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The impact of economic sanctions on international trade in High-Tech products and semiconductors

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Abstract

In 2018, the United States set in motion a comprehensive series of sanctions, which served as the catalyst for a notable technology and trade dispute. This dispute spanned a wide array of Chinese products, semiconductors among them, and marked a significant turning point in the evolving landscape of international commerce and technological competition. This study analyses the effect of sanctions on High-Tech and semiconductor products during the 2016-2019 period using quarterly data. Employing the gravity model of trade and the Poisson Pseudo Maximum Likelihood estimator, the study finds statistically non-significant results for High-Technology products. However, semiconductor exports in general ended up increasing 10 percent despite the sanctions being put in place. The findings indicate that both US exports and imports have experienced growth within the timeframe of measurement.

Keywords: gravity model, international trade, semiconductors, sanctions

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1 Introduction

In recent years, economic sanctions have become a popular approach to tackle international political challenges associated with geopolitical conflicts. The imposition of these sanctions has generated considerable attention regarding the use of sanctions as a foreign policy tool, as well as our understanding of their functionality and effectiveness. Similarly, there has been a notable surge in the adoption of targeted sanctions. These measures aim to concentrate their effects on individuals, companies and organizations deemed responsible for an objectionable behavior. (Drezner, 2011)

Several sectors can be prominent for target sanctioning. In 2018, the Trump Administration imposed 25% tariffs on $34 billion worth of Chinese imports, including semiconductors. The decision to impose tariffs was made due to several concerns the US government had over China's trade practices. In addition to the provision of subsidies to domestic semiconductor firms, China mandated that US firms establish joint ventures with Chinese counterparts as a precondition for accessing the Chinese market. The requirement, which was not a voluntary business decision but a condition for market access, resulted in the forcible transfer of technology from US firms to their Chinese partners. This practice has been viewed as a violation of intellectual property rights by the US government. (Funke & Wende, 2022)

Sanctions in the technology sector can be impactful for several reasons. First, Semiconductors are essential components used in various manufacturing processes and supply chains, playing a crucial role in the production of electronic devices, communication systems, automotive technology, medical equipment, and numerous other industries. With a significant portion of global GDP reliant on semiconductor-powered devices, their importance is undeniable (Miller, 2022). Moreover, sanctions on the technology sector hinder innovation, collaboration and technological development by restricting technology transfers and cutting-edge research (Smeets, 2018). However, despite their significance, there remains a lack of comprehensive understanding regarding the international trade dynamics of semiconductors and the associated implications of sanctions on economic activity.

This paper aims to enhance the understanding of the impact of US sanctions on China’s semiconductor industry and the international trade of semiconductors. It provides contributions to the existing literature in three key aspects. First, an analysis is conducted to examine the extent to which sanctions impact the high technology industry in general. Second, I explore the effect of US sanctions on the Chinese semiconductor industry specifically. Lastly, this analysis serves as a stepping stone for future research, as targeted sanctions become more relevant today. It establishes a framework to explore broader impacts on various industries and regions affected by these sanctions, contributing to a deeper understanding of their effectiveness and policy implications.

The direct impact of US sanctions on Chinese semiconductors is measured using the gravity model, incorporating insights from the latest developments in the gravity literature as summarized by Yotov et al. (2016). A theory-consistent econometric gravity model is employed, where (i) the model incorporates importer- and exporter time fixed effects to account for unobservable multilateral resistance terms; (ii) the Poisson Pseudo Maximum Likelihood (PPML) estimator is applied to address the issue of heteroscedasticity and zero trade flows in trade data; and (iii) exporter-importer fixed effects is included to account for all time-invariant bilateral trade cost and to mitigate endogeneity concerns. There are two main differences from the suggestions made by Yotov et al. (2016) in this study. First, this study does not use data on international and domestic trade flows as the research focuses on a subset of trade relationships where such trade data is not available. Second, instead of using interval data, this study follows consecutive-year data to assess the short term outcomes.

Five datasets are employed to perform the empirical study. It considers two dependent variables. Initially, the study incorporates High-Technology products, categorized according to the Standard International Trade Classification Revision 4 (SITC Rev.4). This category encompasses semiconductors as well as various other products, such as aerospace items, computer office machinery, electronics communication devices, pharmaceuticals, scientific instruments, electrical machinery, chemicals, non-electrical machinery, and armaments. The second dependent variable contains information on the products targeted by the tariffs which is obtained from the United States Trade Representative. This list contains all products targeted by the tariffs; however, specifically semiconductors are selected. Thereafter, trade flow data is extracted from UN COMTRADE database, which provides information on the exporting and importing countries, Harmonized System 6 digit codes for classification of commodities, and their corresponding trade values. The CEPII gravity dataset was used to obtain data on regional trade agreements (RTA) and lastly, the data on sanctions come from 2022 edition of the Global Sanctions Database (GSDB), which covers all 1325 public traceable sanctions over the 1950-2022 time period.

The analysis begins with examining the combined impact of arms and trade sanctions. It then proceeds to estimate the effects of trade and arms sanctions individually. Following this, the results for partial and complete trade sanctions are presented. Transitioning to a more specific focus, the study delves into an in-depth analysis of the semiconductor industry. The aim is to better understand the impact of US sanctions on China's semiconductor sector and its broader implications. The findings reveal non-significant results for the High-Tech products and an increase in trade of semiconductors between US and China, despite the presence of sanctions.

The rest of the paper is organized as follows. Section 2 reviews relevant studies, offering an analysis of past research that contributes to the understanding of sanctions. Section 3 gives a historical background of the semiconductor industry. Section 4 describes the method and model specification. Section 5 presents the results of the study. Section 6 discusses and concludes the findings.

2 Literature Review

Given the ongoing trade conflict between China and the US, there has been a growing curiosity in determining the impact of sanctions. In addition to assessing the immediate implications for the countries directly involved in the dispute, policymakers are keen on examining the transformations within the global supply chain triggered by protectionist measures. Such policies can disrupt established supply chains and lead to shifts in production locations and trade flows, affecting not only the countries directly involved but also other countries that depend on the same supply chains. (Attinasi et al., 2022)

The Council of foreign Relations define sanctions as "the withdrawal of customary trade and financial relations for foreign and security policy purposes. Sanctions may be comprehensive, prohibiting commercial activity with regard to an entire country, […] or they may be targeted, blocking transactions of and with particular businesses, groups, or individuals." (Masters, 2019). This definition is evident in the actions taken by the Trump Administration, which justified their sanctions by stating "we must protect our borders from the ravages of other countries making our products, stealing our companies and destroying our jobs" (Trump, 2017). The key idea is that economic sanctions aim to force a change in policy or behavior in a foreign country by harming its economy. As argued by Robert A. Pape (1997), sanctions can work in two different ways. Either, it can directly convince the targeted government that matters in question are not worth the negative consequences, prompting them to give in. Alternatively, sanctions can indirectly create pressure from the citizens pushing the government to make a change or trigger a popular uprising that replaces the government altogether with one that will meet the demands.

