Trade Sanctions*

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Abstract

How effective are trade sanctions? We study the unprecedented sanctions imposed on Russia following February 2022, when Western countries banned exports accounting for 36% of Russia's prewar import value. Combining novel, hand-collected records of these sanctions with Russian customs data, firm balance sheets, domestic railway shipments, and government procurement contracts, we provide the most comprehensive analysis to date of the economic impact of trade sanctions on a target country. Using a difference-in-differences approach, we find that imports of sanctioned country-product varieties into Russia saw a sharp 55% decline after the war's onset. Although we document substantial rerouting through third countries, it has not fully offset the direct import losses: total imports of sanctioned products fell by 27% through 2023. Russian firms that had relied on soon-to-be-sanctioned imports experienced a 14% decline in output during the same period, not offset by competing firms or entrants. Similar declines are present for manufacturing and technology firms, and firms along the military supply chain. Affected firms have also experienced reduced government procurement sales and incurred additional losses when their buyers or suppliers were exposed to sanctions. Overall, our findings suggest that, contrary to widespread claims of ineffectiveness, export sanctions on Russia have had far-reaching adverse effects.

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1 Introduction

After decades of intensifying globalization, the world is witnessing a resurgent trend toward fragmentation of trade linkages (Gopinath, Gourinchas, Presbitero, and Topalova, 2025). A key manifestation of this shift is the growing use of *trade sanctions*—restrictions on cross-border trade imposed for geopolitical purposes (Morgan, Syropoulos, and Yotov, 2023).

Governments typically impose trade sanctions for two main reasons. One is *economic coercion*: to punish a target country and induce it (or others) to change political behavior. Yet, political concessions are often slow to materialize, making it difficult to assess the effectiveness of sanctions on these grounds. A second, more direct objective is *economic warfare*: to disrupt the target country's productive capacity—particularly by restricting access to high-tech inputs—and thereby erode its industrial base, as well as its technological and military capabilities.[1] Case in point: the EU officially justified the sanctions it imposed on Russia after February 2022 with *"the aim of weakening Russia's economic base, depriving it of critical technologies and markets, and significantly curtailing its ability to wage war"* (European Commission, 2022).

How effective are trade sanctions at achieving this second objective? In particular, do sanctions on exports to the target country—hereafter, *export sanctions*—disrupt its production and supply chains? On one hand, economic theory predicts that if firms cannot easily replace foreign inputs, export sanctions should impede output. This logic is especially compelling for high-tech or specialized goods that are difficult to substitute. On the other hand, a growing body of journalistic, anecdotal, and scholarly accounts questions this view, arguing that export sanctions often fail to bite due to rapid sourcing adjustments and widespread circumvention, raising doubts about whether these restrictions generate any meaningful effects on the target country's imports and downstream production capacity (e.g., Early, 2015).

Despite significant scholarly interest, granular causal estimates of how export sanctions affect a target country's imports, firms, supply chains, and the extent to which these effects are mitigated by circumvention, remain scarce. Such analysis requires not only detailed customs records but

[1] These two objectives are not mutually exclusive: targeted disruptions can simultaneously degrade technological and military capacity and raise the economic cost of noncompliance, thereby reinforcing the coercive function. See Mastanduno (2025) on the recent shift from economic coercion to economic warfare in debates on sanctions' effectiveness, and Lindsay (1986) for a broader typology of sanctions' purposes, including symbolic signaling.

also firm-level accounting data that would allow researchers to link firms' import behavior to their economic performance—data rarely available for countries historically subject to sanctions, such as Cuba or Iran. Moreover, strong causal identification also requires substantial variation in both the timing and coverage of export sanctions. This condition is also seldom met in practice: such sanctions are typically imposed all at once, often alongside other restrictive measures, and tend to target only a narrow set of product codes or be issued by a small group of countries.

We overcome these challenges by studying the effectiveness of export sanctions in the context of Russia following its 2022 invasion of Ukraine. This context is uniquely suitable for our research question, for several reasons. First, it represents one of the most extensive sanctions campaigns in history, imposed against one of the world's biggest economies.[2] It thus tests the limits of sanctions' effectiveness, particularly given Russia's proximity to large trading partners, many of which remained neutral or friendly after the war began and were well positioned to facilitate trade diversion.[3] Second, the export sanctions were imposed by multiple countries at different times and on different product categories, down to the ten-digit level, generating rich variation for identification. Third, Russia offers an unusually data-rich environment, with information available on customs transactions, firm-level financials, domestic railway shipments, and government procurement contracts. We combine these sources with a novel, manually assembled dataset on export sanctions against Russia, covering 35 sanctioning countries and relating to around 6,000 ten-digit product codes observed in Russian customs data. Together, these data allow us to study the economic pass-through of export sanctions with a previously unattainable level of detail.

We begin by documenting several stylized facts. First, export sanctions banned 36% of all country-product varieties that Russia imported before the war by value, constituting one of the largest trade shocks in recent memory.[4] Second, while a large share of sanctioned imports were concentrated in a few high-tech product codes and a few sanctioning countries, a nontrivial portion

[2] As of 2021, Russia ranked as the fourth-largest economy globally in terms of PPP-based GDP and tenth-largest in terms of nominal GDP, according to World Bank (2023).

[3] There are active policy and academic debates about the extent to which trade sanctions on Russia were undermined by rerouting and substitution via third countries. See, e.g., Conway (2023) and Mackinnon (2024), as well as work by Babina et al. (2023), Chupilkin, Javorcik, and Plekhanov (2023), and Tyazhelnikov and Romalis (2024).

[4] For comparison, during the 2018–2021 U.S.–China trade war, the U.S. increased tariffs up to 25.8% on 18% of its imports (Fajgelbaum and Khandelwal, 2022).

of imports within these categories remained unsanctioned. Third, despite coordination within the Western coalition, the specific lists of banned products varied substantially across sanctioning countries. Collectively, these facts underscore the unusual richness of the setting and motivate our empirical analysis.

Our analysis proceeds in two main steps. We begin by assessing whether export sanctions have effectively restricted imports to the target country, Russia. We then examine whether these sanctions have had disruptive effects on production and supply chains within the Russian economy.

In the first stage of our analysis, we explore whether export sanctions effectively reduced imports of the sanctioned country-product varieties. To this end, we pursue two complementary empirical strategies. The first is a simple pre-post difference-in-differences (DiD) approach that compares sanctioned and nonsanctioned country-product import flows before and after the war's onset. The second is a staggered DiD strategy that compares newly sanctioned imports with those not (or not yet) subject to sanctions. While the former approach is simple, transparent, and well-suited to our context—given that most sanctions were imposed in the early stages of the war—the latter allows us to focus on the months just before and after the imposition of sanctions on a specific country-product variety, helping us to further disentangle the effects of trade sanctions from possible heterogeneous effects of broader wartime disruptions.[5]

Both specifications include a rich set of fixed effects to address a number of competing explanations. Granular ten-digit product-by-time fixed effects account for product-specific shocks, such as surges in demand for military-related or dual-use goods. Country-time fixed effects control for country-specific shocks, such as whether a country simultaneously imposes other types of restrictions on doing business with Russia.

