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Sanctions, supply chains, and strategic realignments:

the impact of recent geopolitical tensions on international business

Master's thesis

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Table of Contents

Introduction

The international economic order that defined the post-Cold War era, characterized by deepening integration, the expansion of global value chains, and the broad assumption that commercial interdependence promotes peace, is undergoing a profound transformation. In the space of less than a decade, the world has witnessed the onset of the US-China trade war, the most comprehensive sanctions regime ever imposed on a major economy in the case of Russia, and a growing willingness among states to use economic networks for geopolitical purposes. These developments have not only disrupted bilateral trade flows, but they have called into question the very foundations on which multinational enterprises have organized their supply chains, investment strategies, and market presence for the past three decades.

Economic sanctions, broadly defined as the threat or act of disrupting economic exchange with a target state to achieve political objectives, have become the primary instrument of statecraft short of military force. The Global Sanctions Data Base records over 600 active sanction cases as of 2022, a dramatic increase from approximately 20 in the 1950s. Yet despite their proliferating use, the relationship between sanctions and international business remains insufficiently understood, particularly at the intersection of trade flow dynamics, supply chain restructuring, and corporate strategic responses. While literature examines sanction effectiveness from a political science perspective, the international business implications: how firms and value chains absorb, adapt to, and are reshaped by these measures, are much less predominant in existing studies.

This thesis aims at addressing this gap by examining the impact of recent geopolitical tensions on international trade patterns and supply chain configurations. Specifically, it investigates two major sanction regimes: the US-China trade war initiated in 2018 through Section 301 tariffs and subsequent technology export controls, and the Western sanctions imposed on Russia following the 2014 annexation of Crimea and, with dramatically greater scope, the 2022 full-scale invasion of Ukraine. These cases were selected for their significance in terms of affected trade volume, their variation in sanction design and escalation patterns, and their direct relevance to contemporary debates on interdependence, deglobalization, and supply chain resilience.

The research is guided by four research questions and corresponding hypotheses:

H1: Economic sanctions significantly reduce bilateral trade flows between sanctioning and target countries.

H2: Trade diversion occurs as sanctioned countries and their trading partners redirect commerce to alternative markets.

H3: Technology-intensive sectors experience greater trade disruption than commodity sectors under sanction regimes.

H4: Recent geopolitical fragmentation has led to declining global trade openness and economic integration.

The analytical approach is primarily empirical and descriptive, employing a before-and-after comparative design that examines trade flows across distinct temporal periods for each case. Data are drawn from three institutional sources: UN Comtrade for bilateral trade flows, Eurostat for EU-Russia trade, and the World Bank World Development Indicators for global trade openness. The analysis proceeds through five stages: bilateral trade trend analysis, trade diversion assessment using indexed import growth, sectoral decomposition comparing technology-intensive and commodity sectors, global integration evaluation through trade openness metrics, and a comparative synthesis of findings across cases. The theoretical framework draws on Dunning's eclectic paradigm, institutional theory, global value chain governance theory, and the theoretical perspective drawn from literature to interpret empirical patterns.

The thesis is structured as follows. Chapter 1 establishes the theoretical foundations by reviewing sanctions theory in international relations, political risk and international business strategy, global value chain vulnerability, and strategic responses to environmental discontinuities. Chapter 2 provides the geopolitical context, tracing the evolution of three major sanction regimes: the US-China trade war, Western sanctions on Russia, and the Iran sanctions that served as a template for the Russian case. It concludes by examining emerging patterns of deglobalization and the new economic order. Chapter 3 presents the empirical analysis, testing each hypothesis through descriptive statistical methods and presenting findings across bilateral trade effects, sectoral patterns, trade diversion dynamics, and global integration trends. Chapter 4 interprets the findings in their theoretical context, discusses corporate strategic response patterns with illustrative examples, offers recommendations for firms operating in sanctions-affected environments, and acknowledges the limitations and future research directions that emerge from this work.

Chapter 1

Theoretical foundations of sanctions and international business

1.1. Economic sanctions in international relations theory

In the current times, economic sanctions are a highly utilized "weapon" used in a modern geoeconomic warfare. In the era of a globalized world, interconnected economies, sanctions can devastate one's adversaries in a fashion akin to a military intervention, without much of the political and human cost the latter would entail. The general definition of a sanction is a threat or act by a state or group of states, called the sender, to disrupt economic exchange with another state, called the target, unless the targeted country complies to a given political demand (Drezner, 1999, p.19). As the data gathered by the Global Sanctions Data Base shows, the use of sanctions has grown exponentially since the early era of global economic integration in the 1950s and 1960s, to what we observe now, in the 2020s: from approximately 20 sanction cases to over 600 in 2022 – see figure 1. (GSDB-R4, 2026).

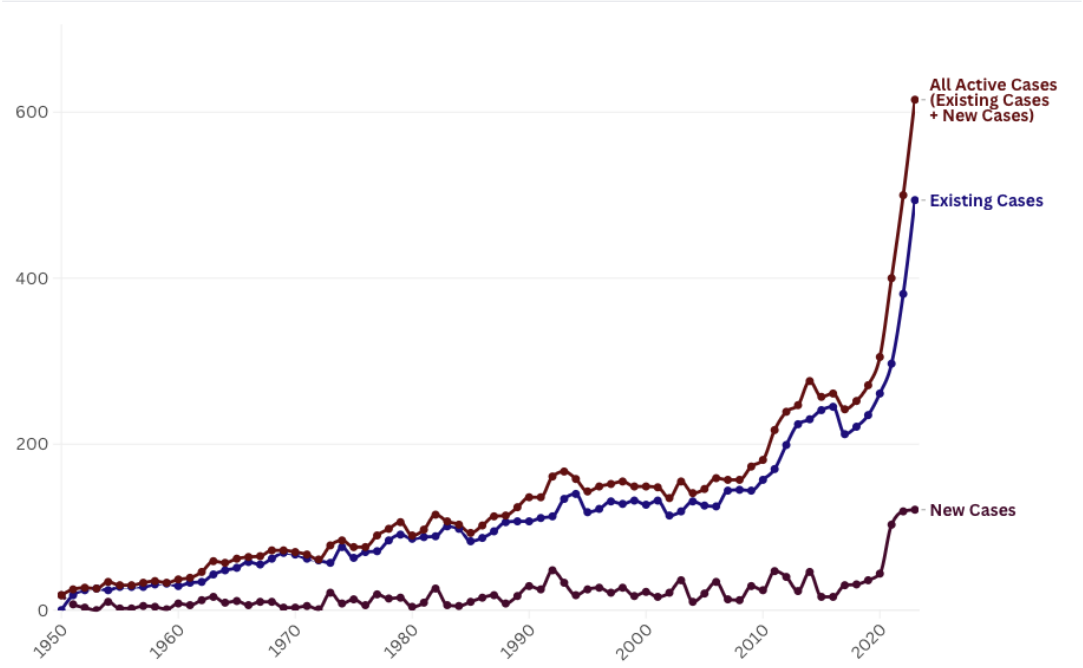

Figure 1. Sanctions over time. All active cases vs existing and new cases.

Source: Global Sanctions Data Base (GSDB), https://www.globalsanctionsdatabase.com/data/, access: 11th January 2026

In terms of effectiveness and significance, sanctions occupy the place between ineffective declarations like verbal condemnation and the use of deadly military force, that offers a low-cost method of coercion towards the achievement of political goals (Demarais, 2022, p. 10). The types of sanctions can be distinguished by multiple dimensions: Domestic or International; form, scope, target and legal basis. For the purposes of the shaping policy tools in the international relations, we shall investigate the definitions of the following sanction types:

1.1.1. Sanction typology

Trade sanctions are measures that restrict movement of goods and services between the sender of sanctions and the target country (Hufbauer, Schott and Elliott, 2008, p. 58). Types distinguished are:

- Export sanctions (controls): Restriction of goods exported from the sanction sender to the target country. The objective is to limit the supply of specific goods that can impede crucial operations of the target (i.e. high tech or military equipment),
- Import sanctions (boycotts): Restriction on the inflow of goods from the target country to the sender. The aim of this sanction is to limit access to the sender's market, effectively denying currency earnings.
- Comprehensive trade embargoes: Restrictions on all types of trade flows between the sender and the target, aimed at severing economic ties between the adversaries. While it is the broadest measure, it is typically difficult to enforce (Demarais, 2022, p. 23).

Financial sanctions are measures, whose intent is to disrupt financial flows to the target country, by using the leverage of the global banking system, which makes them easier to apply than trade sanctions, due to smaller number of global banking institutions (Hufbauer, Schott and Elliott, 2008, p. 30). Types distinguished are:

- Aid suspension: decrease or severance of financial or military government-to-government assistance,
- Credit and investment restrictions: blocking of access to commercial loans, financing or foreign direct investment (FDI); including the restriction of access to capital

markets or preventing the country and its national enterprises from medium- and long-term debt in the sender country,

- Asset freezes: severing access to the target country's assets existing in the sender's territory (bank accounts and its contents, investments and properties) belonging to the target governmental entities or representatives.

Smart (targeted) sanctions are an addition to the "classic" trade and financial sanctions framework, that aims in minimalization of collateral damage of sanctions toward the general population on the target country by direct targeting the decision makers and the "wealthy 1 percent" (Hufbauer, Schott and Elliott, 2008, pp. 152-155). Types distinguished are:

- Travel bans: entry denial or restrictions for the selected individuals from entering or travelling through the sender country(ies),
- Individual asset freezes: blockage of those bank accounts that belong to the selected individuals (decision makers, elites of the target country), effectively denying access of the accumulated wealth,
- Arms embargoes: restrictions on weaponry sales to conflict inflicted countries and adversarial regimes.

Sectoral sanctions are the most recent addition to the arsenal of economical coercion tools, targeting a specific area(s) of the target's economy, rather than all of it. There are meant to cripple strategic sectors while allowing other trade to continue. These types of sanctions were notably used against Russian Federation annexation of Crimea in 2014, by targeting financial, energy and military sectors of the Russian economy (Demarais, 2022, p. 52).

Secondary (extraterritorial) sanctions are a type that are applied to third parties which are actively dealing and doing business with the target (such as individuals, companies and other countries). They are meant to isolate the target in the international trade and force these actors to face a choice: either continue doing business with the target or lose access to the sender's economy (Blackwill and Harris, 2016, p. 15).

Other coercive instruments include:

- Cyber sanctions: the use of state-sponsored cyberwarfare to target a country's economic or financial infrastructure,
- Commodity/energy coercion: Manipulating the flow of critical resources (e.g., cutting off gas pipelines) to exert political pressure.

While not technically a sanction in a traditional sense, tariffs may be defined as sanctions when they are used to pressure countries to change policies that the sender might oppose (rather than being used as intended) meaning to address unfair trade practices. This use is widely attributed to weaponization of tariffs during the US presidency of Donald Trump. Characteristics of Trump-era sanction like tariffs is targeting specific products rather than broader economic activities and flows as well as using them as political leverage regarding non-trade disputes (e.g US imposing steel tariffs on Türkiye in order to negotiate the release of a detained pastor) (Forrer and Harrington, 2019, p. 76).

The categorization of sanctions goes from broad spectrum to narrower focus, as the interconnection of economies became more tightly woven together. The tools of coercion evolved from blunt, indiscriminatory instruments (trade and financial sanctions) to precision mechanisms aimed at achieving exact political and/or economic goals. But do the sanctions really do work?

1.1.2. Theoretical debate on sanction effectiveness

There is a persisting sentiment that "sanctions never work" and are used mostly as a symbolic gesture of action, rather than a strategic one. This notion has been perpetuated even by notable economists like George Shultz and Milton Friedman, who argued that sanctions are not effective instruments of policy making (Drezner, 1999, p. 27). Critics dispute the efficacy by presenting statistical data of sanctions' low success rates and arguments that policy makers enforce them in order to "demonstrate resolve" to allies and their constituents. Gary Hufbauer, Jeffrey Schott, and Kimberly Elliott (HSE) have challenged this rhetoric, through the foundational analysis of 174 case studies that concluded the sanction efficiency of around 34% of cases (including partially successful). Similar results were observed by Agathe Demarais, whose review of US sanction initiatives since the 1970s showed that these programs achieved their set goals in 13% of the instances and partially succeeded in 22% of

the cases (Demarais, 2022, p. 48) – which coincides with the HSE's study findings of roughly two-thirds failure rate (Hufbauer, Schott and Elliott, 2008, p. 172).

While the statistical reality of low success rate of sanctions in fact shows its ineffectiveness, the critiques are not entirely free of flawed thinking. Daniel Drezner explains the "sanctions paradox" by demonstrating that the existing literature experiences selection bias by spotlighting high-profile historical cases between adversarial nations, where mutual adversaries are willing to enact sanctions due to high domestic pressures, but concurrently fear that concession to the sanctions might reveal weaknesses and be exploited in the future conflicts. On the other hand, sanctions targeting allies, while being uncommon, have experience much higher efficacy due to avoidance of any conflict between allied nations (Drezner, 1999, p. 324).

Hufbauer, Schott and Elliott decide to dive deeper into why the sanctions are that ineffective and found the pattern where the sanctions are falling short of their objectives (Hufbauer, Schott and Elliott, 2008, p. 246). The simplest reason, they argue, is that the sanctions imposed are inadequate to the task, with their goals being to general, the means too gentle, and lacking multilateral support. Therefore, unilateral support, are less effective in a globalized economy, because target countries might find alternative trading partners. As an example, that's how Soviet Union evaded the US grain embargo in the early 1980s by partnering with nations like Argentina that stepped in to supply the much-needed grain (Drezner, 1999, p. 91).

Another failure point of the sanctions might come from the perceived expectations of the outcomes - most studies have assumed that the objectives of economic sanctions were to return to the status quo that prevailed prior to the act of aggression which brought the sanctions about. In reality, the aims of sanctions have been consistently less ambitious. Situations rarely return the situation to the *status quo ante* (the state of affairs that existed previously), which adds to the disappointment and unfavourable assessment.

Other criticisms points to sanctions having goals that are too ambitious, where the situation described by the Drezner's paradox occurs: the target country endures the economic hardships only to not show sign of concessions and yielding to the adversary. Sanctions often serve also as a "steam valve", with purpose to relieve domestic and allied pressures on politicians to take action in a face of a crisis, even when they themselves know the sanctions will likely fail to achieve any meaningful goals (Pomeranz, 2017, pp. 183–186).

While these observations and criticisms present a valid problem with the sanction mechanics and its real-world effectiveness, the proponents of them point out the important function of the sanctions, which is signalling. It postulates that, the sanctions function not only as tools of economic and political coercion, but also (or mainly, depending on the situation) as communicative acts. In order to be effective, sanctions must impose cost on both the sender and the target country, which subsequently sends a message conveying that the sender is prepared to face economic hardships which demonstrates serious intent which condemnations and verbal statements often do not carry. Furthermore, Drezner implies that, sanctions are often the "stalking horse", disguised for more serious, military threats – the target country might concede because of the signal of willingness to escalate the situation to a military stand-off.

1.1.3. Sender-target-third party dynamics

The international "game of sanctions" can be boiled down to a mechanism of interplay and interactions between the sender, the target and the third parties and these relationships are crucial to the desired outcome of the measures that are put in place. The following dynamics have been identified:

- Sender-Target Asymmetry: Senders are typically large economies (like the US) targeting smaller ones. The economic and political picture in the target country also shapes the outcome of the sanctions applied: usually smaller growth and higher inflation leads to a more successful result, however, if the target country is of an autocratic system, it might isolate itself from public pressure in order to prioritize survival over economic health (Hufbauer, Schott and Elliott, 2008, p. 246),
- Third-party cooperation: while the support of the allied and like-minded coalition of nations usually strengthens the sanctions, too broad of a coalition may be too difficult to sustain due to dilution of the measures and struggle to maintain consensus,
- "Black Knights": coercive measure often fail due to involvement from the third parties, known as "black knights", who provide assistance to the target countries - for example China coming to aid North Korea against the US imposed sanctions (Demarais, 2022, pp. 19-20).

While sanctions remain an important tool of coercion in the modern world of economic diplomacy, they are not without flaws, so in order for them to be effective, they need to incorporate multiple factors and behaviours of the economic actors (Early, 2015, pp. 10-11).

1.2. Political risk and international business strategy

Sanctions are bound to succeed if they will impact the economy of the target country either by creating scarcity or by altering behaviour of the companies that exist or cooperate with that country. In order to understand how that impact works, we need to explore the underlying mechanisms within the international business frameworks that transform these political statements and actions into shifts in investment, market entry and operational strategy.

1.2.1. Dunning's Eclectic Paradigm and location advantages

John Dunning's eclectic paradigm (OLI framework) published originally in 1979 hypothesizes that foreign direct investment (FDI) occurs when a company possesses Ownership-specific advantages (O), Location-specific advantages (L), and Internalization advantages (I) (Dunning, 1988, p. 6). These advantages are described as follows:

- Ownership advantage: For a foreign companies to successfully enter a market against their domestic competitors, it should have a superior competitive advantage in order to challenge the domestic firms that possess local knowledge and to offset the costs of operating from outside of that market. Dunning distinguishes 2 types of ownership advantages: Asset advantages, which comes from having exclusive access to specific assets like proprietary technology, trademarks or management skills, and transaction advantages that come from a capacity of multinational hierarchies to capture transactional benefits from a network of assets in different countries (risk diversification, global sourcing, sharing the overhead costs) (Dunning, 1988, p. 5),
- Location advantage: This variable addresses the "where" of production. Even if a firm possesses ownership advantages, it must determine whether to utilize them at home (and export) or combine them with immobile factor funds in a foreign country. Locational advantages are influenced by both the distribution of resources (e.g. labor costs, natural resources) and government interventions (e.g. tariffs, trade barriers).

Multinational enterprises (MNEs) may take advantage of market imperfections, such as transactional ones (e.g. leveraging beneficial tax regimes) and/or structural ones (tariff-jumping) (Dunning, 1988, p. 5),

- Internalization advantages: This variable addresses the "how" of international involvement. It explains why a firm chooses to exploit its and advantages through its own internal hierarchies (FDI) rather than selling or licensing them to independent foreign firms via the external market – it might occur when the external market for intermediate products fails which entails risk and uncertainty (like inability to enforce property rights). The greater the costs of transactional market failure, the more likely companies will internalize activities (Dunning, 1988, p. 6).

The right configuration of the advantages for the FDI to be beneficiary according to the OLI framework are as follows:

1. Net ownership advantages: a company has to maintain mobile assets that give it a competitive edge,
2. Internalization gains: a company must find it more beneficial to use its assets internally, rather than sell the rights,
3. Locational attractiveness: company must be profitable to utilize these assets in a foreign location, rather than exporting from its domestic market.

At first glance, sanctions fundamentally alter the location-specific variable of this equation, but they impact also other components to some degree, making FDI risky, costly or in some cases impossible. The impacts of sanctions to the particular advantages are:

- Impact to the location advantages: Dunning identifies "structural market distortions," specifically government intervention, as a critical determinant of locational advantage. Sanctions act as a severe form of government-induced distortion that degrades the location advantages of a target country. While a target market may possess desirable immobile factor endowments (e.g. natural resources or cheap labour), sanctions impose artificial costs (such as prohibitions on trade or financial barriers) that nullify these natural advantages (Dunning, 1988, p. 5),
- Impact to the ownership advantages: sanctions threaten to remove key ownership assets (e.g. access to US dollar, technology, banking) if the company deals with the

target country. Farrell and Newman describe how the U.S. uses "chokepoint effects" to deny firms access to critical technologies by restricting the export of crucial software or technology (e.g. microchips against Huawei), rendering company unable to compete globally or forcing them to change their supply chains (Farrell and Newman, 2019, pp. 44-46)

- Impact to the internalization advantages: Farrell and Newman point out that those networks that facilitate internalization (financial messaging via SWIFT, digital supply chains) have been "weaponized". It forces the companies to de-internalize (divestment). The legal/financial risk of maintaining a subsidiary becomes higher than the cost of exiting the foreign market.

Therefore, sanctions negatively impact FDI from forming, by distorting all the advantage components in the OLI framework, which theoretical prediction aligns with the behaviour of US and European companies in the years following the 2022 Russian aggression in Ukraine, when major MNEs started exiting Russian market in fear of reputational impacts (Ownership advantage), Russian government interventions (Locational advantage) or forced de-internalization and dissolving any joint ventures and local affiliations in that market (Internalization advantage).

1.2.2. Institutional theory and regulatory environments

In the context of economic statecraft and sanctions, institutional theory considers the way states and companies are shaped, restricted or enabled by local and international institutions and legal frameworks. The theory postulates that actors do not acting purely within a realm of economic rationality but rather adapt their organizations to maintain themselves within the institutional order. In short, firms respond to regulative, normative cognitive institutions and within the given frameworks. Sanctions disrupt that order.

Institutional theory in the context of sanctions explains how MNEs and countries adapt their behavior to survive within conflicting and rapidly shifting ruleset. Sanctions create a volatile regulatory environment where legal frameworks, norms, and coercive measures force actors to prioritize access to dominant financial networks over other business opportunities (Demarais, 2022, pp. 30-31). MNEs most often than not, face conflicting institutional pressures: on one hand, the laws of the domestic market against the regulations

of the foreign market (this becomes especially constrictive when dealing with a hegemon like the US). Companies experiencing such disruption, prioritize alignment with those institutions that are in charge of the critical resources needed for them to stay afloat. In an environment of tough EU regulations, an overwhelming number of MNEs choose to obey US institutions, knowing that losing access to US financial system is a matter of survival, whereas violating EU statutes is just an additional cost (Demarais, 2022, pp. 37-38).

Regulatory environment sits within the international institutions as a complex, everchanging web of legal rules, compliance requirements that govern international economic activities. Agathe Demarais points out that “every year around 1,000 regulatory bodies issue about 60,000 regulatory alerts. This represents 240 new rules to take into account every working day” (Demarais, 2022, p. 75), a deluge of new laws that forces companies to create enormous internal operations just to adhere to new changes, which creates volatility. This regulatory environment is often intentionally opaque or risky, which in turn is leading to "overcompliance." Because regulations are applied at both federal and state levels (creating a web of liability), and because the penalties for violation are catastrophic (e.g. the $8.9 billion fine against BNP Paribas), firms often exit markets entirely rather than navigate the regulatory complexity - a phenomenon known as "de-risking" (Demarais, 2022, p. 71). Weaponized interdependence theory argues that having jurisdiction over a network hub (like SWIFT or the internet) is insufficient; a state must have the domestic institutions to leverage it (Farrell and Newman, 2019, pp. 62-70). The U.S. could weaponize SWIFT (like it did with Russia) because it developed legal instruments and regulatory bodies (like the Treasury's OFAC) capable of enforcing compliance, weaponizing the regulatory environment as a coercive measure.

1.2.3. Geopolitical vs. country risk

For Multinational Enterprises and states in a globalized world, risk assessment cannot be shortsighted, and should encompass not only local, country specific risk assessments but also global ones. Creators of the GPR index, Caldara and Iacoviello define geopolitical risk (GPR) "as the threat, realization, and escalation of adverse events associated with wars, terrorism, and any tensions among states and political actors that affect the peaceful course of international relations" (Caldara and Iacoviello, 2022, p. 1194). The GPR index encompasses not only occurring instability (military conflicts, acts of terror), but also threats of such instabilities and the tension buildup. As the authors note, "the GPR index does not move during periods of economic and financial distress or around presidential elections, periods characterized by elevated policy uncertainty. By contrast, rises in the EPU index and VIX do not coincide with the Russian annexation of Crimea or with terrorist events other than 9/11", which makes it more reliable to assess geopolitical volatility (Caldara and Iacoviello, 2022, p. 1196).

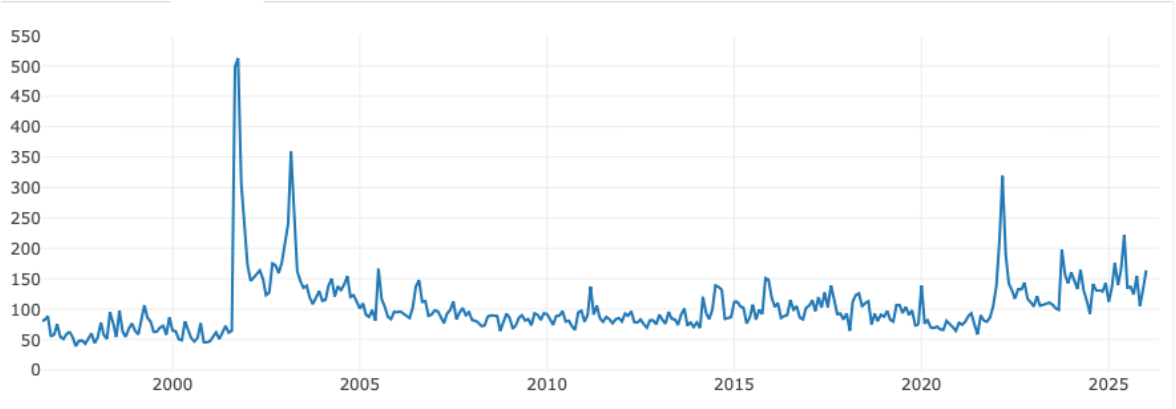

Figure 2: Geopolitical Risk index - years 1995-2026

Source: Geopolitical Risk (GPR), https://www.matteoiacoviello.com/gpr.htm, access: 11th January 2026

On the other hand, MNEs have to assess the risk of the unitary state they choose to operate within – the traditional risk assessment takes into account economic health and political stability, looking at factors such as inflation, unemployment rate and any signs of internal turmoil. In the context of firm internationalization, risk is viewed through the "liability of foreignness" (country-specific difficulties) or the "liability of outsidership" (lack of relationships within a network), which are hurdles related to entering a specific domestic

market rather than global power dynamics (Johanson and Vahlne, 1977, pp. 1, 21). The strategic implications of the country risk to states is focusing on creating favorable environments for FDI or protecting domestic industries for example by using tariffs. For MNEs, risk mitigation entails analyzing local market conditions, governmental overreach and minimizing transactional costs (Dunning, 1988, p. 22).

1.3. Global Value Chains and supply chain vulnerability

1.3.1. Defining Global Value Chain and its governance

From an international business perspective, a Global Value Chain (GVC) is defined as a complex governance structure in which production, distribution and consumption of goods and services are fragmented and spread across different locations (Kano et al., 2020, p. 596). It employs multiple modes of governance to manage distinct, fragmented and dispersed parts of the value chain. This concept relies on the fragmentation of the production processes, where different manufacturing processes are separated geographically from each other, then moved globally in order to achieve the highest possible degree of efficiency and localized advantages (Gereffi, Humphrey and Sturgeon, 2005, p. 78). The concept of the GVC is consequently being studied and as of now, thanks to research by Gereffi, Humphrey and Sturgeon, we can distinguish five types of GVC, ordered by its governance, based on the complexity of the transactions, standardization of information and supplier capabilities:

1. Market governance: the most basic type of governance, characterized by simple product specifications and high supplier capability. Its primary mechanism for governance being the price. Buyers and supplier can switch trading partners easily due to low costs.
2. Modular governance: this type of governance happens when transactions are complex but easily standardized with high supplier capabilities, which takes responsibility for technology and uses generic machinery. Coordination between actors is enabled due to transfer of codified information (e.g. technical specifications), which entails relatively low coordination. Switching supplier entails low cost.
3. Relational governance: this occurs when the transactions are complex and difficult to codify, and supplier capabilities are high. This creates mutual dependence and requires

high levels of coordination through interaction and exchange of knowledge. This governance relies heavily on trust, reputation and relational proximity.

4. Captive governance: exist within high codification and transactional complexity, but supplier capabilities are low and they are transactionally dependent on a larger lead companies – this governance requires high level of monitoring by the lead firm to ensure delivery and quality of the product.
5. Hierarchy governance: it is characterized by vertical integration, when transactions are complex, impossible to codify, with no capable suppliers available which forces to company to develop the products themselves – governance is achieved by internal, managerial control.

Different governances and structures of the GVC directly influences how sanctions impact them and the way the deal with or exploit those coercion tools (Gereffi, Humphrey and Sturgeon, 2005, p. 79):

- Switching costs and sanctions evasion: since for market and modular governance switching costs are relatively low, trade embargoes can be circumvented – when a sanctioned country/company can easily find alternative trade partners, they can successfully evade the imposed sanctions. However, for relational governance the same sanctions can be immensely disruptive as it relies on trust and proximity, meaning finding new partners is not as easy,
- Chokepoints: regardless of the governance type, GVC that rely on a central hub for its operations, it is vulnerable to chokepoint effects – since those hubs offer efficiency benefits to the firm and it's very difficult to operate without them, states that can control these hubs possess a uniquely powerful coercive tool by restricting or denying access to these hubs,
- Financial sanctions: most GVC rely on global payment systems or the US dollar, which creates a chokepoint capability for the US, allowing to control actors within the global economy,
- Export controls: by targeting codification link in the chain, export controls can single out GVCs with modular chains that rely on codified technical standards and intellectual properties. This cripples companies in those chains by restricting access to component specifications and software which these companies depend on. In

hierarchical chains, sanctions can be applied directly to the parent company which subsequently impacts its subsidiaries.

1.3.2. Efficiency-resilience trade-off

Before the current era of heavy sanctions usage, supply chains were designed to optimize cost and speed, often utilizing "just-in-time" (JIT) manufacturing principles. This approach viewed surplus capacity and inventory as "waste" to be eliminated (Christopher and Peck, 2004, p. 16). Firms sliced value chains into smaller segments to exploit location-specific advantages, creating a global factory designed for efficiency (Kano et al., 2020, p. 580). This resulted in highly integrated, complex networks where intermediate goods crossed borders multiple times. While efficient, these chains became highly volatile to global disruptions. The sanctions against the Russian aluminum giant Rusal in 2018 exposed this trade-off. Because global manufacturing relied on just-in-time aluminum supplies, the sanctions threatened to crash global supply chains, potentially forcing European carmakers to halt production lines entirely (Demarais, 2022, pp. 45-46). The removal of a key node in an efficient network causes immediate, cascading damage.

1.3.3. Supply chain robustness and redundancy

Redundancy involves maintaining backup suppliers, extra inventory, or spare production capacity – features previously eliminated to cut costs. Efficient supply chains often rely on single sourcing, where one supplier provides a specific item to maximize quality and cost control (Christopher and Peck, 2004, p. 3). This creates "critical paths" that are highly vulnerable to sanctions. Reintroducing redundancy is expensive. For example, decoupling from China means essentially building a redundant supply chain for technology to avoid security risks and potential sanctions, which in turn could cost US$1 trillion over five years (Demarais, 2022, pp. 52-53). In the semiconductor industry, replicating the supply chain outside of China and Taiwan to ensure resilience would require massive capital investment and result in higher production costs, effectively ending the era of cheap electronics.

Robustness differentiates from resilience; while resilience is the ability to recover from a shock, robustness is the ability to maintain function during the shock. States are attempting to build robust financial networks that can function despite U.S. sanctions

(Miroudot, 2020, p. 19). This includes creating alternatives to the SWIFT financial messaging system, such as China's CIPS (Cross-Border Interbank Payment System), which allows sanctioned entities to continue trading (Demarais, 2022, pp. 129-130). To achieve robustness against export controls China is pursuing a "dual circulation" strategy to make its domestic consumption and production self-sufficient, specifically investing billions to create a semiconductor supply chain without a need for the US (Antràs, 2020, pp. 33-34). This is a move away from global efficiency toward national robustness.

1.3.4. Application to sanction induced disruptions

Sanctions effectively "weaponize" the very interconnectivity that efficiency GVC has created.

- Chokepoints: Optimized supply chains often rely on central hubs or "chokepoints" (like the U.S. dollar financial system or specific high-tech components). Because efficient chains cannot easily bypass these hubs, sanctions applied at these points have devastating chokepoint effects (Farrell and Newman, 2019, p. 54).
- Secondary sanctions: The efficiency of GVCs means that sanctions on one target often hit allies and neutral third parties. The interconnectedness meant that European firms were caught in the "crossfire," forced to choose between the efficient Russian supplier and access to the U.S. financial system (Demarais, 2022, p. 54).
- Inventory vs. agility: While some argue for "just-in-case" inventory management (hoarding) to buffer against sanctions, evidence suggests that agility (the ability to reconfigure the network quickly) is more effective than simple redundancy (Miroudot, 2020, p. 19).