While governments might find economic sanctions appealing for conveying dissatisfaction with another country's actions, there is a debate regarding whether these measures can truly bring about the intended change from an economic standpoint. The question arises as to whether sanctions can effectively achieve the desired outcomes that are often envisioned (Smeets, 2018). In recent years there has been a notable increase in the application of economic sanctions. According to data from the Global Sanctions Data Base, there were a total of 1045 publically documented instances of sanctions being imposed during the 1950-2019 time period. Out of these cases, 77 occurred within the last three years. This surge in the use of economic sanctions highlights a growing trend where countries are increasingly turning to this diplomatic tool as part of their foreign policy strategies (Larch, 2022). While scholars believe that sanctions offer a more humane alternative to military actions, it is important to note that the initial significant body of research on economic sanctions, spanning the 1960 and 1970s, generally arrived at a shared conclusion that economic sanctions were not as successful as military force in achieving their intended goals (Galtung, 1967).

In the 1980s, a new wave of scholars challenged the skepticisms of the effectiveness of sanctions. Hufbauer, Schott, and Elliott (1990) were among the pioneers in conducting a comprehensive empirical analysis that assessed the efficacy of economic sanctions. Studying 116 cases of sanctions imposed since World War I, they revealed a success rate of 34 percent, with 40 of those cases resulting in desired policy changes within targeted nations. They concluded that economic sanctions are a useful alternative to military force. In 2000, Robert A. Hart Jr. conducted an ordered probit analysis on 81 bilateral sanctions using Hufbauer's dataset. In his research, he introduces the concept that country leaders are driven by domestic political considerations, particularly noticeable in democracies, which can potentially shape a nation's foreign policy choices. The study puts forth the hypothesis that democracies are more prone to achieving successful outcomes with economic sanctions. The results indicate a significant link between the domestic regime type, specifically democracies, and the effectiveness of economic sanctions. Additionally, Hart claims that previous studies on sanction success may be underspecified as they do not include the regime type of the sanctioner as part of their explanatory model. Moreover, the extent to which the economic relationship between the sanctioning and target countries is disrupted has also been identified as a significant element in determining the success of sanctions. Bapat and his colleagues

(2013) have found that when economic ties between countries are significantly interrupted due to sanctions, the likelihood of sanctions achieving their desired outcomes increases. This implies that severing or significantly reducing economic interactions between the sanctioning and target countries can contribute to the effectiveness of sanctions.

Several researchers argue that sanctions are ineffective. Pape (1997) criticized Hufbauers study arguing that it inaccurately portrayed many cases as successful outcomes of economic sanctions. He concludes that out of the 40 cases identified as successes, only 5 of them could truly be considered successful outcomes due to economic sanctions. The rest of the cases, according to Pape, were either resolved through the use of force, were not settled at all, or the so called successes were not truly the result of economic sanctions. This leads to a result of a success rate of only 4 percent instead of 34 as previously argued. In 2007, Hufbauer et al. once again examined the historical use of sanctions since 1914. Their investigation revealed that only 13 out of 200 sets of sanctions were able to achieve their intended objectives. They noted that imposing sanctions came with a cost to both to the country imposing the sanctions and the country facing the sanctions. Given the relatively low rate of success and the considerable cost involved, the passage raises a question about the justification for using economic sanctions as a foreign policy tool. It prompts consideration of whether the potential effectiveness of sanction in achieving policy goals is sufficient to offset the negative impacts they create.

In the case of China, Zhao's (2010) study on China explores how its historical experiences with economic sanctions relate to its judgment of their effectiveness. China provides an especially interesting case for this investigation since it is part of a select group of nations that have dealt extensively with sanctions over time. The study examines five key instances of sanctions imposed on China between 1949 and 2010. These sanctions can be classified into two types: strategic and tactical. Strategic sanctions aim to impact another country's security interests by weakening its government or system. In contrast, tactical sanctions are initiated by a country for its own economic or political gain. The study's findings revealed that among the five cases, three were strategic and did not yield the desired outcomes. On the other hand, the two tactical sanctions, which did not challenge China's governance approach, ended up being successful.

Moreover, using a general equilibrium model, Bellora and Fontagne (2019) investigate the tariffs resulting from the “Phase one Deal” agreed in December 2019. They find that the sanctions have a negative effect on both the US and China's economy which will result in a decrease in GDP and real wages by 2030, with more sever impacts on China. Additionally, Cigna et al. (2022) used a reduced form difference-in-difference model to investigate the impact of US tariffs on US imports from China. They find that while the negative direct impacts of US tariffs on US imports from China remain strong, there is no significant evidence supporting short-term trade diversion effects towards third countries. The study also highlights that it is important to investigate specific products as well.

Hufbauer et al. (2007) conducted a study where they compared the impact of economic sanctions in the short term versus the long term. They discovered that after the initial year and the subsequent second year of implementation, economic sanctions tend to become significantly less effective. In other words, their ability to achieve desired outcomes diminishes as time passes. Dizaji and van Bergeijk (2013) support this conclusion by concurring with the results. They assert that economic sanctions have the potential to yield positive results specifically within the first two years after being put into effect. This aligns with the notion that economic sanctions are more likely to be successful in the early stages following their implementation, but their effectiveness tends to wane as time goes on.

3 Historical Background

In the 1950s, Jack Kilby and Robert Noyce invented the first semiconductor chip, a piece of silicone housing four transistors on it. As engineers continued to increase the number of transistors on the chip, its computing power and capabilities grew accordingly (Miller, 2022, p.16). In 1965, Gordon Moore, the founder of Intel and Fairchild, observed that the number of transistors on chips was doubling each year due to advancements in creating smaller transistors. He predicted this exponential growth in computing power would continue for a decade, and this prediction has remained accurate up to the present day. (Miller, 2022, p.xxi)

In the 1960s, the Soviet space program achieved significant advancements by launching the first satellite and sending Yuri Gagarin, the first cosmonaut, to outer space. In response to these achievements, the United States initiated efforts to catch up and began investing a lot of money into the Apollo mission. During this period, both NASA and the US military emerged as the primary customers for the first US semiconductor companies, recognizing the pivotal role of technology and innovation in maintaining nation strength. The US government believed that collaborating with semiconductor producers would guarantee access to cutting edge technology, ensuring the nation’s continued technological competitiveness. (Miller, 2022, p.19)

In the beginning, the semiconductor supply chain was predominantly located in the US. They designed the chips, manufactured them and integrated them into the final product. However, Noyce saw opportunities beyond defense applications and envisioned the widespread adoption of semiconductors in various customer electronics. By targeting the civilian market, he sought to drive mass production and reduce cost, making semiconductors more affordable and accessible to the general public (Miller, 2022, p.29). US chip companies began moving their manufacturing factories abroad to their political allies in Japan, Taiwan and South Korea where labor cost were lower. These companies were banned from sharing technology with their rivals, mainly the Soviet Union and China. Even if Soviet Union or China managed to copy a design and replicate the production, this process took time. Due to Moore’s Law, US companies’ continuous introduction of new designs with higher number of transistors further solidified their lead in the semiconductor industry. As a result, choosing to copy existing designs would have put the Soviet Union and China at a 5-10 year disadvantage in terms of technological advancement. (Miller, 2022, p.43)

