financial embeddedness vary across states and over time.

International trade represents the material dimension of economic interdependence, revealing how states source critical inputs, participate in global value chains and supply goods to partners. Flows of raw materials, intermediate goods and finished products expose economies to external shocks, shape their developmental trajectories and influence their bargaining power in international negotiations. Different forms of trade, including inter-industry exchange, intra-industry specialisation, value chain integration and trade in strategic goods, indicate distinct roles within the global economy. GINA Economic translates bilateral merchandise trade flows into a trade network that highlights major corridors, regional clusters and concentrated dependencies. By allowing users to filter by commodity group and time period, the dashboard supports analysis of both broad trade structures and more specific sectors of interest.

Taken together, the investment and trade layers provide complementary perspectives on the economic underpinnings of international relations. Ownership links and goods flows do not always align: states may be tightly connected through capital positions but only moderately through trade, or vice versa. By placing these layers side by side within a shared network-science framework, GINA Economic enables users to investigate how different dimensions of economic interdependence overlap, diverge or evolve, and how these patterns relate to wider geopolitical developments. The dashboard is designed as a conservative but robust starting point, constrained by the quality and coverage of open-source data but offering a systematic way to visualise and compare complex economic relationships.

The methodological note accompanying the GINA Economic dashboard guides the reader from the conceptual foundations of the framework to its practical implementation. Each chapter builds on the previous one, moving from theory to data, from data to network construction and from network construction to analytical interpretation. The structure mirrors the broader logic of the GINA series and aims to make both the reasoning behind the model and its operational choices transparent.

Section 2 introduces the conceptual foundation of GINA Economic. It clarifies how the project understands international investment and international trade, distinguishing key forms, drivers and trajectories for each. By outlining how structural, situational and relational factors shape the development of investment and trade relationships, the section provides a conceptual basis for interpreting the networks as systems of cross-border economic ties rather than collections of isolated records.

Section 3 presents the typology and data sources underpinning the dashboard. It describes the IMF Direct Investment Positions (DIP) dataset and the UN Comtrade international trade data, explaining what each measures, how they are structured and how they are used within GINA Economic. The section also details the harmonisation of country entities across sources and concludes with a data summary table that provides an overview of coverage, level of analysis and operationalisation choices.

Section 4 explains how the investment and trade network layers are constructed from these datasets. It sets out how actors become nodes, how positions and flows are translated into directed edges, how edge weights are defined and aggregated, and how temporal filters and commodity group selections are applied. A dedicated subsection describes the shared visual logic used across both layers, including layout, colouring and scaling, so that users can understand how to interpret the structures displayed in the dashboard. The section concludes with a summary table of modelling decisions.

Section 5 introduces the analytical outputs available through the dashboard. It outlines the types of insights that can be drawn from the global and state-level networks and discusses the complementary visualisations that support interpretation, including maps, quantitative summaries and temporal comparisons. By illustrating how users can move from abstract network representations to substantive analysis of economic interdependence, the section highlights the added value of the GINA Economic approach.

Section 6 reflects on the main limitations of GINA Economic. It discusses both data-related constraints, such as reporting asymmetries and coverage gaps in the underlying datasets, and methodological simplifications, including aggregation choices and the current focus on visual exploration rather than advanced network metrics. The section also outlines avenues for future development of the dashboard and its analytical features.

Taken together, this methodological note is designed to offer both a contextual foundation and a technical roadmap for using the GINA Economic dashboard. Readers may work through it sequentially to gain a comprehensive understanding of the tool or consult individual sections as standalone references depending on whether their focus lies on conceptual clarity, data transparency, methodological design or analytical application.[1]

[1] Portions of this methodological note were created with support from generative AI tools. In line with the HCSS Maxims for Responsible Use of Generative AI, the use of these tools served only to augment the analytical process, not to substitute expert judgement. All AI generated suggestions were verified for accuracy, authenticity, and integrity. Sweijs, T., Kommandeur, J., and de Ruijter, A. (2024). Augmentation, Not Substitution. HCSS Manual for the Responsible Use of Generative AI.

2. Conceptual Foundation

This section establishes the conceptual basis for the GINA Economic framework by clarifying how international investment and international trade are understood and applied in this project. Because both phenomena involve structured and observable cross-border interactions between state-based economic units, they form complementary layers of the wider economic environment that GINA seeks to analyse. Clear definitions are essential for ensuring that these interactions can be measured consistently, compared across economies, and represented accurately within a network-science approach. Section 2.1 outlines the core elements, forms, and drivers of international investment, while Section 2.2 develops an equivalent foundation for international trade. Together, these concepts provide the groundwork for the typology in Section 3 and for understanding how patterns of ownership and exchange shape the structure and evolution of global economic networks.

2.1. International Investment

2.1.1. Definition

International investment refers to the cross-border acquisition of lasting financial interests in the assets, activities, or enterprises of another economy. Unlike short-term capital movements, these relationships involve a continuing stake that allows investors to exercise a meaningful degree of influence or control over foreign enterprises. In the academic literature, this lasting interest is commonly associated with ownership levels that enable managerial influence. The ten percent voting-power benchmark has become a widely used reference point in studies of foreign direct investment (FDI) and is treated as the practical boundary between direct and portfolio capital[2]. Through these forms of involvement, international investment creates stable cross-border linkages that place firms, capital, and decision-making structures within foreign jurisdictions rather than generating temporary or speculative claims.[3]

International investment takes a variety of forms. Multinational firms may acquire equity in foreign companies, extend intra-group loans to affiliates abroad, or establish new production facilities in other economies. Despite their diversity, these activities share several core features. Capital crosses borders, the resulting relationships are intentional and structured, and investors gain some influence over how economic activity is organised and managed abroad. Through these mechanisms, international investment integrates economies into wider production systems and financial networks that connect activities across multiple territories.[4]

A further characteristic of international investment is that these relationships evolve over time. Positions can deepen through reinvested earnings, grow through additional equity purchases, or contract through divestment. They also shift in response to changing market conditions, regulatory reforms, and broader macroeconomic developments that alter the returns to holding assets abroad. These changes are captured in investment position data, which record the accumulated stock of cross-border claims at specific points in time rather than the transactions that occur within a given year.

This definition provides the conceptual basis for the analysis that follows. By focusing on lasting influence, cross-border ownership, and the long-term nature of investment positions, it distinguishes

[2] Alan M. Rugman, 'Internalization as a General Theory of Foreign Direct Investment', in *Inside the Multinationals 25th Anniversary Edition: The Economics of Internal Markets*, ed. Alan M. Rugman (Palgrave Macmillan UK, 2006), https://doi.org/10.1057/9780230625167_2.
[3] Ahmed Nazzal et al., 'A Systematic Mapping Review of Foreign Direct Investment by Multinational Corporations in Emerging Economies', *Humanities and Social Sciences Communications* 12, no. 1 (2025): 266, https://doi.org/10.1057/s41599-025-04571-y.
[4] Stephen H. Hymer, 'The International Operations of National Firms, a Study of Direct Foreign Investment' (Thesis, Massachusetts Institute of Technology, 1960), https://dspace.mit.edu/handle/1721.1/27375.

international investment from short-term capital movements and aligns with the operational choices applied in GINA Economic.

2.1.2. **Forms of International investment**

International investment takes different forms depending on the nature of the financial relationship established between the investor and the foreign enterprise. For analytical clarity, four broad forms are distinguished here: equity investment, intra-group debt investment, reinvested earnings, and ownership reallocation through corporate restructuring. These forms vary in how influence is exercised and how capital is deployed, but all involve lasting cross-border financial ties that can shape economic behaviour across jurisdictions.