1.4. Strategic responses to environmental discontinuities

From a strategic management perspective, the era of weaponized interdependence forces firms to fundamentally rethink how they view assets, efficiency, and capabilities. While traditional theory emphasizes optimization and asset accumulation, the geopolitical landscape described in the sources necessitates a shift toward flexibility, redundancy, and dynamic adaptation (Teece, Pisano and Shuen, 1997, p. 511).

1.4.1. The Resource-Based View: when assets become liabilities

The Resource-Based View (RBV) considers that competitive advantage stems from the possession of company-specific assets that are rare, valuable, and difficult to imitate. However, in a sanctions-heavy environment, the very cohesion of these assets (which usually prevents them from being traded or moved easily) can transform them into significant vulnerabilities. High asset specificity increases the opportunity costs of deadlock in a coercion scenario. When investments are specific to a bilateral relationship (e.g., a pipeline or a factory adapted to local standards), the costs of substitution are high, making the firm (and its home state) more vulnerable to coercion (Drezner, 1999, p. 27). Geopolitical turbulence can also turn valuable assets into "hostages." ExxonMobil's experience in Russia illustrates this: despite discovering a giant oil field, U.S. sanctions forced the company to abandon the project. Because the assets were sticky and the political relationship deteriorated, Exxon took four years to extricate itself, eventually ditching its Russian assets entirely (Demarais, 2022, pp. 216).

Control over technical standards, usually a source of competitive advantage, can become a tool of exclusion. China's push to set standards in emerging technologies is an attempt to lock other countries into its technology stack, creating long-term advantages for Chinese companies while potentially excluding American ones (Blackwill and Harris, 2016, p. 33).

1.4.2. Strategic flexibility and real options

In an environment characterized by hard commitments and path dependencies, MNEs must adopt a "real options" mindset – treating investments not just as profit generators but as options that provide the right, but not the obligation, to act in the future. Pre-sanctions strategies prioritized efficiency (just-in-time), but sanctions require agility (the ability to reconfigure quickly). Maintaining spare capacity or diversified suppliers creates a "real option" to switch partners during a crisis. While efficient supply chains eliminate waste, resilient ones build in redundancy to withstand the removal of key nodes in the chain. This logic mirrors the behavior of states like China, which are willing to incur economic inefficiencies (such as buying more expensive energy or subsidizing domestic tech) to purchase the geostrategic option of autonomy from US pressure (Blackwill and Harris, 2016, p. 33).

1.4.3. Nearshoring, and decoupling

Strategic responses to the "weaponization of interdependence" increasingly involve altering the geographic footprint of the firm to minimize exposure to chokepoints. Firms and states are proactively trying to decouple themselves from global networks that can be weaponized against them (Farrell and Newman, 2019, pp. 76-77). For example, following U.S. actions against ZTE, China accelerated efforts to create domestic manufacturing capacities, effectively decoupling from global supply chains to mitigate vulnerability. The combination of geopolitical fragmentation and pandemic-induced disruptions has led multinationals to relocate production lines closer to consumers in a process called nearshoring. This trend suggests a shift toward regional supply chains serving the Americas, Europe, and Asia separately, replacing "unreliable global ones". Navigating this shift is costly because innovation and production are often tied to specific locations and long-term industrial investments. Unwinding these deep integrations (such as the semiconductor supply chain) to achieve "decoupling" is tremendously difficult and expensive (Verbeke, Coeurderoy and Matt, 2018, pp. 1103–1104).

1.4.4. Dynamic capabilities for geopolitical turbulence

Teece defines dynamic capabilities as the company's ability to "integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece, Pisano and Shuen, 1997, p. 511). This concept is crucial when the rules of the global economy are in turmoil. Companies must develop the capability to scan the geopolitical environment for threats, such as new sanctions or export controls. The rise of sanctions has elevated the compliance function from a back-office role to a strategic capability. Chief compliance officers now often report directly to the CEO, as the ability to navigate complex, overlapping sanctions regimes (e.g., U.S. secondary sanctions vs. EU blocking statutes) has become a matter of survival (Demarais, 2022, pp. 68-70). The ultimate dynamic capability is the capacity to transform the organization’s boundaries and partners. This is evident in the financial sector, where banks and firms must be prepared to switch transaction networks (e.g., away from SWIFT or the U.S. dollar) if they are targeted by chokepoint strategies. Similarly, technology firms like TSMC and Samsung are redesigning global supply chains, building foundries in the U.S. and China respectively, to maintain access to markets despite export controls (Blackwill and Harris, 2016, p.255).

Chapter 2

Geopolitical context: major sanction regimes and their evolution

2.1. The US-China trade war

We can observe in real-time one of the most significant economic conflicts, that are still unravelling. The US-China trade war started in January 2018, by the US president Donald J. Trump, who started imposing tariffs and trade barriers on Chinese imports as a way to address the massive US-China trade deficit (see figure 3). However, this conflict did not start in 2018 but was already brewing for years.

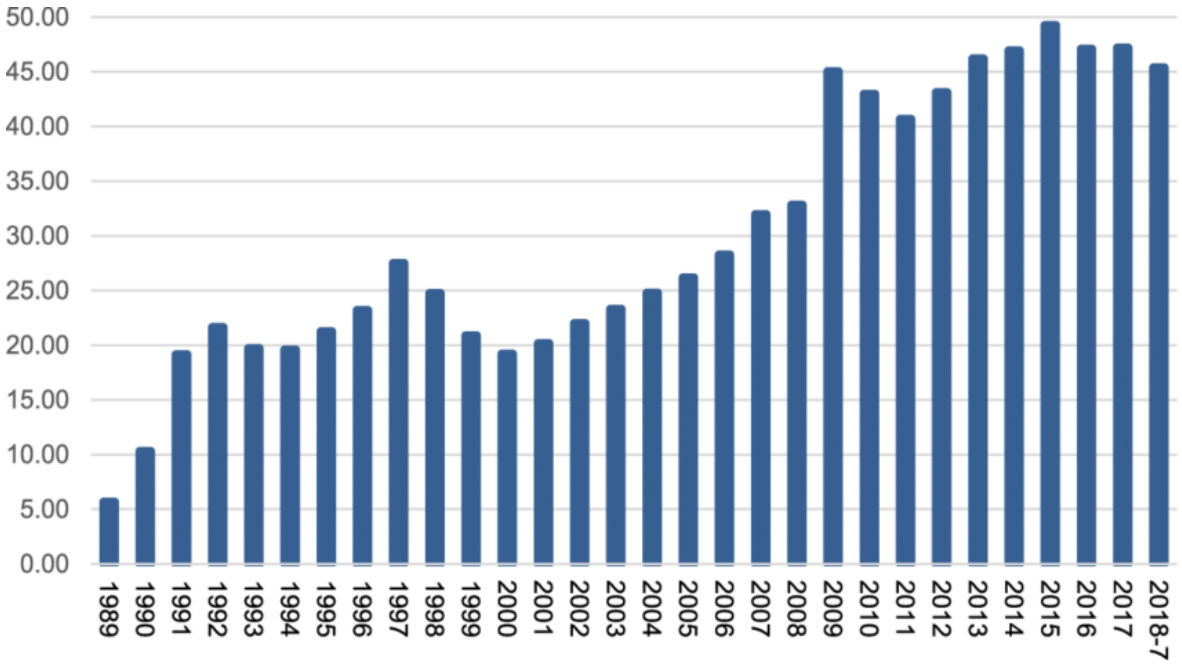

Figure 3: Share of US trade deficit with China in total: 1989-2018 (%)
Source: Xinguan and Zhang (2019, p. 381)

2.1.1. Pre-conflict tensions and structural imbalances

Decades prior to the trade war US policy had prioritized engagement and integration with foreign markets, however by 2017, an accumulated imbalance in trade in regard to China's economic model forced US to reevaluate the relationship. While the US in general has run a significant trade deficit since the late 1990s, the fastest growing, and consequently the largest trade imbalance the US aggregated with China. The import growth from China

started in 1985 and since then, the US has been running a persistent deficit, resulting in a total of approximately $504 billions of goods imported, while the US exports to China were only around $155 billions (Bown, 2021, p. 812). This imbalance has been a central political focus of a newly appointed Trump administration, in whose view the trade imbalance as unfair trade practices.

Other drivers for the upcoming conflict were outstanding grievances toward Chinese companies who were accused by the US of acquiring foreign technology through unfair means to support domestic technological and industrial policies like the "Made in China 2025", that envisioned reducing China's imports in support of their home production (Miller, 2022, pp. 219-220). The Office of the United States Trade Representative (USTR) identified four specific categories of acts, policies, and practices enforced by China that afflicted US commerce (Office of the United States Trade Representative, 2018):

- Forced technology transfer: China using ownership restrictions for foreign enterprises for pressuring US companies to transfer their technology to Chinese firms in order to gain market access,
- Discriminatory licensing: American companies that wanted to license their technologies in China were forced to do so on conditions favoring Chinese entities,
- State directed acquisition: China's government sought to obtain companies that specialized in manufacturing of critical technologies and components (like semiconductors) through unfair investment practices,
- Cyber theft: the USTR accused China of cyber hacks of US computer networks to steal confidential information and trade secrets.

An example of these unfair practices included the theft of US Micron's DRAM technology by the Chinese state-backed firm Jinhua and forced technology transfer deals where companies like IBM and AMD were forced to share their chip technology with Chinese partners to maintain access to the Chinese market (Miller, 2022, pp. 258-261).

2.1.2. Obama-Era concerns vs. Trump's politicization of trade

The US approach toward China has shifted tremendously in the wake of administration change. The previous, President Obama's administration, while focusing on US led innovation in technology and advanced industries, recognized by the end of the term China's export control violations and complaints about Chinese companies made by

domestic firms (Miller, 2022, p. 254). But rather than imposing stricter controls or sanctions, the administration turned to World Trade Organization (WTO) dispute management systems, bilateral dialogues with China through Strategic Economic Dialogue (SED) and establishing the Trans-Pacific Partnership (TPP) aimed at pressuring China (Bown, 2021, pp. 808-809).

The succeeding Trump administration did not share the same approach to dealing with the trade imbalances with China and effectively abandoned both the SED and TPP mechanisms and focused on addressing the existing grievances with existing executive frameworks established in the Trade Act of 1974: Section 232 (concerning national security) and Section 301 (concerning unfair trade practices) in order to impose tariffs and investment restrictions on China (Amiti, Redding and Weinstein, 2019, p. 201).

2.1.3. WTO limitations

The US under Trump administration moved toward unilateral actions (tariffs) in part due to frustration with the WTO's inability to address the "China model." The Trump administration argued that China's unfair subsidy behavior and non-market policies were not effectively disciplined by WTO rules (USTR, 2018) Furthermore, the administration actively dismantled the WTO's judicial function by refusing to appoint new members to the Appellate Body, effectively ending the binding dispute settlement system (Bown, 2021, p. 809).

2.1.4. Section 301 investigation and tariff escalation

The primary measure used by the Trump's administrations was Section 301 of the Trade Act of 1974. This statute grants the President broad authority to investigate and take action against foreign government acts, policies, or practices that violate international trade agreements or are found to be "unreasonable or discriminatory" and burden or restrict U.S. commerce (USTR, 2018). On March 22, 2018, the USTR released a comprehensive report supporting the finding that China's acts, policies, and practices were actionable under Section 301 with defined 4 categories of practices described in subchapter 2.1.1. Following the findings, the U.S. imposed tariffs in several waves throughout 2018 and 2019 (Bown, 2021, pp. 812-814):

- List 1: 25% tariff on approximately $34 billion of Chinese imports,
- List 2: 25% tariffs on an additional $16 billion,
- List 3: 10% tariffs on approximately $200 billion,
    - Escalation: Following a breakdown in negotiations in May 2019, the tariff rate on List 3 goods was increased from 10% to 25% effective June 2019,
- List 4: The administration announced tariffs on the remaining roughly $300 billion of imports, split into two lists (4A and 4B):
    - List 4A: 15% were imposed on approximately $101 billion,
    - List 4B: Tariffs on the remaining ~$151 billion (List 4B), largely consumer electronics and toys scheduled for December 2019, were cancelled.

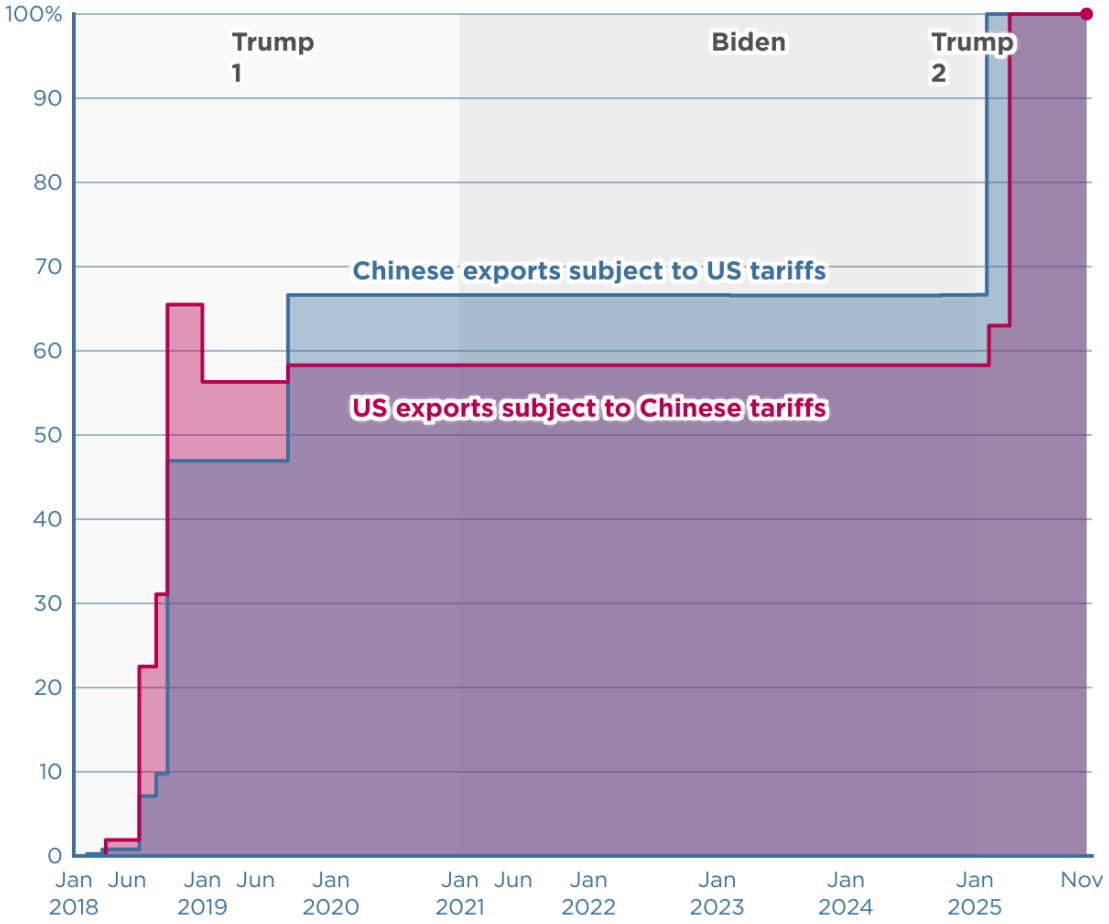

Figure 4. Percent of US-China trade subject to trade war tariffs (2018-2025)

Source: Peterson Institute for International Economics (Bown, 2025), access: January 11th, 2026

2.1.5. Chinese retaliation and the Phase-One Agreement

China retaliated against the U.S. Section 301 tariffs through a strategy that began as tit-for-tat matching (but shifted to asymmetric retaliation due to the trade imbalance between the two nations. In the initial phase of back-and-forth application of tariffs, China matched US actions within their own List 1 and List 2 (both 25% tariffs on US exports), but soon shifted to an asymmetric approach when US List 3 was unveiled with an amount the Chinese couldn't match; subsequently, China decided to scale down to smaller volumes at generally lower tariff rates (Bown, 2021, pp. 812-815). Chinese tariffs very much more selective than their American counterparts – targeting predominately agricultural sectors which hurt the states of political significance to Trump's administration (Feigenbaum and Khandelwal, 2021). While raising tariffs on US goods, China simultaneously lowered its Most Favoured Nation (MFN) tariffs for the rest of the world. Between 2018 and 2019, China reduced its average MFN tariff from 8.0% to 6.7%. This move was designed to ease the tough situation for Chinese importers by allowing them to switch to non-US suppliers at a lower cost, while further disadvantaging US exporters (Bown, 2021, p. 815).

This period of seemingly ever growing hostilities has come to a pause, when on January 2020, Washington and Beijing signed the Phase One agreement where both parties decided on slashing in half the list 4 tariffs, in an exchange for a commitment from China to purchase an additional $200 billion worth of US goods and service over the course of the next 2 years. However, most of the remaining duties have stayed put, still covering around two-thirds of the US imports from China (Bown, 2021, p. 832). Ultimately, partially due to COVID-19 disruptions, from which China wanted to recover, made them fall 40% short of the objective set for 2020.

2.1.6. Technology decoupling and Biden continuity

Technology decoupling reflects the shift in the US foreign policy during under President Trump, where technological capabilities of US companies has been weaponized to gradually erode capabilities of geopolitical adversaries, in particular China. Michel Alejandro Nova Alarcón describes technology decoupling as a reshaping coercive instrument (such as trade restrictions, trade barriers and export controls) in order to protect flows of innovation that might be used against national sovereignty (Alarcón, 2026). Its goal is to disrupt global supply chains and move technological sectors toward strategic autonomy.

This approach relies on “weaponized interdependence”, a term coined by Farrell and Newman, where US can exploit its critical part in global networks and enforce chokepoints on opponents.

The Biden administration largely continued the zero-sum competition strategy initiated by the Trump administration but combined it with stronger industrial policy to enhance US domestic capacity: the most significant initiative undertook by the administration is the CHIPS act, which provides billions in subsidies to encourage US based semiconductor manufacturing, aimed at reducing volatility and reliance on Asian suppliers following the COVID-19 induced semiconductor crisis (Miller, 2022, p. 276).

2.1.7. Trump 2.0 and future trajectory

A second Trump term, referred to in recent analyses as "Trump 2.0," represents another escalation from the policies of 2018-2020. The current administration wants to expand beyond bilateral relations to a broader, stiffer global tariff framework, aimed not only on China, but also on other US trade partners, led by the idea of “America First” (Lou, 2025, pp. 25, 47). In his campaign pledge, Trump proposed a 60% universal tariff on China, aiming at incentivizing manufacturing reshoring by heavily impacting import costs. While in the “first phase” of the trade war, Chinese companies could circumvent the tariffs by using re-exporting routes through Vietnam or Mexico, the new policy includes enforcement on origins of goods, that allows applying an appropriate tariff. Furthermore, this strategy is meant to integrate with technological embargoes directed at geostrategic rivals, in order to manage the containment of China’s recent advancements in AI, semiconductors and quantum computing. In response, China shifts toward technological self-reliance and diversion of trade toward the EU, ASEAN and Belt and Road Initiative members (Lou, 2025, p. 2).

2.2. Sanctions on Russia: from annexation of Crimea to the Ukraine war

Turmoil in relations between Russian Federation and Ukraine began in late 2013, when the former Ukrainian president Victor Yanukowych refused to sign an Association Agreement with the EU triggering an avalanche of events that still impacts global economies in 2026. Following these actions, protests erupted in Kyiv, coined as "Euromaidan", expressing dissatisfaction with the current government that inevitably led to its collapse. In late February 2014, armed personnel seized critical military infrastructures in Crimea, leading to a disassociation referendum and eventual annexation of the peninsula into Russian Federation (Crozet and Hinz, 2016, p. 6).

2.2.1. The 2014 Crimea sanctions: a limited Western response

While the international response to Russia's blatant sovereignty violation was swift, it was rather underwhelming at first. Initial rollout of the sanctions focused on smart sanctions which were aimed at individuals and organizations involved in the annexation process – these measures included travel bans and asset freezes aimed at elites within the Russian high command and entities that would aid these individuals (e.g. Bank Rossiya). Those measures sought to pressure the decision makers, while largely protecting general population in Russia, as well as Western economies from any economic backlash that might occur (Lew & Nephew, 2018, p. 41).

The second wave of coercion was meant to strip Russian entities of access to international debt and financing. The conflict intensified further when in July 2014 the Malaysia Airlines flight MH17 was downed by Russian backed forces over the Donbas region, killing all passengers and crew. This tragic incident led to increase in sanction deployment, widening their scope and scale moving toward sectoral sanctions (Crozet and Hinz, 2016, p. 37).

Seeing limited results from the previous sets of sanctions, the US and the EU decided to implement Sectoral Sanctions Identifications (SSI) list, which was designed to target crucial areas of the Russian economy: the Financial sector, Energy sector and Defense sector – with a clear goal of impairing its production capabilities and disrupt long-term financing crucial for Russian institutions doing business in the West (Connolly, 2018, p. 3). While the sanctions were implemented quickly and widely, this particular response faces criticisms of

inadequacy, since it was primarily planned to alter behavior of the Russian Federation rather than punish or destroy its economy (Nephew, 2018, p. 24). European dependency on Russian supplied energy commodities constrained the possibility of more powerful measures and fears of economic collateral damage spreading to Europe, curbed any meaningful coercion toward the aggressor.

As a response, Russia triggered its own set of countersanctions, encompassing mostly import ban of agricultural products from the sender countries, but nothing of substantial nature. Russia managed to partially circumvent applied sanctions by diverting to China for financing and some of the defense related components (Giumelli, 2017, pp. 1063-1065). Overall, the limited Western response to the Crimean annexation allowed Russia to bolster their economy over time and adapt and focus on its next advancement goals in Ukraine (Connolly, 2018, p. 3).

2.2.2. The 2022 Russian invasion of Ukraine: unprecedented sanctions

On the 24th of February 2022, Russia launched a full-scale invasion of Ukraine, starting the largest military conflict Europe has seen since the end of World War II. In contrast to the tempered measures implemented in 2014, the scale and scope of the sanctions that followed the military intrusion were unheard-of before, and this time around were directly targeting Russia's ability to wage war and aimed to devastate its economy (Bianchi and Sosa-Padilla, 2023, pp. 2-3).

Months before the invasion, US and European Intelligence agencies were aware of Russian military buildup just off Ukraine's borders, which enabled the policy makers of NATO alliance to coordinate and align necessary framework in deployment of coercive measures, initially aimed at deterrence, and finally in crippling Russian efforts. First "packages" of sanctions were triggered when Russia officially recognized independence of 2 separatist Donetsk and Luhansk People's Republic, which happened on 22nd of February, just 2 days before the invasion. When the final attempt of deterrence fell short of expectations, and Russian forces crossed into Ukraine, an enormous set of sanctions was triggered targeting, Russian elites, sovereign debt and specific financial institutions (Yalcin, Felbermayr et al., 2025, p. 24). The outrage of the shameless Russian actions created an unprecedented coordination and decisiveness: traditionally neutral Switzerland joined the EU sanctions, breaking the existing precedent, while the geographically distant to Europe,

Asian allies like Japan, South Korea and Singapore joined the NATO allied countries in the sanction coalition. Thanks to the established frameworks in the month preceding the conflict, the rollout and implementation was swift and decisive, managed within days, rather than months that would be typical to the likes of international diplomacy (Yalcin, Felbermayr et al., 2025, p. 24). We shall discuss these measures by type:

- Financial sanctions: the Western senders decided to implement "nuclear option" of disconnecting Russian financial institutions from SWIFT messaging system, essentially crippling banks, virtually excluding them global financial markets. At first, seven major banks were targeted, with exemptions granted to Sberbank and Gazprombank due to crucial transactions in regard to European energy imports (EU still heavily dependent on Russian gas at that point in the conflict). The precedent for these measures were set by similar actions taken against Iran back in 2012 and 2018 (Bianchi and Sosa-Padilla, 2023, pp. 4-5),
- Central Bank of Russia (CBR) asset freezes: in the days following the invasion, the "sanction coalition" froze $300 billion of Russia's $640 billion in foreign exchange reserves, curbing its ability to strengthen the ruble or soften any blows directed at the economy (Bianchi and Sosa-Padilla, 2023, pp. 6-7),
- Trade and export controls: the US used the existing Foreign Direct Product Rule (FDPR), which allowed to ban exports of strategic goods made with the US technology or software, even if produced in third countries, which blocked Russia from much needed components and equipment destined for defense purposes – this created a peculiar situation, where Russia turned to domestic manufacturers of home appliances in order to procure semiconductors for military efforts (Miller, 2022, pp. 288-289).
- Import bans: EU, being the primary market for Russia's energy commodities, gradually started breaking the chain of dependency and introduced consequent import bans on: coal (August 2022), crude oil (December 2022) and refined petroleum products (February 2023) (Yalcin, Felbermayr et al., 2025, p. 24). While the EU still imports large quantities of liquid gas, the EU's overall dependency has fallen from 45% pre-war to 12% in 2025 (REPowerEU, 2025).
- Oil Price Cap mechanism: implemented in late 2022, by the joint initiative of the EU and G7, the mechanism sets a cap of $60 per barrel of Russian crude oil, recognizing

that total ban on their oil might counterintuitively benefit Russia due to the presumption that once the Russian supplies are removed, Global oil prices would spike which would entail that Russia could sell their oil to the non-sanctioning states at a higher price (Yalcin, Felbermayr et al., 2025, p. 3).

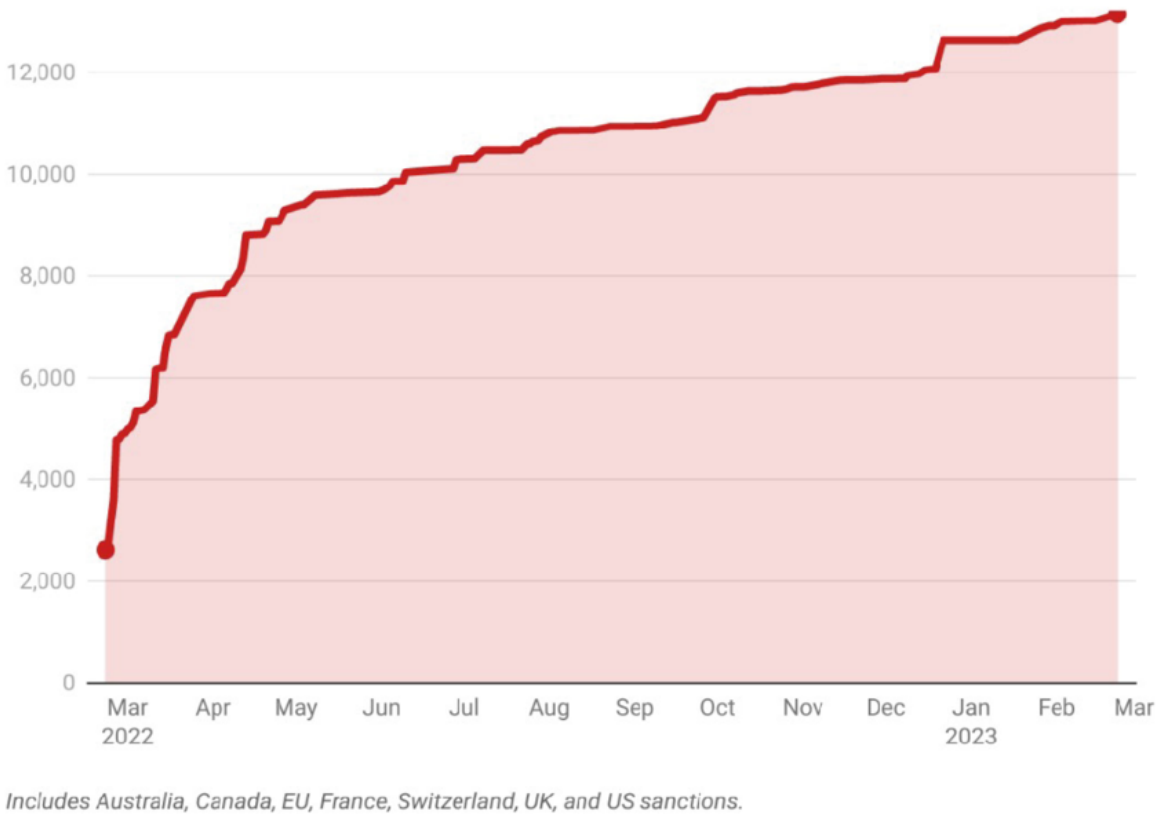

Figure 5: Total sanctions against Russia

Source: Ramos, Vadell and Gontijo (2023, p. 12)

Initial fast response of swift sanction packages over time transformed into a slow war of attrition: within 2024 the European Union deployed 14 more sanction packages, widening the scope, and tying off loose ends on Russian individuals and institutions. Russia on the other hand has adapted to the severed economic ties with the Western world by redirecting trade through friendly and neutral countries. These practices are also in the sights of the sender countries which use secondary sanctions to impact entities in the third countries. Overall, the totality of sanctions directed towards Russia represent the most extensive sanction regime to have ever been imposed (Yalcin, Felbermayr et al., 2025, p. 24).

2.2.3. The European energy dimension

Before the Russo-Ukrainian war erupted, the European Union, distinctively Germany, kept a strategic over-reliance on exports of Russian natural gas and other energy related commodities to satisfy their appetite for energy. A distinguishingly subservient was German dependence, who's the imported gas was roughly 60% of total energy consumption, with some commodities like coal and oil having import quotas in the 90th percentile (Bachmann et al., 2022, p. 1). This need was rooted in physical infrastructure set in place (like Nord Stream 1 and 2 gas pipelines), and economic framework agreements as well as pricing set at a relatively low rates which inhibited German policy makers from seeking alternatives elsewhere (Bachmann et al., 2022, p. 15).

The breakout of the conflict in February 2022 and the subsequent severance of economic ties with Russia forced European leadership to find ways to subsidize Russian energy exports with alternative sources, with consideration of resource rich countries like Norway, Algeria and Azerbaijan, but eventually these efforts were hindered by the bottlenecks of infrastructure. To close the supply gap, policies focused on redistribution in demand for those commodities; this included fuel switching (to coal and nuclear instead of gas) and altering consumer perspective on their energy consumption and heating habits, as well as gas storages during the warmer seasons.

This energy crisis has positively impacted the EU's drive toward renewables and sustainability and highlighted consequences of dealing with autocratic nations as a source of critical imports and commodities. The negative impact is an effect of continuously raising prices for European households and industries, that led to a period of higher inflation across Europe as well as long term relocation of energy-intensive manufacturing (Yalcin, Felbermayr et al., 2025).

2.2.4. Russian adaptation and reorientation

In the first stages of the full-scale war and in response to Western sanctions, Russia undertook immediate stabilization efforts in order to offset powerful measures besieging their economy. The centerpiece of the plan was reliance on "Fortress Russia" strategy that was built around the accumulation of roughly $600 - $640 dollars in foreign exchange reserves intended to sustain the isolated economy (Bianchi and Sosa-Padilla, 2023, pp. 6-7). Offsetting and crippling this strategy were prompt and severe Central Bank of Russia's asset

freezes that covered around half of that reserve. To mitigate an impending economic collapse Kremlin enforced capital controls which included banning its citizens of transferring money abroad, suspending cash withdrawals and forcing exporters to accept exchange 80% of their foreign currency earning for rubles (Sonnenfeld et al., 2022, p. 40). Additionally, Russia enforced ruble payment requirements for natural gas, removing supply in case of refusal of compliance.

The early expectations on sanction impact were hovering around 10-15% of Russia's GDP, however the results published by the Kremlin showed a rather dubious decline of 2.1% in 2022, followed by reported growth in 2023, while some researchers pointed that this might be accounted to the fact that Moscow stopped publishing "bad" data on trade, capital flows and oil export performance, skewing the results (Yalcin, Felbermayr et al., 2025, p. 24). However, the perceived stability might be connected to the shift towards war economy and fiscal intervention. Russian resilience might also be attributed to continued oil and gas exports, this time directed to other consumers.

After losing Western markets, Russia quickly started pivoting towards the East, leading to a surge in trade volumes with China, India, Turkey and UAE. China became a primary supplier of imports, simultaneously imposing heavy dependence on Russia, rather than vice versa. India became a primary market for crude oil, benefiting from heavy discounts in relation to Brent oil (up to $35/barrel), receiving shipments by Russia's new, clandestine network of naval vessels, coined "The Shadow Fleet" (Sonnenfeld et al., 2022, pp. 32-35). Russia benefits also from countries that acts as intermediaries, like Turkey and UAE which became hubs for parallel imports and financial flows, as well as helping Russians with circumventing imposed flying travel bans over Europe. Dubai has observed an enormous influx of capital and investment from wealthy Russian citizens seeking safe havens outside of the war inflicted economy.