Soon after, the allied governments began investing in their own chip companies. Between the 1970s-1980s Toshiba in Japan, Samsung in South Korea and TSMC in Taiwan emerged as strong US competitors. Their advanced chip manufacturing resulted in several US companies shutting down. Consequently, the global landscape of the semiconductor industry evolved, emphasizing a more collaborative and interdependent approach amongst countries. Companies worldwide found themselves relying on one another for critical resources such as materials, software and equipment necessary to manufacture more complex chips. (Brown, 2020)

As the US and its allies pushed the boundaries of chip technology, China found itself lagging behind. The country faced several challenges, including being blocked from accessing advanced chip technology during the Cold War and the loss of talented scientists and engineers who fled China during Mao Zedgong’s rule in 1960s-1970s (Miller, 2022, p.173). However, by the 1990s the Cold War ended, leading to improved relations between US and China, and many export controls being lifted. China seized this opportunity and attracted several chip companies to reallocate their assembly operations to the country. As a result, by the 2000s China became dominant in this aspect of the semiconductor supply chain (Miller, 2022, p.164). However, they soon realized that their industry was completely dependent on their rivals' chip production which was a risk they were not willing to take. In an effort to establish a self-reliant chip industry supply chain, the Chinese government made significant financial investments in domestic chip design and manufacturing companies. The ultimate goal was to create a fully integrated chip industry within China, reducing reliance on imports and achieving greater control over critical semiconductor components. China is still behind other countries when it comes to their ability to compete with the most advanced technology available. (Miller, 2022, p.180)

China's quest to catch up with advanced technology and gain a competitive edge in the global market has led to reports of IP intellectual property theft in the chip industry raising concerns amongst governments. During the Trump Administration two actions were taken to address national security concerns. First, in 2018 Trump introduced a 25% tariff rate on semiconductors as part of a broader trade policy to address perceived unfair trade practices and protect American industries. Second, in response to security risks, the Trump administration banned US companies from selling components to ZTE and conducting business with Huawei. In 2022, during Joe Biden's presidency, further measures were taken. The US government issued a ban on all US companies from selling advanced chips to China. Additionally, it extended the ban to encompass companies worldwide that utilize US semiconductor technology, preventing them from selling advanced chips to China as well. (Brown, 2020)

These actions have intensified the pressure on the countries involved. Since 1949, China has regarded Taiwan as a province requiring reunification, even resorting to the threat of military action to achieve this goal. Taiwan's role in the global chip supply chain is crucial, as it manufactures 60% of the world's semiconductors and 93% of all advanced chips. However, Biden's export controls have now banned Taiwanese chipmakers from selling advanced chips to China, which happens to be Taiwan's largest trading partner, leading to further tension between the countries. (Engel et al., 2023)

4 Data, Method and Methodology

4.1 The Gravity Model of Trade: An Overview

The gravity model of trade is a widely used empirical tool in international economics that explains bilateral trade flows between countries based on their economic size and distance. Its origins can be traced back to the fundamental principle of the physical law of gravity, which states that the force of attraction between two objects is proportional to their mass and inversely proportional to the square of the distance between them. Intuitively, the gravity model suggests that countries with larger economies and closer geographical proximity are more likely to trade with each other. (Yotov et al, 2016)

The theoretical foundation for the structural gravity model of trade was laid by Anderson in 1979, who derived the model under the assumptions that consumers have identical and homothetic preferences and that products are differentiated by origin (Armington, 1969). Anderson and van Wincoop (2003) further developed the structural gravity model, emphasizing the significance of considering general equilibrium effects of the multilateral resistance terms to accurately assess the overall impact of trade costs on bilateral trade between two countries. Moreover, they argue that under technical assumptions that generate trade separability, the structural gravity model can be incorporated into a diverse range of general equilibrium models that determine the size of sales and expenditures in individual countries, in which the primary function of gravity is to determine the distribution pattern of the total sales and expenditures.

The equation for the gravity model, which expresses this relationship mathematically, is as follows:

$$X_{ijt} = \frac{Y_{it}E_{jt}}{Y_t}\left(\frac{\tau_{ijt}}{P_{jt}\Pi_{it}}\right)^{1-\sigma} \tag{1}$$

$$\Pi_{it}{}^{1-\sigma} = \sum_j \left(\frac{\tau_{ijt}}{P_{jt}}\right)^{1-\sigma} \frac{E_{jt}}{Y_t} \tag{2}$$

$$P_{jt}{}^{1-\sigma} = \sum_i \left(\frac{\tau_{ijt}}{\Pi_{it}}\right)^{1-\sigma} \frac{Y_{it}}{Y_t} \tag{3}$$

where X_{ijt} captures the trade flows from exporter *i* to destination country *j*, Y_{it} and E_{jt} is the respective income of the two countries, y_t is the world income, τ_{ijt} captures the bilateral trade friction between country *i and j*, P_{jt} and Π_{it} are multilateral resistance terms and $\sigma > 1$ is the elasticity of substitution among products from different countries.

As explained by Larch and Yotov (2016), Equation (1) governs the bilateral trade flows between two countries by linking bilateral exports to the economic size of the trading partners. The Gravity equation can be broken down into two parts: the size term and the cost term. The size term explains the nature of trade flows between countries, such as the fact that larger producers tend to export more to all destinations, larger markets tend to import more from all sources, and trade between two countries will increase as their respective sizes become more similar. The cost term represent the total impact of trade cost that creates a gap between the actual and frictionless trade. This part of the equation can be divided up into 3 terms. First, τ_{ijt}, explains bilateral trade frictions which include transportation cost which may arise due to distance, cultural differences such as languages, and trade agreements. Lastly, there is the inward, ${P_{jt}}^{1-\sigma}$, and outward, ${\Pi_{it}}^{1-\sigma}$, multilateral resistance terms defined in Equation (2) and Equation (3). The multilateral resistance terms the aggregate effect of trade barriers between a given country and all its trading partners. It represents the degree to which a country's exports and imports are constrained by the combined trade barriers of all its trading partners and they reflect the degree of resistance faced by a country in trading with other countries. The outward multilateral resistance term captures the degree to which a country's exports are constrained, by the trade barriers, while the inward multilateral resistance term captures the degree to which a country's imports are constrained by the trade barriers. (Larch and Yotov, 2016)

4.2 Model specification and Estimation Techniques

The gravity model is chosen for two primary reasons. Firstly, it is a widely recognized and successful model in empirical trade, frequently employed to quantify the effects of various policies on international trade. Secondly, the model allows for individual sector analysis, enabling an investigation into the trade dynamics of specific industries and products.

The theoretical principles discussed in the previous section provide the foundation for constructing a model that corresponds to Equation (1), which is utilized to estimate the partial equilibrium effects of four sets of regression models. These regression models include semiconductor imports, semiconductor exports, high tech imports and high tech exports.

$$X_{ijt}^{k} = exp\left[{\pi_{it}}^{k} + {\chi_{jt}}^{k} + {\mu_{ij}}^{k} + RTA_{ijt}\alpha^{k} + SANCT_{ijt}\beta^{S}\right] + \epsilon_{ijt} \quad (4)$$

X_{ijt}^{k} captures nominal trade flows for trade category k, by exporter i and importer j at time t. This paper begins with focusing on the High-Tech sector due to the increasing share of China in the global manufacturing value chains, which increased from 6% to 19% between 2000 and 2014. This significant surge has been largely driven by China's gains in competitiveness and the growth of its domestic market, particularly in High-Tech sectors, hence making it interesting to see the impact of High-Tech trade patterns in the beginning of the trade war. (Joint Research Center, 2019).