To account for the possibly large spillovers arising from compensatory increases in sanctioned-product imports from third countries, we exclude from the baseline sample imports of sanctioned products from countries that remained relatively friendly to the Russian regime, such as China and Turkey. These flows are incorporated in the second step of our analysis and in robustness checks.

[5]Recent research highlights potential biases in staggered DiD designs when treatment effects vary substantially across units and over time (see Arkhangelsky and Imbens, 2024 for a review). Following the guidance of Rios-Avila, Nagengast, and Yotov (2024), we address these concerns by employing the ETWFE estimator from Wooldridge (2021), which is particularly well-suited for estimating large-scale gravity models.

Using these strategies, we find a massive reduction in the sanctioned country-product imports. The pre-post DiD strategy suggests that imports of sanctioned country-product varieties fell dramatically after the war's onset, decreasing by 55% relative to nonsanctioned flows. Dynamic estimates reveal that the decline was sharp and grew over time, reaching nearly 72% by the end of our study period in December 2023. Estimates from the staggered DiD design are similar: sanctions triggered an immediate drop in imports upon imposition, with effects intensifying over time and converging to comparable magnitudes. Importantly, we observe no pretrends for either strategy, lending support to the parallel-trends assumption underlying our identification argument.

Such large negative estimates are perhaps not surprising: a full and immediate ban placed on a given country-product variety would, in principle, be expected to halt its importation entirely. That the estimated decline is somewhat smaller likely reflects a combination of factors, including imperfect enforcement, the presence of exemptions, or potential measurement limitations. Nevertheless, the sharp reduction in sanctioned imports—observed without pretrends despite a multitude of concurrent shocks—constitutes a strong first stage and supports the validity of our empirical strategy.

Second, we indeed document a large and persistent increase in imports of sanctioned products from countries that remained relatively friendly to the Russian regime, such as China and Turkey. Our pre-post DiD results indicate that such imports have risen sharply, by nearly 150%, since the war's onset. These effects again exhibit no pretrends, intensify over time, and are confirmed in the staggered DiD specification. These patterns suggest that Russia partially offset export sanctions either through *rerouting*, continuing to source sanctioned varieties via third-country intermediaries, or through *substitution*, shifting toward analogs produced domestically in friendly economies.

Next, we disentangle these two channels and find that the post-invasion increase in sanctioned imports from friendly countries was driven *almost entirely by rerouting*. Specifically, we exploit a unique feature of Russian customs data, which record both the country of shipment and the country of origin for each transaction. Using this information, we find that the surge in imports of sanctioned products from friendly countries was almost entirely accounted for by rerouted shipments. Moreover, roughly two-thirds of this increase reflects *rerouting specifically from sanctioning countries*—that is, sanctioned goods originally produced in sanctioning countries but re-exported through intermediaries, likely in violation of export controls. In contrast, genuine substi-

tution toward goods actually manufactured in friendly countries has been much more muted.

Third, we show that such rerouting (and, to the extent it occurred, substitution) did not fully offset the decline in sanctioned imports. Estimating our DiD specifications at the product level, we find that total imports of sanctioned products declined substantially relative to nonsanctioned products across all source countries. For instance, in a pre-post DiD specification with three-digit-product-by-time fixed effects—accounting for time-varying shocks, such as surges in demand, within broad product categories—the decline in overall imports of sanctioned products is estimated at 27%. The effect again comes with no pretrends, persists over time, and is similar in magnitude under the staggered DiD design. Replicating this analysis using mirror-export data from UN Comtrade, available only at the HS6 level, yields an even larger estimate, helping address concerns about spillovers within HS6 codes (e.g., due to relabeling) and potential omissions in Russian customs data. Together, these results suggest that rerouting only partially mitigated the impact of sanctions, on average, offsetting the decline in sanctioned imports only by about half.[6]

So far, we have established that export sanctions were moderately successful in reducing the imports of sanctioned products into Russia despite substantial rerouting through third countries. Yet, these restrictions may still have been ineffective in disrupting production within the target economy due to domestic substitution, compensatory government support (e.g., via procurement contracts, as in Nigmatulina, 2021), or even black-market transactions. To assess this possibility, we now fold in the comprehensive data on the balance sheets of more than 2 million Russian firms and explore the impact of export sanctions on firms and supply chains in the target economy.

First, we investigate whether export sanctions had a negative impact on the performance of Russian firms that were exposed to these restrictions. To this end, we estimate a DiD specification comparing firms that imported the sanctioned country-product varieties prior to the war with those that did not, before and after the war's onset. Our specifications include firm fixed effects to account for time-invariant firm attributes, as well as a range of firm-level characteristics interacted with year fixed effects. In particular, we include industry-year fixed effects to control for time-varying shocks that may have differentially affected industries—such as labor supply disruptions

[6]Firm-product-level estimates controlling for firm-by-year fixed effects confirm a significant average decline in imports of sanctioned products, reinforcing our main findings and providing the bridge to our firm-level analysis.

due to mobilization, which could have had a greater impact on more labor-intensive sectors. We also control for year fixed effects interacted with an indicator for whether a firm was explicitly hit by targeted sanctions, to ensure that any observed effects are not due to direct restrictions on certain firms but rather due to their exposure to export sanctions through their prewar imports.

We find that firms that imported sanctioned country-product varieties prewar experienced a sharp 14% decline in revenues following the war's onset. This negative effect persisted with a similar magnitude throughout both 2022 and 2023, indicating that any adaptation strategies that firms may have employed did not result in a successful recovery, nor was the effect substantially delayed due to firms' preexisting inventories. Besides providing strong evidence for the disruptive effects of export sanctions on firm production, these findings further support our results of an overall decline in sanctioned product imports, alleviating concerns that Russian customs data might be missing significant volumes of unregistered transactions.

Consistent with the revenue decline reflecting an actual contraction in output, we find negative effects of similar magnitudes on other firm-level outcomes, including total cost of goods sold, gross profits, and value added, as well as disaggregated measures of capital, material, and labor expenditures. We also see a 1.3-percentage-point higher probability that firm sales become missing in the data, which can be interpreted as increased firm exit.

The negative impact on firm output is present even when focusing exclusively on firms in manufacturing or science and technology sectors. In fact, the impact on firms in the science and technology sector is significantly larger than on any other broad industry group, reaching approximately 20%. The decline is also present among firms that have ever engaged in military-related procurement. These findings are consistent with the *economic warfare* objective of export sanctions—namely, to undermine high-tech and military-adjacent industrial capabilities—and with the fact that high-tech and manufacturing inputs were among the most heavily sanctioned categories.