Equity investment involves acquiring ownership shares in a foreign enterprise. Equity stakes create long-term relationships in which the investor gains voting rights and participates in strategic decision-making. Academic research consistently identifies equity ownership as the core mechanism through which multinational firms extend managerial influence abroad.[5]

Intra-group debt investment refers to the provision of loans, trade credits, or other financial claims between parent firms and their foreign affiliates. Although these claims do not alter equity ownership, they establish sustained financial links within multinational groups. Recent studies highlight intra-group lending as a key channel through which global firms manage capital, finance operations, and transmit financial conditions across borders.[6]

Reinvested earnings represent retained profits that foreign affiliates reinvest rather than distribute. These reinvested resources strengthen the existing investment relationship by increasing the investor's claims on the foreign enterprise and deepening the cross-border capital link. They are widely recognised in the literature as a major contributor to the expansion of international investment positions over time.

Ownership reallocation reflects changes in cross-border positions that result from mergers, acquisitions, divestments, or corporate restructuring. While these activities are not measured directly, they shape the evolution of investment positions by shifting control and capital across borders. Research on international business emphasises that restructuring events are central to how multinational enterprises adjust their global portfolios and redistribute assets internationally.[7][8]

In practice, these forms often overlap. Firms may deploy debt and equity simultaneously, reinvest profits to expand operations, or adjust ownership structures through acquisitions or divestments. The distinctions nevertheless provide a coherent typology that aligns with how international investment is recorded in investment position data, which capture the accumulated stock of these relationships at specific points in time, as operationalised in Section 3.

2.1.3. **Causes and Drivers**

International investment is shaped by the interaction of structural, situational, and relational drivers. These factors do not determine investment outcomes on their own, but together they influence where cross-border capital flows, how investment relationships form, and how they evolve over time.

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[5] John H. Dunning, *Explaining International Production*, with Internet Archive (London ; Boston : Unwin Hyman, 1988), http://archive.org/details/explainingintern0000dunn.
[6] Stefan Avdjiev et al., *Tracking the International Footprints of Global Firms*, 11 March 2018, https://www.bis.org/publ/qtrpdf/r_qt1803f.htm.
[7] Ahmed Nazzal et al., 'A Systematic Mapping Review of Foreign Direct Investment by Multinational Corporations in Emerging Economies', *Humanities and Social Sciences Communications* 12, no. 1 (2025): 266, https://doi.org/10.1057/s41599-025-04571-y.
[8] United Nations Conference on Trade and Development, *World Investment Report 2023* (2023), https://unctad.org/system/files/official-document/wir2023_en.pdf.

Structural drivers refer to long-term conditions that make some economies more attractive destinations for sustained foreign investment. Research consistently highlights market size, macroeconomic stability, governance quality, infrastructure, and institutional reliability as central determinants of investment decisions[9][10]. Countries with predictable regulatory environments, strong contract enforcement, and developed financial systems are more likely to attract investment that establishes lasting ownership or managerial influence. Conversely, weak governance, political uncertainty, or limited productive capacity can constrain the ability of foreign investors to form durable economic linkages.

Situational drivers are short-term shocks or changes that can trigger, redirect, or suppress investment flows. These include economic crises, commodity price swings, abrupt policy shifts, changes in leadership, and sudden adjustments in interest rates or global financial conditions. Such dynamics alter risk perceptions and expected returns, often leading multinational enterprises to re-evaluate the viability of holding assets abroad. Empirical work shows that situational shocks can temporarily accelerate inflows when new opportunities emerge, or reduce positions sharply when local or global instability increases.[11]

Relational drivers concern how investment is embedded within broader international networks of production, finance, and policy. Modern multinational enterprises organise activities across borders in globally integrated structures, meaning investment decisions are influenced by regional value chains, global corporate strategies, bilateral investment treaties, and economic ties with key partner countries.[12] These relational conditions can amplify investment flows within regional blocs, shape patterns of ownership concentration, or channel capital disproportionately toward economies with strong historical or institutional linkages. As a result, international investment does not occur in isolation but is often part of a wider system of cross-border corporate connections.

Together, these drivers show that investment relationships reflect both long-run structural conditions and dynamic changes in the global economy, as well as the relational architectures in which firms operate. Understanding these factors provides the foundation for analysing how international investment positions evolve over time and how they shape broader patterns of economic interdependence.

2.1.4. **Dynamics and Trajectories**

International investment develops as a process that changes in scale, composition, and strategic orientation over time rather than as a single financial transaction. Investment relationships often expand when firms increase equity stakes, reinvest earnings, or channel additional intra-group financing to their foreign affiliates. These shifts can deepen ownership ties, broaden the scope of cross-border operations, or transform limited holdings into more significant commitments. In many cases, periods of expansion are followed by phases of consolidation as firms respond to profitability pressures, regulatory adjustments, or evolving market conditions. Strategic pauses, reduced capital allocation, or gradual divestment may temper growth without dissolving the underlying investment relationship.[13]

Investment endings vary widely. Some relationships conclude through deliberate divestment that reverses earlier commitments, while others unwind through mergers, acquisitions, or corporate

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[9] Parfait Bihkongnyuy Beri and Gabriel Mhonyera, 'Macroeconomic Drivers, Governance, and Foreign Direct Investment in Central and Eastern European Countries (CEECs)', *Economic and Business Review* 25, no. 3 (2023): 131–45, https://doi.org/10.15458/2335-4216.1323.
[10] European Central Bank, 'Foreign Direct Investment and Its Drivers: A Global and EU Perspective', European Central Bank, 26 June 2018, https://www.ecb.europa.eu/press/economic-bulletin/articles/2018/html/ecb.ebart201804_01.en.html.
[11] 'Drivers of Foreign Direct Investment Inflows to Emerging Asian Economies - Pami Dua, Neha Verma, 2024', accessed 25 November 2025, https://journals.sagepub.com/doi/10.1177/09726527231196722.
[12] Nazzal et al., 'A Systematic Mapping Review of Foreign Direct Investment by Multinational Corporations in Emerging Economies', 2025.
[13] 'Drivers of Foreign Direct Investment Inflows to Emerging Asian Economies - Pami Dua, Neha Verma, 2024'.

restructuring that shifts ownership to new actors.[14] Many investment links do not terminate fully but instead settle into stable plateaus in which positions remain relatively constant even as local or global conditions fluctuate. These enduring arrangements can generate cycles of adjustment, including renewed capital injections or partial withdrawals when incentives shift. Understanding these dynamics is essential for interpreting changes in investment positions across time and for analysing how cross-border economic relationships strengthen, weaken, or transform within the global investment network.

2.1.5. **Analytical Purpose**

Taken together, these conceptual foundations clarify what international investment is, how its main forms differ, and which factors shape its development and evolution over time. They provide the analytical basis for understanding international investment as a system of cross-border economic relationships rather than as isolated financial transactions. The following sections translate these concepts into an operational typology and a network-science approach that identifies economies and investment positions as interconnected nodes and links. This enables GINA Economic to represent patterns of ownership, capital flows, and financial embeddedness as dynamic networks, allowing for systematic comparison across economies and across time periods.

2.2. International Trade

2.2.1. **Definition**

International trade refers to the cross-border exchange of goods between state-based economic units, recorded and regulated through national customs systems. In its most general sense, trade captures how economies procure, supply, and redistribute material products in the global marketplace. Because these exchanges are documented by states, they provide observable and comparable evidence of economic interaction grounded in verifiable transactions. Contemporary research emphasises that merchandise trade forms the material basis of global production networks and supply chains, linking national economies through flows of intermediate inputs, raw materials, and final goods.[15] These exchanges reflect underlying economic structures and reveal patterns of interdependence that shape exposure to external shocks, access to markets, and the distribution of strategic capabilities across states.