Following this, the paper conducts a more in-depth analysis of the sanctioned semiconductors, with a specific objective of quantifying and assessing the impact of US sanctions on China's semiconductor trade patterns. By investigating changes in semiconductor exports, imports, and trade relationships, the study seeks to provide insights into the effects of the sanctions.

Equation (4) employs the Poisson Pseudo Maximum Likelihood (PPML) estimator as proposed by Santos-Silva and Tenreyro (2006) for two main reasons. First, when the gravity model is estimated in log-linear form with the OLS estimator, the presence of heteroscedasticity gives biased estimates. Second, the OLS approach does not take into account the information contained in the zero trade flows causing the gravity equation to omit observations where countries do not report trade. There are instances where certain countries do not report any trade activity with each other, resulting in zero trade flows. The OLS approach treats these as missing data discarding information about the absence of trade between countries. The PPML estimator efficiently addresses these challenges, providing more reliable estimates by handling heteroscedasticity and utilizing information from zero trade flows. (Yotov, 2016)

For the independent variables, Equation (4) begins with incorporating three sets of fixed effects. Initially, exporter-industry-time fixed effect ${\pi_{it}}^k$ and importer-industry-time fixed effects ${\chi_{jt}}^k$ are introduced to control for a wide range of determinants that may influence trade flows within specific industries such as productivity and size which may vary over time. These fixed effects also control for global trends that may influence certain industries and aggregate production and consumption (Yotov et al., 2016). In addition, a set of country-pair-industry fixed effects, ${\mu_{ij}}^k$, is introduced in order to account for time-invariant bilateral trade cost. These trade cost include various factors that do not change over time between two countries, such as geographical proximity, historical ties, culture and other long-term determinants. By incorporating these fixed effects, the model absorbs any unobservable and observable time- invariant bilateral trade cost. This helps ensure that the analysis focuses on the dynamic changes in trade cost over time, while controlling for the influence of these fixed factors that remain stable throughout the observation period (Yotov et al., 2016). Notably, according to research conducted by Baier and Bergstrand (2007), the country-pair-industry fixed effects also serve a vital purpose in handling potential endogeneity issues related to RTAs and sanctions. These fixed effects help control for factors that could lead to reverse-causality in trade policy. For instance, countries that already engage in extensive trade are more likely to sign regional trade agreements. By incorporating these fixed effects, the analysis can better isolate the true impact of RTAs and sanctions on international trade flows, providing more reliable and unbiased results.

Finally, the analysis takes into account the influence of Regional trade agreements (RTAs) by using a binary variable, $RTA_{ijt}\alpha^{k}$. This variable takes a value of one if there is an RTA between the countries i and j during a specific period *t*, and zero if there is no such agreement. Similarly, data on trade sanctions, $SANCT_{ijt}\beta^{S}$, is represented by a dummy variable. This variable serves as an indicator of whether trade sanctions are applied between the country pair for a particular period. When sanctions are in effect, the variable takes a value of one, and if no sanctions are in place, it is assigned a value of zero. These variables enable controlling for the impact of RTA and sanctions on trade flows.

4.3 Data

For the empirical analysis, a quarterly unbalanced panel dataset is constructed. It includes 218 partner countries and 146 reporter countries, covering the period 2016-2019. The study begins in January 2016 to observe trade flow trends in the semiconductor industry prior to the implementation of tariffs. The analysis concludes in December 2019 to avoid confounding effects from the COVID-19 pandemic and the policy responses in early 2020 which could potentially impact the analysis if included in the dataset.

The analysis considers two dependent variables. First, the analysis incorporates High-Technology products defined by the Standard International Trade Classification Revision 4 (SITC Rev.4). This dataset comprises technical products that require extensive research and development for it to be manufactured. Semiconductors are part of this dataset; however it also includes products within the categories of aerospace, computer office machines, electronics communication, pharmacy, scientific instruments, electrical machinery, chemistry, non-electrical machinery and armament (SITC Rev, 4, n.d.). To ensure accuracy and consistency in the analysis, the list of products categorized using SITC codes is converted to the corresponding HS codes. This conversion allows for cross-checking and ensures that the identified products align appropriately between the two code systems. Second, information on the products targeted by the tariffs is obtained from the United States Trade Representative. This list contains all products targeted by the tariffs; however, specifically semiconductors are selected. (ustr.gov, n.d.)

The trade data for these products are sourced from the United Nations COMTRADE database which includes the importing and exporting countries, commodities classified according to the Harmonized system (HS) and the trade value. The analysis is carried out at a HS-6 digit code system, despite the fact that United States imposed tariffs on HS-8 digit product codes. The main reason for this is that the COMTRADE database publishes international trade data up to the HS-6 digit level, where all countries universally classify products in the same way. Utilizing the HS-6 digit level ensures consistency and comparability of data across countries, providing more of reliable foundation for the analysis. (UN COMTRADE, n.d.)

The Regional Trade Agreement (RTA) data is extracted from Centre d'Etudes Prospectives d'Informations Internationales (CEPII, n.d.) and refers to trade agreements where two or more partner countries engage in mutually advantageous trade relationships, without the constraint of being from the same geographical region. This data is reported on annual basis, but when merged assumed to hold for all quarters.

Lastly, the data on sanctions is sourced from the Global Sanctions Data Base (GSDB), providing a comprehensive record of all publicly traceable sanctions worldwide spanning from 1950 to 2022. The GSDB encompasses 1325 sanction cases categorized based on their objectives, success rates, and types. The database distinguishes between six types of sanctions, categorized according to their targeted activities. These include: trade, financial, arms, military assistance, travel, and other sanctions. The trade data is categorized as either partial sanctions referring to only specific products or industries, or as complete sanctions which apply to all industries. Moreover, the trade sanctions are classified according to if they are an export, import or bilateral sanction depending on the trade flow (Felbermayr et al., 2022). The Global Sanction Data Base lacks information about distinct industries, leading to a lack of clarity regarding which industries or products have faced sanctions. In this analysis, we incorporate data on arms sanctions, as they are classified as High-Tech products. Additionally, we include trade sanctions to extend our estimation of the impact of sanctions to encompass other High-Tech products beyond arms. All sanctions which were present during 2016-2019 can be found in the appendix.

5 Empirical Findings

This section unveils the primary findings. Section 5.1 presents an analysis of the average impact of sanctions on high technology products. The analysis begins with looking at sanctions of arms and trade combined. Then it moves on to estimating the effects of trade and arms sanctions separately. Lastly, the results for partial and complete trade sanctions are presented. While this offers valuable insights, it is possible that certain industries or products are affected more than others. Section 5.2 takes a targeted approach by delving into an in-depth analysis of the semiconductor industry. The aim is to better understand the impact of US sanctions on China's semiconductor sector and its broader implications.