We also do not observe any relative increase in firms' government procurement sales, which might have indicated compensatory efforts by the government to support firms adversely affected by export sanctions. On the contrary, we find that exposed firms became 2.4 percentage points less likely to win a government procurement contract in a given year and experienced a 31% decline in the total annual value of contracts secured following the war's onset.

Further, we show that the negative effects of export sanctions were not offset by gains among similar non-exposed and competing firms. The estimated declines for exposed firms persist even after excluding their direct competitors from the control group. Moreover, the effects remain negative and statistically significant when aggregated to the five-digit industry level.

Finally, we leverage firm-to-firm railway shipment data to examine the broader impact of export sanctions on domestic supply chains. We find that firms directly exposed to export sanctions experienced a decline in their in-shipments, further indicating output shrinkage and lack of compensating domestic substitution. Moreover, firms with suppliers or buyers exposed to export sanctions also experienced a decline in their own sales, even controlling for their direct exposure. The effects of export sanctions thus propagate through supply chains, amplifying their overall impact.

Taken together, our results suggest that, while rerouting and substitution have mitigated the impact of export sanctions, these restrictions nevertheless imposed meaningful frictions on production and supply chains within the targeted economy, particularly in more technologically advanced sectors—highlighting the potential of trade sanctions to operate as instruments of economic warfare that constrain industrial, technological, and even military capabilities.

Related Literature. We add to the economics literature on geopolitical threats and international trade—or *geoeconomics* (Clayton, Maggiori, and Schreger, 2025b; Mohr and Trebesch, 2025).

Theoretically, researchers have explored the rationale behind imposing sanctions on other nations. Most existing frameworks consider trade policy and the threat of trade sanctions as instruments of *economic coercion* (Eaton and Engers, 1992; Clayton, Maggiori, and Schreger, 2024, 2025a; Becko, 2024; Becko and O'Connor, 2024; Bianchi and Sosa-Padilla, 2024; Broner, Martin, Meyer, and Trebesch, 2024; Liu and Yang, 2024; Mayer, Mejean, and Thoenig, 2024). Our paper contributes to this ongoing discussion by demonstrating empirically that trade sanctions fulfill a complementary purpose of *economic warfare*: they can disrupt production and supply chains within the target economy and, ultimately, serve to weaken its technological and military capabilities—core foundations of geopolitical power. This channel has been explored only theoretically in Kooi (2024) and is an underlying premise in Alekseev and Lin (2024). More broadly, we provide an empirical assessment of the credibility and limits of geoeconomic influence, both

in terms of coercion and economic warfare aims: how effective is the threat of the United States and its allies in constraining a targeted country's industrial base, and to what extent is that leverage diluted by rerouting through and substitution to third countries? The empirical moments we document—such as the degree of rerouting and substitution responses, and the pass-through of export sanctions to firm-level outcomes—can inform calibration exercises and future theoretical work on the mechanisms and scope of geoeconomic influence.

In terms of the empirical literature, we contribute to the studies of sanctions in three main ways.

First, our paper offers the most detailed empirical assessment of the economic impact of export sanctions and controls on a target country—an area highlighted by Mohr and Trebesch (2025) as heavily understudied.[7] The level of detail is critical for understanding the causal impact of export sanctions on the targeted economy. Measuring effects with trade data alone would not account for domestic substitution responses. Likewise, domestic firm data alone cannot identify which businesses were affected by the inability to import certain country-product varieties, and thus may not identify an impact on firms stemming specifically from export sanctions. Only combining transaction-level customs data with firm-level information allows to trace the full causal chain from export sanctions to the target country's import flows and, ultimately, to firm output and supply chains. Incorporating micro-level data on firms in strategic sectors such as technology and defense further allows us to evaluate the *economic warfare* rationale underlying export sanctions.

Second, we distinguish and quantify two central mechanisms of sanctions evasion, rerouting

[7]Most existing studies analyze either targeted sanctions, which limit all transactions for select firms (Ahn and Ludema, 2020; Nigmatulina, 2021; Draca, Garred, Stickland, and Warrinnier, 2023), financial sanctions (Efing, Goldbach, and Nitsch, 2023; Huang, Jiao, and Wei, 2025), or import sanctions that restrict imports from, rather than exports to a particular country (Haidar, 2017; De Souza, Hu, Li, and Mei, 2024), including oil embargoes and price caps (Hilgenstock, Ribakova, Shapoval, Babina, Itskhoki, and Mironov, 2023; Johnson, Rachel, and Wolfram, 2023a,b; Kilian, Rapson, and Schipper, 2024; Spiro, Wachtmeister, and Gars, 2024; Bai, Fernández-Villaverde, Li, Xu, and Zanetti, 2025). Other studies focus on private sanctions and the exit of multinational enterprises (Hart, Thesmar, and Zingales, 2024; Wellhausen and Zhu, 2024; Chupilkin, Javorcik, Peeva, and Plekhanov, 2025), the consequences for sanctioning countries (Hinz and Monastyrenko, 2022; Crosignani, Han, Macchiavelli, and Silva, 2024; Görg, Jacobs, and Meuchelböck, 2024; Gao, Shroff, and Zhang, 2025) and countries-intermediaries (Corsetti, Demir, and Javorcik, 2024; Li, Li, Park, Wang, and Wu, 2024), the implications of trade sanctions for the exchange rate (Itskhoki and Mukhin, 2025) and the use of the U.S. dollar in trade invoicing (Berthou, 2022; Chupilkin, Javorcik, Peeva, and Plekhanov, 2023). See Morgan, Syropoulos, and Yotov (2023) and Itskhoki and Ribakova (2024) for reviews. Closest to our focus, Kim, Kim, Park, and Sun (2023) study the effect of export sanctions on nighttime luminosity in North Korea, while Liu, Liu, Makarin, and Wen (2025) show that export controls spurred innovation among affected Chinese firms and their suppliers.

and substitution, that have been widely discussed but rarely measured separately. Existing studies typically infer rerouting only indirectly, relying on potentially restrictive assumptions such as the absence of domestic production of certain products in intermediary countries (Chupilkin et al., 2023; Iyoha, Malesky, Wen, Wu, and Feng, 2024; Fisman, Marcolongo, and Wu, 2025; Sagyndykova et al., 2025; Scheckenhofer, Teti, and Wanner, 2025).[8] We leverage a unique feature of Russian customs data, which record both the country of shipment and the country of origin, to identify rerouting *directly*. Our results reveal that *rerouting specifically from sanctioning countries* accounted for most of the observed adjustment, highlighting that effective trade sanctions depend critically on the credible enforcement of secondary sanctions on intermediaries.