Within this project, trade is defined in line with the conventions used by the United Nations Statistics Division, which records bilateral flows of goods reported by national statistical authorities and processed within the UN Comtrade system. This definition covers only merchandise trade and excludes services, financial transfers, and informal or non-recorded exchanges.[16] Each transaction involves at least two identifiable state entities, a reporting economy and a partner economy, and is expressed in monetary value as documented at the border. Because states differ in production capacity, consumption needs, and technological sophistication, trade data reflect both structural economic characteristics and the choices states make when sourcing or supplying goods.[17] These interactions can indicate complementarities in production, dependencies on critical inputs, or the presence of long-standing commercial ties.

International trade also differs from broader concepts of economic globalisation or national competitiveness. It does not measure the movement of capital, labour, or services, nor does it capture firm-level bargaining power or price formation within domestic markets. Instead, it represents recorded cross-border movements of goods that can be consistently aggregated, compared, and mapped across time in a network-science framework. This focus aligns with the structure of UN Comtrade, which

[14] *World Investment Report 2023*.
[15] World Trade Organization, *Global Value Chain Development Report: Beyond Production* (WTO iLibrary, 2021), https://doi.org/10.30875/7eb92281-en.
[16] United Nations Department of Economic and Social Affairs, *International Merchandise Trade Statistics: Compilers Manual - Revision 1* (United Nations, 2017), https://doi.org/10.18356/baa992f0-en.
[17] OECD, 'Interconnected Economies: Benefiting from Global Value Chains', OECD, OECD Publishing, 27 May 2013, https://doi.org/10.1787/9789264189560-en.

provides systematically processed, commodity-classified, directional records of exports and imports. Because these records identify both the sending and receiving state, they can be translated into directed and weighted ties between actors and incorporated into the GINA Economic network model.[18]

2.2.2. **Forms of International Trade**

International trade takes multiple forms that reflect how goods are produced, differentiated, and exchanged across borders. These forms represent established patterns in the global economy and help clarify the types of material relationships that develop between states. Although each form originates from distinct economic mechanisms, all describe structured exchanges that can influence how national industries evolve and how economies connect within wider systems of production.

Inter industry trade captures exchanges in which countries trade goods from different sectors of the economy. This pattern is characteristic of economies that specialise according to their relative factor endowments or resource advantages. Studies in international economics show that states with different technological capacities or natural resource bases tend to exchange dissimilar goods, such as raw materials for manufactured products or agricultural goods for chemicals.[19] This form reflects broad complementarities between trading partners and often persists over long periods.

Intra industry trade refers to the exchange of goods within the same sector or product category. It is common among economies with comparable technological structures or consumer markets, where firms produce differentiated versions of similar goods. Research on product differentiation and market integration highlights that this type of trade increases as industries become more diversified and as states share production capabilities that support variety-based competition.[20] Intra industry flows reveal the depth of industrial integration between economies.

Value chain trade describes exchanges involving intermediate inputs, components, and specialised equipment that move across borders during the production process. As production has become more fragmented internationally, goods increasingly cross multiple jurisdictions before final assembly. Global value chain research shows that these interactions link states through sequences of production tasks and create dense connections between national industries.[21] This form highlights how economies participate in distributed manufacturing systems.

Strategic goods trade concerns exchange of commodities or manufactured items that hold particular importance for economic resilience, technological capability, or national security. These include critical minerals, energy carriers, industrial machinery, and advanced technological components. Recent policy analyses note that concentrated dependence on a limited number of suppliers for such goods can generate strategic vulnerabilities or restrict policy options during periods of disruption.[22] This form draws attention to areas where trade relationships carry heightened political or economic significance.

Together, these forms provide a structured way to interpret the diversity of goods moving across borders. They clarify the functional role that different categories of trade play in shaping economic relationships and provide a basis for analysing how states position themselves within regional and global production systems.

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[18] World Trade Organization, *World Trade Statistical Review 2023* (WTO iLibrary, 2023), https://doi.org/10.30875/9789287074195.
[19] Andrey A. Gnidchenko, 'The Conflicting Ways to Dissect Intra-Industry Trade', *FIW Working Paper Series*, FIW Working Paper series, FIW, September 2019, 193, https://ideas.repec.org//p/wsr/wpaper/y2019i193.html.
[20] Lionel Fontagne and Michael Freudenberg, *Intra-Industry Trade : Methodological Issues Reconsidered*, 1 February 1997.
[21] World Trade Organization, *Global Value Chain Development Report: Beyond Production* (WTO iLibrary, 2021), https://doi.org/10.30875/7eb92281-en.
[22] COMMISSION STAFF WORKING DOCUMENT Strategic Dependencies and Capacities Accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Updating the 2020 New Industrial Strategy: Building a Stronger Single Market for Europe's Recovery (2021), https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52021SC0352.

2.2.3. **Causes and Drivers**

International trade is shaped by the interaction of structural, situational, and relational drivers. These factors do not determine trade outcomes on their own, but together they influence how goods move across borders, how trading relationships develop, and how they adjust over time.

Structural drivers refer to long term conditions that influence the composition and direction of trade. Economic size, production capabilities, factor endowments, and technological development all contribute to the types of goods a country can produce competitively. Research shows that differences in resource availability encourage inter industry trade, while similarities in industrial structures facilitate intra industry exchange.[23] Long standing participation in global value chains also creates stable roles for economies within specialised stages of production, reinforcing trade patterns that persist even when market conditions fluctuate.[24] These structural features create the baseline incentives that shape sustained commercial interaction.

Situational drivers reflect short term developments that can redirect existing trade flows or alter their intensity. Sudden supply disruptions, changes in domestic demand, policy reforms, or price shocks in global commodity markets can shift the direction of trade within relatively short periods. Studies of global supply chains document that shocks such as natural disasters, financial crises, or public health emergencies can prompt rapid reorganisation of sourcing and production arrangements.[25] Policy shifts, including temporary export controls or tariff adjustments, can similarly reshape incentives for firms and governments, leading to measurable but often temporary changes in bilateral trade patterns. These situational factors introduce variability into otherwise stable trading relationships.

Relational drivers concern the position of states within broader commercial and institutional networks. Long standing trade partnerships, regional integration processes, and participation in trade agreements structure expectations about market access and regulatory stability. Network oriented research shows that economies tend to trade more intensively with partners to whom they are institutionally or historically connected, and that such ties can shape the formation of dependencies in strategically important goods.[26] These relational conditions help explain why some trade links remain strong despite shifts in underlying structural or situational drivers, highlighting the embeddedness of trade within wider systems of cooperation.

Together, these drivers show that trading relationships reflect a combination of enduring structural conditions, dynamic shifts in global markets, and the broader network architectures in which states are embedded. Understanding these factors provides the foundation for analysing how trade patterns evolve over time and how they contribute to wider forms of economic interdependence.