5.1 The impact on High-Tech products

Table 1 present the results on the average impact of sanctions on the High-Tech industry. This data includes sanctions on trade and arms combined.

Table 1 : Total impact of Trade and Arms Sanctions on High-Tech products

Dependent Variables	(1) High-Tech imports	(2) High-Tech exports
Sanction	0.242	0.072
	(0.218)	(0.126)
RTA	-0.015	0.063***
	(0.218)	(0.020)
Constant	21.752***	21.602***
	(0.014)	(0.012)
R-squared	0.995	0.994
Observations	188 551	177 417

Notes: Using the PPML approach, this table reports estimates of the impact of trade + arms sanctions on trade in High-Tech products. The dependent variable includes imports of High-Tech products (1) and exports of High-Tech products (2), while the independent variables capture the effects of sanctions and RTA. All estimates are obtained with importer-time fixed effects, exporter time fixed effects, and country-pair fixed effects. Standard errors are clustered by country pair and are reported in the parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Lastly, the number of observations as well as McFedden's pseudo R^2 is reported.

Column (1) assesses the impact of sanctions on countries' imports. The estimate indicates a positive impact of sanctions on imports; however, this impact lacks statistical significance. This suggests a possible increase in imports when sanctions are in place, meaning that sanctions have not had the desired effect. Furthermore, the coefficient for Regional Trade Agreements (RTA) is negative and lacks statistical significance. This indicates a subtle adverse influence of regional trade agreements on imports of High-Tech products. In Column (2), the focus shifts to the effect on countries' exports. Once again, the impact of sanctions on exports is positive but lacks statistical significance. On the other hand, the RTA coefficient has turned positive and is statistically significant at the 1 percent level. This suggests that Regional Trade Agreements have a significant positive effect on promoting exports of High-Tech products.

In Table 2, the findings draw a distinction between trade sanctions and arms sanctions. The analysis indicates that trade sanctions do not exhibit a statistically significant impact on High-Tech imports, suggesting that these sanctions do not have an impact on imports of High-Tech products. Similarly, the results confirm the earlier observation: RTAs have, a non-significant, negative association with High-Tech imports, implying that such agreements do not promote High-Tech imports of these products. On the contrary, when examining the impact on trade sanctions on High-Tech exports seen in column 2, the study reveals a different pattern. Trade sanctions on High-Tech exports continue to exhibit a non-statistically significant result except that it is negative this time. In contrast, RTAs demonstrate a positive influence on trade, with statistical significance at the 1 percent level, indicating that these agreements have a beneficial effect on exports in High-Tech products.

Table 2 : Impact of Trade and Arms Sanctions Individually on High-Tech Products

Dependent Variables	(1) High-Tech Imports (Trade)	(2) High-Tech Exports (Trade)	(3) High-Tech Imports (Arms)	(4) High-Tech Exports (Arms)
Sanction	0.242	-0.226	-	-1.375***
	(0.218)	(0.138)		(0.290)
RTA	-0.015	0.063***	-	0.063***
	(0.020)	(0.020)		(0.020)
Constant	21.755***	21.606***	-	21.645***
	(0.012)	(0.015)		(0.014)
R-squared	0.995	0.994		0.994
Observations	188 551	177 417		177 417

Notes: Using the PPML approach, this table report estimates of the impact of trade sanctions on High-Tech imports (1) and exports (2), as well as the impact of arm sanctions on High-Tech imports (3) and exports (4). The independent variables capture sanctions and RTA. All estimates are obtained with importer-time fixed effects, exporter time fixed effects, and country-pair fixed effects. Standard errors are clustered by country pair and are reported in the parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Lastly, the number of observations as well as McFedden's pseudo R^2 is reported.

Column (3) has been dropped from the analysis due to collinearity issues as it was determined that no new import arm sanctions were introduced during the 2016-2019 period, resulting in a lack of variability in the data for this specific category.

In Column (4), the data reveals a significant and substantial negative effect of arms sanctions on trade. Notably, High-Tech exports have experienced a pronounced decline of approximately 60 percent, calculated as ((exp(-1.375) - 1) × 100). This substantial difference in impact between arms sanctions and trade sanctions can be attributed to their specific focuses. Arms sanctions directly target High-Tech products, which explain why they have a more pronounced effect on these industries. By singling out a specific category of High-Tech products, arms sanctions have a more direct and potent impact in explaining the decline in trade of High-Tech goods. In contrast, trade sanctions encompass a broader range of products and may not always sanction High-Tech products specifically.

Lastly, Table 3 provides the estimations for Partial and Complete Trade Sanctions on High-Tech products with the objective of comparing if complete sanctions have a stronger effect. Consistent with the earlier findings, the estimates reveal non-statistically significant results for both RTAs and Sanctions in the context of Partial sanctions for High-Tech imports. Once more, the coefficient associated with sanctions shows a positive value, whereas the coefficient linked to RTAs displays a negative value. This implies that neither of these factors achieves the desired outcomes.

Table 3 : Impact of Partial and Complete Trade Sanctions on High-Tech Products

Dependent Variables	(1) High-Tech Imports (Partial)	(2) High-Tech Exports (Partial)	(3) High-Tech Imports (Complete)	(4) High-Tech Exports (Complete)
Sanction	0.242	0.064	-	-
	(0.220)	(0.129)		
RTA	-0.015	0.064***	-	-
	(0.020)	(0.020)		
Constant	21.755***	21.603***	-	-
	(0.012)	(0.012)		
R-squared	0.995	0.994		
Observations	188 551	177 417		

Notes: Using the PPML approach, this table report estimates of the impact of Partial and Complete Trade Sanctions on High-Tech products. Column (1) and (2) investigate partial sanctions, while column (3) and (4) show that complete sanctions have been dropped due to no new complete sanctions being introduced during 2016-2019. All estimates are obtained with importer-time fixed effects, exporter time fixed effects, and country-pair fixed effects. Standard errors are clustered by country pair and are reported in the parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Lastly, the number of observations as well as McFedden's pseudo R^2 is reported.

Turning our attention to Partial sanctions on High-Tech exports, the estimates indicate a positive effect, but this effect lacks statistical significance. In contrast, the coefficient for RTAs is positive and attains statistical significance at the 1 percent level, suggesting that RTAs have a notable positive influence on High-Tech exports.

Moreover, a PPML regression was employed to examine the effect of complete sanctions on High-Tech trade. However, no new complete sanctions were introduced during the specified time period under study. As a result, the model lacks the necessary variation in complete sanctions to generate meaningful estimates. In essence, there are no changes in the complete sanctions variable, which means there is no empirical basis to estimate any impact on High-Tech trade in this specific scenario. Consequently, the model could not produce valid results or insights due to the absence of relevant data points for estimating the effect of complete sanctions.

5.2 The impact on Semiconductors

Investigating the impact of sanctions on the semiconductor industry is important for several reasons. First, given that a substantial portion of the global economy relies on devices powered by semiconductors, their significance is unquestionable. Sanctions may disrupt the adaptation and development of technology products, affecting long term competitiveness and innovation. Second, China currently represents approximately 60 percent of global semiconductor demand ("China's impact on the semiconductor industry: 2016 update", 2017). Failing to maintain competitiveness in the global market could potentially impact a China's GDP by discouraging Chinese customers as well as customers worldwide from purchasing products originating from Chinese sources. Third, the semiconductor industry operates on a highly interconnected and globalized supply chain. Sanctions targeting the semiconductor industry may disrupt these supply chains, affecting production and availability of critical technologies.