Third, by leveraging highly granular variation in export sanctions against Russia—at the ten-digit product-by-country-by-month level—we are able to provide particularly rigorous estimates of the causal impact of trade sanctions. Granularity and time variation of sanctions data is crucial, because it allows us to separate the inclusion of a 10-digit HS product to the sanction list from concurrent macroeconomic shocks, policy changes, and other country- or product-specific demand and supply factors, many of which occurred in the very first month of the 2022 conflict. Our analysis thus complements existing work that often focuses on a single sanctioning country, narrower product sets, or a single implementation date (e.g., Liu, Liu, Makarin, and Wen, 2025).[9]

The rest of this paper is organized as follows. Section 2 provides the background on the Russian invasion of Ukraine in February 2022, and the sanctions that followed. Section 3 describes the data. Section 4 presents the stylized facts. Section 5 analyzes the sanctions' impact on import flows. Section 6 examines the sanctions' impact on exposed firms and on broader supply chains. Section 7 explores the impact on military-related imports and production. Section 8 concludes.

[8] A notable exception is contemporaneous work by Chupilkin et al. (2025), who focus on the rerouting of privately sanctioned Western trademarks. We complement their analysis by offering a comprehensive assessment of the circumvention of state-imposed export sanctions—a key instrument in governments' geoeconomic toolkit.

[9] We also add to the literature on wars and trade. This literature has documented the negative impact of conflicts on international trade as well as the peace-inducing effects of trade integration (Martin, Mayer, and Thoenig, 2008a,b; Thoenig, 2023; see also Kleinman, Liu, and Redding, 2024). Closely related to our context, Korovkin and Makarin (2023) and Korovkin, Makarin, and Miyauchi (2025) examine, respectively, the negative impact of the 2014 Russia-Ukraine conflict on their bilateral trade and the disruption and reorganization of production networks within Ukraine. For broadly related studies on Russia and its invasion of Ukraine, see Guriev and Treisman (2019); Frye, Gehlbach, Marquardt, and Reuter (2023); Egorov and Sonin (2023).

2 Background

Following the Russian invasion of Ukraine in February 2022, Western countries imposed an unprecedented level of sanction measures against Russia—more than 19,000, making Russia one of the most sanctioned countries in world history (Trefanenko, 2025). In fact, as of this writing, this figure exceeds the total number of sanctions imposed on Iran, Venezuela, Myanmar, and Cuba combined (Forbes, 2025).

These international sanctions against Russia were not the first. Sanctions were also imposed several years earlier, after Russia's annexation of Crimea in 2014 and the start of the Donbas War. However, they were much more limited in scope and primarily targeted politically connected and state-owned firms. On the contrary, the post-2022 sanctions were much more comprehensive.

The post-2022 sanctions included measures that targeted Russia's financial system, such as the freezing of more than $300 billion of the Russian Central Bank's reserves and the exclusion of key Russian banks from the SWIFT international payment system. Sanctions have also been levied against individuals, freezing assets and imposing travel bans on Russian elites and government officials. Western companies have been barred from providing Russia with services in the IT, consulting, and legal fields, with many large multinational companies exiting Russia voluntarily. Russian airlines and shipping companies have faced transportation bans, further isolating the country from global supply chains.

While the above sanctions are important and deserve to be studied separately, this paper will focus on post-2022 *trade* sanctions, which were of two types: against Russian exports and against Russian imports. Sanctions targeting Russian imports (our *export sanctions*) began almost immediately after the invasion, while sanctions against Russian exports came later, toward the end of 2022. The latter included a ban on exporting maritime oil from Russia to G7 countries and the EU, along with a price cap on exports to all other countries (Johnson et al., 2023b). Eventually, similar restrictions were applied to other raw materials. In this paper, however, we focus exclusively on the impact of export sanctions, with the goal of understanding whether restricted access to banned inputs has disrupted the production processes and supply chains of Russian firms.

Export sanctions have significantly restricted Russia's access to Western high-tech inputs, par-

ticularly in sectors such as semiconductors, aerospace, and energy, but have also targeted a broader range of industries. In the words of official EU sources, they included bans on the exports of:

> "cutting-edge technology (e.g. quantum computers and advanced semiconductors, electronic components and software); specific goods and technology needed for oil refining; energy industry equipment, technology and services; aviation and space industry goods and technology (e.g. aircraft, aircraft engines, spare parts or any kind of equipment for planes and helicopters, jet fuel); maritime navigation goods and radio communication technology; a number of dual-use goods (goods that could be used for both civil and military purposes), such as drones and software for drones or encryption devices; luxury goods (e.g. luxury cars, watches, jewellery); arms and related materiel of all types, including civilian firearms and their parts; chemicals, generators and thermostats; IT, electronic and optical components; cameras, lenses, toy drones, laptops and hard drives; and other goods which could enhance Russian industrial capacities" (Council of the European Union, 2024).

We provide additional details in Section 4 on the scope of these sanctions and the products targeted.

The impact of these export sanctions on the Russian economy remains highly debated. Some observers argue that they have inflicted long-term damage by restricting access to crucial technologies and foreign capital, forcing Russia to pay higher prices for components and to depend on a narrower set of trading partners (Luck, 2025). Others note that the country has proven more resilient than anticipated, with redirected trade routes through Turkey, China, and other "friendly" or neutral states fully mitigating some of the initial supply shocks (Krueger, 2024). The resulting landscape has led to a complex "cat-and-mouse" dynamic, where sanctions pressure is met by increasingly inventive evasion tactics, from parallel imports to disguised rerouted shipments.

While rigorous causal estimates of the pass-through of export sanctions on Russia remain limited, important descriptive evidence comes from Simachev et al. (2023), who surveyed over 1,800 Russian firms and found that nearly two-thirds reported negative effects from sanctions in the first year of the war. Among the challenges faced by importers, 30% of the surveyed firms reporting difficulties with importing necessary goods and services and 17% facing issues with importing and

servicing essential machinery. Yet it remains unclear whether these self-reported effects align with objective customs data, and to what extent such disruptions translated into measurable declines in firm output—questions that this paper seeks to address.

3 Data

Data on the Sanctions Against Russia's Imports. One of our key challenges is the absence of readily available data detailing which countries imposed export sanctions on what specific product codes and when these sanctions were enacted. To address this gap, we manually compile a novel dataset on export sanctions imposed by nine major trading partners of Russia following February 2022: Australia, Canada, the European Union, Japan, South Korea, Switzerland, Taiwan, the United Kingdom, and the United States (a total of 35 countries).

As a starting point for our dataset, we used the records available on the online platform Alta.ru, where the experts in the industry provide detailed information on the sanctioned products and their description, the sanctioning countries, and the type of trade flow being sanctioned: Russian exports, Russian imports, reexports to Russia, or transit through Russia (Alta, 2025). We methodically cross-referenced and supplemented this dataset with the information we extracted from official legal documents from the sanctioning countries. Most crucially, we carefully identified the dates when each restriction was imposed and added export sanction information for Taiwan.