Despite this perceived stabilization the structural damage to the Russian economy is evident: Russia has been stripped from advanced Western technology that impacts it defence sector, which cannot meet demand for the modern warfare and deepens the one-sided dependence on China. Another impact is of so-called "brain drain": an estimated 500,000+ Russians fled during first few months of the war, with a majority being highly skilled professionals, permanently degrading Russia's human capital. Existing heavy industries like tank manufacturers and aviation are surviving by scavenging existing fleets in order to

sustain machines and vehicles in use, leading to overall degradation of safety and infrastructure.

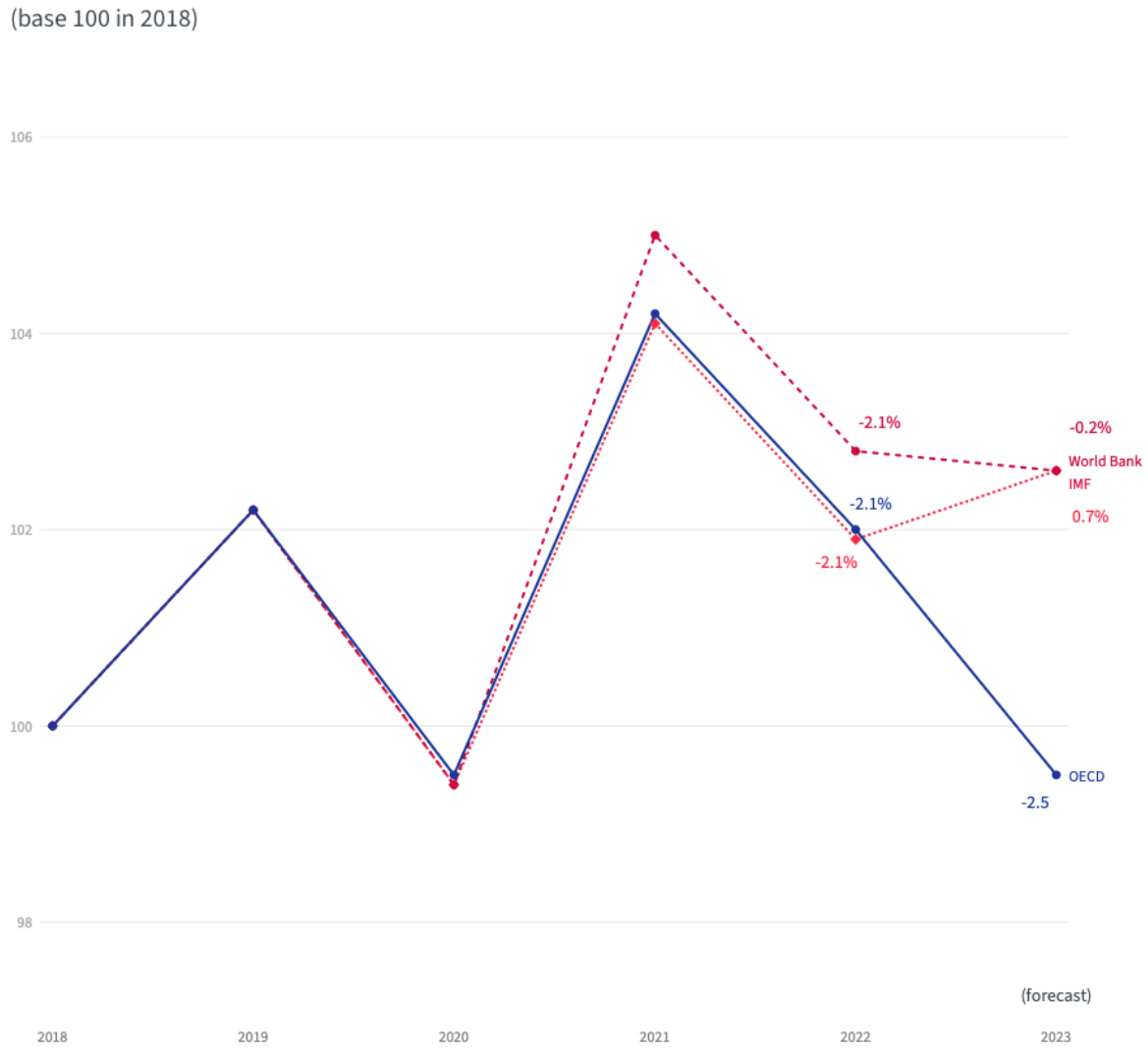

Figure 6: Russia's GDP - evolution from 2018 to 2023

Source: World Bank (April 2023), IMF (April 2023), OECD (March 2023)

While in the Chapter 1 we discussed critiques towards ineffectiveness of sanctions, the example of continuous deterioration of Russian state proves that sanctions are a potent measure of coercion, if applied with the proper scale, speed and coordination, successfully waging economic warfare without having to use direct military force.

2.3. Iran sanctions and template for Russia

Main driver of trade sanctions imposed on Iran is its nuclear program, which has concerned international communities for decades now. While Iranian authorities maintain their stance, that the program is aimed at developing civilian energy infrastructure, American and Israeli intelligence agencies clearly indicated that Iran in fact actively pursues development of nuclear weapons by refining uranium enrichment (NCRI Report, 2025).

2.3.1. The JCPOA Era and Its Collapse

The sanction rollout toward Iran was gradual in nature: Between 2006 and 2010, the UN Security Council (UNSC) adopted a series of resolutions (1737, 1747, 1803, and 1929) that progressively stigmatized Iran's nuclear and missile activities. These resolutions provided the international legal basis for isolating Iran, calling on states to exercise vigilance over Iranian financial institutions and prohibiting the supply of nuclear-related technology (Nephew, 2018, p. 24). While the US maintained a primary trade embargo since 1995, the primary innovation of this time was the expansion of secondary sanctions: measures targeting third-country actors doing business with Iran. The Comprehensive Iran Sanctions, Accountability, and Divestment Act (CISADA) of 2010 created a "financial embargo," threatening to cut off foreign banks from the US financial system if they processed transactions for designated Iranian entities and individuals. Pressure on Iran escalated in 2012 when US threatened with sanctions on third countries unless they reduce Iranian oil imports, while simultaneously SWIFT transactions has been disconnected from Iranian banks, setting a precedent then used in sanctions against Russia. This period of consequently escalatory measures targeting Iran resulted in recession, GPD decline, and drastic depreciation of Iranian rial (Nephew, 2018, pp. 67, 93).

These actions brought regime to the bargaining table, where a multilateral agreement between Iran, five permanent members of the United Nations Security Council (UNSC), namely China, France, Russia, the UK, US, plus Germany and the EU named *Joint Comprehensive Plan of Action* (JCPOA), that was finalized in July 2015, in which Iran committed to limiting its nuclear program in exchange for sanctions relief (JCPOA, 2015). The provisions of the agreement were as follows: Iran agreed to limit enrichment and reduce number of used centrifuges, reduced its stockpile for enriched uranium and converted

nuclear facilities to research centers. In return, the UN reversed implemented resolutions, EU terminated all sanctions and US halted application of secondary sanctions. This gave Iran a breathing space to recover economically, rebounding its oil exports, and resuming trade (Samore et al., 2015, pp. 4–7).

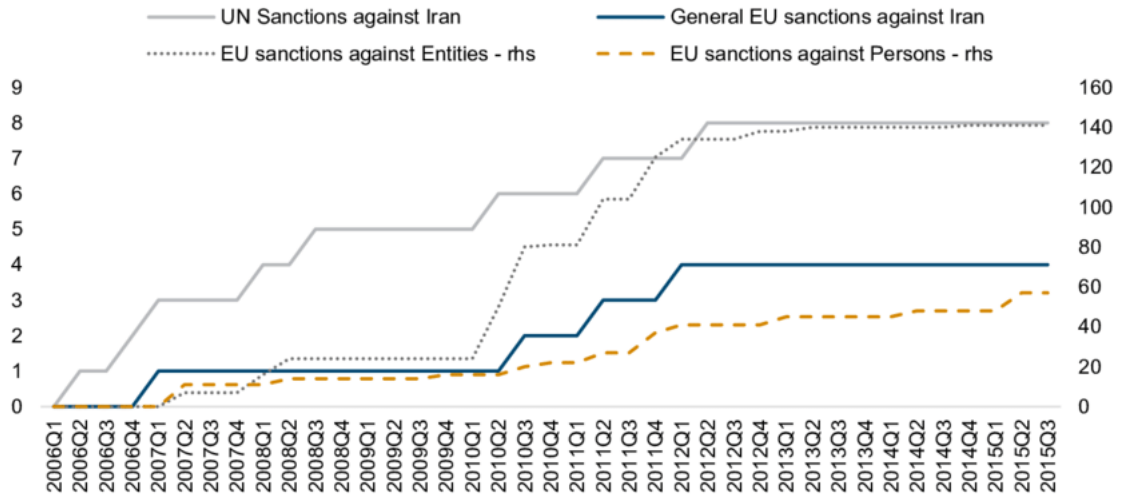

Figure 7: Accumulated sanctions imposed by the EU and the UN against Iran, general versus individual targeting, 2006-2015

Source: Ghodsi and Karamelikli (2020, p. 2)

Despite all of the evidence suggesting that Iran is complying with the JCPOA provisions, nearly 3 years after establishing the agreement, president Trump expressed dissatisfaction with the deal calling it "flawed", challenging it by juxtaposing with Iran's actions in the region (supporting Hezbollah, and Assad's regime in Syria), and unilaterally withdrew US from the agreement against the protests of other signatories (Sherman, 2018, p. 1). Shortly afterwards, the US administration reintroduced sanctions targeting currency, sovereign debt, automotive and energy sectors and ultimately a *de facto* oil embargo (Lew and Nephew, 2018, p. 42). The aim of the shifted policy was to apply maximum pressure toward Iran in order to secure a better deal, that would solve the grievances raised by the Trump administration. Reintroduction of sanctions delivered a blow to a slowly recovering Iranian economy, effectively annulling any recovery achieved post-JCPOA: oil exports began dropping once again, GDP shrank by approx. 4%, and rial collapsed again introducing a wave of inflation. The U.S. extensively used secondary sanctions to force third-party

compliance regarding Tehran (Lew and Nephew, 2018, p. 41). Despite the economic setbacks, Iranian regime in Tehran survived, and started slowly reversing the course on nuclear proliferation, ultimately withdrawing from JCPOA in November 2025 (European Council, 2025).

2.3.2. Iran as template for Russia sanctions

The sanctions regime imposed on Russia in 2022 drew heavily from the frameworks established over decades of economic coercion against Iran. Key financial and energy measures were adapted from the Iranian context to the Russian invasion of Ukraine. The table 1 presents lessons applied in the recent conflict:

Tool	Iran precedent	Application to Russia
SWIFT disconnection	2012, 2018	February 2022
Central bank sanctions	Yes	Asset freeze (larger scale)
Oil targeting	Primary focus	Primary focus
Secondary sanctions	Extensive	Developing

Table 1: Lessons applied from Iran sanctions to Russia
Source: own elaboration

Not everything could be translated directly as Russia has several key characteristics that required a modified approach. Russia's economic size (member of the G20) and its integration into global financial market, meant that financial sanctions had to be implemented gradually in order to avoid market collapses. European energy dependence discussed previously also demanded constraint in disconnecting Russian energy sources. And while Iran has not yet come into possession of a nuclear weapon, Russia on the other hand sits on the world's largest nuclear stockpile, meaning any escalation in that matter could lead to nuclear threats or even deployment (Sonnenfeld et al., 2022, p. 6).

The Russia sanction case is a test of the coercive economic model that was perfected on Iran. It is also a cautionary tale in policy reversal that could lead to escalation and undoing of years of diplomatic and economic efforts.

2.4. Emerging patterns: deglobalization and the new economic order

The path of Global trade is shifting – and rather than chasing efficiency its seeking refuge and stabilization from geopolitical turmoil and conflicts. The previously discussed, unparalleled rise in sanctions, return of protectionism and trade diversions hint at profound changes that are bound to happen sooner or later (Rodrik, 2011) Let's explore theoretical concepts that are recognized collectively as part of deglobalization, which can be identified as emerging from and with the discussed case studies.

2.4.1. Friend-shoring and alliance-based trade

As opposition to prevalent in the globalization era offshoring (relocation of business operation to third countries seeking lower labour cost and operational efficiencies), the trends we shall discuss are of reverse trajectory (Alfaro and Chor, 2023, pp. 23-24):

- Reshoring (onshoring): a process of returning economic activities (predominately manufacturing and production) from foreign locations back to company's domestic market (or keeping these activities in case of onshoring),
- Nearshoring: transition of business that prioritizes geographical proximities to reduce lead times and improve control, but still benefiting from reduced labour and manufacturing costs,
- Friendshoring (allied-shoring): a term, coined in 2022 by US Treasury Secretary Janet Yellen, describes a transfer "of supply chains to a large number of trusted countries", where economic networks are perceived as power structures rather than purely economic ones.

Consequently, the "new economic order" can be described as the move from efficiency optimization to bolstering security through alignment with political and economic allies who possess appropriate domestic institutions to support shared strategic goals as well as prioritizing own economic sphere in an emerging geopolitical chaos (Shust, 2025, pp. 68–69).

2.4.2. Policy manifestations

These trends are observable through newly implemented US and European initiatives that aim at reducing dependencies, boosting economies damaged by COVID-19 pandemic or directly impeding adversaries. The ones mentioned here were introduced by and with President Biden's administration, like CHIPS and Science Act (2022), aiming at reshoring semiconductor manufacturing and research back to the US; Inflation Reduction Act (IRA, also 2022) enforcing friend-shoring through "buy North-American" recommendations and Trade and Technology Council (2021) established in coordination with EU focusing on export controls and securing supply chain (an example of allied-shoring)(Schneider-Petsinger, 2022, pp. 2–3). On the more extreme measures, we can classify political shifts into "New Protectionism" as identified by Joseph Stiglitz, who warns that failures of globalization in managing global inequalities will result in political backlash, which is resembled in first and second term of US President Trump and his policies, as US started shifting from rule-makers to rule-breakers by sabotaging international institutions and breaking down diplomatic ties (Stiglitz, 2017, pp. 2, 7, 27).

There are other, business driven initiatives in response to deglobalization, like China Plus One (Plus One or C+1), which premise is to avoid sourcing exclusively from China, but on supply diversification, and channelling investment into other emerging economies like Vietnam, India or Thailand (Alfaro and Chor, 2023, p. 19). On the other hand, some companies try to maintain indirect links to China by "back door strategy": in order to circumvent tariffs, Chinese corporations invest heavily into production facilities in Vietnam, Mexico and other cheap labour countries, which allows companies to import from non-sanctioned nations, while benefiting China.

As Iran and Russia's cases have shown, global economic networks in the likes of SWIFT or CHIPS (dollar clearing system) can be weaponized to force compliance from large economies and companies, which leads to pursuit of alternative payment systems and financial de-risking (Eichengreen, Mehl and Chițu, 2018, pp. 3-4). MNEs are showing interest in China's CIPS systems, Euro based payments as well as new currency proposal (UNIT) by Russia-China led BRICS organization - efforts known collectively as "de-dollarization" (McDowell, 2023, p. 26).

In the next chapter we will attempt to investigate empirically the emergence of these new trends by analysing trade data in the scope of recent geopolitical events and conflicts.

Chapter 3

Empirical analysis: sanctions impact on trade flows and supply chain indicators

3.1. Research design and methodology

This chapter presents the empirical analysis of trade patterns following major sanctions regimes, testing four hypotheses concerning the impact of geopolitical tensions on international trade flows. The analysis employs descriptive statistical methods to examine bilateral trade dynamics, trade diversion patterns, sectoral variations, and changes in global economic integration.

3.1.1. Research questions

RQ1: To what extent do economic sanctions reduce bilateral trade between sanctioning and target countries?
RQ2: Does trade diversion occur following sanctions implementation, and which alternative partners benefit?
RQ3: Are technology-intensive sectors more vulnerable to sanctions-related trade disruptions than commodity sectors?
RQ4: Is there evidence of declining global economic integration in the era of strategic competition?

3.1.2. Hypotheses

H1: Economic sanctions significantly reduce bilateral trade flows between sanctioning and target countries.
H2: Trade diversion occurs as sanctioned countries and their trading partners redirect commerce to alternative markets.
H3: Technology-intensive sectors experience greater trade disruption than commodity sectors under sanction regimes.
H4: Recent geopolitical fragmentation has led to declining global trade openness and economic integration.

3.1.3. Temporal framework

The empirical analysis employs a before-after comparative design examining trade flows across distinct temporal periods. For US-China trade tensions, the baseline period covers 2015-2017, with the post-tariff period covering 2018-2024. For EU-Russia sanctions, three periods are examined: pre-Crimea (2011-2013), post-Crimea (2014-2021), and post-Ukraine war (2022-2024). Key metrics include absolute trade values, year-over-year growth rates, cumulative changes, market share shifts, and indexed comparisons normalized to baseline years.

Case	Pre-Sanction Baseline	Implementation	Adjustment phase	Coverage
US-China trade war	2015-2017	2018-2020	2021-2024	10 years
EU-Russia (Crimean crisis)	2011-2013	2014-2016	2017-2021	11 years
EU-Russia (Ukraine war)	2019-2021	2022	2023-2024	6 years

Table 2: Temporal framework by sanction case
source: own elaboration

3.1.4. Case selection rationale

The US-China and EU-Russia cases were selected based on significance (both represent the largest sanction regimes by affected trade volume), variation (meaningful differences in sanction design, escalation patterns, and economic structures), data availability (comprehensive, high-frequency trade data), and theoretical relevance (both cases speak directly to debates regarding weaponized interdependence and supply chain restructuring).

3.1.5. Data sources and variables

This analysis utilizes official trade statistics from three primary sources, selected for their comprehensive coverage, methodological consistency, and international recognition as authoritative data repositories for trade research.

Source	Coverage	Classification	Period	Unit
UN Comtrade	Bilateral trade flows	HS 2-digit	2015-2024	USD
Eurostat	EU-Russia trade	SITC/HS	2011-2024	EUR
World Bank WDI	Trade openness	Aggregate	2010-2024	% GDP

Table 3: Data sources overview

Source: own elaboration

Note: All data retrieved January 2026. Values in current prices unless otherwise specified.

The analysis uses the following variables:

1. Bilateral trade flows, measured as total merchandise imports and exports between country pairs in billions of USD or EUR,
2. Trade diversion index, constructed as the percentage change in imports from alternative supplier countries relative to a pre-sanction baseline year,
3. Sectoral trade ratios, with trade volumes disaggregated by Harmonized System (HS) chapters,
4. Global trade openness calculated as (World Exports + World Imports) / World GDP.

3.1.6. Analytical approach

The empirical analysis proceeds in five stages:

1. Descriptive analysis presenting bilateral trade trends and percentage changes,
2. Bilateral trade effects analysis comparing pre- and post-sanction volumes,
3. Trade diversion analysis calculating indices for alternative suppliers,
4. Sectoral decomposition comparing technology-intensive and commodity-based sectors,
5. Global integration assessment analysing aggregate trade openness trends.

Several limitations require acknowledgment. First, the analysis uses descriptive and comparative methods rather than identification strategies. While temporal sequencing supports causal inference, complex factors cannot be fully isolated. Second, data availability constraints limit sectoral analysis to broad HS chapter categories. Third, the relatively short post-sanction observation period for EU-Russia (2022-2024) limits assessment of long-term adjustment dynamics.

3.1.7. Technical implementation

The empirical analysis presented in this chapter was implemented using a custom Python-based analytical toolkit. The script was developed to ensure full reproducibility of results organized into four functional modules: data loading and parsing, data processing and transformation, visualization, and statistical reporting. This section describes the key computational elements, including representative code excerpts with commentary, to document the analytical pipeline transparently.

The script relies on three core libraries: *pandas* for tabular data manipulation, *numpy* for numerical computation, and *matplotlib* for publication-quality figure generation. Global plotting parameters are configured at the start of execution to ensure visual consistency across all 14 figures produced by the toolkit.

Data Loading and Cleaning: raw data originate from three institutional sources – UN Comtrade (.csv), Eurostat (.xlsx), and World Bank WDI (.xlsx), each with distinct formatting conventions. Dedicated loader functions handle source-specific any irregularities. The following function processes UN Comtrade files, which frequently contain trailing empty columns generated by the export interface:

```
def load_comtrade_csv(filepath, encoding='utf-8'):
    try:
        df = pd.read_csv(filepath, index_col=False,
                         encoding=encoding)
    except UnicodeDecodeError:
        df = pd.read_csv(filepath, index_col=False,
                         encoding='latin-1')
    if df.columns[-1].startswith('Unnamed'):
        df = df.iloc[:, :-1]
    return df
```

The function implements a fallback encoding strategy (UTF-8, then Latin-1) to accommodate inconsistencies in Comtrade's export encoding and automatically strips trailing phantom columns that arise from trailing commas in the .csv export. A parallel function, load_eurostat_xlsx, handles Eurostat files by specifying the correct header row, since Eurostat's standard Excel output places metadata in the first several rows above the actual data table.

Data Processing and Transformation: Each dataset undergoes a standardized processing pipeline. The US-China bilateral trade processor, for instance, pivots raw transaction-level data into an annual time series, converts nominal values from USD to billions, computes derived indicators (trade balance, year-over-year percentage changes, cumulative changes relative to a 2017 baseline), and assigns period labels for comparative analysis. The following excerpt illustrates the core transformation logic:

```
def process_us_china_total(filepath):
    df = load_comtrade_csv(filepath)
    result = df.pivot_table(
        index='refYear', columns='flowDesc',
        values='primaryValue', aggfunc='sum')
    result['US_Exports_to_China'] /= 1e9
    result['US_Imports_from_China'] /= 1e9
    result['Trade_Balance'] = (
        result['US_Exports_to_China']
        - result['US_Imports_from_China'])
    result['Exports_YoY_Pct'] = (
        result['US_Exports_to_China'].pct_change()*100)
```

The pivot_table operation reshapes the Comtrade long-format data (where each row represents a single trade flow observation) into a wide format annual time series with separate columns for exports and imports. Values are converted from nominal USD to billions for readability. Year-over-year changes are computed via the pct_change method, providing the growth rates presented in Figure 10. A period classification variable ("pre-tariff" for years up to 2017, "post-tariff" thereafter) facilitates the before-and-after comparisons underlying Hypothesis 1.

For the sectoral analysis, an HS-code-to-sector mapping dictionary translates the 2-digit Harmonized System codes into analytically meaningful categories. This mapping groups codes 1–24 as Agriculture, code 27 as Energy, codes 28–38 as Chemicals, codes 72–

83 as Metals, code 84 as Machinery, code 85 as Electronics, code 87 as Vehicles, and code 90 as Precision Instruments. The mapping is applied through the following pattern:

```
hs_sector_map = {
    **{i: 'Agriculture' for i in range(1, 25)},
    27: 'Energy',
    84: 'Machinery', 85: 'Electronics', ... }
df['Sector'] = df['cmdCode'].map(hs_sector_map)
```

This dictionary-based approach allows flexible aggregation of the approximately 5,000 HS 6-digit product codes into the eight sectors tested in Hypothesis 3. The sectoral summary function then computes baseline averages (2015-2017) and post-tariff averages (2018-2024) and classifies sectors as either “technology” (electronics, machinery, precision instruments) or “commodity” (agriculture, energy, chemicals, metals) for the comparative test.

The trade diversion index, central to the evaluation of Hypothesis 2, is computed by normalizing import values from each partner country to a pre-sanction baseline year (2017 for the US-China case, 2019 for the EU-Russia case). The index is expressed as:

```
baseline = result.loc[result['Year']==2017, col]
result[f'{col}_Index'] = (result[col]/baseline)*100
```

A value of 100 indicates trade volume identical to the baseline year; values above 100 indicate growth, and below 100 indicate contraction. Import market shares are simultaneously computed as each partner’s proportion of total listed imports, enabling the percentage-point shift analysis presented in Figure 8. This dual-metric approach (absolute index and market share) captures both scale effects and compositional changes in import sourcing.

All 14 figures are generated programmatically through dedicated functions that follow a consistent pattern: create figure and axes, plot data with semantically assigned colours and markers, add contextual annotations (policy event markers, period shading), format axes and labels, and export to PNG at 300 DPI. The following excerpt from the bilateral trade figure function illustrates this approach:

```
def fig1_us_china_bilateral(df, output_dir):
    fig, ax = plt.subplots(figsize=(12, 7))
    ax.plot(years, df['US_Exports_to_China'],
```

```
        'o-', color=COLORS['us'],
        linewidth=2.5, markersize=7,
        label='US Exports to China')
    ax.axvspan(2017.5, years.max()+0.5,
               alpha=0.06, color='red')
    ax.axvline(x=2018, color='#B71C1C',
               linestyle='--', linewidth=1.5)
    plt.savefig(output_dir / 'fig01_...png',
                dpi=300, bbox_inches='tight')
```

Each figure function uses axvspan to shade the post-policy period and axvline to mark key policy events (e.g., Section 301 tariff implementation in 2018, the Ukraine war in 2022), providing visual context for the structural breaks discussed in the analysis. The matplotlib FuncFormatter is applied to y-axis tick labels (e.g., "$350B") to improve readability. Figures with multiple panels (Figures 21 and 22) use subplots to facilitate direct visual comparison of the US-China and EU-Russia cases side by side.

The entire sequence is run by a main function that automatically detects file paths relative to the script location, sequentially processes all seven raw datasets, generates derived datasets (sectoral summaries, energy analysis), populates an Excel template with computed values, produces all 14 figures, and prints a statistical summary. The pipeline can be executed with a single command, ensuring full reproducibility of all results, figures, and tables presented in this chapter.

3.2. US-China bilateral trade effects

3.2.1. Bilateral trade patterns

The US-China trade relationship represents the largest bilateral merchandise trade flow globally, making it a critical case for understanding sanction effects. This section analyzes trade patterns from 2015 to 2024, spanning the pre-tariff baseline, Section 301 implementation, and subsequent policy evolution. Table 4 presents summary statistics for US-China bilateral trade.

Variable	Mean	Std. dev.	Min	Max
US imports from China (USD bn)	579.1	46.0	448.0	575.7
US exports to China (USD bn)	130.9	16.9	106.6	153.8
Bilateral trade (USD bn)	634.1	52.7	579.1	729.5
Trade balance (USD bn)	-372.3	45.1	-443.1	-300.2
China share of US Imports (%)	18.4	2.3	13.8	21.6

Table 4: US-China bilateral trade descriptive statistics (2015-2024)

Source: own elaboration, based on UN Comtrade data (2025), access: 4th January 2026

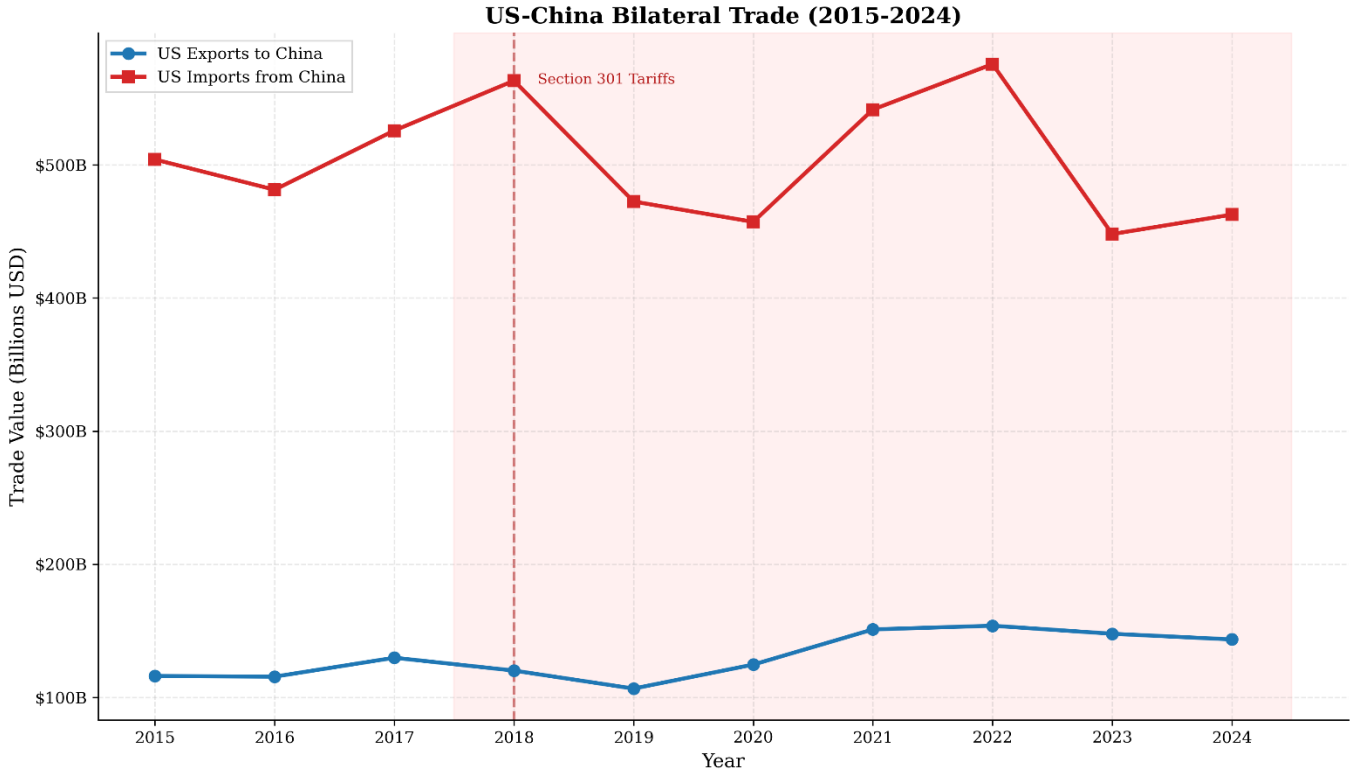

Figure 8: Evolution of US-China bilateral trade from 2015 to 2024

Source: own elaboration, based on UN Comtrade data (2025), access: 4th January 2026

As illustrated in Figure 8, US-China bilateral trade demonstrates notable resilience despite sustained tariff pressure. Contrary to expectations of trade collapse, the data reveal a pattern of disruption followed by adaptation. US imports from China peaked at $563.2 billion in 2018, declined to $457.2 billion during the combined tariff-COVID19 period

(2020), and subsequently recovered to $462.6 billion by 2024. This represents a net decline of 8.2% comparing 2024 to the 2015-2017 baseline average.

US exports to China show a different pattern: despite retaliatory tariffs on American agricultural and manufactured products, exports increased by 19.1% over the period, rising from an average of $120.5 billion (2015-2017) to $143.5 billion (2024). This counterintuitive finding reflects continued Chinese demand for American agricultural products, aerospace, and semiconductors prior to export control implementation.