2.2.4. **Dynamics and Trajectories**

International trade develops as a process that shifts in scale, composition, and direction over time rather than as a set of isolated exchanges. Trade relationships often expand when economies increase production capacity, diversify export structures, or integrate more deeply into global value chains. These developments can broaden the range of goods exchanged, intensify flows in established sectors, or position states more centrally within regional production systems. Research indicates that expanding industrial capabilities and the deepening of supply chain linkages tend to reinforce cross border exchanges and increase the movement of intermediate goods.[27] In many cases, periods of expansion are followed by phases of adjustment as firms and governments respond to changing costs,

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[23] Gnidchenko, 'The Conflicting Ways to Dissect Intra-Industry Trade'.
[24] Organization, *Global Value Chain Development Report* (WTO iLibrary, 2021).
[25] Gary Gereffi, 'What Does the COVID-19 Pandemic Teach Us about Global Value Chains? The Case of Medical Supplies', *Journal of International Business Policy* 3, no. 3 (2020): 287–301, https://doi.org/10.1057/s42214-020-00062-w.
[26] World Trade Organization, *World Trade Report 2019: The Future of Services Trade* (WTO iLibrary, 2019), https://doi.org/10.30875/7e6f8c91-en.
[27] OECD, 'COVID-19 and Global Value Chains: Policy Options to Build More Resilient Production Networks', *OECD Policy Responses to Coronavirus (COVID-19)*, ahead of print, OECD Publishing, 2 June 2020, https://doi.org/10.1787/04934ef4-en.

technological developments, or fluctuations in global demand. Strategic recalibration, selective sourcing changes, or moderated shipment volumes may temper earlier growth without dissolving the underlying trade relationship.

Trade contractions vary considerably. Some relationships decline gradually as industries relocate or as competitiveness shifts, leading to a sustained reorientation of sourcing patterns. Others change more abruptly in response to external shocks, such as geopolitical tensions, transport disruptions, or commodity price volatility. Studies on production network resilience show that such shocks can generate short term breaks in established trade routes, followed by gradual reconfiguration as firms adapt and seek alternative suppliers.[28] Many trade links do not disappear entirely but instead stabilise at consistent levels, with flows remaining relatively steady even as broader market conditions fluctuate. These settled patterns can still experience periodic adjustments, including renewed growth or further consolidation when incentives shift. Understanding these dynamics is essential for interpreting changes in trade flows across time and for analysing how cross border exchange relationships strengthen, weaken, or reorganise within the wider international trading system.

2.2.5. **Analytical Purpose**

The concepts outlined above clarify how international trade operates as a system of material exchanges that connect states through varying forms, drivers, and trajectories. By distinguishing the types of goods exchanged and the conditions that shape their movement, this framework provides a basis for interpreting trade as a set of structured relationships rather than a collection of isolated transactions. These distinctions make it possible to identify which links are broad and diversified, which are shaped by specialised production processes, and which reflect concentrated or strategically significant dependencies. In the network approach used in this study, each trade interaction becomes a directed and weighted connection between states. This translation allows patterns of exchange, exposure, and interdependence to be represented as part of a wider international structure that can be compared across actors and periods.

[28] Chenggang Wang et al., 'The Impact of Global Value Chain Restructuring on the OFDI Transformation of Manufacturing Industry: Evidence from China', *Sustainability* 17, no. 12 (2025), https://doi.org/10.3390/su17125448.

3. Typology and Data Sources

This section provides a guide to the data foundations of GINA Economic by outlining the two core sources used to map economic linkages between states. It explains how the IMF's Direct Investment Positions dataset captures long-term cross-border investment ties, how UN Comtrade records and harmonises global merchandise trade flows, and why the analysis uses aggregated HS sections to represent trade patterns. It also describes the country standardisation step that ensures consistent actor definitions across all datasets. Together these elements establish a coherent, comparable basis for constructing the investment and trade networks used in later analysis.

3.1. IMF Direct Investment Positions Data

Foreign direct investment (FDI) reflects long-term cross-border relationships in which investors exercise control or significant influence over enterprises abroad. To capture these relationships in a consistent and comparable way, the International Monetary Fund compiles the Direct Investment Positions by Counterpart Economy (DIP) dataset, formerly the Coordinated Direct Investment Survey (CDIS)[29]. The dataset provides a structured overview of bilateral inward and outward direct investment positions and enables systematic analysis of the geography of global investment ties[30].

DIP is based on coordinated reporting by a large group of economies and covers data annually from end December 2009 onward. Its methodological framework follows the IMF's Balance of Payments and International Investment Position Manual, Sixth Edition (BPM6)[31], and the OECD's Benchmark Definition of Foreign Direct Investment, Fourth Edition (BD4)[32].

Direct investment is defined as a cross-border relationship in which a resident investor holds at least 10 percent of the voting power in a foreign enterprise. This threshold signals the presence of sustained managerial influence and distinguishes direct investment from portfolio holdings that do not provide meaningful control.

Inward direct investment refers to the equity and debt positions through which foreign investors hold claims on domestic enterprises, while **outward direct investment** reflects the equity and debt positions through which domestic investors hold claims on enterprises abroad.

The DIP dataset reports **positions**, which are stock measures that show the value of direct investment at the end of each year. Positions capture how much investment is held between economies at a specific point in time. They differ from flows, which record the investment transactions that occur during the year. DIP therefore tracks only the accumulated value of cross-border investment links and does not include flows, reinvested earnings or income data.

Financial instruments in DIP include both equity and debt relationships between affiliated enterprises. Equity covers listed shares, unlisted shares and other equity. Debt includes deposits, loans, debt securities and trade credit between direct investors and their direct investment enterprises.

Resident financial enterprises, which are banks, holding companies and other firms whose main activity is financial intermediation, are shown separately because they often channel investment that

[29] IMF, 'Direct Investment Positions by Counterpart Economy (Formerly CDIS)', 2025, https://data.imf.org/en/datasets/IMF.STA:DIP.
[30] Rita Mesias, 'The Coordinated Direct Investment Survey Guide 2015', in *The Coordinated Direct Investment Survey Guide 2015* (International Monetary Fund, 2015), https://www.elibrary.imf.org/display/book/9781513519418/9781513519418.xml.
[31] International Monetary Fund, *Balance of Payments and International Investment Position Manual, Sixth Edition (BPM6)* (2009), https://www.imf.org/external/pubs/ft/bop/2007/bopman6.htm.
[32] Organisation for Economic Co-operation and Development (OECD), *OECD Benchmark Definition of Foreign Direct Investment - Fourth Edition* (Paris, 2009), https://doi.org/10.1787/9789264045743-en.

ultimately originates elsewhere. These entities can act as pass-through points, meaning large volumes of direct investment may flow through them without being intended for use in the domestic economy. Distinguishing financial from non-financial enterprises therefore helps analysts identify when investment positions reflect genuine economic relationships and when they reflect financial routing or the activity of global financial centres.

For our analysis, we focus only on inward and outward net direct investment positions for resident enterprises that are not financial intermediaries. This choice directs attention to investment links in the real economy, since non-financial enterprises represent genuine productive activity rather than financial routing. Using net positions highlights the overall balance of investment between country pairs, and including both equity and debt provides a complete picture of the underlying bilateral investment relationships.

3.2. UN Comtrade International Trade Data

International trade flows shape geopolitical relationships by revealing the material exchanges that underpin economic interdependence, supply chain exposure, and strategic dependencies. To capture these exchanges in a systematic and globally comparable way, the United Nations Statistics Division (UNSD) maintains UN Comtrade, the central repository of official international merchandise trade statistics. The database consolidates exports and imports reported by almost 200 countries and areas, providing harmonised long-term series of bilateral trade flows across thousands of commodity categories.

UN Comtrade compiles data submitted by national statistical offices and customs authorities and standardises them using internationally agreed commodity classifications – including the Harmonized System (HS), the Standard International Trade Classification (SITC), and specialised conversion tables that map across versions and systems. The dataset provides both trade values and quantities or weights when reported, ensuring that the flows of goods can be analysed in financial, physical, or mixed terms.

Trade flows in Comtrade are recorded as bilateral interactions, with each reporting country listing its exports to or its imports from every partner economy. Because countries may differ in their reporting practices, such as valuation methods (FOB vs. CIF), commodity detail, or attribution of trading partners, UNSD conducts extensive processing that includes classification conversion, validation, detection of anomalies and the estimation of missing quantity information. This improves comparability across countries and years, although national reporting asymmetries still remain.