Many sanctions were imposed based solely on the textual description of products, with product codes provided only for general reference. In such cases, Alta.ru supplied the corresponding ten-digit product codes from the Russian classification system that, in their expert judgment, best matched each description. Likewise, when sanctions were issued at the ten-digit level in foreign classification systems, Alta.ru reported the most likely Russian ten-digit equivalents. In addition, some sanctions included further textual conditions. For instance, Swiss sanctions on luxury wristwatches applied only to models above a certain price threshold. Because we do not observe actual prices (which we can only approximate through unit values), we disregard such conditional information and treat all items within the affected ten-digit category as "sanctioned," even though some may be formally exempt. In this sense, our classification method likely overstates the set of sanctioned trade flows, implying that our estimated effects should be interpreted as a conservative

lower bound on the true impact of export sanctions.

Overall, we have identified around 72,000 distinct country-product sanctioned varieties with 50 unique dates of sanction imposition. Partly to minimize the noise in the process of pinpointing precise sanction dates, in addition to a staggered DiD approach, we will also rely on a simple pre-post DiD comparing country-product imports before and after the start of the war.

Customs Data. To study the impact of sanctions on trade flows, we rely on a transaction-level dataset of international shipments as recorded by the Federal Customs Service of Russia. For each transaction, the dataset contains the country of shipment, the country of origin, the ten-digit product code (where the first six digits match the Harmonized System [HS] product classification), the product description, information on the sending and buying firms (including the tax ID for the firms located in Russia), the total weight of each shipment, and its total contract value.

To assess the completeness of this dataset, Figure A.1 compares the total value of all imports recorded in these data (in blue)[10] to several benchmarks: mirror export data from UN Comtrade reported by other countries (yellow), data from the World Trade Organization (WTO; green), and the official records from the Russian Statistics Service (red), which ceased publication shortly before the invasion. When aggregated, our data match almost exactly the Russian official import statistics and closely match the UN Comtrade's mirror exports to Russia and the WTO-reported Russian imports. The persistent level difference between our data and mirror exports likely stems from differences in the treatment of insurance and freight costs (CIF vs. FOB valuation). Overall, these estimates suggest that our data correctly reflect the volume and evolution of Russian imports. This is in line with Babina et al. (2023), Chupilkin et al. (2023), and Huang et al. (2025), who also find that the quality of the Russian customs data was not severely affected by the start of the war.[11]

When merging the customs data with our export sanctions dataset, we account for changes in classification of product codes introduced in January 2022. Following Pierce and Schott (2012), we retire the actual product codes and replace them with synthetic ones that remain consistent throughout our study period. We apply the same procedure both for product codes in our customs

[10] Throughout this paper, including this figure, we exclude imports of physical cash.

[11] A potential limitation of the Russian customs data are its incomplete coverage of shipments within the Eurasian Economic Union (EAEU). To verify that this omission does not drive our results, we replicate our main trade estimates using mirror export statistics from UN Comtrade, which include these flows. See Online Appendix C.2.

data and in our sanctions data. Specifically, for cases where product codes split or merged during the classification transition, synthetic codes represent the connected set of altered codes. Throughout, we define each product's HS2 or HS3 codes based on the modal HS2 or HS3 codes within its respective connected set.

Firm Accounting Data. We use the universe of reporting-firm balance sheets and financial statements from 2017 through 2023.[12] These data are collected and made available by the Federal Tax Authority. Firm balance sheets record yearly revenues, profits, capital, material, and labor expenditures, along with other firm-level variables. We merge this dataset with the import transactions using buyer-firm tax ID ("INN") to assess the impact of export sanctions on firms.

Data on Domestic Railway Shipments. We also use data on the universe of firm-to-firm railway shipments, collected by the state-owned monopolist Russian Railways. For each shipment, the dataset records its weight, product code and description, buyer and seller information, and the nature of the shipment (import, export, or domestic shipment). In our context, railway shipment data are helpful because, for a subset of firms, they offer granular proxy measures for the quantity of their domestic outgoing and incoming shipments and provide insight into the structure of their domestic supply chain network. As such, we restrict our attention to domestic shipments.

Government Procurement Data. We extract data on procurement purchases from the Marker database, which compiles publicly available records of purchases by government and state-owned entities from *zakupki.gov.ru* for the years 2012 through 2023. In principle, all domestic purchases of goods and services by public entities are required to be reported in this database. In 2023, the total volume of such purchases amounted to approximately 18% of Russian GDP. To identify military-related procurement, we search for a set of relevant keywords appearing in contract titles or descriptions, such as "GOZ" or "gosoboronzakaz." Each contract record provides the seller's name and, in most cases (unless classified), that of the buyer. Using this approach, we identify 10,588 firms that acted as buyers and 24,240 firms that served as suppliers in military procurement

[12]Federal Law No. 402-FZ, as revised in 2018, exempts firms whose reports "may contain state secrets" from balance sheet disclosure. However, we observe no significant postinvasion decline in the number of reporting firms, with counts consistently fluctuating between 2.2 and 2.3 million in 2019–2023. As a robustness check, we further replicate our firm-level analysis using a balanced panel of firms.

contracts at any point between 2012 and 2023.

Summary Statistics. Tables A.1 and A.2 display the summary statistics for Russian imports and firms, respectively. Table A.1 describes quarterly import flows between 2019Q1 and 2023Q4, showing significant variation in import values, transaction counts, and weights. Notably, 28% of country-product-quarter observations correspond to flows ever subject to sanctions, with 7% under active sanctions in a given quarter. Table A.2 presents firm-level statistics for Russian enterprises from 2017 to 2023, highlighting substantial heterogeneity in their sales, capital, and profitability. Only 2.5% of firms were directly exposed to export sanctions; that is, they imported soon-to-be-sanctioned country-product varieties before the war. About 9.8% and 9.1% of all firms are in the manufacturing and science and technology sectors, respectively. Additional data on railway shipments in Panel C of Table A.2 highlight the firms' extensive domestic logistical networks, showing substantial variation in shipment weights and the number of trading partners.[13]

4 Stylized Facts

Using our comprehensive data, we first establish several stylized facts about the export sanctions imposed on Russia after February 2022. These patterns highlight substantial variation in these restrictions across countries, products, and time, enabling our granular empirical analysis.[14]

Magnitude and Evolution of Export Sanctions. First, we examine the size of imposed export sanctions as well as how it varies with the timeline of the sanctions' introduction.

Figure 1 depicts the cumulative shares of all sanctioned country-product and product-level imports over time. According to our calculations, more than 36% of all country-product imports to Russia, weighted by prewar value, had been sanctioned by July 2024 (Figure 1a). At the product level, more than 80% of all imports in prewar value had been sanctioned by at least one country by July 2024 (Figure 1b). Given Russia's status as one of the world's largest economies, sanctions of

[13]For summary statistics in Panels A and B of Table A.2 and throughout the rest of this paper, we exclude one firm with an abnormally high reported revenue of 30 trillion rubles—an amount exceeding the entire Russian federal budget. The exclusion of this outlier does not affect our results.