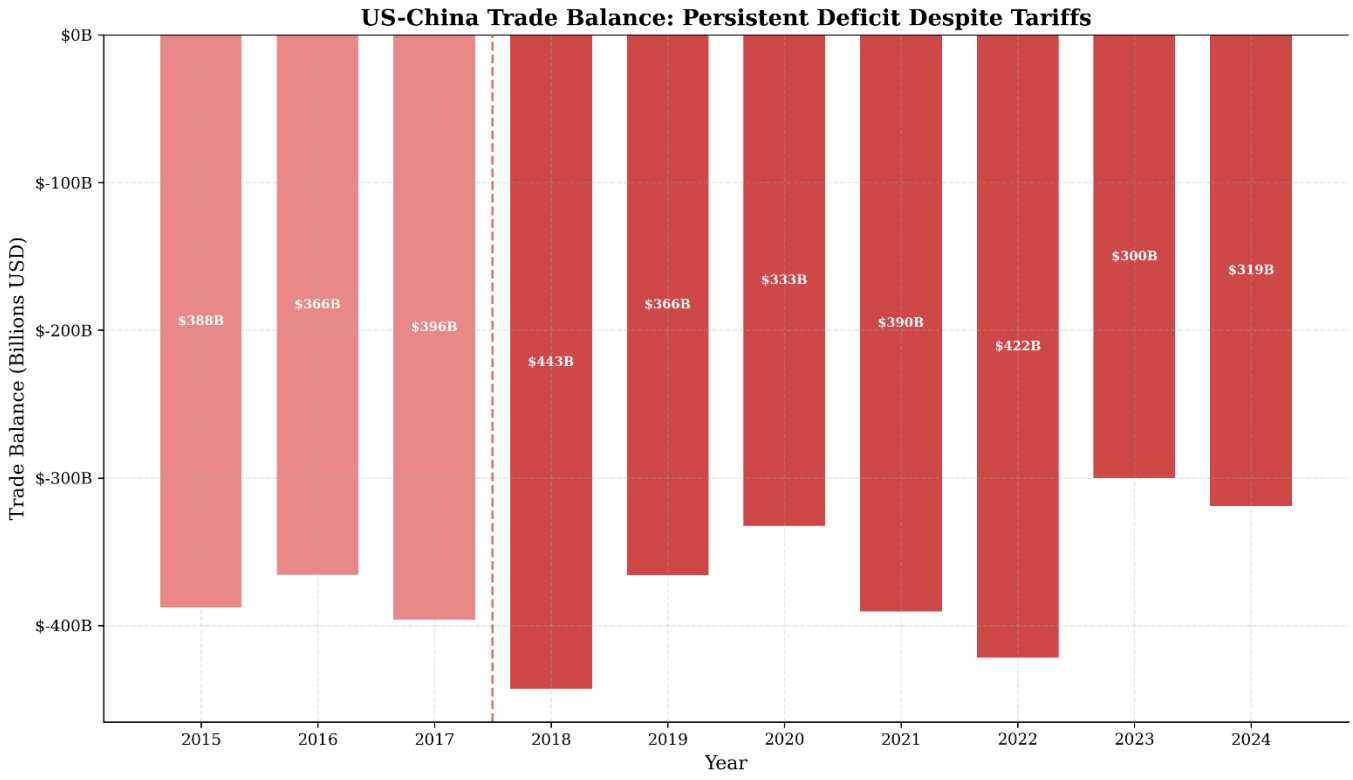

Figure 9: US-China trade balance (2015-2024)

Source: own elaboration, based on UN Comtrade data (2025), access: 4th January 2026

Figure 9 reveals that the US trade deficit with China (the stated target of tariff policy) showed limited sustained reduction. The deficit contracted from $396 billion (2017) to $332.5 billion (2020), representing an 16% reduction. However, by 2022, the deficit had widened again to $422 billion, nearly returning to pre-tariff levels. This pattern suggests that tariff policy alone proved insufficient to address structural trade imbalances.

3.2.2. Trade dynamics and volatility

To capture trade dynamics beyond level changes, Figure 10 presents year-over-year percentage changes in bilateral trade flows.

Figure 10: US-China trade year-over-year changes (2016-2024).

Source: own elaboration, based on UN Comtrade data (2025), access: 4th January 2026

Figure 10 highlights several notable patterns. First, trade volatility increased markedly following the 2018 tariff implementation, with the standard deviation of annual import changes rising from 4.2 percentage points (2015-2017) to 12.8 percentage points (2018-2024). Second, the COVID-19 pandemic (2020) produced the sharpest single-year disruption, with imports declining 19.4% year-over-year. Third, the 2021 recovery (+18.5% imports) demonstrates rapid post-pandemic normalization. Fourth, relative stabilization in 2024 indicates emergence of a potentially new equilibrium at elevated tariff levels.

3.2.3. Trade diversion from China

Hypothesis 2 aims to predict that tariffs induce trade diversion toward alternative suppliers. Figure 11 presents a trade diversion index measuring US import growth from potential beneficiary countries relative to the 2017 baseline.

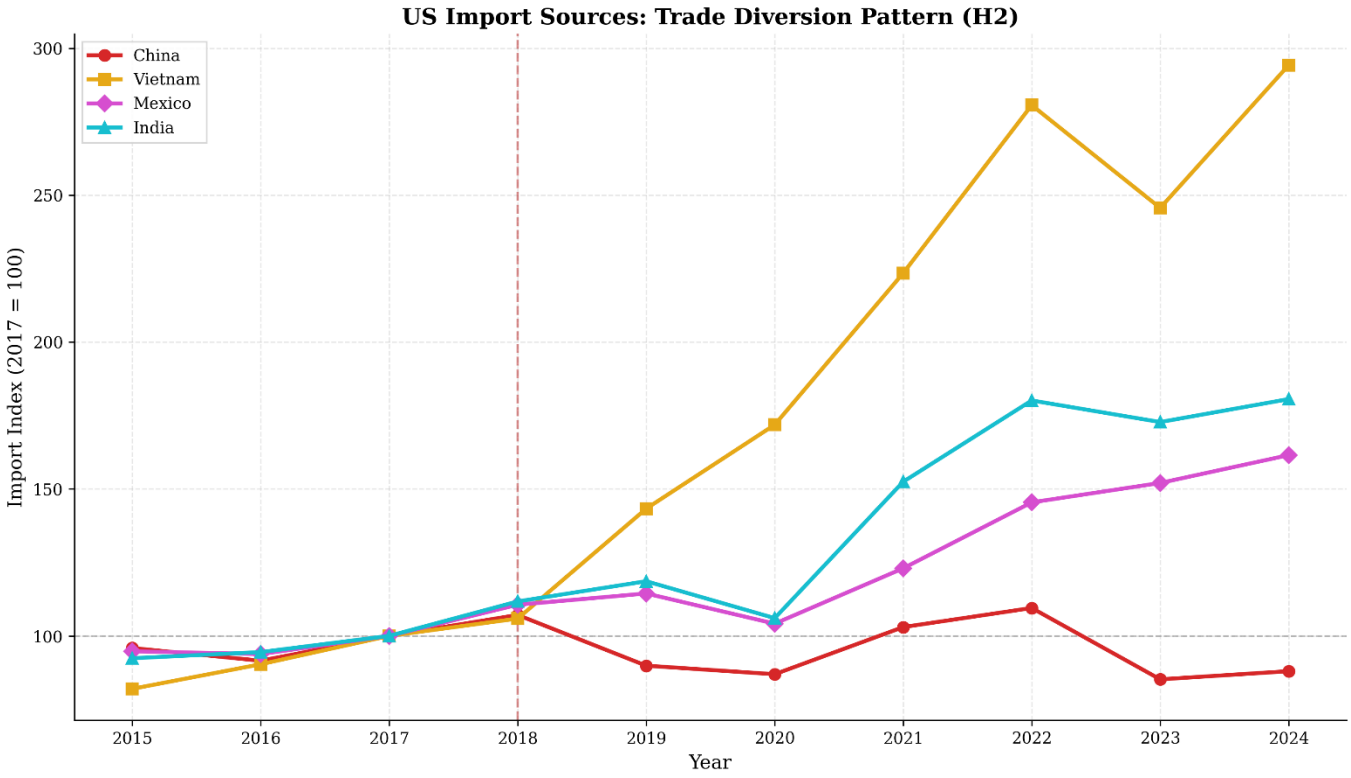

Figure 11: US trade diversion from China: import growth index (2017-2024)

Source: own elaboration, based on UN Comtrade data (2025), access: 4th January 2026

Country	2017 (USD bn)	2024 (USD bn)	Change (%)	Share Gain (pp)
Vietnam	48.4	142.5	+194.2	+2.8
India	50.5	91.2	+80.6	+0.9
Mexico	315.7	510.0	+61.5	+1.9
China	525.8	462.6	-12.0	-5.4

Table 5: US import growth from alternative suppliers (2017-2024)

Source: own elaboration, based on UN Comtrade data (2025), access: 4th January 2026

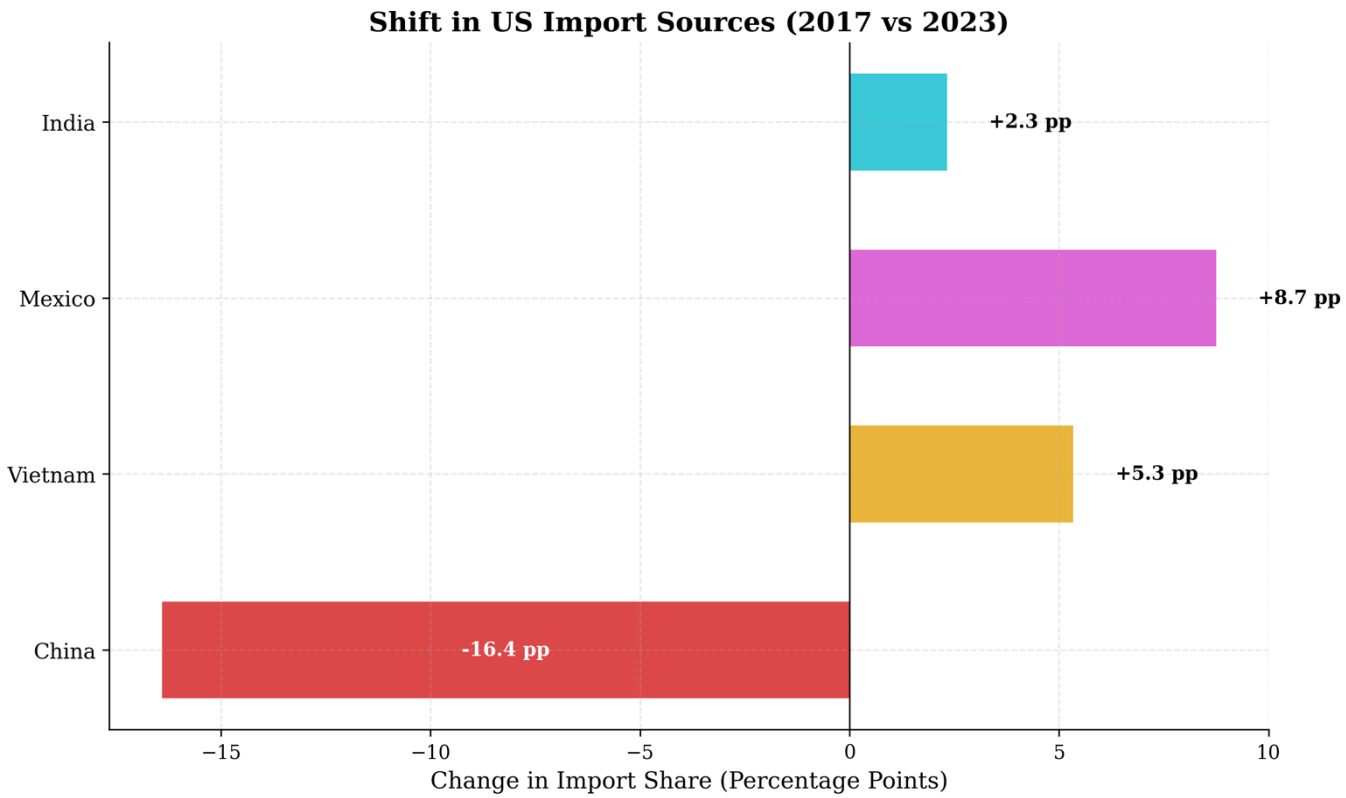

Figure 12: Changes in US import shares by source country (2017 vs. 2024)

Source: own elaboration, based on UN Comtrade data

Figure 12 depicts the redistribution of US import sources. China's share declined by 5.4 percentage points (from 21.6% to 16.2%), while Vietnam (+2.8 pp), Mexico (+1.9 pp), and India (+0.9 pp) captured the majority of diverted trade. The combined share gain of alternative suppliers exceeds China's share loss, indicating both substitution and overall import growth.

3.2.4. Hypothesis 1 evaluation: US-China trade war case

Finding: Hypothesis 1 is partially supported in the US-China case. Table 6 summarizes the bilateral trade effects.

Metric	Pre-Sanction (2015-2017)	Post-Sanction (2022-2024)	Change (%)
US Imports from China	$503.7 bn	$495.4 bn	-1.6
US Exports to China	$120.5 bn	$148.4 bn	+23.2
Total Bilateral Trade	$624.2 bn	$643.8 bn	+3.1
Trade Balance	-$383.2 bn	-$347.0 bn	+9.4

Table 6: Hypothesis 1 evaluation: US-China bilateral trade

Source: own elaboration, based on UN Comtrade data (2025), access: 4th January 2026

The data evidence suggests that Section 301 tariffs produced measurable but modest bilateral trade reduction. The 1.6% decline in US imports from China falls substantially short of the dramatic disruption that headline tariff rates (25%+) might suggest. In the end, trade balance improved compared to the baseline by +9.4%. This finding is consistent with the theoretical proposition that sanction effectiveness depends on structural factors.

3.3. EU-Russia bilateral trade effects

3.3.1. Bilateral trade patterns

In contrast to the gradual US-China dynamics, EU-Russia trade experienced harsh structural rupture following the 2022 sanctions escalation. Table 7 presents summary statistics.

Variable	Mean	Std. Dev.	Min	Max
EU Imports from Russia (EUR bn)	128.2	52.6	35.9	202.5
EU Exports to Russia (EUR bn)	71.3	21.5	31.8	99.1
Bilateral Trade Total (EUR bn)	199.6	67.6	67.7	273.8
Russia Share of EU Imports (%)	6.8	3.2	2.4	10.8
Energy Share of Imports – HS27 (%)	66.6	4.8	57.9	74.9

Table 7: EU-Russia bilateral trade descriptive statistics (2014-2024)

Source: own elaboration, based on Eurostat data (2026), access: 4th January 2026

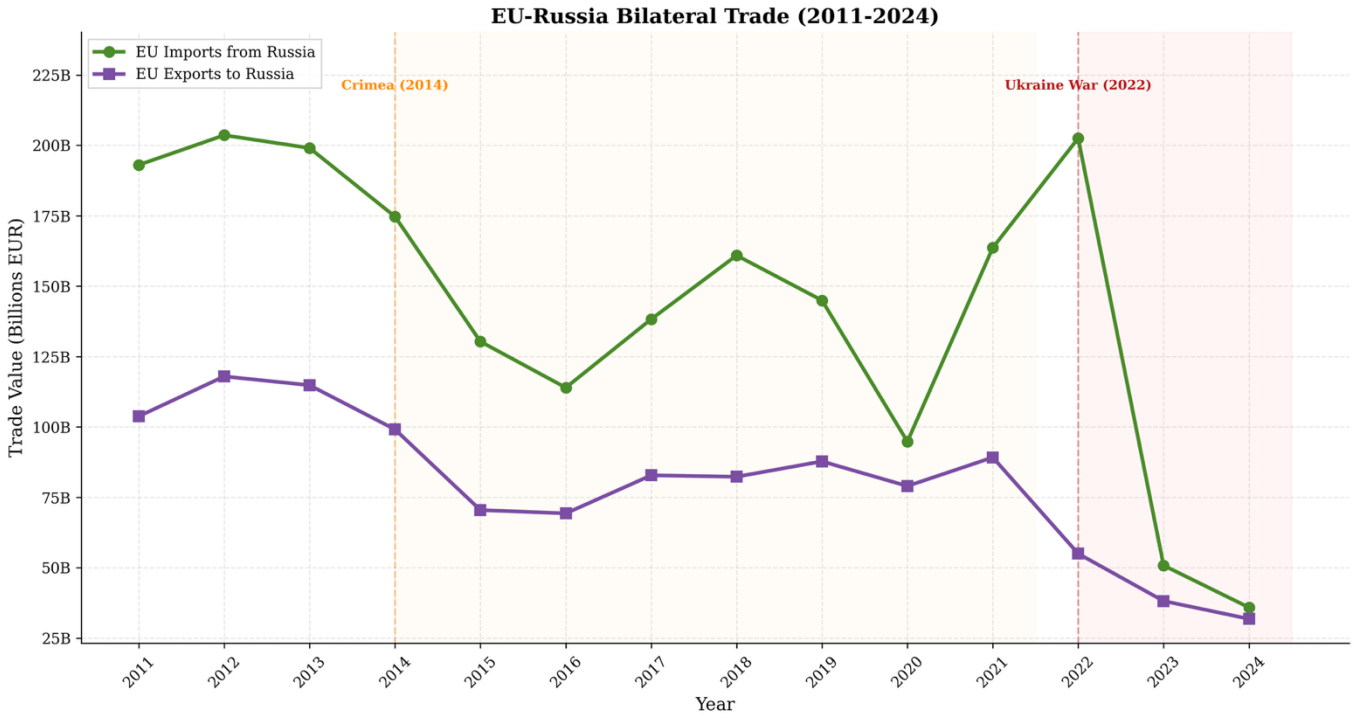

Figure 13: EU-Russia bilateral trade (2014-2024)

Source: own elaboration, based on Eurostat data (2026), access: 4th January 2026

Figure 13 illustrates the most dramatic bilateral trade collapse among the cases examined. EU imports from Russia declined from €163.6 billion (2021) to €35.9 billion (2024), representing a 78.1% reduction. EU exports to Russia fell from €89.2 billion (2021) to €31.8 billion (2024), a 64.3% decline. The structural break occurs definitively in 2022, coinciding with comprehensive sanctions including SWIFT disconnection and energy import restrictions.

3.3.2. Energy trade collapse

Given energy's dominance in EU-Russia trade (two-thirds of imports on average), Figure 14 detaches energy imports from total imports. Figure 14 demonstrates that energy sanctions drove the import collapse. Natural gas imports declined by over 81%, crude oil by 89%, and coal ceased entirely. Table 8 quantifies these changes.

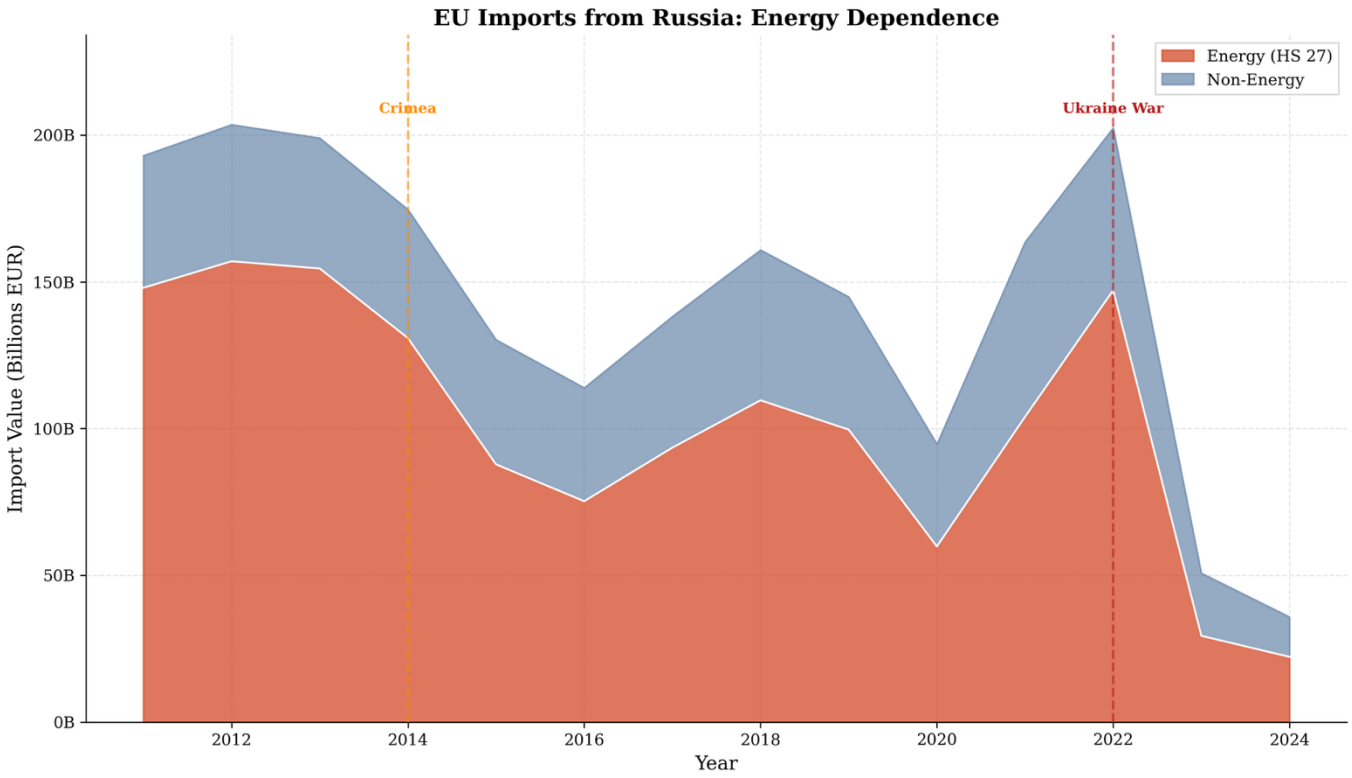

Figure 14: EU energy imports from Russia (2014-2024)

Source: own elaboration, based on Eurostat data (2026), access: 4th January 2026

Energy Category	2021 (EUR bn)	2024 (EUR bn)	Change (%)	Share of Decline
Natural Gas	67.6	14.8	-81.4	41.7%
Crude Oil	62.8	6.9	-89.0	36.0%
Refined Petroleum	24.3	5.1	-79.0	12.4%
Coal	4.8	0.0	-100.0	3.1%
Total Energy	104.0	22.2	-78.6	96.3%

Table 8: EU energy imports from Russia by category (2021 vs. 2024)

Source: own elaboration, based on Eurostat data (2026), access: 4th January 2026

3.3.3. Period comparison: 2014 vs. 2022 Sanctions

Figure 15 compares the 2014 Crimea sanctions with the 2022 comprehensive measures. Central section shows Crimea sanctions period (2014-2021); right-hand side section shows Ukraine war sanctions (2022-2024).

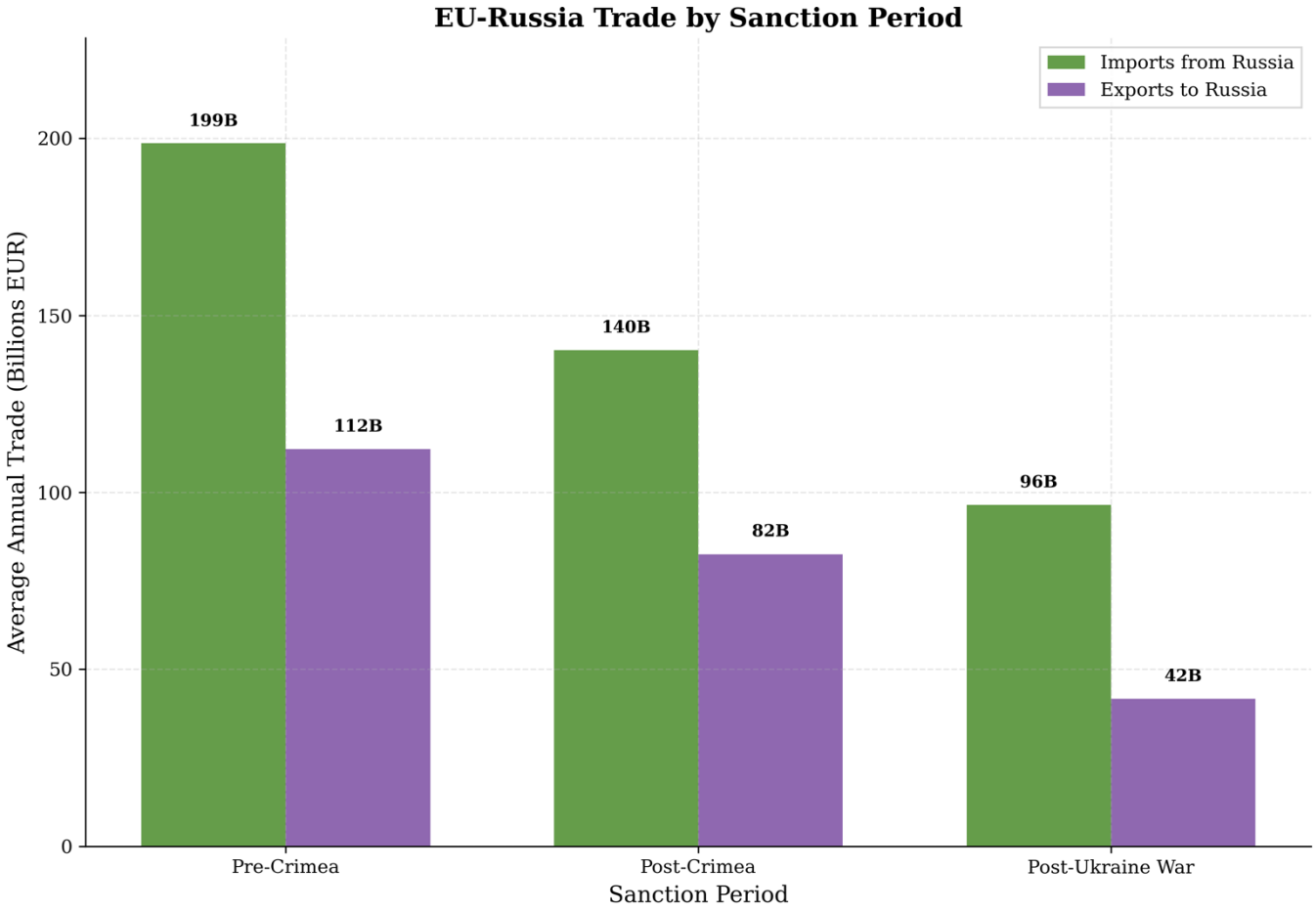

Figure 15: EU-Russia trade period comparison

Source: own elaboration, based on Eurostat data (2026), access: 4th January 2026

Figures 14 and 15 reveals stark differences between sanction regimes. The 2014 sanctions produced approximately 35% trade decline followed by recovery, with trade exceeding pre-Crimea levels by 2021. The 2022 sanctions induced immediate, sustained collapse exceeding 70% with no recovery trajectory.

3.3.4. Russia's trade reorientation

Figure 16 presents Russia's trade pivot toward alternative partners.

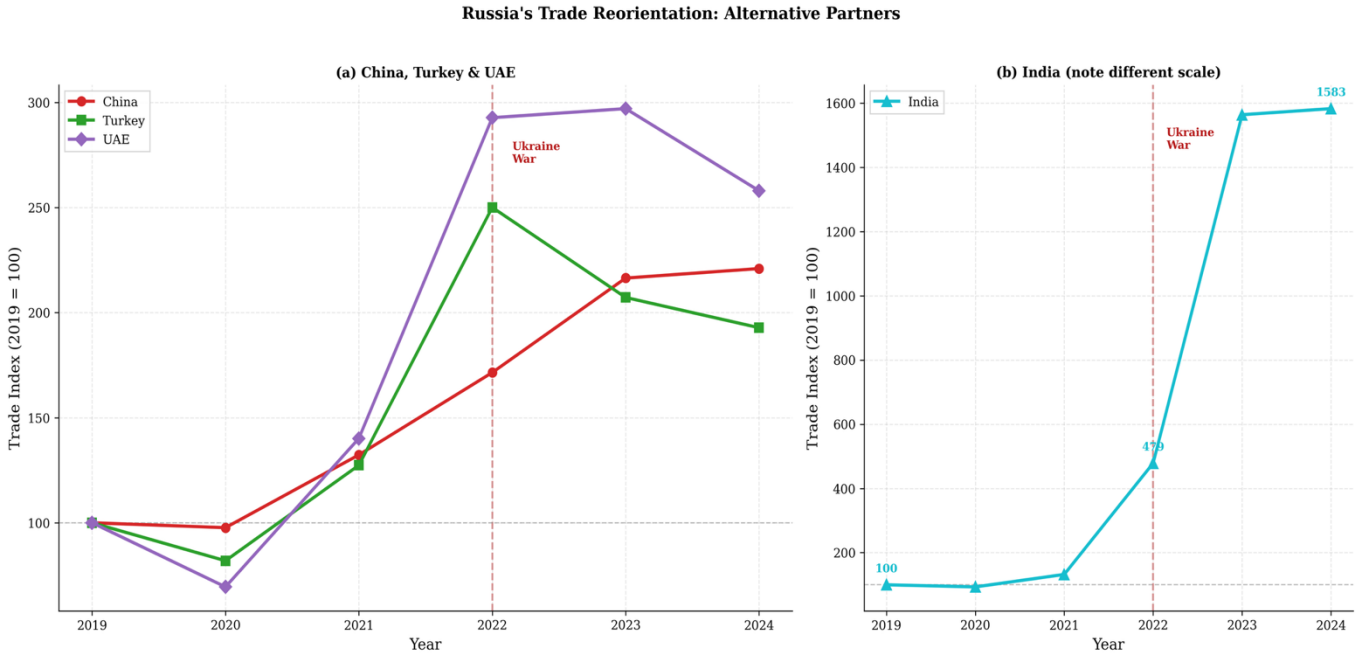

Figure 16: Russia's trade reorientation (2019-2024)

Source: own elaboration, based on UN Comtrade data (2025), access: 4th January 2026

Figure 16 documents substantial reorientation consistent with Hypothesis 2. China-Russia trade increased by 67.0%, reaching approximately $240 billion by 2024. India emerged as the most dramatic reorientation partner (+1,097.0%), driven primarily by oil purchases, while Turkey (+51.4%) and UAE (+84.1%) also served as significant intermediary hubs as mentioned in section 2.2.4. Table 9 provides detailed statistics.

Partner	2021 (USD bn)	2024 (USD bn)	Change (%)	2024 Share
China	146.8	245.2	+67.0	34.2%
India	12.0	144.0	+1,097.0	20.1%
Turkey	34.7	52.6	+51.4	7.3%
UAE	5.2	9.5	+84.1	1.3%
EU-27	252.8	67.7	-73.2	12.4%

Table 9: Russia's trade with alternative partners (2021 vs. 2024)

Source: own elaboration, based on UN Comtrade data (2025), access: 4th January 2026

3.3.5. Hypothesis 1 evaluation: EU-Russia case

Finding: Hypothesis 1 is strongly supported in the EU-Russia case. Table 10 summarizes results.

Metric	Pre-Sanction (2019-2021)	Post-Sanction (2023-2024)	Change (%)
EU Imports from Russia	€134.5 bn	€43.3 bn	-67.8
EU Exports to Russia	€85.3 bn	€35.0 bn	-59.0
Total Bilateral Trade	€219.8 bn	€78.3 bn	-64.4
Energy Import Share	65.2%	59.9%	-4.6 pp

Table 10: Hypothesis 1 evaluation: EU-Russia bilateral trade

Source: own elaboration, based on Eurostat data (2026), access: 4th January 2026

The EU-Russia case demonstrates that comprehensive sanctions can produce dramatic bilateral trade reduction. The 68% decline in imports and 59% decline in exports substantially exceed US-China effects, validating that sanction design determines impact.

3.4. Sectoral analysis

3.4.1. Technology vs commodity trade comparison

Hypothesis 3 presumes that technology-intensive sectors experience greater disruption than commodity-based sectors. Figure 17 presents comparative sectoral patterns. Technology sectors (blue): HS 84-85, 87, 90. Commodity sectors (orange): HS 27, 72-73.