Commodities are disaggregated into detailed product codes. HS classifications provide granular coverage of goods ranging from raw materials to complex manufactured products, while SITC categories support analysis over longer historical series. Each record includes the reporter, partner, product code, year, monetary value and, when available, physical volume or weight. Supplementary units such as litres or number of items are included when they are reported or when they can be statistically estimated.

Comtrade's **temporal coverage** is comprehensive: many countries report data back to 1962, with annual updates processed and published throughout the year following national submissions. This long-term consistency enables the analysis of structural shifts in trade patterns, supply chain transformations, and evolving dependencies between states. Data availability varies by country and commodity, and confidentiality restrictions may occasionally suppress detailed flows. Nonetheless, Comtrade remains the most complete and authoritative source of global merchandise trade statistics.

Table 1: H2 Chapters used for Commodity Aggregation

Chapter Name	H2 Codes
Live Animals; Animal Products	01, 02, 03, 04, 05
Vegetable Products	06, 07, 08, 09, 10, 11, 12, 13, 14
Animal, Vegetable or Microbial Fats and Oils	15
Prepared Foodstuffs; Beverages, Spirits and Vinegar; Tobacco	16, 17, 18, 19, 20, 21, 22, 23, 24
Mineral Products	25, 26, 27
Products of the Chemical or Allied Industries	28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38
Plastics and Articles Thereof; Rubber and Articles Thereof	39, 40
Raw Hides and Skins, Leather, Furskins, Articles of Animal Gut	41, 42, 43
Wood and Articles of Wood; Wood Charcoal	44, 45, 46
Pulp of Wood or of Other Fibrous Cellulosic Material; Paper and Paperboard	47, 48, 49
Textiles and Textile Articles	50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63
Footwear, Headgear, Umbrellas, Prepared Feathers, Artificial Flowers	64, 65, 66, 67
Articles of Stone, Plaster, Cement, Asbestos, Mica; Ceramic Products; Glass and Glassware	68, 69, 70
Natural or Cultured Pearls, Precious or Semi-Precious Stones, Precious Metals	71
Base Metals and Articles of Base Metal	72, 73, 74, 75, 76, 78, 79, 80, 81, 82, 83
Machinery and Mechanical Appliances; Electrical Equipment	84, 85
Vehicles, Aircraft, Vessels and Associated Transport Equipment	86, 87, 88, 89
Optical, Photographic, Cinematographic, Measuring, Checking, Precision Instruments	90, 91, 92
Arms and Ammunition; Parts and Accessories Thereof	93
Miscellaneous Manufactured Articles	94, 95, 96
Works of Art, Collectors' Pieces and Antiques	97

Although UNSD applies extensive validation and harmonisation procedures, UN Comtrade retains both the data reported by each country and the corresponding mirror data reported by its partners. As a result, a reporter's recorded exports to a partner may not match that partner's recorded imports from the reporter. These asymmetries arise from differences in valuation, timing, reporting practices or partner attribution, and they are not reconciled within the database.

To analyse trade patterns at a manageable level of detail, we collected data at the two-digit level of the Harmonized System (HS2) and aggregated these codes into broader commodity sections following the official HS 2022 classification maintained by the World Customs Organization.[33] This grouping consolidates hundreds of detailed product categories into economically meaningful sections while preserving the international comparability of the underlying trade data.

[33] World Customs Organization (WCO), 'HS Nomenclature 2022 Edition', 2022, https://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/hs-nomenclature-2022-edition/hs-nomenclature-2022-edition.aspx.

Table 2: Overview of Data Sources

Dataset	What It Measures	Source	Coverage	Level of Analysis	Use in GINA Economic
IMF Direct Investment Positions (DIP)	Bilateral stocks of inward and outward foreign direct investment measured as year-end positions.	International Monetary Fund (IMF), Direct Investment Positions by Counterpart Economy (formerly CDIS).	2009–2024 (annual; end-of-year).	Country–country positions by inward/outward direction, instrument (equity/debt) and sector.	Only net positions for resident non-financial enterprises are used. These map to directed weighted edges between states. Edge weights represent net direct investment positions (all instruments). Actor set includes only states.
UN Comtrade International Merchandise Trade Statistics	Bilateral flows of goods recorded as exports, imports, values and quantities.	United Nations Statistics Division (UNSD), UN Comtrade Database.	1913–2024 (annual; varies by reporter).	Country–country–commodity flows at aggregated H2 levels.	Data collected at H2 level and aggregated into HS sections. Trade flows map to directed edges between states. Edge weights represent total trade value over selected years. Actor set includes only states.

3.3. Countries standardization

To ensure consistency across datasets and prevent mismatches in naming or country definitions, the GINA series uses an internal reference table as the master standard for all country and state entities. In GINA Economic, both datasets were parsed and all country entries were automatically matched to this reference; ambiguous or unmatched cases were resolved through manual verification. The table links a unique numeric identifier to a harmonised country name that is used across all pages, charts, and network components. This harmonisation step ensures that actors are represented consistently across time and across data sources, and establishes a coherent actor base before network construction begins.

4. Network Construction

This section describes how the GINA Economic framework translates international investment and trade data into two relational network layers. Each layer is constructed directly from position- or transaction-level records and follows clear rules for defining nodes, edges, weighting, and temporal selection. Section 4.1 outlines how bilateral FDI positions become an investment network capturing cross-border ownership links, while Section 4.2 explains the construction of the trade network based on UN Comtrade flows. Section 4.3 details the shared visual logic applied to both layers. Together, these procedures ensure transparent, reproducible, and conceptually aligned representations of global capital integration and merchandise exchange.

4.1. Investment Network

The foreign direct investment (FDI) layer translates bilateral position data from the IMF DIP dataset into a relational structure that captures how states are linked through cross-border ownership. This operationalisation builds directly on the concepts and data conventions outlined in Section 3.1, where inward and outward positions are defined.

Node set. Nodes represent all economies appearing in the DIP dataset as either reporting economies or counterpart economies. Coverage follows DIP's country list with the naming standardization described in Section 3.3, producing a state-level network consistent with the geographical definitions described in Section 3.1.

Position-to-edge translation. Each filtered DIP record becomes a directed interaction between two economies. Direction follows the ownership logic defined in Section 3.1, with inward positions treated as edges from the foreign investor to the reporting economy and outward positions treated as edges from the reporting economy to the foreign destination. Records lacking complete dyadic information are excluded.

Edge aggregation and weighting. All position records for the same ordered state pair are aggregated into a single directed edge. Edge weight equals the reported stock value for that relationship in current USD. Negative values arising from disinvestment or valuation adjustments are preserved analytically but visualised using absolute values for consistent edge scaling. Threshold filters allow users to focus on economically significant relationships.

Temporal selection. Temporal filtering occurs before graph construction. Users may select a single year or a multi-year interval, and the network visualises the most recent year in the selected period to reflect the stock nature of FDI, as described in Section 3.1. Multi-year selection is used for comparison rather than aggregating stock values.

The resulting investment network represents cross-border capital relationships, where directed edges indicate the direction of ownership links and edge weights reflect their scale. This approach highlights major investment corridors, the role of financial hubs, and the asymmetries that structure global capital integration. Because it directly reflects position-level FDI data from the IMF DIP dataset, the network provides a consistent and transparent representation of international investment patterns that complements the trade layer of GINA Economic.

4.2. Trade Network

The trade layer of the GINA Economic network translates bilateral merchandise trade flows from the UN Comtrade database into a relational structure that captures how economies exchange goods. This

operationalisation follows directly from the data framework outlined in Section 3.2, which defines trade flows as documented interactions between a reporting economy and its trading partner.