Table 4 showcases the effects of sanctions on Semiconductor products. The analysis begins by conducting a gravity regression encompassing all countries within the dataset, displayed in column (1) and (2). The measurement period captures two notable instances of sanctions: the United States imposing sanctions on China's semiconductor industry in 2018, and Japan implementing export controls on South Korea in 2019. In addition, the analysis takes into account countries that are subject to complete sanctions covering all types of products.

In column (1), the results reveal a lack of statistical significance regarding the impact of sanctions on semiconductor imports. This suggests that sanctions have not proven effective in hindering semiconductor import trade. The coefficient for RTAs, while negative, is also statistically insignificant, indicating that they do not appear to promote semiconductor import trade. However, when examining semiconductor exports, the sanctions display a positive coefficient that is statistically significant at a 10 percent level. This signifies that the sanctions have not led to a reduction in semiconductor exports, but rather a growth of 10 percent, ((exp(0.098) - 1) × 100). Furthermore, RTAs exhibit a statistically significant positive relationship with semiconductor exports, implying that their presence contributes positively to semiconductor export performance.

Table 4 : Impact of Sanctions on Semiconductor Products

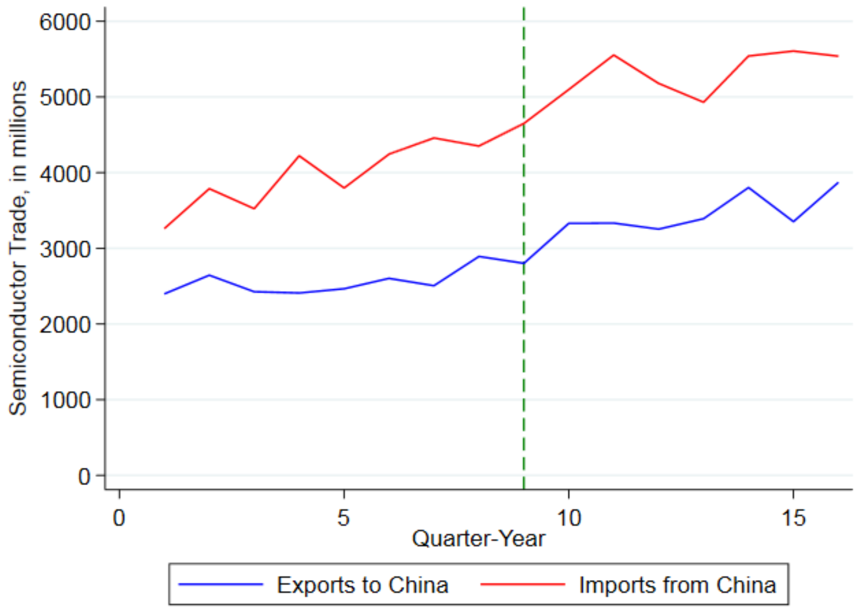
Dependent Variables	(1) Semiconductor Imports All	(2) Semiconductor Exports All	(3) Semiconductor Imports >20 Mil.	(4) Semiconductor Exports >20 Mil.
Sanction	0.055	0.098*	0.053	0.097*
	(0.046)	(0.057)	(0.046)	(0.057)
RTA	-0.034	0.115***	-0.035	0.115***
	(0.027)	(0.028)	(0.027)	(0.028)
Constant	21.268***	21.389***	21.312***	21.462***
	(0.014)	(0.018)	(0.014)	(0.018)
R-squared	0.996	0.996	0.995	0.996
Observations	169 325	158 857	60 607	58 086

Notes: Applying the PPML approach, this table presents estimations concerning the influence of sanctions on Semiconductor imports (1) and exports (2) across all countries in the dataset. Additionally, Column (3) and (4) provide estimations of the effects of sanctions on Semiconductors for countries engaged in trade exceeding 20 million dollars per quarter, separately. All estimates are obtained with importer-time fixed effects, exporter time fixed effects, and country-pair fixed effects. Standard errors are clustered by country pair and are reported in the parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Lastly, the number of observations as well as McFedden's pseudo R^2 is reported.

Due to the concentrated nature of the semiconductor industry, this study chooses to exclude smaller nations and instead centers its attention solely on countries involved in trade surpassing 20 million dollars per quarter. This deliberate decision is aimed at yielding more valuable insights regarding the effects of sanctions on semiconductor trade, as the analysis directs its focus toward countries that have substantial influence within the industry. These findings are displayed in column (3) and (4). Once again, the results indicate that there is no statistical significance in terms of the impact of sanctions and RTAs on semiconductor imports. Specifically, the coefficients for sanctions remain positive, while those for RTAs are negative. In column (3), when observing semiconductor exports, the sanctions maintain a positive coefficient that is now statistically significant at a 5 percent threshold. The RTAs continue to have a statistically significant positive coefficient at a 1 percent level.

To enhance our understanding, Figure 1 presents a visual representation of semiconductor exports from the US to China spanning the years 2016 to 2019. This graphical illustration offers a concrete portrayal of the trade dynamics between these key players within the semiconductor industry, providing a clearer grasp of their trade relationship.

Figure 1: Semiconductors trade between US and China, 2016-2019

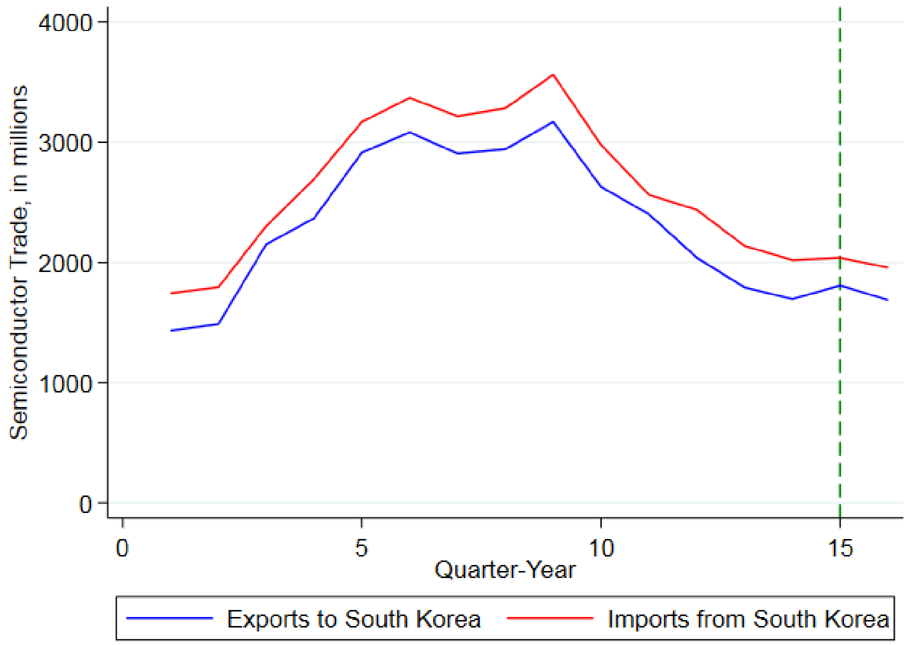


Notes: This figure illustrates the evolution of semiconductor exports from the United States to China and imports from China, spanning the period 2016 - 2019. Author's own processing based on data from COMTRADE.