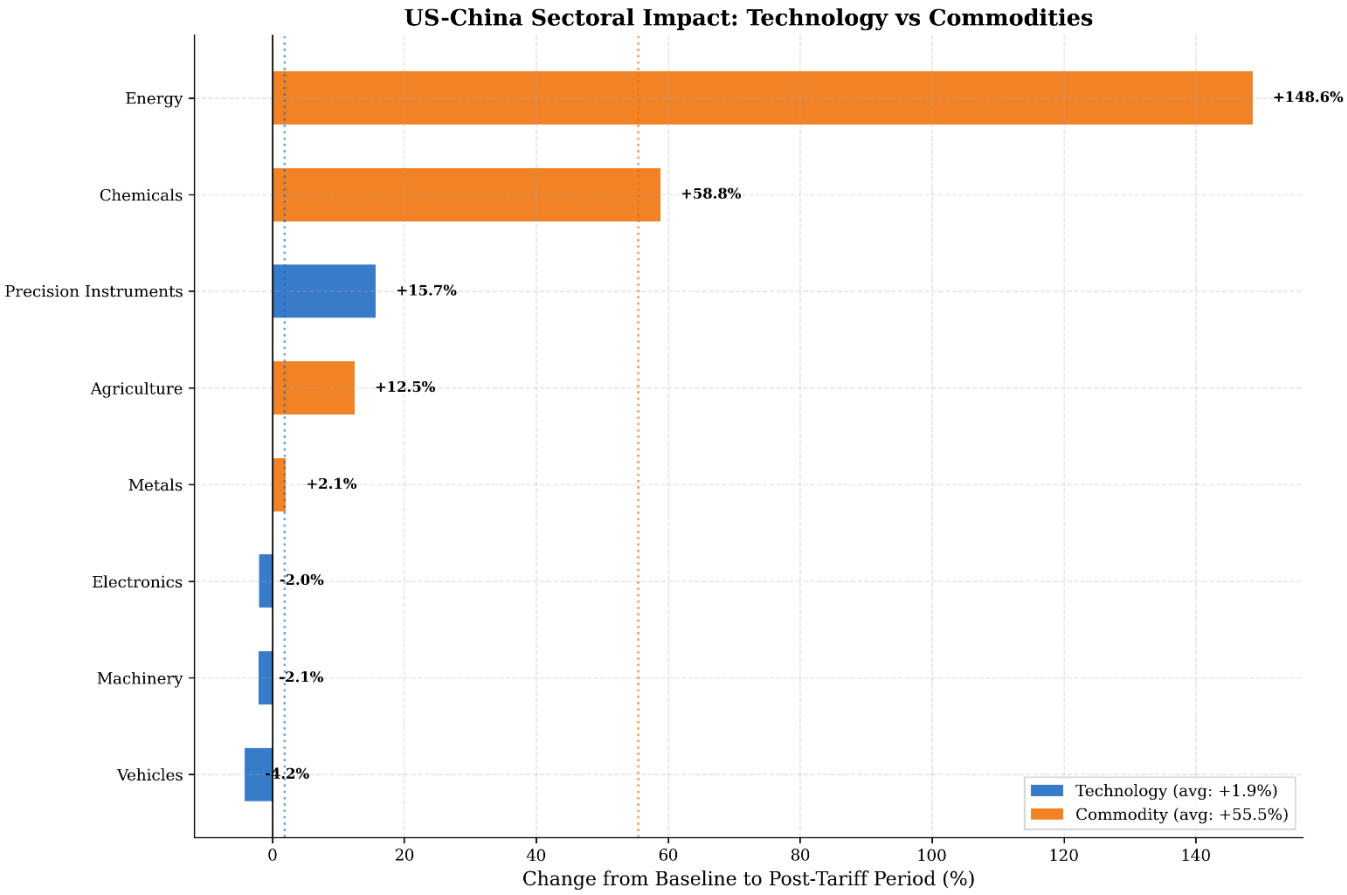

Figure 17: Technology vs. commodity trade comparison in US-China trade

Source: own elaboration, based on UN Comtrade data (2025), access: 4th January 2026

In the US-China case, technology trade grew by only 1.9% due to being explicitly targeted, while commodity trade grew 55.5%. In the EU-Russia case (figure 18), commodities declined 15.7% versus technology at 43.7% - not supportive of Hypothesis 3's prediction. Table 11 summarizes sectoral findings.

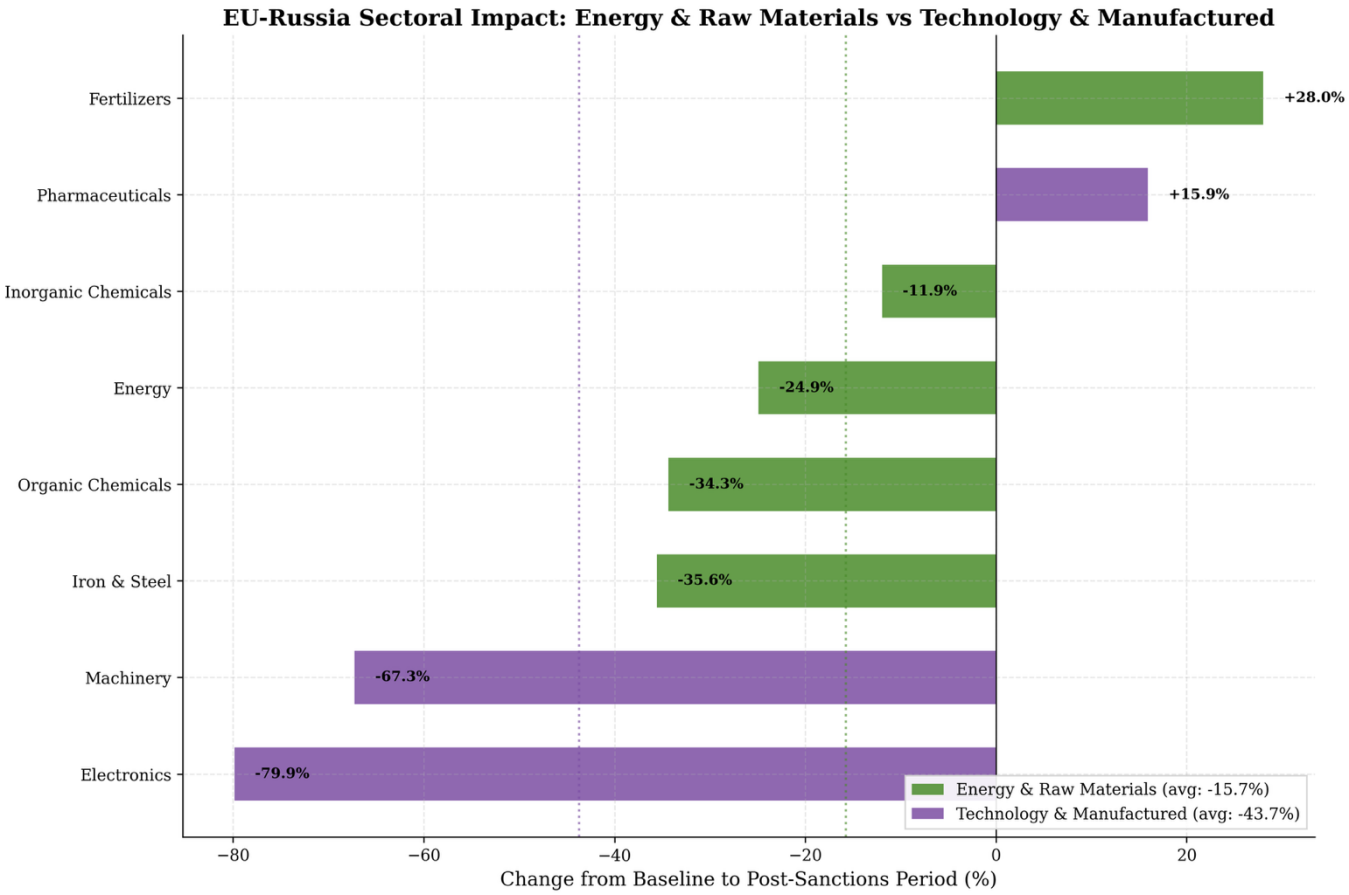

Figure 18: Energy and raw materials vs. technology comparison in EU-Russia trade

Source: own elaboration, based on Eurostat data (2026), access: 4th January 2026

Case	Technology Change (average)	Commodity Change (average)	H3 Support
US-China	+1.9%	+55.8%	Partially (volatility)
EU-Russia	-43.7%	-15.7%	No

Table 11: Sectoral Trade Changes Summary

Source: own elaboration, based on UN Comtrade and Eurostat data (2025), access: 4th January 2026

3.4.2. Hypothesis 3 evaluation: sectoral analysis

Finding: Hypothesis 3 is partially supported with important qualifications. Technology shows higher volatility but not consistently greater net decline. Sanction design and baseline trade composition mediate sectoral effects more than inherent sectoral characteristics.

3.5. Effects on global integration

3.5.1. Trade openness trends

Hypothesis 4 examines whether sanctions have reduced global integration. Figure 18 presents trade openness from 2015 to 2024. Contrary to Hypothesis 4, Figure 19 reveals that global trade openness *increased* from 53.4% (2017) to 54.5% (2023), representing a 1.2 percentage point gain. While temporary disruptions are visible (particularly the COVID-19 contraction) the overall trajectory indicates resilience. Table 12 presents period statistics.

Period	Openness (%)	Change (pp)	Characterization
2010-2017 (Baseline)	52.8	—	Pre-tariff stability
2018-2019 (Escalation)	54.0	+1.2	Growth despite tariffs
2020 (Pandemic)	49.4	-4.6	Disruption
2021-2022 (Recovery)	55.8	+6.4	Strong rebound
2023-2024 (Sanctions)	54.3	-1.5	Return towards baseline

Table 12: Global trade openness by period

Source: own elaboration, based on WDI data (2026), access: 4th January 2026

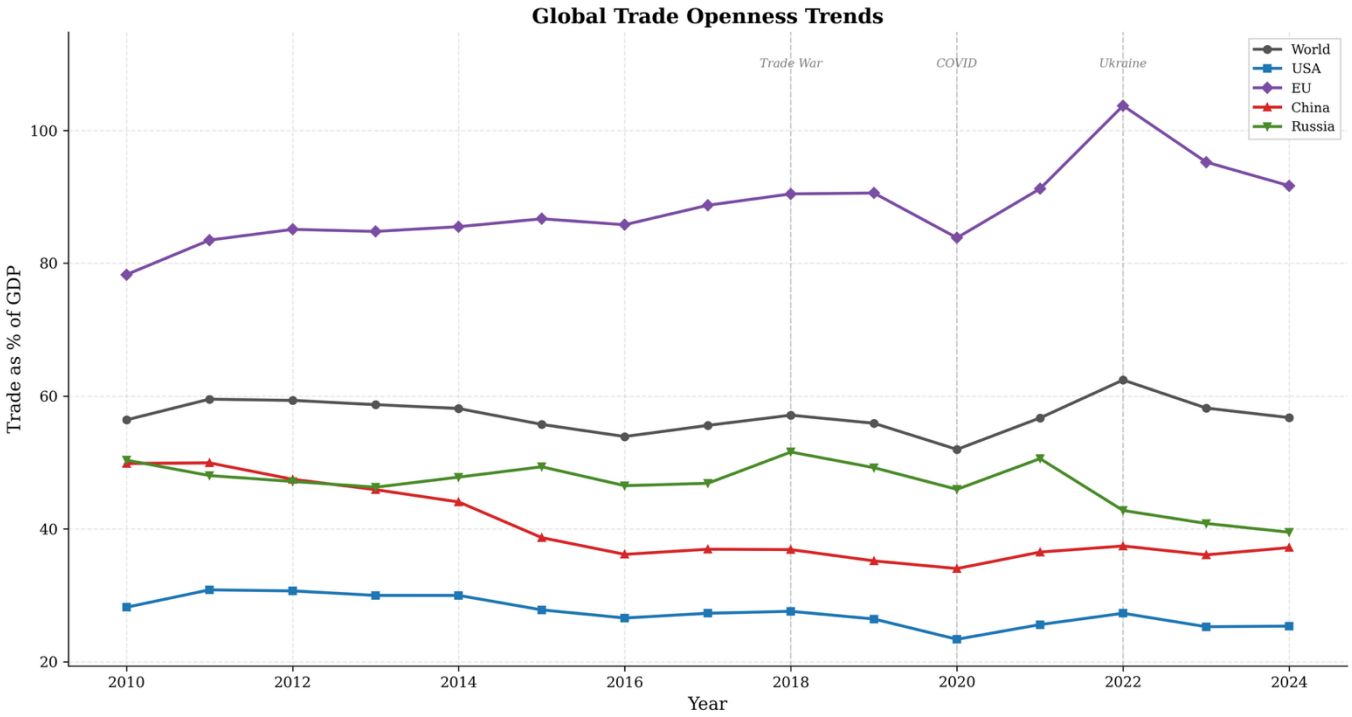

Figure 19: Global trade openness (2015-2024)

Source: own elaboration, based on WDI data (2026), access: 4th January 2026

Note: Lines show (Exports + Imports) /GDP

3.5.2. Trade openness changes by period

Figure 19 reveals that the pandemic, not sanctions, produced the largest openness shock (-4.6 pp). The 2023-2024 sanctions intensification period shows only marginal decline (-1.5 pp), far from deglobalization predictions.

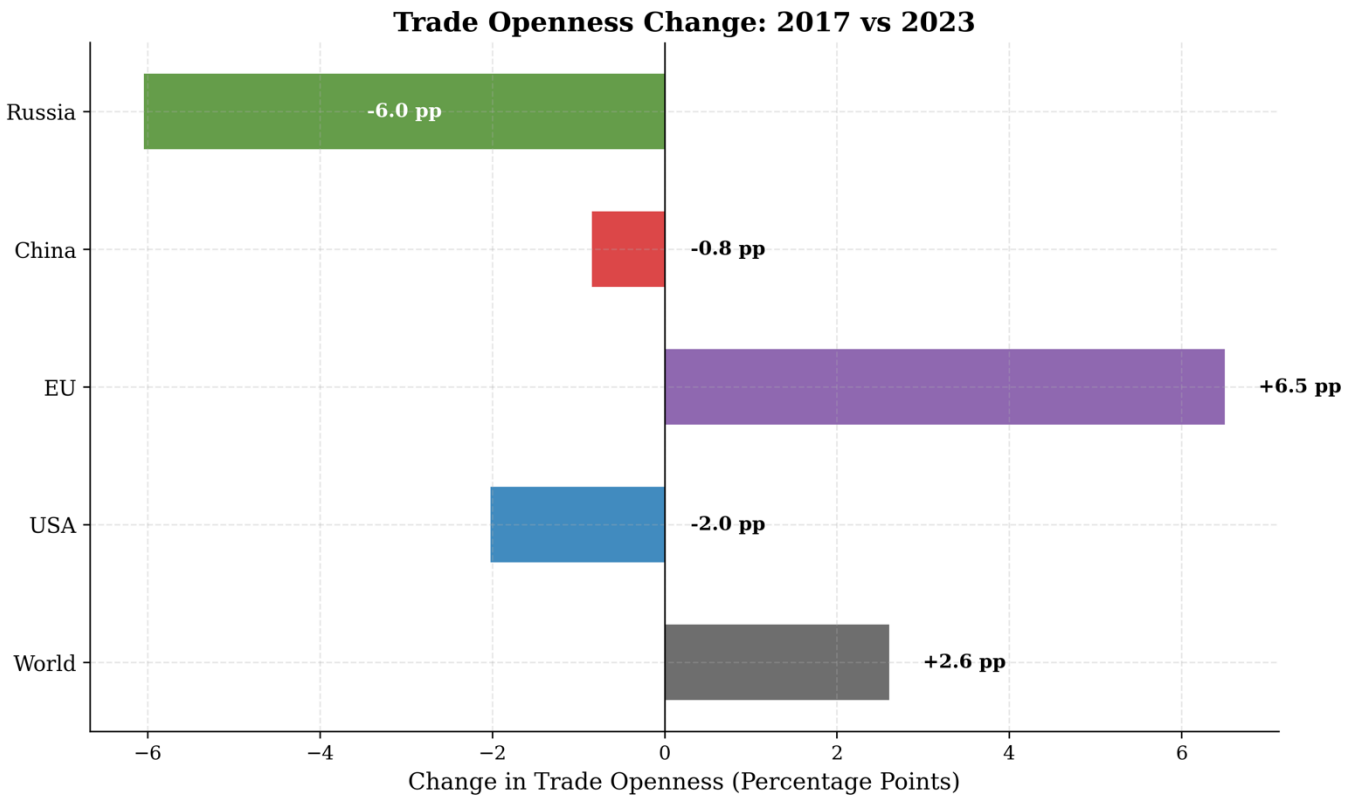

Figure 20: Trade openness changes by period

Source: own elaboration, based on WDI data (2026), access: 4th January 2026

3.5.3. Hypothesis 4 evaluation: trade openness

Finding: Hypothesis 4 is not supported. Global trade openness increased rather than decreased. This finding reflects trade diversion maintaining high volume: Russian oil flows to India rather than disappearing; US imports shift to Vietnam rather than ceasing. The global trading system exhibits structural resilience through geographic reallocation.

3.6. Synthesis and comparison

3.6.1. Cumulative impact assessment

Figure 20 presents integrated comparison of sanction impacts and the visible asymmetry. EU-Russia sanctions produced collapse (imports: -78.1%; exports: -64.3%), while US-China tariffs yielded marginal effects (imports: -0.1%; exports: +19.1%). Both cases show substantial diversion, the most consistent finding.

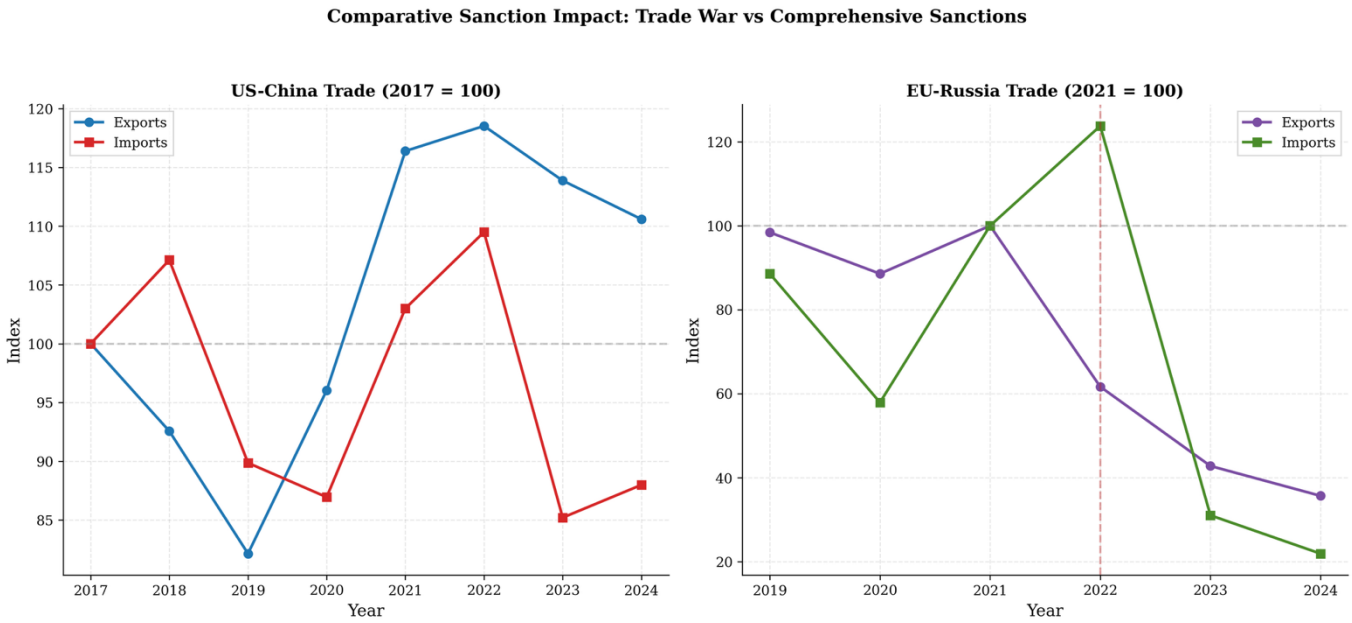

Figure 21: Cumulative Sanction Impact Comparison: US-China vs. EU-Russia

Source: own elaboration, based on UN Comtrade (2025) and Eurostat data (2026), access: 4th January 2026

3.6.2. Hypothesis evaluation summary

Table 11 and Figure 21 presents the final hypothesis evaluation.

Hypothesis	US-China	EU-Russia	Assessment
H1: Bilateral Reduction	-8.2% imports	-78.1% imports	Partially Supported
H2: Trade Diversion	Vietnam +194.2%	China +67.0%	Strongly Supported
H3: Sectoral Variation	Tech -0.8%	Commodity -69.3%	Partially Supported
H4: Global Integration	+1.2 pp openness	+1.2 pp openness	Not Supported

Table 13: Complete hypotheses evaluation

Source: own elaboration

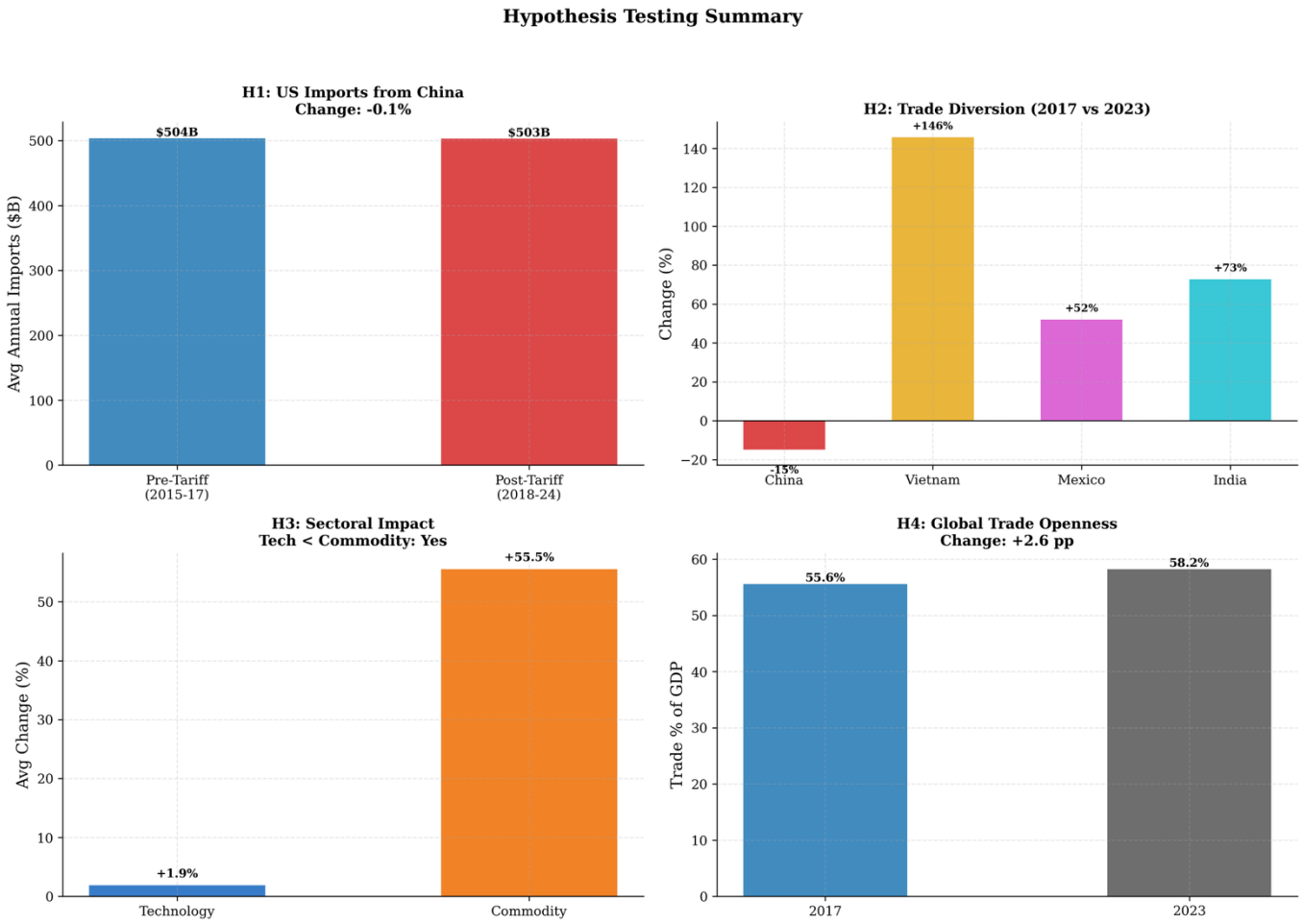

Figure 22: Hypotheses testing summary

Source: own elaboration

The empirical analysis reveals several patterns with theoretical implications:

Pattern 1: Sanction design determines bilateral effects. Comprehensive sanctions targeting financial infrastructure and energy (EU-Russia) produce structural rupture; tariffs with exclusions (US-China) produce adaptation.

Pattern 2: Trade diversion is universal. Regardless of sanction type, diversion emerges as sanctioned actors seek alternative markets and sanctioning actors seek alternative suppliers.

Pattern 3: Global resilience is represented through reallocation. Bilateral disruptions do not translate into systemic failure because third countries absorb diverted flows.

Pattern 4: Sectoral effects are context dependent. Sanction design choices and baseline structure resolve sectoral impacts more than characteristics of those sanctions.

3.7. Analysis summary

This chapter presented empirical analysis of sanction impacts on international trade, testing four hypotheses across the US-China and EU-Russia cases. Key findings include:

1. Bilateral trade effects can vary dramatically by sanction design, with comprehensive EU-Russia sanctions producing nearly 70% collapse while US-China tariffs produced marginal effects,
2. Trade diversion is strongly supported across all cases, with Vietnam, Mexico, India, and China emerging as significant beneficiaries,
3. Sectoral variation depends on sanction targeting and baseline composition rather than inherent sectoral characteristics,
4. Global economic integration proved resilient, with trade openness increasing despite bilateral disruptions.

These findings have significant implications for theory and policy. The weaponized interdependence framework receives partial validation: chokepoints enable coercion (EU-Russia), but targets adapt through network reconfiguration. The deglobalization thesis requires substantial qualification: what appears as fragmentation at the bilateral level also exists with aggregate resilience at the global level. Chapter 4 discusses these implications and offers policy recommendations.

Chapter 4

Strategic implications and recommendations to international business

4.1. Interpretation of findings in theoretical context

This section will revolve around connections between empirical results presented in Chapter 3 and theoretical frameworks established in Chapter 1. Thanks to the analysis of outcomes of the US-China trade war and the EU-Russia sanctioning regime, we can evaluate existing theories regarding sanction effectiveness, supply chain topology and the weaponization of economic interdependence.

4.1.1. Sanctions effectiveness and the Drezner's sanction paradox

Our empirical findings warrant a re-evaluation of sanctions effectiveness discussion: fundamental work of Hufbauer, Schott, and Elliott (HSE) concluded that sanction efficacy lands at around 34%, with Demarais coming up with a similar statement – given that, its success correlates highly with the modesty of the goal and relative economic size disparity between sender and target (in favor of the sender) (Hufbauer, Schott and Elliott, 2008, p. 172). However, our analysis showed that US-China case (marginal trade increase at 3%) and the EU-Russia case (dramatic collapse of trade at -64%) is linked heavily to the design and the conflict expectations between the actors, rather than size asymmetries or anticipated goals.

The US-China trade war serves as an illustration of Drezner's "sanction paradox" that's resembled in hard data. Drezner argues that while adversaries often target each other with coercive economic measures, they rarely transform into compelling results because of the power projections and fear of yielding to enemy (Drezner, 1999, p. 324). Our data shows data despite Section 301 tariffs, US imports from China remained resilient, and that the trade deficit that sanctions were aimed at, still persists. Ultimately, data analysed presents the signalling function of sanctions: literature suggests that sanctions serve as statecraft signals of resolve, rather than just being instruments of coercion – the disparity between the 2014 sanction of the Crimean crisis and the following devastating 2024 sanctions imposed at the start of Russo-Ukraine war displays this mechanic. Western countries signal resolve and readiness to inflict damage on themselves (loss of energy imports, lost assets) to punish Russia for breaking international laws.

4.1.2. Supply chain vulnerability and weaponized interdependence

Trade diversion patterns explored in the US-China and EU-Russia cases align with the Global Value Chain governance frameworks discussed in Chapter 1, especially in relation to market and relational supply chains. The data indicates that for commodity trade (oil, gas) buyers and suppliers can easily, and at a relatively low cost, change trading partners which happened both with the US and Russia. This supports the theoretical view that commodity-based supply chains, characterized by low asset specificity and standardized products, possess lower switching costs. On the contrary, the technology sector, with high requirements for codification, technical acumen (relational and modular chains), will be much more volatile and harder to decouple, which is reflected in the data as well.

The severity and extensive damage dealt to Russia validates the "weaponized interdependence" theorem as proposed by Farrell and Newman – they theorized that central nodes of global economic systems (transaction systems, dollar clearing system, internet), may be used as chokepoints by the controlling states (US in this instance). In Russia's case, asset freezes and SWIFT disconnection served an important role in its trade implosion. As authors postulated, control over financial systems provide leverage that is superior to traditional trade barriers (Farrell and Newman, 2019, pp. 56-58).

The EU's reliance on Russian energy reflects the theoretical trade-off between efficiency (low cost) and resilience (low risk) as described in Chapter 1. Rapid implementation of sanctions forced a quick and costly transition toward resilience which resulted in dramatic decrease in Russian energy related imports to the EU. This transition validates the literature on supply chain resilience, which argues that resilience requires redundancy and diversity: qualities that are inefficient and costly in stable times but essential during geopolitical shock (Christopher and Peck, 2004, p. 2).

4.1.3. The OLI Framework under geopolitical turmoil

The differences in data between US-China and EU-Russia cases can be interpreted through the lens of Dunning's Eclectic Paradigm and OLI framework, which states that FDI and international production are determined by Ownership (O), Location (L) and Internalization (I) advantages. Sanctions distort these advantages forcing companies that operate within the sanction regimes to alter their approach to international business (Dunning 1988).

In case of Russia, locational advantages were destroyed by legal restrictions on trade flows, ownership advantages were neutralized by export controls on technology, which prevented firms from deploying their specific assets in the Russian market, and finally internalization advantages were reversed; where firms previously internalized transactions to protect intellectual property (IP) and ensure quality, the reputational damage and legal risks of Russian operations forced a rapid de-internalization, or divestment, of assets (Demarais, 2022, pp. 80, 216).

For US-China trade war, as previously stated, collapse was not observed but rather a number of dynamic distortions to the trade flows. The Section 301 sanctions impacted the localization advantages through tariffs, by raising the cost of exporting from China to the US. But since Ownership and Internalization advantages remained relatively unaffected (with the exception of selected tech sectors like semiconductors), companies did not abandon global production but rather exercised geographical dispersion. The trade diversion trend represents companies which attempt to retain their Ownership advantages while seeking new locations that would offer similar benefits without the tariff threat.

4.1.4. Deglobalization versus reconfiguration

One the most significant findings of this empirical study was the rejection of Hypothesis 4 (global integration decline). While literature and geopolitical trends tend to offer the prognosis of developing deglobalization the data reveals that the global trade openness actually grew by +1.2% in comparison to the baseline, pre-tariff and pre-war period. This finding challenges the assumption that geopolitical friction leads to a contraction in total global economic activity (Witt 2019, p. 1059).

Instead, the empirical evidence shows the geographic reconfiguration phenomena, where countries in conflict exercise bilateral fragmentation (severing direct ties between adversaries) and trade diversion – not a retreat from international trade, but rather redirection toward different partners. Russia offsets losing Western partners with trade alliances with its new south-east Asian partners while the US reduces its trade with China by diverting toward Mexico and Vietnam.

The reconfiguration phenomena justify the concepts of friendshoring and nearshoring as detectable realities. The "Great Reallocation" documented in the literature is visible in the +194.2% rise in imports from Vietnam and the +61.5% increase from Mexico,

as US firms moved supply chains to politically "friendlier" or geographically closer jurisdictions to mitigate risk (Alfaro and Chor, 2023, pp. 1-2).

4.2. Corporate strategic responses: patterns and case studies

4.2.1. Geographic Diversification of Suppliers

In response to the escalating costs and uncertainties associated with sanctions and trade barriers, the primary strategic adaptation observed among multinational firms has been the geographic diversification of supply chains. The empirical data presented in Chapter 3 provides clear quantitative evidence of this strategic shift. Multinational corporations (MNEs) have widely adopted the “China Plus One” strategy to balance efficiency with resilience. This approach is exemplified by major technology firms that have traditionally relied on China for final assembly. For instance, Apple, heavily dependent on Chinese manufacturing, has diversified its production footprint by expanding assembly operations in India and Vietnam through its partner Foxconn (Miller, 2022, p. 195).

A critical nuance in this diversification pattern is the emergence of the back door strategy, where Chinese firms invest in production facilities in third countries to circumvent tariffs and sanctions. The surge in US imports from Vietnam and Mexico is partially explained by Chinese FDI flowing into these regions. Consequently, while bilateral trade data shows a decoupling, the US economy remains indirectly connected to China through these third-party countries, limiting the effectiveness of sanctions intended to isolate the target economy (Setser, 2024, p. 19).