Node set. Nodes represent all economies appearing as either reporters or partners within the selected period. This includes sovereign states and recognised customs territories, following UN Comtrade's geographical classification without modification. As a result, the trade network consists only of state-level economic units, aligning with the territorial definitions used in Section 3.2.

Transaction-to-edge translation. Each row in the filtered Comtrade dataset corresponds to a bilateral trade flow between two economies in a specific year. For every record with valid reporter and partner identifiers, a directed interaction is created between the two economies. Direction follows standard trade conventions: export records generate edges from reporter to partner, while import records generate edges from partner to reporter. Records with missing dyadic information are excluded. This produces a directed graph in which edges represent verifiable flows of goods.

Edge aggregation and weighting. Multiple transactions between the same ordered pair of economies are aggregated into a single directed edge. Each transaction contributes a weight equal to its recorded monetary value, and the final edge weight reflects the total value of goods traded between the two economies during the user-selected period. Users may examine all goods or restrict the dataset to specific commodity groups, but in all cases edge weights represent the scale of commercial exchange rather than the number of transactions.

Commodity disaggregation. Commodity filtering is based on the HS classification structure described in Section 3.2. Users may focus on individual commodity groups or aggregate across all goods. This enables comparisons between sector-specific trading patterns and broader structures of economic interdependence.

Temporal selection. Temporal filtering is applied before graph construction. Users may select a single year or a multi-year range, and only transactions within the chosen interval are included. Multi-year selections aggregate monetary values across all years in the period, producing a cumulative representation of sustained commercial relationships.

The resulting trade network represents international goods exchange as a weighted, directed structure in which edge weights capture the scale of bilateral commerce. This approach highlights major trading hubs, regional clusters, and long-standing dependencies within global supply chains. Because it directly reflects transaction-level data from UN Comtrade, the network provides a transparent and reproducible representation of cross-border trade that complements the investment layer of GINA Economic.

4.3. Visual Representation

Both network layers use a common visual logic to ensure that structural differences between conflict and cooperation networks reflect the underlying data rather than presentation choices. The layout, colouring, and highlighting mechanisms are identical across the two layers, providing a consistent basis for comparison.

Layout algorithm. Nodes are positioned using a ForceAtlas2-based force-directed layout. This algorithm places actors closer together when they share strong or frequent connections and farther apart when their ties are weaker or absent.[34] This creates a map of the network where clusters emerge naturally from the data: actors involved in many interactions tend to appear near the centre, while those with fewer links move toward the edges. Because the conflict and cooperation layers use the same layout rules, any differences in how the networks look stem from the underlying relationships rather than from the visual method itself.

[34] Mathieu Jacomy et al., 'ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software', *PLOS ONE* 9, no. 6 (2014): e98679, https://doi.org/10.1371/journal.pone.0098679.

Colour Assignment. In both layers, node colours represent communities detected through a greedy modularity algorithm. The method groups actors that are more closely connected to one another than to the rest of the network.[35] Using the same approach for conflict and cooperation ensures that colour patterns reflect the structure of each network rather than predefined categories. Clusters therefore emerge from the interaction data itself, making visual differences comparable across layers.

Node and edge size. Visual prominence in both networks is driven by the underlying edge weights. Edge thickness reflects the weight assigned during network construction, meaning that frequently interacting conflict dyads or high-value arms transfer pairs appear with thicker links. Node size is derived from the same logic and is calculated by summing the weights of all edges connected to a given actor. In the conflict network this highlights actors involved in many recorded violent events, while in the cooperation network it highlights states participating in substantial volumes of arms transfers.

Together, these shared visual rules ensure that both layers can be interpreted using the same intuitive cues. Differences in structure, clustering, or actor prominence therefore reflect genuine variation in patterns of violence and cooperation rather than artefacts of design. This coherence allows users to compare the two networks directly and to identify how conflict and cooperation patterns align, diverge, or overlap within the broader economic landscape.

Table 2: Summary of Network Construction Choices in GINA Economic

Feature	Investment Layer	Trade Layer
Underlying Data	IMF Direct Investment Positions (DIP) dataset	UN Comtrade International Merchandise Trade Statistics
Nodes	All economies listed as reporting or counterpart economies in DIP	All economies listed as reporters or partners in Comtrade
Edges	Bilateral FDI positions; each inward or outward record creates a link	Bilateral trade flows; each import or export record creates a link
Directionality	Directed	Directed
Edge Definition	Inward: foreign → domestic; Outward: domestic → foreign	Export: reporter → partner; Import: partner → reporter
Edge Weighting	Stock value of FDI positions (absolute USD) aggregated per dyad	Total trade value (USD) aggregated per dyad
Node Size Logic	Sum of all inward and outward FDI values linked to that economy	Sum of all import and export values linked to that economy
Layout Method	ForceAtlas2-based force-directed layout (shared across layers)	ForceAtlas2-based force-directed layout (shared across layers)
Community Detection	Greedy modularity algorithm (optional)	Greedy modularity algorithm

[35] Heru Cahya Rustamaji et al., 'Community Detection with Greedy Modularity Disassembly Strategy', *Scientific Reports* 14, no. 1 (2024): 4694, https://doi.org/10.1038/s41598-024-55190-7.

5. Analysis and Visualization

This section explains how the outputs of GINA Economic can be interpreted and how the different visualization support analytical use. The dashboard translates the methodological choices described in earlier sections into interactive network views, maps and quantitative indicators. Section 5.1 illustrates the types of insights that users can draw from the network visualisations, both at the global level and for selected states. Section 5.2 introduces the complementary tools available on each page, including geographic representations, summary metrics and temporal trends, and describes how these elements contribute to a fuller understanding of conflict and cooperation patterns. Together, these components guide the reader in using GINA Economic as an exploratory and comparative analytic environment.

5.1. Network Analysis

This section presents examples of how the GINA Economic dashboard can be used to derive analytical insights from the trade and investment networks. Although the two layers capture different types of interactions, their shared visual and structural logic allows them to be interpreted side by side. At the global level, the networks reveal broad patterns of clustering, centrality and structural division. At the state level, they highlight how individual countries relate to others through both violent and cooperative ties. Taken together, these examples illustrate how the network approach can uncover meaningful patterns in the international economic environment and support more informed analysis of global financial and commercial interactions.

5.1.1. Global dynamics

The global trade and investment networks for 2024 display a highly interconnected structure with a clearly identifiable periphery composed of smaller economic actors. In the trade network, the United States and China emerge as the two dominant nodes. China occupies a bridging position between the core and the periphery, functioning as the primary conduit through which peripheral countries maintain significant trade flows. These peripheral actors are largely located in Africa, Asia, and South America. The United States, by comparison, is more closely integrated into the dense core of the network, maintaining substantial trade flows with major economic powers in Asia and Oceania, including Japan, South Korea, Singapore, Australia, and the Philippines, as well as with European partners. Germany appears as the third-largest node and is positioned close to both the United States and China, with a slight orientation toward the Asian and Oceanian cluster.