During 2016 to mid-2017 there was a constant flow of exports. The 8th quarter marks a minor export decline following the announcement of sanctions. However, ever since the sanctions were implemented in the 9th quarter, represented by the dotted vertical line, there has been a stable increase in exports of semiconductors from US to China. For the imports, US experienced two smaller fluctuations during the first year. Thereafter, imports from China were steadily increasing, researching a peak in the 12th quarter when it began to experience a slight decline. The decline did not last long and trade from china went back up again holding a constant pace for the end of the period.

Figure 2 presents the trade between Japan and South Korea during 2016 – 2019. Japan imposed export controls on South Koreas semiconductor industry in July 2019 leading us to not clearly see the effect the sanctions has on semiconductor products.

Figure 2: Semiconductors trade between Japan and South Korea, 2016-2019



Notes: This figure illustrates the evolution of semiconductor exports from the Japan to South Korea and imports from South Korea, spanning the period 2016 - 2019. Author's own processing based on data from COMTRADE.

In the beginning of 2016 until 9th quarter when US imposed sanctions on China, there had been a steady increase of both Japanese exports to South Korea as well as a very similar steady pattern of imports from South Korea to Japan. From the 9th quarter both the imports and exports of semiconductor products began to decrease. The last quarter has a slight decline in both exports and imports of semiconductor products which may give a hint that the sanctions are working, however further analysis must be done to draw that conclusion.

6 Discussion and Conclusion

This paper has relied on the gravity model of trade to analyze the impact of sanctions on High-Tech products and the Semiconductor industry. The analysis was carried out using the Poisson Pseudo Maximum Likelihood estimator during the period 2016-2019. While the study offers valuable insights, it is important to acknowledge its limitations. First, the study aims at capturing short terms effects of US sanctions on China. In some cases this causes no new import sanctions being introduced during the time period measured. This results in the model lacking necessary variation in order to be able generating meaningful and statistically significant estimates. In order to provide a more comprehensive understanding on the effect of sanctions on High-Tech trade one could conduct further research analyzing a longer time period. Second, due to the relatively limited timeframe under examination, this study does not incorporate interval data. Yotov et al. (2016) propose that there might be a temporal delay before sanctions take full effect. However, as discussed in the literature review, empirical evidence suggests that sanctions tend to yield their maximum impact within a span of approximately two years after their implementation making it worthy to investigate. Third, due to lack in data this study does not include domestic trade flows as recommended by Yotov et al. (2016). Excluding domestic trade flows may result in RTAs estimates being biased downwards as much of the additional trade between RTA members are due to domestic trade diversion. In conclusion, it is important to note that the analysis conducted in this study is based on general trade sanctions, which are not specifically targeted at individual industries. This limitation arises from the absence of comprehensive industry-specific data. As a result, the study's findings and conclusions pertain to the broader context of trade sanctions and their impact, rather than delving into the intricate dynamics of particular industries that might be affected differently by sanctions. While this limitation provides valuable insights into the overall effects of trade sanctions, it also emphasizes the need for further research that considers the nuances and variations that may arise within specific industries.

Despite these acknowledged limitations, the analysis has yielded noteworthy results that contribute to our understanding of the impact of sanctions on High-Tech products and the Semiconductor industry. For High-Tech imports the estimates for both sanctions and RTAs are non-statistically significant for all the tables presented. This may be due to the fact that there have not been enough observations on import sanctions as well as regional trade agreements during this period to confidently claim that the changed observed is due to treatment or a random chance.

When shifting the focus to Sanctions on High-Tech exports the analysis uncovers a negative result, however again, being statistically non-significant. On the contrary, the RTAs were positive and statistically significant at 1 percent for all tables estimating High-Tech exports indicating that RTAs have promoted trade in the High-Tech industry.

Arms sanctions had the strongest effect on High-Tech products exported revealing a significant and substantial negative effect resulting in a 60 percent decrease during the period measured.

When analyzing the effect of sanctions on Semiconductor products, the study unveiled a significant finding: despite the sanctions imposed, there was a positive increase in exports at a 10 percent significance level, indicating that these measures did not achieve their intended objective. The exports of semiconductors exhibited an approximate 10 percent increase despite the presence of sanctions. Similarly, the results underscore the beneficial role of RTAs in fostering export growth. Moreover, the analysis delves into the specific context of the US and China. The findings reveal that both US exports and imports have shown growth within this timeframe, even considering the efforts by the Trump administration to limit trade in the semiconductor industry.

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Appendix

Table 5: Sanction cases 2016-2019

(1) Case ID	(2) Start Year	(3) End Year	(4) Target Country	(5) Sender Country	(6) Trade	(7) Arms
16	1950	2022	Israel	LAS	1	0
26	1951	2022	Korea, North	UN	0	1
50	1958	2022	Cuba	United States	0	1
72	1962	2022	Cuba	United States	1	0
328	1987	2020	Cyprus	United States	0	1
352	1989	2022	Armenia	Azerbaijan	1	0
363	1989	2022	China	United States	0	1
411	1991	2018	Myanmar	Australia	0	1
431	1992	2022	China	EU	0	1
463	1992	2022	Somalia	UN	0	1
464	1992	2017	Sudan	United States	0	1
512	1994	2022	Haiti	United States	0	1
522	1995	2022	Armenia	OSCE	0	1
524	1995	2022	Azerbaijan	OSCE	0	1
559	1996	2022	Iran	United States	1	0
560	1996	2022	Libya	United States	1	0
593	1997	2017	Sudan	United States	1	0
598	1998	2022	ECOWAS	ECOWAS	0	1
600	1998	2017	France	United States	1	0
676	2002	2022	Afghanistan	EU +	0	1
677	2002	2022	Afghanistan	UN	0	1
689	2002	2022	Zimbabwe	Australia	0	1
691	2002	2022	Zimbabwe	EU +	1	1
692	2002	2022	Zimbabwe	Switzerland	1	1
694	2002	2022	Zimbabwe	United Kingdom	1	0
705	2003	2022	Congo	UN	0	1
733	2004	2022	Iraq	EU	0	1
738	2004	2022	Sudan	UN	0	1
739	2004	2022	Syria	United States	1	0
741	2005	2022	Congo	EU	0	1
743	2005	2017	Cote d'Ivoire	Canada	0	1
753	2005	2022	Sudan	EU +	0	1
764	2006	2022	Belarus	United States	1	0
765	2006	2022	Congo	United States	1	0
775	2006	2022	Korea, North	Australia	1	1
776	2006	2022	Korea, North	EU	1	1
777	2006	2022	Korea, North	Japan	1	0
779	2006	2022	Korea, North	UN	1	1
780	2006	2022	Lebanon	EU	0	1
782	2006	2022	Lebanon	UN	0	1
788	2006	2022	Sudan	United States	1	0
789	2006	2017	Sudan	United States	1	0
794	2006	2022	Venezuela	United States	0	1
795	2007	2022	Afghanistan	New Zealand	0	1
807	2007	2017	Sudan	United States	1	0
812	2008	2022	Korea, North	United States	1	0
817	2008	2022	Somalia	UN	0	1
819	2008	2022	Zimbabwe	Canada	0	1
821	2009	2018	Eritrea	Russia	1	0
822	2009	2018	Eritrea	UN	0	1
836	2009	2022	Korea, North	Japan	1	0
845	2009	2022	Somalia	EU +	0	1
846	2009	2022	Somalia	Switzerland	1	1
850	2010	2021	Colombia	United States	1	0
853	2010	2018	Eritrea	EU	0	1
858	2010	2022	Iraq	UN	0	1
859	2010	2022	Korea, North	Korea, South	1	0