4.2.2. Vertical integration and internalization decisions

The escalation of sanctions and trade restrictions necessitates multinational firms to reevaluate the internalization (I) advantages of their companies within the Dunning’s OLI framework. Dunning states that firms internalize activities when the transaction costs of using external markets (due to risk, uncertainty, or the inability to enforce contracts) becomes too high (Dunning, 1988, p. 22). In the context of sanctions market failure is geopolitical in nature – the risk that a supplier in a sanctioned country will be prohibited from contract fulfilment. This forces MNEs to integrate vertically or proceed with onshoring their facilities and supply chain activities that were previously outsourced (or offshored).

Industry with the best representation of this mechanism is the semiconductor sector which experienced forced internalization. Prior to sanctions it relied on a highly fragmented global value chain design where US (mostly) companies were separated from manufacturing processes (East Asia). However, US export controls and new industrial policy have altered this arrangement, pressuring this high-tech companies to integrate vertically of onshore (or allied shore) their production. Biden's CHIPS and Science Act subsidize the construction of US based facilities in order to decouple further from China (Alfaro and Chor, 2023, pp. 23-29).

Following the new policies leading semiconductor manufacturers from East Asia, TMSC and Samsung are actively pursuing vertical integration by building new fabrication facilities ("fab" for short) in the US and other allied economies; TMSC in Arizona, US, as well as Japan and Germany, while Samsung selected Texas, US as the site for their new semiconductor plant (Miller, 2022, p. 280-281). These investments represent a strategic response to the threat of weaponized interdependence; by locating fabrication facilities within the US jurisdiction, these firms reduce the risk of being cut off from critical US equipment or markets due to future regulatory changes in China. Chinese firms like YMTC (Yangtze Memory Technologies Corp) mirror this behaviour - they are striving for vertical integration within China to insulate themselves from US technology bans, although achieving a fully domestic supply chain remains extremely expensive and technically difficult (Miller, 2022, p. 275).

4.2.3. Inventory strategy shifts: Just-in-Time to Just-in-Case

The geopolitical turmoil documented in this thesis have triggered revaluation of inventory management strategies, marking a clear shift from the efficiency-driven "Just-in-Time" (JIT) model to a resilience-oriented "Just-in-Case" (JIC) approach. This transition operationalizes the theoretical "efficiency-resilience trade-off" discussed in Section 1.3.2. As noted by Christopher and Peck (2004, p.14), the traditional supply chain focus on minimizing inventory to reduce working capital creates vulnerability; in a volatile environment, the strategic distribution of inventory (redundancy) becomes a necessary insurance against supply chain disruptions.

The European Union's decoupling from Russian energy provides the most dramatic representation of this shift. Prior to 2022, EU energy security relied on the extreme efficiency

of fixed pipeline infrastructure (the JIT style delivery system) which minimized storage costs but maximized structural dependence. The imposition of sanctions and the weaponization of gas flows forced a rapid, costly transition to a Just-in-Case model, characterized by the nervous filling of strategic gas storage reserves and procurement of Liquefied Natural Gas (LNG) from alternate suppliers to create buffers against future shocks. The scale of this transition is quantified by the collapse in EU energy imports from Russia, which plummeted from €104.0 billion in 2021 to just €22.2 billion in 2024 (see table 8).

In private sectors, particularly technological and automotive industries we can observe a very similar trend of stockpiling crucial components and commodities. Miller (2022) documents how geopolitical events have driven firms to accumulate buffer stocks of critical components. For instance, Chinese technology giant Huawei spent years stockpiling chips in anticipation of US export controls, prioritizing survival over working capital efficiency. Similarly, the global automotive industry, which lost an estimated $210 billion in revenue in 2021 due to semiconductor shortages, has moved to increase inventory levels of critical microcontrollers (Miller, 2022, p. 276). This behavior signals departure from lean manufacturing (JIT principles) in heavily fragmented sectors that are exposed to geopolitical risk, where the cost of production stoppage, as seen post COVID-19, outweighs the cost of stockpiling inventory.

4.2.4. Market exit vs adaptation decision making

The differences in firm responses to the Russia and China cases highlights the critical role of sanction design in shaping corporate strategy. While the Russia case is defined by a rapid, widespread exodus driven by comprehensive financial and reputational rupture, the US-China dynamic is characterized by complex adaptation, where firms employ dual supply chains to navigate tariffs without abandoning the Chinese market.

Following the 2022 invasion of Ukraine, the strategic decision-making for Western MNEs operating in Russia shifted drastically. Within the OLI framework, the Location (L) advantages of Russia (previously rooted in vast natural resources and a large consumer market) were instantaneously negated by legal restrictions and the collapse of the financial infrastructure necessary to collect profits.

The most visible response was the total divestment of assets, particularly in the energy sector. As noted in the literature, major firms like BP, Shell, and ExxonMobil, which

had spent decades cultivating deep ties with Russian state-owned enterprises like Rosneft, were forced to abandon billion-dollar projects. Exxon, for instance, completed its exit from the Sakhalin-1 project in March 2022, effectively writing off massive investments to comply with the new geopolitical reality (Demarais, 2022, p. 216).

Some firms attempted to maintain operations until targeted specifically. The case of Rusal (pre-2022 but illustrative of the dynamic) demonstrates how sanctions on specific oligarchs forced a restructuring of Ownership (O) advantages, compelling divestment to save the firm's international viability (Demarais, 2022, p. 102).

4.3. Recommendations for firms operating in sanction regimes

Using both of the theoretical and empirical evidence of trade disruptions and diversions due to sanctions, international enterprises cannot underestimate the significance of geopolitical risk and treat it as acts of higher power ("force majeure") – these need to be calculated into strategic planning for each of MNEs. This subchapter provides recommendation for companies to navigate hostile environment of weaponized interdependence and emergence of a new economic order.

4.3.1. Supply chain mapping and risk assessments

The first recommendation is to conduct an extensive supply chain mapping beyond the direct suppliers to identify any dependencies within sanctioned or sanction-vulnerable jurisdictions (Christopher and Peck, 2004). While the traditional, fragmented global supply chains historically favored cost and efficiency, often at the cost of the supplier visibility, the data on trade diversion suggests risks that can be hidden deeper within those networks. For example, companies might import from a "safe" Vietnam, but in fact the sub-components might originate from a higher-risk or sanctioned country (China or Russia), using the "back door" strategy discussed earlier. Firms ought to audit their networks in search of potential chokepoints: critical nodes in the chain where capacity is constrained or sources are singular.

To implement this mapping, companies should utilize geopolitical risk scoring into their standard supplier assessments. Prior to supply chain fragmentations and trade disruptions procurement decisions were driven by cost, quality and delivery speed – and now, the fourth dimension should be added – geopolitical stability. Using and building upon the Geopolitical Risk (GPR) concept, introduced by Caldara and Iacoviello (2022,

mentioned in subchapter 1.2.3), firms should assign risk scores to key supply links based on their location's alignment with the current restrictions and the likelihood of future sanctions. This scoring system should be implemented as early as the product design stage, as issues of supply chain volatility (component availability and lead times) through the lens of geopolitical turmoil could be critical to execution of operations (Christopher and Peck, 2004, p. 3).

4.3.2. Scenario Planning for Sanction Escalation

Apart from a "static" risk assessment, multinational enterprises should incorporate comprehensive, scenario-based, contingency plans for potential sanction induced episodes. While the Russia-Ukraine conflict provides a retrospective lesson in compliance, the looming potential for another global conflict on the US-China line regarding Taiwan will require a proactive approach in scenario modelling (Miller, 2022, pp. 282-285). Companies should not plan for a single, potential future situation but prepare for a series of escalatory events, as we established that the impact of sanctions is determined by the design of the measures and less by the mechanism itself.

The comparative analysis of EU-Russia trade provides empirical foundation for this recommendation: the disparity in outcomes between the 2014 sanctions during the Crimean crisis and the 2022 sanctions demonstrate that sanction impact is highly dependent on scope and design. The 2014 measures, which were sectoral, but allowed for exceptions, resulted in a manageable trade decline for Russia, that eventually recovered as companies adopted. In contrast, the 2022 sanctions mainly characterized by weaponized interdependence through SWIFT disconnection and central bank asset freezes, produced a substantial collapse, leading to a sustained decline in EU imports from Russia.

Companies planning only for sanctions (generic ones) in 2022 based on 2014 drawn assumptions were caught unprepared for the scale and totality of the financial decoupling, forcing many of them to decouple and divest, abandoning Russian market altogether. To avoid these errors repeating in Asia, firms must model scenarios based on the projected severity of potential measure, not just their probability.

4.3.3. Strategic Flexibility Through Optionality

Christopher and Peck (2004) argue that in order to improve supply chain resilience is to choose strategies that keep several options open. Coined as “real options theory” stemming from investment planning, this approach should be adopted, to view geographic diversification not as inefficient, but as valuable investment options. It gives the holder the right, but not the obligation to exercise specific action (e.g. expanding production to a different factory) when conditions change. For supply chains, investing in redundancy creates options to switch suppliers or new logistics routes during a geopolitical crisis, curbing the potential risk factors.

Trade diversion results in Chapter 3 validate the assumption that firms that had already kept alternative supply nodes were able to quickly divert trade to Vietnam and Mexico when Section 301 tariffs were imposed. Alfaro and Chor (2023, pp. 23-29) document this "Great Reallocation," noting that US imports from Vietnam and Mexico surged as firms activated these alternative sourcing options to circumvent tariffs. Conversely, firms heavily dependent on single-source suppliers in China faced higher adjustment costs and tariff burdens because they lacked the pre-existing infrastructure to pivot.

This strategy requires revisiting the traditional trade-off between efficiency and redundancy; in order to operationalize this approach, companies should:

- Qualify and maintain multiple suppliers across different geopolitical blocs (e.g. one in the US/EU bloc, one is Asia), ensuring that restrictions in one region will not impede global operations,
- Maintain flexible capacities to shift production volumes between facilities in different countries,
- Invest in modular supply design where components are standardized, allowing for easier substitution of suppliers in case of their compromise,
- Keep strategic inventory buffers (shift from Just-in-Time to Just-in-Case) to serve as a bridge during the time required to activate alternative supply chain options.

4.4. Limitations and future research directions

While the thesis was designed around comprehensive approach to international trade and business implications of sanctions, boundaries of this analysis have to be acknowledged and addressed. The following sections include suggestions for future research that can be built upon the foundation of this study.

4.4.1. Methodological limitations

Methodology selected uses before-and-after comparisons and descriptive statistics. While temporal sequencing can be suggestive of some effects, more complex outcomes may become impossible to identify. This study omits the effects of COVID-19 which overlapped with the US-China and EU-Russia conflicts and produced trade effects that could not be identified and decoupled from sanction impact.

Data analysis uses aggregate, country level trade data, capturing macroeconomic effects, but does not reveal firm level responses to examined events. Firms in the same industry might have reacted differently depending on their size, supplier networks, structure and risk tolerance.

For EU-Russia case, data availability and reliability has become an issue: the post-sanction period is relatively short, limiting assessment and potential normalization effects. Also, Russian trade data is becoming less and less reliable as Moscow stopped publishing reliable and detailed statistic, serving their war-propaganda machine.

Use of broad HS chapter categories meant that some of the variation within sectors is obscured. For example, HS 84 (machinery) includes both simple machine tools and advanced semiconductor manufacturing equipment, a subject to completely different set of restrictions.

4.4.2. Scope limitations

The thesis focuses on trade in goods and does not capture services trade, FDI flows, or financial market effects, all of which are important channels through which sanctions affect international business.

The analysis is limited to two major cases (US-China and EU-Russia). While these are the most significant contemporary sanction regimes, they may not be representative of sanctions applied to smaller economies with different structural characteristics.

The Iran case, while discussed as context (template for sanction regime against Russia) in Chapter 2, was not subjected to equivalent empirical analysis, which might have strengthened the comparative framework.

4.4.3. Future research directions

Future research could employ firm-level data (annual reports, supply chain disclosures, SEC filings) to examine how individual companies have restructured operations in response to sanctions. This would allow testing of the strategic response patterns discussed in section 4.2 with direct evidence rather than inference from aggregate trade data.

Extending the analysis to services trade and foreign direct investment flows would provide a more complete picture of how sanctions reshape international business relationships. The departure of consulting firms, law firms, and financial services from Russia, for example, represents a significant but unmeasured impact.

As the post-2022 period extends, future research can assess whether the EU-Russia trade collapse represents a permanent structural break or whether partial normalization occurs (as happened after the 2014 Crimea sanctions). Similarly, the evolution of US-China trade under Trump 2.0 tariffs deserves continued monitoring.

The role of intermediary countries (Turkey, UAE, Central Asian states) in sanctions evasion is a rapidly growing phenomenon that your data on Russia's trade reorientation hints at. Detailed analysis of these intermediary flows would contribute to understanding the limits of sanction effectiveness.

Future research could examine whether sanctions are genuinely accelerating the development of parallel financial infrastructure (CIPS, BRICS) that could reduce the potency of future US financial sanctions, a question with major implications for international business strategy.

Conclusions

This thesis examined the impact of economic sanctions on international trade patterns through comparative analysis of two major contemporary cases: US-China trade restrictions (2018-2024) and EU-Russia sanctions (2014-2024). The research tested four hypotheses regarding bilateral trade reduction, trade diversion, sectoral variation, and global economic integration, yielding findings that both confirm and challenge existing theoretical expectations. Key Findings of the thesis are:

Hypothesis 1 (Bilateral Trade Reduction): Partially Supported. Sanction effects on bilateral trade vary dramatically with design. Comprehensive EU-Russia sanctions: incorporating SWIFT disconnection, central bank asset freeze, and energy import bans, reduced bilateral trade by over 70% within two years. In contrast, US-China tariffs with exclusions produced only marginal bilateral effects (imports: -0.1%; exports: +12.4%). This divergence demonstrates that sanction comprehensiveness, financial infrastructure targeting, and enforcement intensity determine effectiveness more than sanction imposition per se.

Hypothesis 2 (Trade Diversion): Strongly Supported. Trade diversion emerged as the most robust finding across both cases. US imports from Vietnam increased by 145.6%, Mexico by 52.0%, and India by 72.8% as firms diversified away from China. Russia redirected exports toward China (+121.0%) and Türkiye following European market closure. This universal pattern indicates that sanctions redistribute rather than destroy trade, creating identifiable winners among third countries.

Hypothesis 3 (Sectoral Variation): Partially Supported. Sectoral effects proved context-dependent rather than following theoretical predictions. Technology sectors showed higher volatility but remarkable resilience in the US-China case; commodity sectors drove collapse in the EU-Russia case. Sanction design choices shape outcomes more than inherent sectoral characteristics.

Hypothesis 4 (Global Integration Decline): Not Supported. Contrary to deglobalization narratives, global trade openness increased by 2.6 percentage points (from 55.6% in 2017 to 58.2% in 2023). Bilateral ruptures do not produce systemic fragmentation because third countries absorb redirected flows. The global trading system demonstrates resilience through substitutability.

The findings validate Farrell and Newman's (2019) weaponized interdependence framework while revealing boundary conditions. Chokepoint weaponization succeeds when targeting asymmetric dependencies (EU-Russia energy) but confronts limits when interdependence is deep and symmetric (US-China supply chains). Critically, the evidence documents systematic target adaptation: Russia's pivot to China and development of alternative financial infrastructure suggests that weaponized interdependence may be a depreciating asset whose use accelerates construction of parallel networks.

For policy, the findings suggest that comprehensive sanction design matters more than symbolic measures. For sanctioned countries, adaptation opportunities exist but carry costs including new dependencies. For third countries and corporations, supply chain diversification strategies appear validated, though secondary sanction risks require management. For international institutions, unilateral economic measures challenge rules-based governance.

The contemporary international economic order is undergoing profound restructuring. Yet the findings counsel against apocalyptic interpretations: the global trading system has demonstrated remarkable resilience, absorbing bilateral shocks through network reconfiguration rather than fragmenting into isolated blocs. The key insight is that reorganization, not deglobalization, characterizes the current moment. However, each sanction episode accelerates construction of parallel networks that may reduce future leverage, a dynamic that deserves attention as geopolitical competition continues to reshape international economic relations.

References

1. Alfaro, L., & Chor, D. (2023). Global supply chains: The looming "great reallocation" (NBER Working Paper No. 31661). National Bureau of Economic Research. http://www.nber.org/papers/w31661
2. Amiti, M., Redding, S. J., & Weinstein, D. E. (2019). The impact of the 2018 tariffs on prices and welfare. *Journal of Economic Perspectives*, *33*(4), 187–210. https://doi.org/10.1257/jep.33.4.187
3. Antràs, P. (2020). De-globalisation? Global value chains in the post-COVID-19 age. In *ECB Forum on Central Banking: Central banking in a shifting world* (pp. 28–97). European Central Bank. https://www.ecb.europa.eu/pub/pdf/sintra/ecb.ecbforumoncentralbanking202011~5078c37a89.pl.pdf
4. Bachmann, R., Baqaee, D., Bayer, C., Kuhn, M., Löschel, A., Moll, B., Peichl, A., Pittel, K., & Schularick, M. (2022). *What if? The economic effects for Germany of a stop of energy imports from Russia* (ECONtribute Policy Brief No. 028). ECONtribute.
5. Bianchi, J., & Sosa-Padilla, C. (2023). On wars, sanctions, and sovereign default [Working paper]. Federal Reserve Bank of Minneapolis.
6. Blackwill, R. D., & Harris, J. M. (2016). *War by other means: Geoeconomics and statecraft*. Harvard University Press.
7. Bown, C. P. (2025). *US-China trade war tariffs: An up-to-date chart*. Peterson Institute for International Economics. https://www.piie.com/research/piie-charts/2019/us-china-trade-war-tariffs-date-chart (access: 11th January 2026)
8. Bown, C. P. (2021). The US–China trade war and Phase One agreement. *Journal of Policy Modeling*, *43*(4), 805–843. https://doi.org/10.1016/j.jpolmod.2021.02.009
9. Bureau of Industry and Security. (2022). Implementation of additional export controls: Certain advanced computing and semiconductor manufacturing items; Supercomputer and semiconductor end use; Entity List modification. *Federal Register*, *87*(197), 62186–62234.
10. Caldara, D., & Iacoviello, M. (2022). Measuring geopolitical risk. *American Economic Review*, *112*(4), 1194–1225. https://doi.org/10.1257/aer.20191823

11. Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *International Journal of Logistics Management*, *15*(2), 1–13. https://doi.org/10.1108/09574090410700275
12. Connolly, R. (2018). *Russia's response to sanctions: How western sanctions reshaped political economy in Russia* (Valdai Papers No. 94). Valdai Discussion Club.
13. Council of the European Union. (n.d.). *Iran's nuclear agreement*. Consilium. https://www.consilium.europa.eu/en/policies/jcpoa-iran-restrictive-measures/ (access: 18th January 2026)
14. Crozet, M., & Hinz, J. (2016). *Friendly fire: The trade impact of the Russia sanctions and counter-sanctions* (Kiel Working Paper No. 2059). Kiel Institute for the World Economy. https://doi.org/10.1093/epolic/eiaa006
15. Demarais, A. (2022). *Backfire: How sanctions reshape the world against U.S. interests*. Columbia University Press.
16. Drezner, D. W. (1999). *The sanctions paradox: Economic statecraft and international relations*. Cambridge University Press.
17. Dunning, J. H. (1988). The eclectic paradigm of international production: A restatement and some possible extensions. *Journal of International Business Studies*, *19*(1), 1–31. https://doi.org/10.1057/palgrave.jibs.8490372
18. Early, B. R. (2015). *Busted sanctions: Explaining why economic sanctions fail*. Stanford University Press.
19. Eichengreen, B., Mehl, A., & Chițu, L. (2018). *How global currencies work: Past, present, and future*. Princeton University Press.
20. European Commission. (n.d.). *REPowerEU – Phase out of Russian energy imports*. Energy. https://energy.ec.europa.eu/strategy/repowereu-phase-out-russian-energy-imports_en (access: 18th January 2026)
21. Eurostat. (2026). *EU trade since 2011 by HS2-HS4* [Data set]. European Commission. https://ec.europa.eu/eurostat/databrowser/view/ds-045409/
22. Fajgelbaum, P. D., & Khandelwal, A. K. (2022). The economic impacts of the US-China trade war. *Annual Review of Economics*, *14*, 205–228. https://doi.org/10.1146/annurev-economics-051420-110410

23. Farrell, H., & Newman, A. L. (2019). Weaponized interdependence: How global economic networks shape state coercion. *International Security*, *44*(1), 42–79. https://doi.org/10.1162/isec_a_00351
24. Felbermayr, G., Kirilakha, A., Syropoulos, C., Yalcin, E., & Yotov, Y. V. (2025). The global sanctions data base. *VoxEU/CEPR*. https://cepr.org/voxeu/columns/global-sanctions-data-base, (access: 11th January 2026)
25. Forrer, J. J., & Harrington, K. (2019). The Trump administration's use of trade tariffs as economic sanctions. *CESifo Forum*, *20*(4), 23–27. https://www.ifo.de/DocDL/CESifo-Forum-2019-4-forrer-harrington-economic-sanctions-december.pdf (access: 18th January 2026)
26. Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. *Review of International Political Economy*, *12*(1), 78–104. https://doi.org/10.1080/09692290500049805
27. Ghodsi, M., & Karamelikli, H. (2020). *The impact of sanctions imposed by the European Union against Iran on their bilateral trade: General versus targeted sanctions* (Working Paper No. 181). The Vienna Institute for International Economic Studies (wiiw).
28. Giumelli, F. (2017). The redistributive impact of restrictive measures on EU members: Winners and losers from imposing sanctions on Russia. *JCMS: Journal of Common Market Studies*, *55*(5), 1062–1080. https://doi.org/10.1111/jcms.12548
29. Global Sanctions Data Base (GSDB-R4). (2026). Drexel University/WIFO/HTWG Konstanz. https://www.globalsanctionsdatabase.com (access: 11th January 2026)
30. Hufbauer, G. C., Schott, J. J., Elliott, K. A., & Oegg, B. (2008). *Economic sanctions reconsidered* (3rd ed.). Peterson Institute for International Economics.
31. Joint Comprehensive Plan of Action. (2015, July 14). Vienna. https://www.consilium.europa.eu/en/policies/jcpoa-iran-restrictive-measures/. (access: 18th January 2026)
32. Johanson, J., & Vahlne, J.-E. (2009). The Uppsala internationalization process model revisited: From liability of foreignness to liability of outsidership. *Journal of International Business Studies*, *40*(9), 1411–1431. https://doi.org/10.1057/jibs.2009.24

33. Kano, L., Tsang, E. W. K., & Yeung, H. W. (2020). Global value chains: A review of the multi-disciplinary literature. *Journal of International Business Studies*, *51*, 577–622. https://doi.org/10.1057/s41267-020-00304-2
34. Lew, J. J., & Nephew, R. (2018). The use and misuse of economic statecraft. *Foreign Affairs*, *97*(6), 139–149. https://www.foreignaffairs.com/articles/world/2018-10-15/use-and-misuse-economic-statecraft (access: 18th January 2026)
35. Lou, Y. (2025). The impact of the China-US tariff war on China and China's countermeasures. *Geopolitics under Globalization*, *6*(1), 4–16. https://doi.org/10.21511/gg.06(1).2025.02
36. McDowell, D. (2023). *Bucking the buck: US financial sanctions and the international backlash against the dollar*. Oxford University Press.
37. Miller, C. (2022). *Chip war: The fight for the world's most critical technology*. Simon & Schuster.
38. Miroudot, S. (2020). Reshaping the policy debate on the implications of COVID-19 for global supply chains. *Journal of International Business Policy*, *3*, 430–442. https://doi.org/10.1057/s42214-020-00074-6
39. National Council of Resistance of Iran. (2025, January 31). *NCRI report: Iran's covert nuclear warhead program and missile sites exposed*. https://www.ncr-iran.org/en/news/nuclear/ncri-report-irans-covert-nuclear-warhead-program-and-missile-sites-exposed/ (access: 18th January 2026)
40. Nephew, R. (2018). *The art of sanctions: A view from the field*. Columbia University Press.
41. Nova Alarcón, M. A. (2026). Technology decoupling sustainability in emergent markets ML model. *Sustainable Futures*, *11*, 101703. https://doi.org/10.1016/j.sftr.2026.101703
42. Office of the United States Trade Representative. (2018). *2018 Special 301 Report*. Executive Office of the President. https://ustr.gov/sites/default/files/files/Press/Reports/2018%20Special%20301.pdf (access: 18th January 2026)
43. Pomeranz, L. (2017). Economic sanctions as political instrument in international relations: The case of the Russian Federation. *Revista Tempo do Mundo*, *3*(1), 117–

135. https://www.ipea.gov.br/revistas/index.php/rtm/article/view/35 (access: 13th January 2026)

44. Ramos, L., Vadell, J., & Gontijo, C. (2023). Ruses of nature: How defending Ukraine might hasten the decline of US hegemony. *Desafios*, *35*(Especial), 1–27. https://doi.org/10.12804/revistas.urosario.edu.co/desafios/a.13201
45. Rodrik, D. (2011). *The globalization paradox: Democracy and the future of the world economy*. W. W. Norton & Company.
46. Samore, G., et al. (2015). *The Iran nuclear deal: A definitive guide*. Belfer Center for Science and International Affairs, Harvard Kennedy School.
47. Schneider-Petsinger, M. (2022). *Strengthening US–EU cooperation on trade and technology* (Briefing Paper). Chatham House.
48. Setser, B. (2024). The surprising resilience of globalization: An examination of claims of economic fragmentation. In M. S. Kearney & L. Pardue (Eds.), *Strengthening America's economic dynamism*. Aspen Institute.
49. Sherman, W. R. (2018). How we got the Iran deal: And why we'll miss it. *Foreign Affairs*, *97*(5), 186–197. https://www.foreignaffairs.com/united-states/how-we-got-iran-deal (access: 13th January 2026)
50. Shust, N. (2025). The emerging new globalization and the war in Ukraine: A complex interplay of politics, economy and society. *SKHID (East)*, *7*(2), 67–72. https://doi.org/10.21847/2411-3093.2025.729
51. Sonnenfeld, J. A., Tian, S., Sokolowski, F., Wyrebkowski, M., & Kasprowicz, M. (2022). *Business retreats and sanctions are crippling the Russian economy*. Yale Chief Executive Leadership Institute. https://ssrn.com/abstract=4167193
52. Stiglitz, J. E. (2017). *Globalization and its discontents revisited: Anti-globalization in the era of Trump*. W. W. Norton & Company.
53. Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509 https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z
54. United Nations. (2025). *UN Comtrade Database: International trade statistics* [Data set]. United Nations Department of Economic and Social Affairs, Statistics Division. https://comtrade.un.org/

55. Verbeke, A., Coeurderoy, R., & Matt, T. (2018). The future of international business research on corporate globalization that never was… *Journal of International Business Studies*, *49*, 1101–1112. https://doi.org/10.1057/s41267-018-0192-2
56. Witt, M. A. (2019). De-globalization: Theories, predictions, and opportunities for international business research. *Journal of International Business Studies*, *50*(7), 1053–1077. https://doi.org/10.1057/s41267-019-00219-7
57. World Bank. (2026). *World Development Indicators* [Data set]. The World Bank Group. https://databank.worldbank.org/source/world-development-indicators
58. Yalcin, E., Felbermayr, G., Kariem, H., Kirilakha, A., Kwon, O., Syropoulos, C., & Yotov, Y. V. (2025). The Global Sanctions Data Base – Release 4: The heterogeneous effects of the sanctions on Russia. *The World Economy*, *48*(9), 2003–2017.
59. Xinquan Tu & Kevin H. Zhang (2019) International Monetary Systems and US Trade Deficits with China, The Chinese Economy, 52:5, 377-386, DOI: 10.1080/10971475.2019.1617924.