[14]See Egorov, Korovkin, Makarin, and Nigmatulina (2025) for an extended discussion. Note, however, that their figures may differ slightly from those reported here, as they rely on trade data coming from aggregated UN Comtrade rather than the granular Russian customs records used in this paper.

this magnitude represent one of the most significant trade shocks in recent history.

The timeline of sanction impositions informs our empirical strategy for assessing the impact on imports. Nearly two-thirds of sanctions were introduced within the first few months of the war, making a simple pre-post DiD approach—comparing sanctioned and nonsanctioned import flows before and after the war's onset—a suitable baseline. However, since there was still substantial variation in sanction impositions between July 2022 and December 2023, a staggered DiD offers an additional layer of rigor, allowing us to leverage this timing variation to strengthen identification.

Most-Sanctioned Products. Figure A.2a lists the 20 most-sanctioned two-digit product categories, ranked by the share of their 2021 import value to Russia that was later prohibited. Consistent with the economic warfare goal of the sanctions, the most heavily targeted categories fall under HS2 codes 84, 85, and 87, which include technologically sophisticated goods, such as electronics, drones, vehicles, and microchips. At the same time, sanctions extend well beyond the high-tech sectors. Notably, across all the sanctioned product categories, nonsanctioned imports still account for a substantial share of prewar import value—often more than half. This rich variation enables us to identify the effects of sanctions on import flows even within broad product groups.

Most-Sanctioning Countries. Figure A.2b ranks countries by the volume of their sanctioned 2021 exports to Russia while also showing their total prewar exports to Russia. Germany stands out as the country that contributed the most to these sanctions in absolute terms, banning around $25 billion of its own 2021 exports to Russia and leaving only $7 billion untouched. Notably, however, for nearly all sanctioning countries, some portion of exports remained nonsanctioned—providing variation to distinguish the effects of export sanctions from broader country-specific shocks.

Not All Countries Sanctioned the Same Products. Table A.3 reports the pairwise correlations between the lists of sanctioned products across countries. While some country pairs, such as the EU and the United Kingdom, exhibit a high degree of alignment in their sanctioned product lists, coordination appears significantly weaker among other country pairs. Notably, there is minimal overlap between the EU's list and those of Australia, Canada, or Taiwan. These gaps in coordination further assure us that variation exists even in sanctioned products across sanctioning countries, i.e., at the *country-product* level, further strengthening our identification strategy.

Aggregate Trends by Sanctioning Country Status. Next, we examine the evolution of total Russian imports in the raw data shipped from sanctioning and other countries. Figure A.3a reveals a sharp decline in monthly imports shipped from countries that imposed sanctions. These imports plummeted by roughly two-thirds in March 2022, falling from around $15 billion to just above $5 billion, and continued to gradually decline afterwards. Monthly imports shipped from nonsanctioning countries also experienced an initial drop—by approximately one-third, from $12 billion to $8 billion, likely due to heightened aggregate uncertainty—but in contrast they quickly rebounded, eventually surpassing prewar levels and reaching around $15 billion per month.

Aggregate Trends by Sanctioned Product Status. Figure A.3b highlights trends in imports by the sanctioned product status. Imports of products sanctioned by at least one country fell sharply after the invasion, from a prewar peak of $24 billion to $14 billion in March 2022. By 2023, they had partially recovered to about $18 billion, but remained below the 2021 average. In contrast, imports of nonsanctioned products remained stable from 2018 to 2023. Together, these patterns suggest that the primary adjustment in Russian import flows occurred via a shift from sanctioning to nonsanctioning countries, rather than between sanctioned and nonsanctioned product categories.

Figure A.4 further disaggregates imports of sanctioned products by route: from sanctioning countries (blue area), from nonsanctioning countries shipping their own goods (purple), and from nonsanctioning countries shipping goods originating elsewhere (grey). The initial collapse in sanctioned imports was nearly offset by the end of 2022 through increased flows from nonsanctioning countries, along both route types. At first glance, these figures may suggest that export sanctions had minimal impact on either the inflows of sanctioned goods or the Russian economy—an assertion we rigorously evaluate in the rest of this paper.

Online Appendix B complements these aggregate patterns by zooming in on two product categories critical to wartime production: semiconductors and critical components. These case studies not only underscore the richness of our data but also illustrate the limitations of relying on descriptive patterns alone. In particular, they show how confounding factors—such as surging wartime demand for semiconductors—can obscure the true effects of export sanctions. These simultaneity concerns highlight the importance of our econometric framework in isolating causal impacts.

5 Results: Impact on Trade

We start by estimating the causal impact of export sanctions on Russian imports. Our analysis proceeds in three steps. First, we quantify the relative decline in imports of sanctioned country-product varieties. Second, we evaluate the extent to which there has been rerouting through and substitution to third countries and disentangle these two channels. Third, we examine whether the combined volume of rerouted and substituted imports was sufficient to compensate for the loss of sanctioned imports within sanctioned product categories.

5.1 Impact on Sanctioned Country-Product Imports

We begin by estimating the impact of export sanctions on imports of sanctioned country-product varieties—the "first-stage" estimates that would form the basis for our subsequent results.

Pre-Post DiD. As our first and baseline empirical strategy, we estimate the following pre-post DiD equation, comparing the import flows of sanctioned and nonsanctioned country-product varieties before and after the war's onset:

$$y_{gct} = \theta_t \, Sanctioned_{gc} + \tau_{gc} + \eta_{gt} + \omega_{ct} + \zeta_{gct} \tag{1}$$

Here, y_{gct} are (log-)import flows from country of shipment c to Russia of a ten-digit product code g at quarter t, measured either by total value or by total weight shipped; $Sanctioned_{gc}$ is an indicator that takes a value of 1 if a product-g-country-c variety has been sanctioned at any point, and 0 otherwise; τ_{gc} are the product-country fixed effects; η_{gt} are the product-quarter fixed effects; and ω_{ct} are the country-quarter fixed effects. The standard errors are two-way clustered by product and country, allowing for correlated errors along both dimensions.

Product-by-quarter fixed effects are central to our identification argument, as they absorb any time-varying product-specific shocks, such as surging demand for war-related inputs or reduced demand for high-tech goods due to falling household incomes. Likewise, country-by-quarter fixed effects capture time-varying country-specific shocks, such as boycotts or policy changes, as well as shifts in trade logistics that are not specific to particular products.

Importantly, to mitigate control group contamination arising from rerouting and trade diversion—

documented later in Section 5.2—our baseline sample excludes imports of ten-digit products sanctioned by at least one country but shipped from countries that remained relatively friendly to the Russian regime, such as China and Turkey.[15]

Figure 2a presents the estimated impact of export sanctions on imports of sanctioned country-product varieties. Prior to the invasion, trends in sanctioned and nonsanctioned import flows were closely aligned, providing support for the parallel-trends assumption underlying our identification argument. Following the invasion, however, we observe a sharp and growing divergence: import value of sanctioned country-product varieties declined massively relative to their nonsanctioned counterparts. In the second quarter of 2022—almost immediately after the war's onset—sanctioned imports had already fallen by 0.39 log points, equivalent to a 32% decline. This decline deepened over time: by the fourth quarter of 2023, the value of sanctioned imports was 1.26 log points below zero, corresponding to a total decline of 72%. These results suggest that the sanctions were not only quickly binding but that their scope and enforcement has increased over time.