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(1) Case ID	(2) Start Year	(3) End Year	(4) Target Country	(5) Sender Country	(6) Trade	(7) Arms
867	2010	2018	Norway	China	1	0
868	2010	2022	Somalia	United States	1	0
872	2011	2022	Afghanistan	EU +	0	1
873	2011	2022	Afghanistan	United States	0	1
875	2011	2022	Belize	United States	1	0
876	2011	2022	Bolivia	United States	1	0
879	2011	2022	Costa Rica	United States	1	0
881	2011	2022	Dominican Rep.	United States	1	0
885	2011	2018	Eritrea	UN	1	0
889	2011	2022	Indonesia	United States	1	0
893	2011	2022	Jamaica	United States	1	0
894	2011	2022	Korea, North	Canada	1	0
895	2011	2022	Korea, North	United States	1	0
896	2011	2022	Libya	Australia	0	1
897	2011	2022	Libya	Canada	1	1
899	2011	2022	Libya	EU +	1	0
902	2011	2022	Libya	Switzerland	1	0
903	2011	2022	Libya	UN	0	1
906	2011	2022	Panama	United States	1	0
907	2011	2022	South Sudan	EU +	0	1
908	2011	2022	Syria	Australia	1	1
909	2011	2022	Syria	Canada	1	0
911	2011	2022	Syria	LAS	1	1
913	2011	2022	Syria	United States	1	0
919	2012	2022	Belize	United States	1	0
938	2012	2022	Myanmar	Australia	0	1
939	2012	2022	Myanmar	Canada	0	1
940	2012	2022	Myanmar	Switzerland	0	1
949	2012	2022	Somalia	EU +	1	0
950	2012	2022	Somalia	UN	1	0
951	2012	2022	Somalia	United States	1	0
952	2012	2022	Syria	Canada	1	0
954	2012	2022	Syria	Switzerland	1	1
957	2013	2022	Belize	United States	1	0
960	2013	2022	CAR.	UN	0	1
963	2013	2022	Egypt	EU+	1	1
965	2013	2018	Eritrea	Russia	0	1
966	2013	2022	Greece	United States	1	0
972	2013	2021	Moldova	Russia	1	0
973	2013	2022	Myanmar	EU +	1	1
974	2013	2022	Nigeria	United States	1	0
976	2013	2022	Somalia	Switzerland	1	0
977	2013	2022	Syria	Canada	1	0
978	2013	2022	Syria	EU +	1	1
979	2013	2021	Taiwan	United States	1	0
980	2014	2022	Armenia	United Kingdom	1	0
981	2014	2022	Australia	Russia	1	0
982	2014	2022	Azerbaijan	United Kingdom	1	0
984	2014	2022	Canada	Russia	1	0
985	2014	2022	CAR.	EU	0	1
988	2014	2018	Colombia	United States	1	0
989	2014	2022	EU	Russia	1	0
993	2014	2022	Israel	Spain, UK	1	1
996	2014	2022	Nigeria	UN	0	1
997	2014	2022	Norway	Russia	1	
998	2014	2022	Russia	Australia	1	1
999	2014	2022	Russia	Canada	1	0
1000	2014	2022	Russia	EU	1	1
1001	2014	2022	Russia	EU +	1	0
1002	2014	2022	Russia	Japan	1	0
1004	2014	2022	Russia	Switzerland	1	1
1005	2014	2022	Russia	United States	1	0

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(1) Case ID	(2) Start Year	(3) End Year	(4) Target Country	(5) Sender Country	(6) Trade	(7) Arms
1015	2014	2022	Ukraine	Canada	0	1
1018	2014	2022	Ukraine	EU +	1	0
1019	2014	2022	Ukraine	Japan	1	0
1022	2014	2022	Ukraine	Switzerland	1	1
1023	2014	2022	Ukraine	United States	1	1
1024	2014	2022	United States	Russia	1	0
1026	2015	2017	Afghanistan	UN	0	1
1027	2015	2022	ALB, MNE, ISL	Russia	1	0
1033	2015	2022	Korea, North	United States	1	0
1036	2015	2018	Ukraine	South Vietnam	1	0
1037	2015	2022	Venezuela	United States	1	0
1038	2015	2022	Yemen, North	EU	0	1
1039	2015	2022	Yemen, North	UN	0	1
1043	2016	2017	Egypt	Saudi Arabia	1	0
1045	2016	2022	Iran	Canada	1	0
1047	2016	2022	Korea, North	United States	1	0
1048	2016	2017	Liberia	Canada	0	1
1055	2017	2022	China	United States	1	0
1063	2017	2022	Korea, North	Burkina Faso	1	0
1064	2017	2022	Korea, North	United States	1	0
1072	2017	2022	Russia	United States	1	0
1078	2017	2022	Venezuela	EU+	1	1
1086	2018	2018	China	United States	1	0
1087	2018	2022	China	United States	1	1
1089	2018	2022	Dominican Rep.	United States	1	0
1090	2018	2022	Ghana	United States	1	0
1093	2018	2022	Iran	Korea, South	1	0
1094	2018	2022	Iran	United States	1	0
1096	2018	2022	Lebanon	United States	1	0
1099	2018	2022	Nicaragua	United States	1	0
1102	2018	2022	Saudi Arabia	USA, FRA, DEU, CAN	1	0
1103	2018	2022	Sierra Leone	United States	1	0
1104	2018	2022	South Sudan	United States	0	1
1107	2018	2018	Turkey	United States	1	0
1108	2018	2022	Venezuela	Switzerland	1	1

Notes: The table lists all sanctions for the period of 2016-2019, which are used in the analysis. The first column (1), Case ID, contains an identification number that uniquely differentiate individual sanction cases. The second (2) column indicate the specific year in which a sanction was initiated, while the third (3) displays the year in which a sanction came to an end. There are sanctions that extend past 2022, however the data collection concluded at that point in time. Column five (5) presents the country or region responsible for imposing the sanctions and column (4) is the targeted countries. Some of the sanctioning periods will be denoted with EU+. This indicates that there were other European countries that joined EU in imposing sanctions. Lastly, column (6) and (7) capture whether the countries imposed trade sanctions, armed sanctions or both. Note that some countries imposed both but on different periods. This data is obtained from the GSDB.