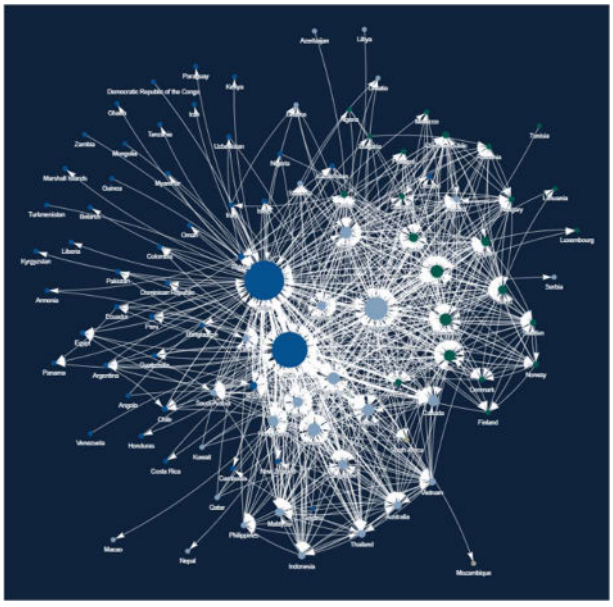

Figure 1 - Global network of goods trade (2022-2024)

This highlights that, compared with other European economies such as the United Kingdom and France, Germany sustains a broader pattern of extra-regional trade engagement. Community detection outcomes align closely with expectations regarding regional proximity and economic weight. Countries in the grey community are predominantly European, those in green are mainly Asian and Oceanian, and the blue community consists of major powers and peripheral states. This indicates that geographic proximity continues to correlate strongly with the intensity of trade flows.

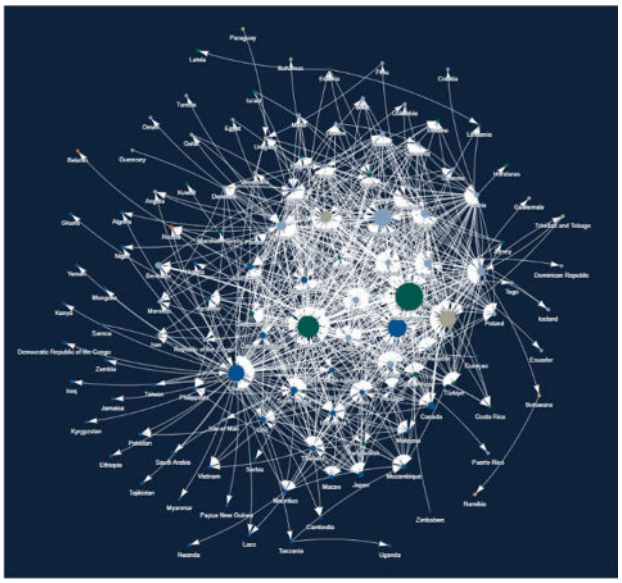

Figure 2 - Global network of Foreign Direct Investment (2022-2024)

The investment network exhibits a different configuration. It does not feature dominant actors to the same extent as the trade network. Instead, the two largest nodes are Germany and the Netherlands, followed by Hong Kong and Luxembourg, and then the United States and China. In this case, community detection captures regional structures less clearly. For example, European countries appear across multiple clusters, suggesting that investment patterns are shaped less by geography and more by institutional or financial specialisation. It is notable, however, that China again connects strongly to several peripheral countries, primarily through outward investment. This reinforces the observation that China maintains significant economic ties with smaller states not only via trade but also through direct investment activities.

5.1.2. **State Comparisons**

Considering the 500 biggest trade flows of all goods from 2022 to 2024 for Ukraine, Russia and Iran a few considerations can be made: first, Russia (the big node in blue) still maintains solid reported trade interactions with many countries, including ones that have comparable trade with Ukraine. Among these we find Japan, Belgium and Egypt. China has the biggest role in the network outside of the three selected countries. Moreover, there are countries that share substantial interactions with all three countries, Iran included, like India, Italy and South Korea.

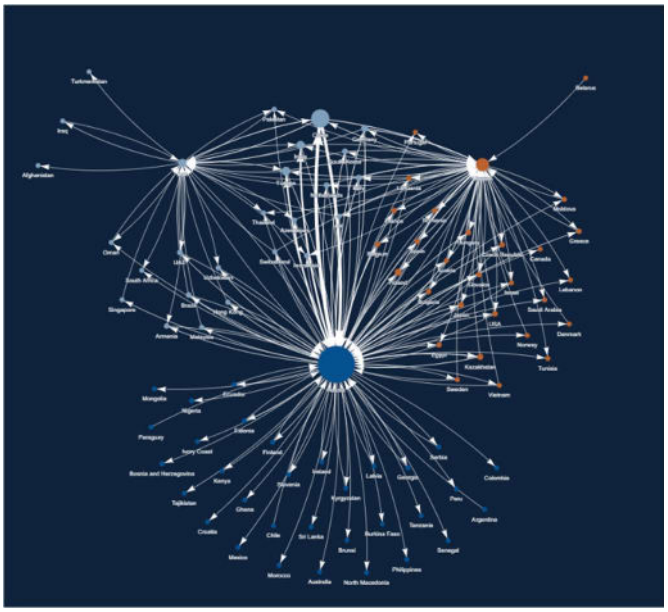

Figure 3 - Largest trade flows for Ukraine, Russia and Iran (2022-2024)

5.2. Additional visualizations

Beyond the network layers, GINA Economic provides several complementary visualisations that allow users to explore spatial patterns, quantitative summaries and temporal trends. These tools offer alternative entry points into the data and help contextualise the relational structures shown in the network views.

5.2.1. **Map-based patterns**

Both the trade and investment layers include a global map visualisation that summarises country-level economic activity for the selected period. In the trade layer, the choropleth displays total trade volume

(imports and exports combined), or can be filtered to show only imports or exports, highlighting major trading nations and regional patterns of commercial integration. In the investment layer, the map can show total FDI stock, inward positions (foreign claims on domestic enterprises), or outward positions (domestic claims on foreign enterprises), making it possible to identify major investment hubs and patterns of cross-border ownership concentration.

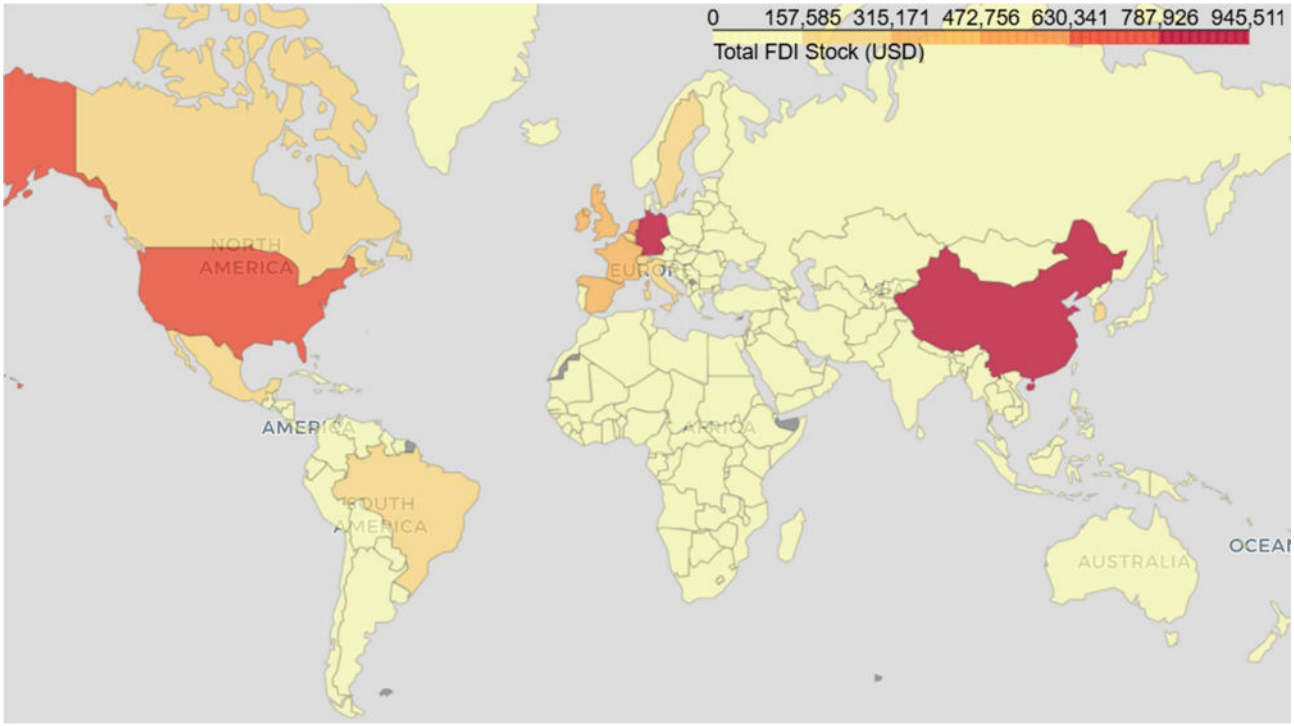

Figure 4 - Map of FDI stocks (2024)

The map also functions as an entry point into the state-level view: selecting a country on the map directly loads its corresponding network and metrics. This provides an intuitive bridge between spatial patterns of economic activity and relational structures of bilateral exchange.