Table C.1 in Online Appendix C reports estimates from a nondynamic version of Equation (1), where we interact $Sanctioned_{gc}$ with a simple postinvasion indicator instead of the yearly dummies. Across columns, we progressively introduce richer sets of fixed effects. The estimates are consistently large and negative, with the inclusion of country-quarter fixed effects playing a particularly important role in absorbing the overall decline in imports from sanctioning countries stemming from broader geopolitical and logistical disruptions unrelated to export sanctions per se. Our preferred specification in column (7) implies an average decline of 55% ($= \exp^{-0.802} - 1$) in the value of sanctioned imports after the war's onset.

Staggered DiD. As a second, complementary identification strategy, we employ a staggered DiD design. This approach exploits variation in the timing of sanctions across different country-product pairs, comparing import flows that have just been sanctioned to those not yet sanctioned and those never sanctioned at that point in time. By doing so, this method isolates the effect of export

[15] We define friendly countries as Armenia, Belarus, China, Georgia, Hong Kong, Kazakhstan, Kyrgyzstan, Serbia, Turkey, and the UAE. This classification is based on journalistic accounts documenting these countries as common rerouting hubs for Russian imports. However, our results are robust to alternative classifications. The full-sample analog, presented in Online Appendix C.1, yields inflated but qualitatively similar estimates.

sanctions from potential country-product-specific shocks triggered by the war's onset.[16]

Specifically, we estimate the following equation, allowing for flexible patterns of heterogeneity in sanctions' impact across time and treated flows:

$$y_{gct} = \sum_{e} \sum_{s \geq e} \beta_{es} \mathbb{1}(E_{gc} = e) \times \mathbb{1}(t = s) + \tau_{gc} + \eta_{gt} + \omega_{ct} + \zeta_{gct} \tag{2}$$

where E_{gc} is the month when sanctions take effect on product g by country c (for nonsanctioned imports, $E_{gc} = \infty$). The rest of the notation follows Equation (1), though, importantly, t now represents a month (instead of a quarter) to closely examine the timing of the sanctions' introduction. Under the assumptions of parallel trends and no anticipation, the coefficients β_{es} recover the causal dynamic effects of trade sanctions on each cohort e. The latter assumption may be more demanding here than in the pre-post design, as some cohorts were sanctioned later into the war; we address this issue in our robustness checks.

Following the recent research highlighting potential biases in staggered DiD designs when treatment effects vary substantially across units and over time (Arkhangelsky and Imbens, 2024), we estimate Equation (2) using the ETWFE estimator from Wooldridge (2021), which is particularly well-suited for estimating computationally intensive gravity models (Rios-Avila et al., 2024). All staggered DiD event-study figures include pretrend coefficients, which we estimate separately, closely following specification (2) but omitting all post-treatment observations of treated units from the estimation (*cf.* Borusyak, Jaravel, and Spiess, 2024).

Figure 2b presents the resulting estimates averaged across cohorts. Similar to the pre-post DiD design, sanctions had an immediate adverse impact on the value of sanctioned import flows, which intensified over time. The decline reaches approximately -0.5 log point (equivalent to a 39% reduction) within five to seven months of the sanctions' imposition, and then continues to intensify over the following months, eventually reaching close to -1 log points (a 63% reduction).

[16] Given the inclusion of granular product- and country-quarter fixed effects, a wartime shock would only threaten identification in Equation (1) if it differentially affected specific country-product pairs. One example might be that the military effort may have increased demand for advanced chips predominantly produced in Taiwan. Such a wartime demand spike would only bias our results toward zero and make our estimates a lower bound of the sanctions' impact. Nevertheless, staggered design accommodates any such heterogeneous country-product shocks triggered by the start of the war by comparing changes in imports just around the imposition of export sanctions on each sanctioned variety.

Column (1) of Table C.2 aggregates these dynamic estimates to a single average, suggesting a 59% ($= \exp^{-0.895} - 1$) relative decline in the value of sanctioned imports after the sanctions' imposition.

Overall, the results from both pre-post and staggered DiD designs indicate an immediate and large decline in sanctioned country-product imports as a result of export sanctions. Such a decline is perhaps not surprising—if anything, one may wonder why the bans did not result in a complete 100% halt in sanctioned imports. This likely reflects a combination of imperfect enforcement, the presence of sanction exemptions, and measurement limitations, as some sanctions may apply only to specific product descriptions even within a given ten-digit HS code. Nevertheless, the sharp reduction in sanctioned imports, observed without pretrends despite numerous simultaneous shocks, provides strong validation of our identification strategy and establishes a robust first stage necessary for examining further pass-through effects of export sanctions.

Robustness. We confirm the robustness of our baseline estimates through a series of checks, with full details reported in Online Appendix C.1. First, we obtain effects of similar magnitude when using import weight instead of import value, suggesting that the observed declines are not solely driven by price changes. Second, we re-estimate our main specifications on the full sample, thereby including imports of sanctioned products from friendly countries that were excluded from the baseline to alleviate control group contamination. As expected, the estimated declines become somewhat inflated, but the overall patterns remain consistent. Third, the results remain unchanged when we broaden the set of "friendly" countries to include all BRICS members. Fourth, accounting for smaller nations for which we don't have the sanctions data does not affect our estimates. Fifth, we show that our findings are not sensitive to the transformation of the outcome variable: the results remain sizable when using a simple logarithm transformation that omits zeros and estimating extensive- and intensive-margin effects separately. Sixth, excluding the earliest sanction cohorts from the staggered specification does not alter the results, suggesting that the staggered DiD is indeed leveraging variation distinct from the pre-post design. Finally, we adjust for possible anticipation of postinvasion sanctions in the staggered DiD design by redefining the reference period to prewar months for all sanctioned flows; the resulting estimates closely match our baseline.

5.2 Rerouting and Substitution

Jointly Identifying Rerouting and Substitution. Next, we quantitatively examine the extent to which third-country imports of sanctioned products to Russia have increased—either through the reexport of goods originally produced elsewhere (*rerouting*) or through independent production of those goods within those third countries (*substitution*). To operationalize this analysis, we use a set of countries introduced in Section 5.1 as relatively friendly to the Russian regime. We then estimate an augmented version of Equation (1) that separately tracks the evolution of imports from these friendly countries for products sanctioned by at least one country on the full sample:

$$y_{gct} = \theta_t \, Sanctioned_{gc} + \gamma_t \left(Sanctioned_g \times Friendly_c \right) + \tau_{gc} + \eta_{gt} + \omega_{ct} + \zeta_{gct} \tag{3}$$

where $Sanctioned_{gc}$ remains an indicator that takes a value of 1 if a product-g-country-c variety has been sanctioned at any point, and 0 otherwise; $Sanctioned_g$ is an indicator for whether a product g was ever sanctioned by *any* country; $Friendly_c$ indicates whether country c is classified as friendly; the coefficients γ_t thus trace the relative changes in imports of sanctioned products from friendly countries, compared to the imports of nonsanctioned products from friendly countries and to the imports of sanctioned products from neutral countries. All other variables and the clustering of standard errors are the same as in Equation (1).