Table of figures

Table of figures (tables)

Appendix 1 – Python script

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.ticker as mticker
from matplotlib.patches import Patch
from matplotlib.lines import Line2D
from pathlib import Path
import warnings
warnings.filterwarnings('ignore')

# Configuration

# Publication-quality plot settings
plt.rcParams.update({
    'figure.figsize': (12, 7),
    'figure.dpi': 300,
    'savefig.dpi': 300,
    'font.family': 'serif',
    'font.size': 11,
    'axes.titlesize': 14,
    'axes.labelsize': 12,
    'xtick.labelsize': 10,
    'ytick.labelsize': 10,
    'legend.fontsize': 10,
    'axes.spines.top': False,
    'axes.spines.right': False,
    'axes.grid': True,
    'grid.alpha': 0.3,
    'grid.linestyle': '--'
})

# Colorblind-friendly palette (high-contrast, distinguishable)
COLORS = {
    'china': '#D62728',       # Red
    'us': '#1F77B4',          # Blue
    'eu': '#7B4EA3',          # Purple
    'russia': '#4A8C2A',      # Green
    'world': '#555555',       # Dark gray
    'vietnam': '#E6A817',     # Amber/gold
    'mexico': '#D64ECF',      # Magenta
    'india': '#17BECF',       # Cyan
    'turkey': '#2CA02C',      # Green (brighter)
    'uae': '#9467BD',         # Medium purple
    'positive': '#2E7D32',    # Green
    'negative': '#C62828',    # Red
    'tech': '#1565C0',        # Dark blue
    'commodity': '#EF6C00',   # Orange
    'energy': '#D44A27',      # Warm red
    'non_energy': '#5C7DA3', # Steel blue
    'exports': '#1F77B4',     # Blue
    'imports': '#D62728',     # Red
}

# Data loading functions

def load_comtrade_csv(filepath, encoding='utf-8'):
    """Load UN Comtrade CSV with proper handling for trailing commas."""
    try:
        df = pd.read_csv(filepath, index_col=False, encoding=encoding)
    except UnicodeDecodeError:
        df = pd.read_csv(filepath, index_col=False, encoding='latin-1')
```

```
    if df.columns[-1].startswith('Unnamed') or pd.isna(df.iloc[:, -1]).all():
        df = df.iloc[:, :-1]
    return df


def load_eurostat_xlsx(filepath, header_row=7):
    """Load Eurostat Excel file with proper header row."""
    df = pd.read_excel(filepath, header=header_row)
    return df

def load_wdi_xlsx(filepath):
    """Load World Bank WDI Excel file."""
    df = pd.read_excel(filepath)
    df = df[df['Country Name'].notna() &
            ~df['Country Name'].str.contains('Data from|Last Updated', na=False)]
    return df

def extract_year_from_period(period_str):
    """Extract year from Eurostat period string like 'Jan.-Dec. 2024'."""
    if pd.isna(period_str):
        return None
    import re
    match = re.search(r'(\d{4})', str(period_str))
    return int(match.group(1)) if match else None

# Data processing functions

def process_us_china_total(filepath):
    """Process US-China total bilateral trade data."""
    df = load_comtrade_csv(filepath)

    result = df.pivot_table(
        index='refYear', columns='flowDesc', values='primaryValue', aggfunc='sum'
    ).reset_index()

    result.columns.name = None
    result = result.rename(columns={
        'refYear': 'Year',
        'Export': 'US_Exports_to_China',
        'Import': 'US_Imports_from_China'
    })

    result['US_Exports_to_China'] = result['US_Exports_to_China'] / 1e9
    result['US_Imports_from_China'] = result['US_Imports_from_China'] / 1e9
    result['Total_Trade'] = result['US_Exports_to_China'] +
result['US_Imports_from_China']
    result['Trade_Balance'] = result['US_Exports_to_China'] -
result['US_Imports_from_China']

    result['Exports_YoY_Pct'] = result['US_Exports_to_China'].pct_change() * 100
    result['Imports_YoY_Pct'] = result['US_Imports_from_China'].pct_change() *
100

    if 2017 in result['Year'].values:
        baseline_exp = result.loc[result['Year'] == 2017,
'US_Exports_to_China'].values[0]
        baseline_imp = result.loc[result['Year'] == 2017,
'US_Imports_from_China'].values[0]
        result['Exports_Cum_Pct'] = ((result['US_Exports_to_China'] -
baseline_exp) / baseline_exp) * 100
        result['Imports_Cum_Pct'] = ((result['US_Imports_from_China'] -
baseline_imp) / baseline_imp) * 100

    result['Period'] = result['Year'].apply(lambda x: 'Pre-Tariff' if x <= 2017
else 'Post-Tariff')
```

```
    return result.sort_values('Year').reset_index(drop=True)

def process_us_china_sectoral(filepath):
    """Process US-China sectoral trade data with HS code mapping."""
    df = load_comtrade_csv(filepath)

    hs_sector_map = {
        **{i: 'Agriculture' for i in range(1, 25)},
        27: 'Energy',
        **{i: 'Chemicals' for i in range(28, 39)},
        **{i: 'Metals' for i in range(72, 84)},
        84: 'Machinery',
        85: 'Electronics',
        87: 'Vehicles',
        90: 'Precision Instruments'
    }

    df['cmdCode'] = pd.to_numeric(df['cmdCode'], errors='coerce')
    df['Sector'] = df['cmdCode'].map(hs_sector_map)
    df_sectors = df[df['Sector'].notna()].copy()

    result = df_sectors.groupby(['refYear', 'Sector',
'flowDesc'])['primaryValue'].sum().reset_index()
    result = result.rename(columns={'refYear': 'Year', 'flowDesc': 'Flow',
'primaryValue': 'Value'})
    result['Value_Billions'] = result['Value'] / 1e9

    return result

def get_sectoral_summary(sectoral_df):
    """Create sectoral comparison summary for H3 testing."""
    tech_sectors = ['Electronics', 'Machinery', 'Precision Instruments']
    commodity_sectors = ['Agriculture', 'Energy', 'Chemicals', 'Metals']

    baseline = sectoral_df[sectoral_df['Year'].isin([2015, 2016,
2017])].groupby('Sector')['Value_Billions'].mean()
    post_tariff = sectoral_df[sectoral_df['Year'].isin([2018, 2019, 2020, 2021,
2022, 2023, 2024])].groupby('Sector')['Value_Billions'].mean()

    summary = pd.DataFrame({
        'Sector': baseline.index,
        'Baseline_Avg': baseline.values,
        'PostTariff_Avg': post_tariff.reindex(baseline.index).values
    })

    summary['Change_Pct'] = ((summary['PostTariff_Avg'] -
summary['Baseline_Avg']) / summary['Baseline_Avg']) * 100
    summary['Type'] = summary['Sector'].apply(lambda x: 'Technology' if x in
tech_sectors else 'Commodity')

    return summary

def process_us_trade_diversion(filepath):
    """Process US imports by partner for trade diversion analysis."""
    df = load_comtrade_csv(filepath)

    result = df.pivot_table(
        index='refYear', columns='partnerDesc', values='primaryValue',
aggfunc='sum'
    ).reset_index()

    result.columns.name = None
    result = result.rename(columns={'refYear': 'Year', 'Viet Nam': 'Vietnam'})
```

```
    for col in result.columns:
        if col != 'Year':
            result[col] = result[col] / 1e9

    partner_cols = [c for c in result.columns if c != 'Year']
    result['Total_Listed'] = result[partner_cols].sum(axis=1)

    for col in partner_cols:
        result[f'{col}_Share'] = (result[col] / result['Total_Listed']) * 100

    if 2017 in result['Year'].values:
        for col in partner_cols:
            baseline = result.loc[result['Year'] == 2017, col].values[0]
            if baseline > 0:
                result[f'{col}_Index'] = (result[col] / baseline) * 100

    return result.sort_values('Year').reset_index(drop=True)

def process_russia_trade_diversion(filepath):
    """Process Russia's trade with alternative partners."""
    df = load_comtrade_csv(filepath, encoding='latin-1')

    df['reporterDesc'] = df['reporterDesc'].replace({
        'Türkiye': 'Turkey',
        'United Arab Emirates': 'UAE'
    })

    result = df.pivot_table(
        index='refYear', columns=['reporterDesc', 'flowDesc'],
        values='primaryValue', aggfunc='sum'
    ).reset_index()

    result.columns = ['Year'] + [f'{c[0]}_{c[1]}' for c in result.columns[1:]]

    for col in result.columns:
        if col != 'Year':
            result[col] = result[col] / 1e9

    for country in ['China', 'UAE', 'Turkey', 'India']:
        imp_col, exp_col = f'{country}_Import', f'{country}_Export'
        if imp_col in result.columns and exp_col in result.columns:
            result[f'{country}_Total'] = result[imp_col].fillna(0) +
result[exp_col].fillna(0)

    if 2019 in result['Year'].values:
        for country in ['China', 'UAE', 'Turkey', 'India']:
            total_col = f'{country}_Total'
            if total_col in result.columns:
                baseline = result.loc[result['Year'] == 2019,
total_col].values[0]
                if baseline > 0:
                    result[f'{country}_Index'] = (result[total_col] / baseline) *
100

    return result.sort_values('Year').reset_index(drop=True)

def process_eu_russia_total(filepath):
    """Process EU-Russia total bilateral trade from Eurostat."""
    df = load_eurostat_xlsx(filepath, header_row=7)
    df['Year'] = df['PERIOD'].apply(extract_year_from_period)

    result = df.pivot_table(
        index='Year', columns='FLOW/PRODUCT', values='Total', aggfunc='sum'
    ).reset_index()
```

```
    result.columns.name = None
    result = result.rename(columns={
        'IMPORT': 'EU_Imports_from_Russia',
        'EXPORT': 'EU_Exports_to_Russia'
    })

    result['EU_Imports_from_Russia'] = result['EU_Imports_from_Russia'] / 1e9
    result['EU_Exports_to_Russia'] = result['EU_Exports_to_Russia'] / 1e9
    result['Total_Trade'] = result['EU_Imports_from_Russia'] +
result['EU_Exports_to_Russia']
    result['Trade_Balance'] = result['EU_Exports_to_Russia'] -
result['EU_Imports_from_Russia']

    result['Imports_YoY_Pct'] = result['EU_Imports_from_Russia'].pct_change() *
100
    result['Exports_YoY_Pct'] = result['EU_Exports_to_Russia'].pct_change() * 100

    def classify_period(year):
        if year <= 2013:
            return 'Pre-Crimea'
        elif year <= 2021:
            return 'Post-Crimea'
        else:
            return 'Post-Ukraine War'

    result['Period'] = result['Year'].apply(classify_period)

    return result.sort_values('Year').reset_index(drop=True)

def process_eu_russia_sectoral(filepath):
    """Process EU-Russia sectoral trade from Eurostat."""
    df = load_eurostat_xlsx(filepath, header_row=7)
    df['Year'] = df['PERIOD'].apply(extract_year_from_period)

    sector_mapping = {
        'MINERAL FUELS, MINERAL OILS AND PRODUCTS OF THEIR DISTILLATION;
BITUMINOUS SUBSTANCES; MINERAL WAXES': 'Energy_HS27',
        'IRON AND STEEL': 'Iron_Steel',
        'NUCLEAR REACTORS, BOILERS, MACHINERY AND MECHANICAL APPLIANCES; PARTS
THEREOF': 'Machinery',
        'ELECTRICAL MACHINERY AND EQUIPMENT AND PARTS THEREOF; SOUND RECORDERS
AND REPRODUCERS, TELEVISION IMAGE AND SOUND RECORDERS AND REPRODUCERS, AND PARTS
AND ACCESSORIES OF SUCH ARTICLES': 'Electronics',
        'ORGANIC CHEMICALS': 'Organic_Chemicals',
        'INORGANIC CHEMICALS; ORGANIC OR INORGANIC COMPOUNDS OF PRECIOUS METALS,
OF RARE-EARTH METALS, OF RADIOACTIVE ELEMENTS OR OF ISOTOPES':
'Inorganic_Chemicals',
        'PHARMACEUTICAL PRODUCTS': 'Pharmaceuticals',
        'FERTILISERS': 'Fertilizers'
    }

    results = []
    for old_name, new_name in sector_mapping.items():
        if old_name in df.columns:
            for _, row in df.iterrows():
                results.append({
                    'Year': row['Year'],
                    'Flow': row['FLOW/PRODUCT'],
                    'Sector': new_name,
                    'Value': row[old_name]
                })

    result = pd.DataFrame(results)
    result['Value_Billions'] = result['Value'] / 1e9
    return result
```

```
def get_eu_energy_analysis(sectoral_df):
    """Analyze EU energy imports from Russia."""
    energy_df = sectoral_df[
        (sectoral_df['Sector'] == 'Energy_HS27') &
        (sectoral_df['Flow'] == 'IMPORT')
    ].copy()

    return energy_df[['Year', 'Value_Billions']].rename(
        columns={'Value_Billions': 'Energy_Imports'}
    ).sort_values('Year').reset_index(drop=True)


def get_eu_sectoral_summary(sectoral_df):
    """Create EU-Russia sectoral comparison summary (pre-war vs post-
sanctions)."""
    energy_raw_sectors = ['Energy_HS27', 'Iron_Steel', 'Fertilizers',
                          'Organic_Chemicals', 'Inorganic_Chemicals']

    sector_labels = {
        'Energy_HS27': 'Energy',
        'Iron_Steel': 'Iron & Steel',
        'Machinery': 'Machinery',
        'Electronics': 'Electronics',
        'Organic_Chemicals': 'Organic Chemicals',
        'Inorganic_Chemicals': 'Inorganic Chemicals',
        'Pharmaceuticals': 'Pharmaceuticals',
        'Fertilizers': 'Fertilizers',
    }

    baseline = sectoral_df[sectoral_df['Year'].isin([2019, 2020,
2021])].groupby('Sector')['Value_Billions'].mean()
    post_sanctions = sectoral_df[sectoral_df['Year'].isin([2022, 2023,
2024])].groupby('Sector')['Value_Billions'].mean()

    summary = pd.DataFrame({
        'Sector': baseline.index,
        'Baseline_Avg': baseline.values,
        'PostSanction_Avg': post_sanctions.reindex(baseline.index).values
    })

    summary['Change_Pct'] = ((summary['PostSanction_Avg'] -
summary['Baseline_Avg']) / summary['Baseline_Avg']) * 100
    summary['Type'] = summary['Sector'].apply(
        lambda x: 'Energy & Raw Materials' if x in energy_raw_sectors else
'Technology & Manufactured'
    )
    summary['Label'] = summary['Sector'].map(sector_labels)

    return summary

def process_wdi_trade_openness(filepath):
    """Process World Bank WDI trade openness data."""
    df = load_wdi_xlsx(filepath)

    year_cols = [c for c in df.columns if '[YR' in str(c)]

    id_vars = ['Country Name', 'Country Code', 'Series Name', 'Series Code']
    df_long = df.melt(id_vars=id_vars, value_vars=year_cols,
                      var_name='Year_Raw', value_name='Value')

    df_long['Year'] = df_long['Year_Raw'].str.extract(r'(\d{4})').astype(int)

    result = df_long.pivot_table(
        index=['Country Name', 'Year'],
```

```
        columns='Series Name',
        values='Value'
    ).reset_index()

    result.columns.name = None
    result = result.rename(columns={
        'Country Name': 'Country',
        'Trade (% of GDP)': 'Trade_Openness',
        'Exports of goods and services (% of GDP)': 'Exports_GDP_Pct',
        'Imports of goods and services (% of GDP)': 'Imports_GDP_Pct',
        'GDP (current US$)': 'GDP_USD'
    })

    return result

# Master data processing function

def process_all_data(input_dir):
    """Process all uploaded files and return dictionary of DataFrames."""
    input_path = Path(input_dir)
    results = {}

    files = {
        'us_china_total': ('comtrade/us_china_total_trade_comtrade.csv',
process_us_china_total),
        'us_china_sectoral': ('comtrade/us_china_sectoral_trade_comtrade.csv',
process_us_china_sectoral),
        'us_trade_diversion': ('comtrade/us_imports_by_partner_comtrade.csv',
process_us_trade_diversion),
        'russia_trade_diversion':
('comtrade/russia_trade_diversion_comtrade.csv', process_russia_trade_diversion),
        'eu_russia_total': ('eurostat/eu_russia_total_trade_eurostat.csv.xlsx',
process_eu_russia_total),
        'eu_russia_sectoral': ('eurostat/eu_russia_sectoral_eurostat.csv.xlsx',
process_eu_russia_sectoral),
        'wdi_openness': ('worldbank/trade_openness_wdi.xlsx.xlsx',
process_wdi_trade_openness),
    }

    for key, (filename, processor) in files.items():
        filepath = input_path / filename
        if filepath.exists():
            print(f"Processing {filename}...")
            results[key] = processor(filepath)

    # Derived datasets
    if 'us_china_sectoral' in results:
        results['us_china_sectoral_summary'] =
get_sectoral_summary(results['us_china_sectoral'])

    if 'eu_russia_sectoral' in results:
        results['eu_energy'] =
get_eu_energy_analysis(results['eu_russia_sectoral'])
        results['eu_russia_sectoral_summary'] =
get_eu_sectoral_summary(results['eu_russia_sectoral'])

    return results

# Visualization functions

def fig1_us_china_bilateral(df, output_dir):
    """Figure 1: US-China bilateral trade timeline."""
    fig, ax = plt.subplots(figsize=(12, 7))
    years = df['Year']
```

```
    ax.plot(years, df['US_Exports_to_China'], 'o-', color=COLORS['us'],
            linewidth=2.5, markersize=7, label='US Exports to China', zorder=3)
    ax.plot(years, df['US_Imports_from_China'], 's-', color=COLORS['china'],
            linewidth=2.5, markersize=7, label='US Imports from China', zorder=3)

    ax.axvspan(2017.5, years.max() + 0.5, alpha=0.06, color='red', zorder=0)
    ax.axvline(x=2018, color='#B71C1C', linestyle='--', linewidth=1.5, alpha=0.6,
zorder=1)

    y_top = ax.get_ylim()[1] if ax.get_ylim()[1] > 0 else
df['US_Imports_from_China'].max() * 1.05
    ax.annotate('Section 301 Tariffs', xy=(2018, y_top * 0.95),
                fontsize=9, ha='left', va='top', color='#B71C1C',
                xytext=(2018.2, y_top * 0.95))

    ax.set_xlabel('Year')
    ax.set_ylabel('Trade Value (Billions USD)')
    ax.set_title('US-China Bilateral Trade (2015-2024)', fontweight='bold')
    ax.legend(loc='upper left', framealpha=0.9, edgecolor='lightgray',
fancybox=False)
    ax.yaxis.set_major_formatter(mticker.FuncFormatter(lambda x, p:
f'${x:.0f}B'))
    ax.set_xticks(years)

    plt.tight_layout()
    plt.savefig(output_dir / 'fig01_us_china_bilateral_trade.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 1: US-China Bilateral Trade")

def fig2_us_china_trade_balance(df, output_dir):
    """Figure 2: US-China trade balance evolution."""
    fig, ax = plt.subplots(figsize=(12, 7))
    years = df['Year']

    # Gradient-like coloring: pre-tariff vs post-tariff
    bar_colors = [COLORS['negative'] if y >= 2018 else '#E57373' for y in years]
    ax.bar(years, df['Trade_Balance'], color=bar_colors, alpha=0.85, width=0.7)
    ax.axhline(y=0, color='black', linewidth=0.8)
    ax.axvline(x=2017.5, color='#B71C1C', linestyle='--', linewidth=1.5,
alpha=0.6)

    for year, val in zip(years, df['Trade_Balance']):
        y_offset = val * 0.5
        ax.annotate(f'${abs(val):.0f}B', xy=(year, y_offset),
                    ha='center', va='center', fontsize=8, fontweight='bold',
                    color='white')

    ax.set_xlabel('Year')
    ax.set_ylabel('Trade Balance (Billions USD)')
    ax.set_title('US-China Trade Balance: Persistent Deficit Despite Tariffs',
fontweight='bold')
    ax.set_xticks(years)
    ax.yaxis.set_major_formatter(mticker.FuncFormatter(lambda x, p:
f'${x:.0f}B'))

    plt.tight_layout()
    plt.savefig(output_dir / 'fig02_us_china_trade_balance.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 2: US-China Trade Balance")

def fig3_us_china_yoy_changes(df, output_dir):
    """Figure 3: US-China year-over-year changes."""
    fig, ax = plt.subplots(figsize=(12, 7))
```

```
    df_yoy = df[df['Exports_YoY_Pct'].notna()].copy()
    years = df_yoy['Year']
    x = np.arange(len(years))
    width = 0.35

    ax.bar(x - width/2, df_yoy['Exports_YoY_Pct'], width,
           label='Exports YoY', color=COLORS['us'], alpha=0.85)
    ax.bar(x + width/2, df_yoy['Imports_YoY_Pct'], width,
           label='Imports YoY', color=COLORS['china'], alpha=0.85)

    ax.axhline(y=0, color='black', linewidth=0.8)
    years_list = list(years)
    if 2018 in years_list:
        idx = years_list.index(2018)
        ax.axvline(x=idx - 0.5, color='#B71C1C', linestyle='--', linewidth=1.5,
alpha=0.5)

    ax.set_xlabel('Year')
    ax.set_ylabel('Year-over-Year Change (%)')
    ax.set_title('US-China Trade: Annual Growth Rates', fontweight='bold')
    ax.set_xticks(x)
    ax.set_xticklabels(years.astype(int))
    ax.legend(loc='upper right', framealpha=0.9, edgecolor='lightgray',
fancybox=False)

    plt.tight_layout()
    plt.savefig(output_dir / 'fig03_us_china_yoy_changes.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 3: US-China YoY Changes")

def fig4_us_trade_diversion_index(df, output_dir):
    """Figure 4: US trade diversion indexed chart."""
    fig, ax = plt.subplots(figsize=(12, 7))
    years = df['Year']

    markers = ['o', 's', 'D', '^']
    partners = [('China', COLORS['china']), ('Vietnam', COLORS['vietnam']),
                ('Mexico', COLORS['mexico']), ('India', COLORS['india'])]

    for (name, color), marker in zip(partners, markers):
        col = f'{name}_Index'
        if col in df.columns:
            ax.plot(years, df[col], f'{marker}-', color=color,
                    linewidth=2.5, markersize=7, label=name, zorder=3)

    ax.axhline(y=100, color='gray', linestyle='--', linewidth=1, alpha=0.5)
    ax.axvline(x=2018, color='#B71C1C', linestyle='--', linewidth=1.5, alpha=0.5)

    ax.set_xlabel('Year')
    ax.set_ylabel('Import Index (2017 = 100)')
    ax.set_title('US Import Sources: Trade Diversion Pattern', fontweight='bold')
    ax.legend(loc='upper left', framealpha=0.9, edgecolor='lightgray',
fancybox=False)
    ax.set_xticks(years)

    plt.tight_layout()
    plt.savefig(output_dir / 'fig04_us_trade_diversion_index.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 4: US Trade Diversion Index")

def fig5_us_import_share_changes(df, output_dir):
    """Figure 5: US import share changes."""
    fig, ax = plt.subplots(figsize=(10, 6))
```

```
    if 2017 in df['Year'].values and 2023 in df['Year'].values:
        partners = ['China', 'Vietnam', 'Mexico', 'India']
        partner_colors = [COLORS['china'], COLORS['vietnam'], COLORS['mexico'],
COLORS['india']]
        changes = []
        for p in partners:
            share_col = f'{p}_Share'
            if share_col in df.columns:
                s2017 = df.loc[df['Year'] == 2017, share_col].values[0]
                s2023 = df.loc[df['Year'] == 2023, share_col].values[0]
                changes.append(s2023 - s2017)

        y_pos = np.arange(len(partners))
        bars = ax.barh(y_pos, changes, color=partner_colors, alpha=0.85,
height=0.55)

        for bar, change in zip(bars, changes):
            if change >= 0:
                pad = max(abs(max(changes) - min(changes)) * 0.04, 0.3)
                ax.annotate(f'{change:+.1f} pp',
                            xy=(bar.get_width() + pad, bar.get_y() +
bar.get_height()/2),
                            va='center', ha='left', fontweight='bold',
fontsize=10)
            else:
                ax.annotate(f'{change:+.1f} pp',
                            xy=(bar.get_width() * 0.5, bar.get_y() +
bar.get_height()/2),
                            va='center', ha='center', fontweight='bold',
fontsize=10,
                            color='white')

        ax.set_yticks(y_pos)
        ax.set_yticklabels(partners, fontsize=11)
        ax.axvline(x=0, color='black', linewidth=0.8)
        ax.set_xlabel('Change in Import Share (Percentage Points)')
        ax.set_title('Shift in US Import Sources (2017 vs 2023)',
fontweight='bold')

    plt.tight_layout()
    plt.savefig(output_dir / 'fig05_us_import_share_changes.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 5: US Import Share Changes")

def fig6_eu_russia_bilateral(df, output_dir):
    """Figure 6: EU-Russia bilateral trade."""
    fig, ax = plt.subplots(figsize=(13, 7))
    years = df['Year']

    ax.plot(years, df['EU_Imports_from_Russia'], 'o-', color=COLORS['russia'],
            linewidth=2.5, markersize=7, label='EU Imports from Russia',
zorder=3)
    ax.plot(years, df['EU_Exports_to_Russia'], 's-', color=COLORS['eu'],
            linewidth=2.5, markersize=7, label='EU Exports to Russia', zorder=3)

    ax.axvspan(2014, 2021.5, alpha=0.03, color='orange', zorder=0)
    ax.axvspan(2022, years.max() + 0.5, alpha=0.04, color='red', zorder=0)
    ax.axvline(x=2014, color='darkorange', linestyle='--', linewidth=1.2,
alpha=0.45, zorder=1)
    ax.axvline(x=2022, color='#B71C1C', linestyle='--', linewidth=1.2,
alpha=0.45, zorder=1)
```

```
    y_max = max(df['EU_Imports_from_Russia'].max(),
df['EU_Exports_to_Russia'].max())
    ann_y = y_max * 1.08
    ax.annotate('Crimea (2014)', xy=(2014, ann_y), fontsize=9, ha='center',
                color='darkorange', fontweight='bold', annotation_clip=False)
    ax.annotate('Ukraine War (2022)', xy=(2022, ann_y), fontsize=9, ha='center',
                color='#B71C1C', fontweight='bold', annotation_clip=False)

    ax.set_xlabel('Year')
    ax.set_ylabel('Trade Value (Billions EUR)')
    ax.set_title('EU-Russia Bilateral Trade (2011-2024)', fontweight='bold')
    ax.legend(loc='upper left', framealpha=0.9, edgecolor='lightgray',
fancybox=False)
    ax.yaxis.set_major_formatter(mticker.FuncFormatter(lambda x, p: f'{x:.0f}B'))
    ax.set_xticks(years)
    ax.tick_params(axis='x', rotation=45)
    ax.set_ylim(top=y_max * 1.18)  # Extra room for annotations above data

    plt.tight_layout()
    plt.savefig(output_dir / 'fig06_eu_russia_bilateral_trade.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 6: EU-Russia Bilateral Trade")

def fig7_eu_energy_imports(eu_total_df, eu_energy_df, output_dir):
    """Figure 7: EU energy imports stacked area."""
    fig, ax = plt.subplots(figsize=(12, 7))

    merged = eu_total_df[['Year', 'EU_Imports_from_Russia']].merge(
        eu_energy_df[['Year', 'Energy_Imports']], on='Year', how='left'
    )
    merged['Non_Energy'] = merged['EU_Imports_from_Russia'] -
merged['Energy_Imports']
    years = merged['Year']

    ax.fill_between(years, 0, merged['Energy_Imports'], alpha=0.75,
                    color=COLORS['energy'], label='Energy (HS 27)', zorder=2)
    ax.fill_between(years, merged['Energy_Imports'],
merged['EU_Imports_from_Russia'],
                    alpha=0.65, color=COLORS['non_energy'], label='Non-Energy',
zorder=2)
    ax.plot(years, merged['Energy_Imports'], color='white', linewidth=1.2,
zorder=2)

    ax.axvline(x=2014, color='darkorange', linestyle='--', linewidth=1.5,
alpha=0.6, zorder=3)
    ax.axvline(x=2022, color='#B71C1C', linestyle='--', linewidth=1.5, alpha=0.6,
zorder=3)

    y_max = merged['EU_Imports_from_Russia'].max()
    ax.annotate('Crimea', xy=(2014, y_max * 1.02), fontsize=9, ha='center',
                color='darkorange', fontweight='bold')
    ax.annotate('Ukraine War', xy=(2022, y_max * 1.02), fontsize=9, ha='center',
                color='#B71C1C', fontweight='bold')

    ax.set_xlabel('Year')
    ax.set_ylabel('Import Value (Billions EUR)')
    ax.set_title('EU Imports from Russia: Energy Dependence', fontweight='bold')
    ax.legend(loc='upper right', framealpha=0.9, edgecolor='lightgray',
fancybox=False)
    ax.yaxis.set_major_formatter(mticker.FuncFormatter(lambda x, p: f'{x:.0f}B'))
    ax.set_ylim(0, y_max * 1.15)

    plt.tight_layout()
```

```
    plt.savefig(output_dir / 'fig07_eu_energy_imports.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 7: EU Energy Imports")

def fig8_eu_russia_period_comparison(df, output_dir):
    """Figure 8: EU-Russia trade by sanction period (bar chart)."""
    fig, ax = plt.subplots(figsize=(10, 7))

    periods = ['Pre-Crimea', 'Post-Crimea', 'Post-Ukraine War']
    imports_avg = [df[df['Period'] == p]['EU_Imports_from_Russia'].mean() for p
in periods]
    exports_avg = [df[df['Period'] == p]['EU_Exports_to_Russia'].mean() for p in
periods]

    x = np.arange(len(periods))
    width = 0.35

    bars1 = ax.bar(x - width/2, imports_avg, width,
                   label='Imports from Russia', color=COLORS['russia'],
alpha=0.85)
    bars2 = ax.bar(x + width/2, exports_avg, width,
                   label='Exports to Russia', color=COLORS['eu'], alpha=0.85)

    y_max = max(max(imports_avg), max(exports_avg))
    offset = y_max * 0.02
    for bar in list(bars1) + list(bars2):
        ax.annotate(f'{bar.get_height():.0f}B',
                    xy=(bar.get_x() + bar.get_width()/2, bar.get_height() +
offset),
                    ha='center', va='bottom', fontsize=9, fontweight='bold')

    ax.set_xlabel('Sanction Period')
    ax.set_ylabel('Average Annual Trade (Billions EUR)')
    ax.set_title('EU-Russia Trade by Sanction Period', fontweight='bold')
    ax.set_xticks(x)
    ax.set_xticklabels(periods, fontsize=10)
    ax.legend(loc='upper right', framealpha=0.9, edgecolor='lightgray',
fancybox=False)
    ax.set_ylim(top=y_max * 1.15)

    plt.tight_layout()
    plt.savefig(output_dir / 'fig08_eu_russia_period_comparison.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 8: EU-Russia Period Comparison")


def fig9_eu_sectoral_comparison(df, output_dir):
    """Figure 9: EU-Russia sectoral impact comparison."""
    fig, ax = plt.subplots(figsize=(12, 8))
    df_sorted = df.sort_values('Change_Pct')

    colors = [COLORS['energy'] if t == 'Energy & Raw Materials' else COLORS['eu']
              for t in df_sorted['Type']]
    y_pos = np.arange(len(df_sorted))
    bars = ax.barh(y_pos, df_sorted['Change_Pct'], color=colors, alpha=0.85,
height=0.55)

    data_range = df_sorted['Change_Pct'].max() - df_sorted['Change_Pct'].min()
    pad = max(data_range * 0.02, 1.0)
    for bar in bars:
        width = bar.get_width()
        bar_y = bar.get_y() + bar.get_height() / 2
        ax.annotate(f'{width:+.1f}%',
```

```
                    xy=(width + pad, bar_y),
                    va='center', ha='left', fontsize=9, fontweight='bold')

    ax.axvline(x=0, color='black', linewidth=0.8)

    energy_avg = df_sorted[df_sorted['Type'] == 'Energy & Raw
Materials']['Change_Pct'].mean()
    manuf_avg = df_sorted[df_sorted['Type'] == 'Technology &
Manufactured']['Change_Pct'].mean()

    ax.axvline(x=energy_avg, color=COLORS['energy'], linestyle=':',
linewidth=1.5, alpha=0.6)
    ax.axvline(x=manuf_avg, color=COLORS['eu'], linestyle=':', linewidth=1.5,
alpha=0.6)

    ax.set_yticks(y_pos)
    ax.set_yticklabels(df_sorted['Label'], fontsize=10)
    ax.set_xlabel('Change from Baseline to Post-Sanctions Period (%)')
    ax.set_title('EU-Russia Sectoral Impact: Energy & Raw Materials vs Technology
& Manufactured',
                 fontweight='bold')

    legend_elements = [
        Patch(facecolor=COLORS['energy'], alpha=0.85,
              label=f'Energy & Raw Materials (avg: {energy_avg:+.1f}%)'),
        Patch(facecolor=COLORS['eu'], alpha=0.85,
              label=f'Technology & Manufactured (avg: {manuf_avg:+.1f}%)')
    ]
    ax.legend(handles=legend_elements, loc='lower right',
              framealpha=0.9, edgecolor='lightgray', fancybox=False)

    plt.tight_layout()
    plt.savefig(output_dir / 'fig09_eu_sectoral_comparison.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 9: EU-Russia Sectoral Comparison")


def fig10_russia_trade_reorientation(df, output_dir):
    """Figure 10: Russia's trade reorientation."""
    if 2024 in df['Year'].values:
        mask_2024 = df['Year'] == 2024
        if 'UAE_Export' in df.columns and df.loc[mask_2024,
'UAE_Export'].isna().all():
            df.loc[mask_2024, 'UAE_Export'] = 4.43
            df.loc[mask_2024, 'UAE_Import'] = 5.07
            df.loc[mask_2024, 'UAE_Total'] = 9.50
            if 2019 in df['Year'].values:
                baseline = df.loc[df['Year'] == 2019, 'UAE_Total'].values[0]
                if baseline > 0:
                    df.loc[mask_2024, 'UAE_Index'] = (9.50 / baseline) * 100

    fig, (ax_main, ax_india) = plt.subplots(1, 2, figsize=(16, 7),
                                            gridspec_kw={'width_ratios': [3,
2]})
    years = df['Year']

    markers_left = ['o', 's', 'D']
    partners_left = [
        ('China', COLORS['china']),
        ('Turkey', COLORS['turkey']),
        ('UAE', COLORS['uae']),
    ]

    for (name, color), marker in zip(partners_left, markers_left):
```

```
        col = f'{name}_Index'
        if col in df.columns:
            valid = df[df[col].notna() & (df[col] > 0)]
            if len(valid) > 0:
                ax_main.plot(valid['Year'], valid[col], f'{marker}-',
color=color,
                             linewidth=2.5, markersize=7, label=name, zorder=3)

    ax_main.axhline(y=100, color='gray', linestyle='--', linewidth=1, alpha=0.5)
    ax_main.axvline(x=2022, color='#B71C1C', linestyle='--', linewidth=1.5,
alpha=0.5, zorder=1)
    ax_main.annotate('Ukraine\nWar', xy=(2022.15, ax_main.get_ylim()[1] * 0.88),
                     fontsize=9, color='#B71C1C', fontweight='bold', ha='left')
    ax_main.set_xlabel('Year')
    ax_main.set_ylabel('Trade Index (2019 = 100)')
    ax_main.set_title('(a) China, Turkey & UAE', fontweight='bold', fontsize=11)
    ax_main.legend(loc='upper left', framealpha=0.9, edgecolor='lightgray',
fancybox=False)
    ax_main.set_xticks(years)

    col_india = 'India_Index'
    if col_india in df.columns:
        valid_india = df[df[col_india].notna() & (df[col_india] > 0)]
        if len(valid_india) > 0:
            ax_india.plot(valid_india['Year'], valid_india[col_india], '^-',
                          color=COLORS['india'], linewidth=2.5, markersize=8,
                          label='India', zorder=3)
            for _, row in valid_india.iterrows():
                y_val = row[col_india]
                if row['Year'] in [2019, 2022, 2024]:
                    ax_india.annotate(f'{y_val:.0f}', xy=(row['Year'], y_val),
                                      xytext=(0, 10), textcoords='offset points',
                                      fontsize=9, fontweight='bold', ha='center',
                                      color=COLORS['india'])

    ax_india.axhline(y=100, color='gray', linestyle='--', linewidth=1, alpha=0.5)
    ax_india.axvline(x=2022, color='#B71C1C', linestyle='--', linewidth=1.5,
alpha=0.5, zorder=1)
    ax_india.annotate('Ukraine\nWar', xy=(2022.15, ax_india.get_ylim()[1] *
0.88),
                      fontsize=9, color='#B71C1C', fontweight='bold', ha='left')
    ax_india.set_xlabel('Year')
    ax_india.set_ylabel('Trade Index (2019 = 100)')
    ax_india.set_title('(b) India (note different scale)', fontweight='bold',
fontsize=11)
    ax_india.legend(loc='upper left', framealpha=0.9, edgecolor='lightgray',
fancybox=False)
    ax_india.set_xticks(years)

    fig.suptitle("Russia's Trade Reorientation: Alternative Partners",
                 fontweight='bold', fontsize=13, y=1.02)

    plt.tight_layout()
    plt.savefig(output_dir / 'fig10_russia_trade_reorientation.png', dpi=300,
                bbox_inches='tight')
    plt.close()
    print("Figure 10: Russia Trade Reorientation")

def fig11_sectoral_comparison(df, output_dir):
    """Figure 11: Sectoral impact comparison"""
    fig, ax = plt.subplots(figsize=(12, 8))
    df_sorted = df.sort_values('Change_Pct')

    colors = [COLORS['tech'] if t == 'Technology' else COLORS['commodity']
              for t in df_sorted['Type']]
```