5.2.2. **Quantitative Overview**

Both layers present a set of summary statistics that provide a quick overview of the magnitude and direction of activity in the selected period. In the conflict layer, these include total events, total fatalities and the number of active conflict dyads, each shown with a year-on-year change to indicate escalation or de-escalation. In the cooperation layer, statistics summarise the number of transfers, total SIPRI TIV value and counts of imports and exports, again with a delta relative to the previous year. These indicators offer a compact snapshot of the broader trends that underpin the network structures and help users situate individual actors or regions within global patterns.

5.2.3. **Temporal Dynamics**

A dedicated time-series view in both layers illustrates how trade and investment activity evolves over time. For trade, users can track changes in import and export volumes across the selected period, identifying patterns of commercial growth, regional integration or shifts in commodity flows linked to economic policy changes. For investment, time series show inward and outward FDI positions or total stock values, helping reveal long-term ownership relationships, surges in cross-border investment or the emergence of new bilateral investment patterns.

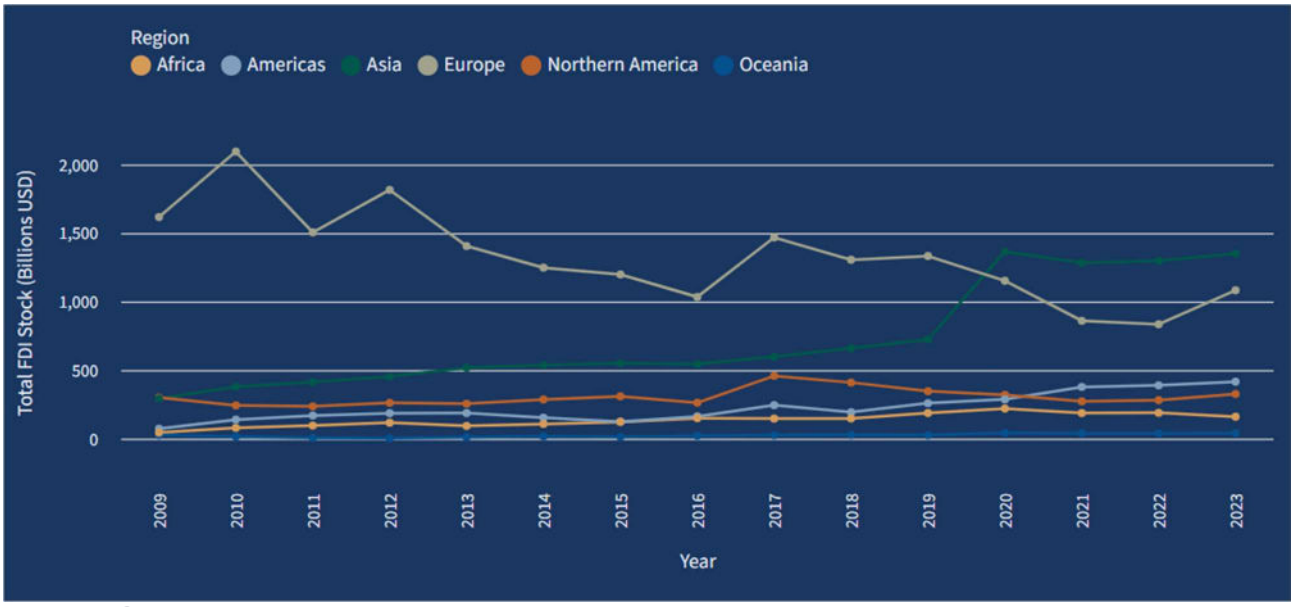

Figure 5 - Global-level time series tool for Investment page

Users may choose different chart types (area, line or bar) and aggregation levels (global totals, regional breakdown, or commodity groups for trade), allowing them to switch between cumulative and discrete visual styles depending on the analytical question.

6. Limitations

This section outlines the main constraints that affect how GINA Economic data and results should be interpreted. Section 6.1 highlights limitations in the underlying IMF and UN Comtrade datasets, including inconsistent country reporting, valuation differences, confidentiality gaps and the fact that both sources capture stocks or gross flows rather than finer-grained dynamics. Section 6.2 explains how methodological choices such as aggregation, simplified edge weighting, the absence of advanced network metrics and small layout variations introduce additional analytical boundaries.

6.1. Data Limitations

Several considerations arise when interpreting the FDI and trade data used in the GINA Economic framework. The IMF Direct Investment Positions (DIP) dataset depends heavily on the quality and consistency of national statistical reporting. Not all economies provide complete bilateral data, and some positions may reflect gaps in coverage rather than true economic relationships. Inward and outward positions reported by different countries often do not match because of differences in valuation practices, reporting schedules, or exchange rate adjustments. FDI values also represent investment stocks at the end of the year, not flows or reinvested earnings, which limits the extent to which short-term investment dynamics can be inferred from the dataset.

The UN Comtrade database similarly relies on customs and statistical agencies for complete and accurate reporting. Coverage varies across economies and years, and some countries apply confidentiality rules that suppress the values of specific commodities. Reporter and partner data frequently differ because exports are reported on an FOB basis while imports are recorded on a CIF basis. Additional discrepancies arise from time lags, transhipments, and different partner attribution rules. Comtrade records gross trade flows, which do not indicate domestic value added or distinguish between production and re-export. These factors should be considered when interpreting trade patterns, particularly in comparisons across countries or product categories.

Although these limitations do not invalidate the underlying data, users should remain aware that the structure of the investment and trade networks may reflect reporting practices as well as real economic relationships.

6.2. Methodological Limitations

The methodological design of GINA Economic aims to provide a clear and accessible representation of cross-border ownership and exchange, but it necessarily simplifies several complex processes. Converting position-level and transaction-level data into network structures requires aggregation choices that may conceal relevant detail. For investment data, aggregation combines multiple position types into a single edge weight and represents stocks rather than the flow of capital over time. For trade data, aggregation across years merges short-term fluctuations with long-term structural relationships. These choices improve comparability but also reduce temporal specificity.

The current version of GINA Economic does not compute advanced network metrics such as centrality, equivalence, or clustering scores. It is primarily designed for visualization and exploratory analysis rather than for rigorous quantitative modeling. Layout algorithms introduce small random variations that can

change node placement slightly between runs. Differences in temporal coverage and country lists between DIP and Comtrade also limit the ability to make perfect cross-layer comparisons. Finally, both underlying datasets are updated periodically rather than continuously, and they may contain definitional inconsistencies that affect the precision of derived indicators.

Despite these constraints, GINA Economic provides a transparent and reproducible framework for examining broad patterns of global trade and investment. Future versions will introduce deeper analytical functionality and improved integration of economic indicators.

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