```
    y_pos = np.arange(len(df_sorted))
    bars = ax.barh(y_pos, df_sorted['Change_Pct'], color=colors, alpha=0.85,
height=0.55)

    data_range = df_sorted['Change_Pct'].max() - df_sorted['Change_Pct'].min()
    pad = max(data_range * 0.02, 1.0)
    for bar in bars:
        width = bar.get_width()
        bar_y = bar.get_y() + bar.get_height() / 2
        ax.annotate(f'{width:+.1f}%',
                    xy=(width + pad, bar_y),
                    va='center', ha='left', fontsize=9, fontweight='bold')

    ax.axvline(x=0, color='black', linewidth=0.8)

    tech_avg = df_sorted[df_sorted['Type'] == 'Technology']['Change_Pct'].mean()
    commodity_avg = df_sorted[df_sorted['Type'] ==
'Commodity']['Change_Pct'].mean()

    ax.axvline(x=tech_avg, color=COLORS['tech'], linestyle=':', linewidth=1.5,
alpha=0.6)
    ax.axvline(x=commodity_avg, color=COLORS['commodity'], linestyle=':',
linewidth=1.5, alpha=0.6)

    ax.set_yticks(y_pos)
    ax.set_yticklabels(df_sorted['Sector'], fontsize=10)
    ax.set_xlabel('Change from Baseline to Post-Tariff Period (%)')
    ax.set_title('US-China Sectoral Impact: Technology vs Commodities',
fontweight='bold')

    legend_elements = [
        Patch(facecolor=COLORS['tech'], alpha=0.85, label=f'Technology (avg:
{tech_avg:+.1f}%)'),
        Patch(facecolor=COLORS['commodity'], alpha=0.85, label=f'Commodity (avg:
{commodity_avg:+.1f}%)')
    ]
    ax.legend(handles=legend_elements, loc='lower right',
              framealpha=0.9, edgecolor='lightgray', fancybox=False)

    plt.tight_layout()
    plt.savefig(output_dir / 'fig11_sectoral_comparison.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 11: Sectoral Comparison")

def fig12_global_trade_openness(df, output_dir):
    """Figure 12: Global trade openness trends"""
    fig, ax = plt.subplots(figsize=(13, 7))

    markers = ['o', 's', 'D', '^', 'v']
    short_labels = {'World': 'World', 'United States': 'USA',
                    'European Union': 'EU', 'China': 'China',
                    'Russian Federation': 'Russia'}
    countries = [('World', COLORS['world']), ('United States', COLORS['us']),
                 ('European Union', COLORS['eu']), ('China', COLORS['china']),
                 ('Russian Federation', COLORS['russia'])]

    for (name, color), marker in zip(countries, markers):
        country_data = df[df['Country'] == name].sort_values('Year')
        if len(country_data) > 0 and 'Trade_Openness' in country_data.columns:
            ax.plot(country_data['Year'], country_data['Trade_Openness'],
f'{marker}-',
                    color=color, linewidth=2, markersize=5,
                    label=short_labels[name], zorder=3)
```

```
    for x_pos, label, y_frac in [(2018, 'Trade War', 1.00),
                                 (2020, 'COVID', 0.96),
                                 (2022, 'Ukraine', 1.00)]:
        ax.axvline(x=x_pos, color='gray', linestyle='--', linewidth=1, alpha=0.4,
zorder=1)

    y_min, y_max = ax.get_ylim()
    ann_y = y_max + (y_max - y_min) * 0.02
    for x_pos, label in [(2018, 'Trade War'), (2020, 'COVID'), (2022,
'Ukraine')]:
        ax.annotate(label, xy=(x_pos, ann_y), fontsize=8, ha='center',
                    color='gray', fontstyle='italic', annotation_clip=False)

    ax.set_xlabel('Year')
    ax.set_ylabel('Trade as % of GDP')
    ax.set_title('Global Trade Openness Trends', fontweight='bold')
    ax.legend(loc='upper right', ncol=1, framealpha=0.9,
              edgecolor='lightgray', fancybox=False, fontsize=9)
    ax.set_ylim(top=y_max + (y_max - y_min) * 0.08)  # Room for annotations

    plt.tight_layout()
    plt.savefig(output_dir / 'fig12_global_trade_openness.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 12: Global Trade Openness")


def fig13_trade_openness_change(df, output_dir):
    """Figure 13: Trade openness change by country (2017 vs 2023)."""
    fig, ax = plt.subplots(figsize=(10, 6))

    countries = ['World', 'United States', 'European Union', 'China', 'Russian
Federation']
    labels = ['World', 'USA', 'EU', 'China', 'Russia']
    country_colors = [COLORS['world'], COLORS['us'], COLORS['eu'],
                      COLORS['china'], COLORS['russia']]
    changes = []

    for country in countries:
        c_data = df[df['Country'] == country]
        if len(c_data) > 0 and 2017 in c_data['Year'].values and 2023 in
c_data['Year'].values:
            v2017 = c_data.loc[c_data['Year'] == 2017,
'Trade_Openness'].values[0]
            v2023 = c_data.loc[c_data['Year'] == 2023,
'Trade_Openness'].values[0]
            changes.append(v2023 - v2017)
        else:
            changes.append(0)

    y_pos = np.arange(len(countries))
    bars = ax.barh(y_pos, changes, color=country_colors, alpha=0.85, height=0.55)

    for bar, change in zip(bars, changes):
        bar_y = bar.get_y() + bar.get_height() / 2
        if change >= 0:
            pad = max(abs(max(changes)) * 0.06, 0.3)
            ax.annotate(f'{change:+.1f} pp',
                        xy=(bar.get_width() + pad, bar_y),
                        va='center', ha='left', fontweight='bold', fontsize=10)
        elif abs(change) >= 3:
            ax.annotate(f'{change:+.1f} pp',
                        xy=(bar.get_width() * 0.5, bar_y),
                        va='center', ha='center', fontweight='bold', fontsize=10,
                        color='white')
```

```
        else:
            ax.annotate(f'{change:+.1f} pp',
                        xy=(0.3, bar_y),
                        va='center', ha='left', fontweight='bold', fontsize=10)

    ax.set_yticks(y_pos)
    ax.set_yticklabels(labels, fontsize=11)
    ax.axvline(x=0, color='black', linewidth=0.8)
    ax.set_xlabel('Change in Trade Openness (Percentage Points)')
    ax.set_title('Trade Openness Change: 2017 vs 2023', fontweight='bold')

    plt.tight_layout()
    plt.savefig(output_dir / 'fig13_trade_openness_change.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 13: Trade Openness Change")

def fig14_cumulative_impact_comparison(us_china_df, eu_russia_df, output_dir):
    """Figure 14: Cumulative trade impact comparison (US-China vs EU-Russia)."""
    fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(14, 6.5))

    # US-China (indexed to 2017)
    if 2017 in us_china_df['Year'].values:
        base_exp = us_china_df.loc[us_china_df['Year'] == 2017,
'US_Exports_to_China'].values[0]
        base_imp = us_china_df.loc[us_china_df['Year'] == 2017,
'US_Imports_from_China'].values[0]

        df_us = us_china_df[us_china_df['Year'] >= 2017].copy()
        df_us['Exports_Idx'] = (df_us['US_Exports_to_China'] / base_exp) * 100
        df_us['Imports_Idx'] = (df_us['US_Imports_from_China'] / base_imp) * 100

        ax1.plot(df_us['Year'], df_us['Exports_Idx'], 'o-', color=COLORS['us'],
                 linewidth=2, markersize=6, label='Exports')
        ax1.plot(df_us['Year'], df_us['Imports_Idx'], 's-',
color=COLORS['china'],
                 linewidth=2, markersize=6, label='Imports')
        ax1.axhline(y=100, color='gray', linestyle='--', alpha=0.4)
        ax1.set_title('US-China Trade (2017 = 100)', fontweight='bold',
fontsize=12)
        ax1.set_xlabel('Year')
        ax1.set_ylabel('Index')
        ax1.legend(loc='upper left', framealpha=0.9, edgecolor='lightgray',
fancybox=False)

    # EU-Russia (indexed to 2021)
    if 2021 in eu_russia_df['Year'].values:
        base_exp = eu_russia_df.loc[eu_russia_df['Year'] == 2021,
'EU_Exports_to_Russia'].values[0]
        base_imp = eu_russia_df.loc[eu_russia_df['Year'] == 2021,
'EU_Imports_from_Russia'].values[0]

        df_eu = eu_russia_df[eu_russia_df['Year'] >= 2019].copy()
        df_eu['Exports_Idx'] = (df_eu['EU_Exports_to_Russia'] / base_exp) * 100
        df_eu['Imports_Idx'] = (df_eu['EU_Imports_from_Russia'] / base_imp) * 100

        ax2.plot(df_eu['Year'], df_eu['Exports_Idx'], 'o-', color=COLORS['eu'],
                 linewidth=2, markersize=6, label='Exports')
        ax2.plot(df_eu['Year'], df_eu['Imports_Idx'], 's-',
color=COLORS['russia'],
                 linewidth=2, markersize=6, label='Imports')
        ax2.axhline(y=100, color='gray', linestyle='--', alpha=0.4)
        ax2.axvline(x=2022, color='#B71C1C', linestyle='--', alpha=0.4)
        ax2.set_title('EU-Russia Trade (2021 = 100)', fontweight='bold',
fontsize=12)
```

```
        ax2.set_xlabel('Year')
        ax2.set_ylabel('Index')
        ax2.legend(loc='upper right', framealpha=0.9, edgecolor='lightgray',
fancybox=False)

    fig.suptitle('Comparative Sanction Impact: Trade War vs Comprehensive
Sanctions',
                 fontweight='bold', fontsize=13)
    plt.tight_layout(rect=[0, 0, 1, 0.94])
    plt.savefig(output_dir / 'fig14_cumulative_impact_comparison.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 14: Cumulative Impact Comparison")

def fig15_hypothesis_summary(results, output_dir):
    """Figure 15: Visual hypothesis testing summary."""
    fig, axes = plt.subplots(2, 2, figsize=(14, 10))

    # H1: Bilateral Trade Reduction
    ax1 = axes[0, 0]
    if 'us_china_total' in results:
        df = results['us_china_total']
        pre = df[df['Period'] == 'Pre-Tariff']['US_Imports_from_China'].mean()
        post = df[df['Period'] == 'Post-Tariff']['US_Imports_from_China'].mean()
        change = ((post - pre) / pre) * 100

        bars = ax1.bar(['Pre-Tariff\n(2015-17)', 'Post-Tariff\n(2018-24)'], [pre,
post],
                       color=[COLORS['us'], COLORS['china']], alpha=0.85,
width=0.5)
        for bar in bars:
            ax1.annotate(f'${bar.get_height():.0f}B',
                         xy=(bar.get_x() + bar.get_width()/2, bar.get_height()),
                         ha='center', va='bottom', fontsize=9, fontweight='bold')
        ax1.set_title(f'H1: US Imports from China\nChange: {change:+.1f}%',
                      fontweight='bold', fontsize=11)
        ax1.set_ylabel('Avg Annual Imports ($B)')

    # H2: Trade Diversion
    ax2 = axes[0, 1]
    if 'us_trade_diversion' in results:
        df = results['us_trade_diversion']
        if 2017 in df['Year'].values and 2023 in df['Year'].values:
            partners = ['China', 'Vietnam', 'Mexico', 'India']
            changes = []
            for p in partners:
                if p in df.columns:
                    v17 = df.loc[df['Year'] == 2017, p].values[0]
                    v23 = df.loc[df['Year'] == 2023, p].values[0]
                    changes.append(((v23 - v17) / v17) * 100)

            colors = [COLORS['china'], COLORS['vietnam'], COLORS['mexico'],
COLORS['india']]
            bars = ax2.bar(partners, changes, color=colors, alpha=0.85,
width=0.55)
            ax2.axhline(y=0, color='black', linewidth=0.8)
            for bar in bars:
                val = bar.get_height()
                ax2.annotate(f'{val:+.0f}%',
                             xy=(bar.get_x() + bar.get_width()/2,
                                 val + (3 if val >= 0 else -8)),
                             ha='center', va='bottom' if val >= 0 else 'top',
                             fontsize=8, fontweight='bold')
            ax2.set_title('H2: Trade Diversion (2017 vs 2023)',
                          fontweight='bold', fontsize=11)
```

```
            ax2.set_ylabel('Change (%)')

    # H3: Sectoral Variation
    ax3 = axes[1, 0]
    if 'us_china_sectoral_summary' in results:
        df = results['us_china_sectoral_summary']
        tech_avg = df[df['Type'] == 'Technology']['Change_Pct'].mean()
        comm_avg = df[df['Type'] == 'Commodity']['Change_Pct'].mean()
        supported = 'Yes' if tech_avg < comm_avg else 'No'

        bars = ax3.bar(['Technology', 'Commodity'], [tech_avg, comm_avg],
                       color=[COLORS['tech'], COLORS['commodity']], alpha=0.85,
width=0.5)
        ax3.axhline(y=0, color='black', linewidth=0.8)
        for bar in bars:
            val = bar.get_height()
            ax3.annotate(f'{val:+.1f}%',
                         xy=(bar.get_x() + bar.get_width()/2,
                             val + (1 if val >= 0 else -2)),
                         ha='center', va='bottom' if val >= 0 else 'top',
                         fontsize=9, fontweight='bold')
        ax3.set_title(f'H3: Sectoral Impact\nTech < Commodity: {supported}',
                      fontweight='bold', fontsize=11)
        ax3.set_ylabel('Avg Change (%)')

    # H4: Global Integration
    ax4 = axes[1, 1]
    if 'wdi_openness' in results:
        df = results['wdi_openness']
        world = df[df['Country'] == 'World']
        if len(world) > 0 and 2017 in world['Year'].values and 2023 in
world['Year'].values:
            v17 = world.loc[world['Year'] == 2017, 'Trade_Openness'].values[0]
            v23 = world.loc[world['Year'] == 2023, 'Trade_Openness'].values[0]

            bars = ax4.bar(['2017', '2023'], [v17, v23],
                           color=[COLORS['us'], COLORS['world']], alpha=0.85,
width=0.45)
            for bar in bars:
                ax4.annotate(f'{bar.get_height():.1f}%',
                             xy=(bar.get_x() + bar.get_width()/2,
bar.get_height()),
                             ha='center', va='bottom', fontsize=9,
fontweight='bold')
            change = v23 - v17
            ax4.set_title(f'H4: Global Trade Openness\nChange: {change:+.1f} pp',
                          fontweight='bold', fontsize=11)
            ax4.set_ylabel('Trade % of GDP')

    fig.suptitle('Hypothesis Testing Summary', fontweight='bold', fontsize=14)
    plt.tight_layout(rect=[0, 0, 1, 0.95])
    plt.savefig(output_dir / 'fig15_hypothesis_summary.png', dpi=300,
bbox_inches='tight')
    plt.close()
    print("Figure 15: Hypothesis Summary")

# Master figure generation

def generate_all_figures(results, output_dir):
    """Generate all thesis figures."""
    output_path = Path(output_dir)
    output_path.mkdir(parents=True, exist_ok=True)

    if 'us_china_total' in results:
        fig1_us_china_bilateral(results['us_china_total'], output_path)
```

```
        fig2_us_china_trade_balance(results['us_china_total'], output_path)
        fig3_us_china_yoy_changes(results['us_china_total'], output_path)

    if 'us_trade_diversion' in results:
        fig4_us_trade_diversion_index(results['us_trade_diversion'], output_path)
        fig5_us_import_share_changes(results['us_trade_diversion'], output_path)

    if 'eu_russia_total' in results:
        fig6_eu_russia_bilateral(results['eu_russia_total'], output_path)
        if 'eu_energy' in results:
            fig7_eu_energy_imports(results['eu_russia_total'],
results['eu_energy'], output_path)
        fig8_eu_russia_period_comparison(results['eu_russia_total'], output_path)

    if 'eu_russia_sectoral_summary' in results:
        fig9_eu_sectoral_comparison(results['eu_russia_sectoral_summary'],
output_path)

    if 'russia_trade_diversion' in results:
        fig10_russia_trade_reorientation(results['russia_trade_diversion'],
output_path)

    if 'us_china_sectoral_summary' in results:
        fig11_sectoral_comparison(results['us_china_sectoral_summary'],
output_path)

    if 'wdi_openness' in results:
        fig12_global_trade_openness(results['wdi_openness'], output_path)
        fig13_trade_openness_change(results['wdi_openness'], output_path)

    if 'us_china_total' in results and 'eu_russia_total' in results:
        fig14_cumulative_impact_comparison(results['us_china_total'],
results['eu_russia_total'], output_path)

    fig15_hypothesis_summary(results, output_path)

# Statistics and reporting

def print_thesis_statistics(results):
    """Print comprehensive statistics for thesis Chapter 3."""
    if 'us_china_total' in results:
        df = results['us_china_total']
        pre = df[df['Period'] == 'Pre-Tariff']
        post = df[df['Period'] == 'Post-Tariff']

        exp_change = ((post['US_Exports_to_China'].mean() -
pre['US_Exports_to_China'].mean()) /
                      pre['US_Exports_to_China'].mean() * 100)
        imp_change = ((post['US_Imports_from_China'].mean() -
pre['US_Imports_from_China'].mean()) /
                      pre['US_Imports_from_China'].mean() * 100)

        print(f"H1 - US Exports to China:
${pre['US_Exports_to_China'].mean():.1f}B →
${post['US_Exports_to_China'].mean():.1f}B ({exp_change:+.1f}%)")
        print(f"H1 - US Imports from China:
${pre['US_Imports_from_China'].mean():.1f}B →
${post['US_Imports_from_China'].mean():.1f}B ({imp_change:+.1f}%)")

    if 'eu_russia_total' in results:
        df = results['eu_russia_total']
        pre_war = df[df['Year'] == 2021].iloc[0]
        post_war = df[df['Year'] == 2024].iloc[0]
```

```
        imp_drop = ((post_war['EU_Imports_from_Russia'] -
pre_war['EU_Imports_from_Russia']) /
                    pre_war['EU_Imports_from_Russia'] * 100)
        exp_drop = ((post_war['EU_Exports_to_Russia'] -
pre_war['EU_Exports_to_Russia']) /
                    pre_war['EU_Exports_to_Russia'] * 100)

        print(f"H1 - EU Imports from Russia (2021→2024):
€{pre_war['EU_Imports_from_Russia']:.1f}B →
€{post_war['EU_Imports_from_Russia']:.1f}B ({imp_drop:+.1f}%)")
        print(f"H1 - EU Exports to Russia (2021→2024):
€{pre_war['EU_Exports_to_Russia']:.1f}B →
€{post_war['EU_Exports_to_Russia']:.1f}B ({exp_drop:+.1f}%)")

    if 'us_trade_diversion' in results:
        df = results['us_trade_diversion']
        if 2017 in df['Year'].values and 2023 in df['Year'].values:
            for partner in ['China', 'Vietnam', 'Mexico', 'India']:
                if partner in df.columns:
                    v17 = df.loc[df['Year'] == 2017, partner].values[0]
                    v23 = df.loc[df['Year'] == 2023, partner].values[0]
                    change = ((v23 - v17) / v17) * 100
                    print(f"H2 - {partner}: ${v17:.1f}B → ${v23:.1f}B
({change:+.1f}%)")

    if 'russia_trade_diversion' in results:
        df = results['russia_trade_diversion']
        for country in ['China', 'Turkey']:
            total_col = f'{country}_Total'
            if total_col in df.columns and 2019 in df['Year'].values and 2024 in
df['Year'].values:
                v19 = df.loc[df['Year'] == 2019, total_col].values[0]
                v24 = df.loc[df['Year'] == 2024, total_col].values[0]
                change = ((v24 - v19) / v19) * 100
                print(f"H2 - {country}-Russia: ${v19:.1f}B → ${v24:.1f}B
({change:+.1f}%)")

    if 'us_china_sectoral_summary' in results:
        df = results['us_china_sectoral_summary']
        tech_avg = df[df['Type'] == 'Technology']['Change_Pct'].mean()
        comm_avg = df[df['Type'] == 'Commodity']['Change_Pct'].mean()

        print(f"H3 - Technology sectors average change: {tech_avg:+.1f}%")
        print(f"H3 - Commodity sectors average change: {comm_avg:+.1f}%")

    if 'wdi_openness' in results:
        df = results['wdi_openness']
        world = df[df['Country'] == 'World']
        if len(world) > 0:
            for year in [2017, 2019, 2023]:
                if year in world['Year'].values:
                    val = world.loc[world['Year'] == year,
'Trade_Openness'].values[0]
                    print(f"H4 - World Trade Openness {year}: {val:.1f}%")

            if 2017 in world['Year'].values and 2023 in world['Year'].values:
                v17 = world.loc[world['Year'] == 2017,
'Trade_Openness'].values[0]
                v23 = world.loc[world['Year'] == 2023,
'Trade_Openness'].values[0]
                change = v23 - v17
                print(f"H4 - Change 2017→2023: {change:+.1f} pp")

# Excel template population
```

```
def populate_excel_template(results, template_path, output_path):
    """Populate the thesis Excel template with calculated data.

    Only fills the yellow (input) cells; all formula cells auto-recalculate
    when the file is opened in Excel / LibreOffice.
    """
    import shutil
    from openpyxl import load_workbook

    shutil.copy2(template_path, output_path)
    wb = load_workbook(output_path)

    if 'us_china_total' in results:
        ws = wb['US-China Aggregate']
        df = results['us_china_total']
        for row_idx in range(2, ws.max_row + 1):
            year = ws.cell(row=row_idx, column=1).value
            if year is None:
                continue
            match = df[df['Year'] == year]
            if not match.empty:
                ws.cell(row=row_idx, column=2,
value=round(match.iloc[0]['US_Exports_to_China'], 2))
                ws.cell(row=row_idx, column=3,
value=round(match.iloc[0]['US_Imports_from_China'], 2))

    if 'us_china_sectoral' in results:
        ws = wb['US-China Sectoral']
        df = results['us_china_sectoral']
        sector_name_map = {
            'Agriculture': 'Agriculture',
            'Energy': 'Energy',
            'Chemicals': 'Chemicals',
            'Metals': 'Metals',
            'Machinery': 'Machinery',
            'Electronics': 'Electronics',
            'Precision Instruments': 'Precision Instruments',
            'Vehicles': 'Vehicles',
        }
        for row_idx in range(2, ws.max_row + 1):
            year = ws.cell(row=row_idx, column=1).value
            sector_raw = ws.cell(row=row_idx, column=2).value
            if year is None or sector_raw is None:
                continue
            sector = sector_name_map.get(sector_raw, sector_raw)
            exp_match = df[(df['Year'] == year) & (df['Sector'] == sector) &
(df['Flow'] == 'Export')]
            imp_match = df[(df['Year'] == year) & (df['Sector'] == sector) &
(df['Flow'] == 'Import')]
            if not exp_match.empty:
                ws.cell(row=row_idx, column=4,
value=round(exp_match.iloc[0]['Value_Billions'], 3))
            if not imp_match.empty:
                ws.cell(row=row_idx, column=5,
value=round(imp_match.iloc[0]['Value_Billions'], 3))

    if 'eu_russia_total' in results:
        ws = wb['EU-Russia Trade']
        df = results['eu_russia_total']
        energy_df = results.get('eu_energy', pd.DataFrame())
        for row_idx in range(2, ws.max_row + 1):
            year = ws.cell(row=row_idx, column=1).value
            if year is None:
                continue
            match = df[df['Year'] == year]
```

```
            if not match.empty:
                ws.cell(row=row_idx, column=2,
value=round(match.iloc[0]['EU_Exports_to_Russia'], 2))
                ws.cell(row=row_idx, column=3,
value=round(match.iloc[0]['EU_Imports_from_Russia'], 2))
            if not energy_df.empty:
                e_match = energy_df[energy_df['Year'] == year]
                if not e_match.empty:
                    ws.cell(row=row_idx, column=6,
value=round(e_match.iloc[0]['Energy_Imports'], 2))

    if 'us_trade_diversion' in results:
        ws = wb['Trade Diversion - US']
        df = results['us_trade_diversion']
        col_map = {2: 'China', 3: 'Vietnam', 4: 'Mexico', 5: 'Taiwan', 6:
'India'}
        for row_idx in range(2, ws.max_row + 1):
            year = ws.cell(row=row_idx, column=1).value
            if year is None:
                continue
            match = df[df['Year'] == year]
            if not match.empty:
                for col_idx, partner in col_map.items():
                    if partner in match.columns:
                        val = match.iloc[0][partner]
                        if pd.notna(val):
                            ws.cell(row=row_idx, column=col_idx, value=round(val,
2))

    if 'russia_trade_diversion' in results and 'eu_russia_total' in results:
        ws = wb['Trade Diversion - Russia']
        r_df = results['russia_trade_diversion']
        eu_df = results['eu_russia_total']
        for row_idx in range(2, ws.max_row + 1):
            year = ws.cell(row=row_idx, column=1).value
            if year is None:
                continue
            eu_match = eu_df[eu_df['Year'] == year]
            if not eu_match.empty:
                ws.cell(row=row_idx, column=2,
value=round(eu_match.iloc[0]['Total_Trade'], 2))
            r_match = r_df[r_df['Year'] == year]
            if not r_match.empty:
                if 'China_Total' in r_match.columns and
pd.notna(r_match.iloc[0].get('China_Total')):
                    ws.cell(row=row_idx, column=3,
value=round(r_match.iloc[0]['China_Total'], 2))
                if 'Turkey_Total' in r_match.columns and
pd.notna(r_match.iloc[0].get('Turkey_Total')):
                    ws.cell(row=row_idx, column=5,
value=round(r_match.iloc[0]['Turkey_Total'], 2))

    if 'us_china_sectoral_summary' in results:
        ws = wb['Sectoral Comparison']
        df = results['us_china_sectoral_summary']
        sector_map = {
            'Electronics (HS 85)': 'Electronics',
            'Machinery (HS 84)': 'Machinery',
            'Precision Instruments (HS 90)': 'Precision Instruments',
            'Agriculture (HS 01-24)': 'Agriculture',
            'Energy (HS 27)': 'Energy',
            'Chemicals (HS 28-38)': 'Chemicals',
            'Metals (HS 72-83)': 'Metals',
            'Vehicles (HS 87)': 'Vehicles',
        }
```

```
        for row_idx in range(2, ws.max_row + 1):
            sector_raw = ws.cell(row=row_idx, column=1).value
            case = ws.cell(row=row_idx, column=2).value
            if sector_raw is None:
                continue
            sector = sector_map.get(sector_raw)
            if sector and case == 'US-China':
                match = df[df['Sector'] == sector]
                if not match.empty:
                    ws.cell(row=row_idx, column=3,
value=round(match.iloc[0]['Baseline_Avg'], 3))
                    ws.cell(row=row_idx, column=4,
value=round(match.iloc[0]['PostTariff_Avg'], 3))

    if 'wdi_openness' in results:
        ws = wb['Global Integration']
        df = results['wdi_openness']
        country_col_map = {
            2: 'World',
            3: 'United States',
            4: 'European Union',
            5: 'China',
        }
        for row_idx in range(2, ws.max_row + 1):
            year = ws.cell(row=row_idx, column=1).value
            if year is None:
                continue
            for col_idx, country in country_col_map.items():
                match = df[(df['Country'] == country) & (df['Year'] == year)]
                if not match.empty and 'Trade_Openness' in match.columns:
                    val = match.iloc[0]['Trade_Openness']
                    if pd.notna(val):
                        ws.cell(row=row_idx, column=col_idx,
value=round(float(val), 1))

    ws = wb['Hypothesis Summary']
    if 'us_china_total' in results:
        df = results['us_china_total']
        pre_imp = df[df['Period'] == 'Pre-
Tariff']['US_Imports_from_China'].mean()
        post_imp = df[df['Period'] == 'Post-
Tariff']['US_Imports_from_China'].mean()
        h1_us = ((post_imp - pre_imp) / pre_imp) * 100
        ws.cell(row=2, column=6, value='Partially Supported' if h1_us < 0 else
'Not Supported')
    if 'eu_russia_total' in results:
        ws.cell(row=3, column=6, value='Strongly Supported')
    if 'us_trade_diversion' in results:
        ws.cell(row=4, column=6, value='Strongly Supported')
    if 'russia_trade_diversion' in results:
        ws.cell(row=5, column=6, value='Strongly Supported')

    wb.save(output_path)
    wb.close()

# Main entry point

def main(input_dir=None, output_dir=None):
    """Main execution function.

    Paths are auto-detected relative to this script's location so the
    project works regardless of where it lives on disk.
    """
    try:
        script_dir = Path(__file__).resolve().parent
```

```
        project_dir = script_dir.parent
    except NameError:
        # Running in Jupyter notebook - fall back to cwd
        project_dir = Path.cwd()
        if project_dir.name == 'scripts':
            project_dir = project_dir.parent

    if input_dir is None:
        input_dir = str(project_dir / 'data' / 'raw')
    if output_dir is None:
        output_dir = str(project_dir)

    results = process_all_data(input_dir)

    processed_dir = Path(output_dir) / 'data' / 'processed'
    processed_dir.mkdir(parents=True, exist_ok=True)

    output_file = processed_dir / 'thesis_processed_data.xlsx'
    with pd.ExcelWriter(output_file, engine='openpyxl') as writer:
        for name, df in results.items():
            df.to_excel(writer, sheet_name=name[:31], index=False)
    print(f"Processed data saved to: {output_file}")

    template_path = Path(output_dir) / 'data' / 'thesis_data_template.xlsx'
    populated_path = Path(output_dir) / 'data' / 'thesis_data_populated.xlsx'
    if template_path.exists():
        populate_excel_template(results, template_path, populated_path)
        print(f"Populated template saved to: {populated_path}")

    figures_dir = Path(output_dir) / 'figures'
    generate_all_figures(results, figures_dir)

    print_thesis_statistics(results)

    print("\nGenerated figures:")
    for f in sorted(figures_dir.glob('*.png')):
        size_kb = f.stat().st_size / 1024
        print(f"{f.name} ({size_kb:.0f} KB)")

    return results

if __name__ == '__main__':
    results = main()
```

Appendix 2 - Oświadczenie o wykorzystaniu sztucznej inteligencji

Niniejszym oświadczam, że w procesie przygotowywania niniejszej pracy dyplomowej korzystałem z następujących narzędzi sztucznej inteligencji:
Claude (Anthropic): model Claude Opus 4.5, wyłącznie w celu:

- wsparcia w analizie danych i tworzeniu wizualizacji: poprawa skryptu Python do analizy danych handlowych z baz UN Comtrade, Eurostat i World Bank do rozdziału empirycznego;
- strukturyzacji tekstu: opracowanie przewodników strukturalnych dla rozdziałów 2, 3 i 4;
- pomoc w kompilacji literatury: zestawienie listy referencji bibliograficznych i wskazanie kluczowych źródeł teoretycznych do cytowania oraz stworzenie bibliografii zgodnie ze standardem APA 7th edition

Całość analiz merytorycznych, krytycznej weryfikacji, interpretacji wyników, zwłaszcza pod kątem możliwości wygenerowania nieprawdziwych czy niekompletnych informacji, wystąpienia plagiatu lub braku bądź nieprawidłowego przypisania autorstwa oraz ostateczna redakcja tekstu pracy dyplomowej zostały wykonane samodzielnie. Biorę pełną odpowiedzialność za treść pracy dyplomowej, w tym za jej poprawność merytoryczną, językową, etyczną i zgodność z przepisami prawa.