Figure 3a presents the results. The impact on sanctioned country-product imports remains large and negative, closely mirroring the numbers in Figure 2a, since the θ_t coefficients are estimated off the same set of flows. At the same time, imports of sanctioned products from friendly countries increased sharply after the invasion, consistent with rerouting or substitution. These alternative channels are economically meaningful: by the end of 2023, sanctioned imports from friendly countries had risen by 1.1 to 1.2 log points, corresponding to a 200%–232% increase in value.[17]

Table C.3 shows the nondynamic analog of these estimates, with increasingly more stringent sets of fixed effects. The estimates are large and statistically significant across columns.

[17] We emphasize that the coefficients θ_t and γ_t are not directly comparable, as each reflects percentage changes relative to different baseline levels. Even though they are similar in absolute magnitude, the total volume of prewar imports, indicated via dashed lines on Figure 3a, was significantly larger for the enemy countries than for the friendly ones. As such, the increase in imports from the friendly countries due to substitution and rerouting was unlikely to fully compensate for the decline in sanctioned flows—a point we further investigate in Section 5.3.

Our preferred specification, in column (7), reveals an average postinvasion increase of 138% ($= \exp^{0.867} - 1$) in sanctioned imports from friendly countries.

Figure 3b replicates this analysis using a staggered DiD design. The analysis broadly follows Equation (2), with the key difference that the timing for imports of sanctioned products from friendly countries is defined based on when the first country imposed sanctions on that product. The estimates yield similar patterns and magnitudes to the pre-post DiD results. Notably, the increase in imports from friendly countries takes one to two months to materialize, and the adjustment being slightly slower when using import weight as the outcome (Figure C.3b). This pattern broadly mirrors the gradual decline in sanctioned imports and may reflect firms' search frictions in finding alternative suppliers or a gradual depletion of their inventories.[18]

Decomposing Rerouting and Substitution. Next, we disentangle and quantify the roles of rerouting and substitution. Leveraging a unique feature of the Russian customs data—which reports both the country of origin and the country of shipment for each transaction—we decompose imports of sanctioned products from friendly countries into three categories: (i) goods produced in the country of shipment (*substitution*), (ii) goods produced in a sanctioning country (*rerouting from sanctioning countries*), and (iii) goods produced in another nonsanctioning country (*rerouting from other countries*). We then reestimate the specifications from Figure 3, replacing total imports of sanctioned products from friendly countries with these three disaggregated flows. Direct imports from sanctioning countries are excluded—so the θ_t terms are no longer estimated—and imports from neutral countries continue to serve as the control group.

Figure 4 presents the results.[19] We find that the postinvasion increase in imports of sanctioned products from friendly countries is almost entirely accounted for by rerouting, with substitution playing only a limited role. Moreover, about two-thirds of this increase reflects *rerouting specifically from sanctioning countries*. The fact that this pattern emerges despite strong incentives to

[18] As a robustness check, we allow a sanctioned product to arrive to Russia not only through friendly countries, but also through those sanctioning countries that never sanctioned this particular product. Figure C.7 shows the estimates of the extended version of Equation (3), where in addition to θ_t and γ_t, we also estimate the effect of an interaction of sanctioned product $Sanctioned_g$ with those sanctioning countries that never sanctioned g. Thus, we remove this group of observations from our control group. We find no evidence of substantial rerouting and substitution from such subset of sanctioning countries, and therefore our results remain largely unaffected.

[19] Figure C.4 reports analogous results using import weight instead of import value.

misreport the origin of sanctioned products lends additional credibility to our customs data and further supports the interpretation of widespread circumvention of export sanctions.

Overall, our findings in this section indicate a significant increase in the inflows of sanctioned products from third countries, primarily driven by rerouting rather than substitution—and particularly by rerouting from sanctioning countries. This pattern suggests that Russian firms and their foreign intermediaries have actively adapted to trade restrictions, thus potentially undermining their effectiveness. In the next section, we assess whether such adaptation has fully offset the decline in sanctioned imports by conducting estimation at a more-aggregate product level.

5.3 Impact on Total Imports of Sanctioned Products

We now assess whether the rerouting and substitution documented earlier have fully compensated for the decline in imports of sanctioned country-product varieties. Specifically, we examine whether export sanctions have led to an overall reduction in the total imports of sanctioned products, irrespective of their country of shipment or origin.

Pre-Post DiD. We first estimate a product-level version of the pre-post DiD Equation (1):

$$y_{gt} = \theta_t \, Sanctioned_g + \omega_{h(g)t} + \tau_g + \eta_t + \zeta_{gt} \tag{4}$$

where y_{gt} are the (log-)import flows of a product g into Russia at quarter t; $Sanctioned_g$ is an indicator that takes a value of 1 if the product g has been sanctioned at any point by *any* country, and 0 otherwise; $\omega_{h(g)t}$ are the higher-level (three-digit in our baseline specification) product category-quarter fixed effects; and the τ_g and η_t are the ten-digit product and quarter fixed effects. The standard errors are clustered at the product level.

Higher-level product category-quarter fixed effects are important as they absorb time-varying shocks at the broader product-group level—for example, wartime surges in demand for certain types of electronics or machinery. To the extent that one is still concerned about war-related shocks that differentially affect specific ten-digit products within these groups, such as other types of sanctions, the staggered DiD specification introduced below helps address this by isolating changes in imports just around the imposition of first sanctions on each product.

Figure 5a presents the results. We find that total imports of sanctioned products to Russia declined sharply and persistently, though by a smaller magnitude than in the country–product-level analysis. Specifically, the decline ranges from -0.4 to -0.5 log points, corresponding to a 32%–39% reduction. Table 1 reports the nondynamic estimates, first without and then with the HS3-quarter fixed effects. Across specifications, the estimates confirm the sizable decline, with our preferred specification in column (4) implying an average reduction of 27% ($= \exp^{-0.31} - 1$). Column (6) additionally shows that the unit values of sanctioned products—calculated as the ratio of total value to total weight—did not exhibit a differential increase following the war's onset. While this may initially appear surprising, it is consistent with the possibility of quality downgrades within product categories or substitution toward lower-cost varieties.

Staggered DiD. We corroborate these patterns using a complementary staggered DiD design, in which treatment is defined by the month in which a product is first sanctioned by any country. Crucially, this strategy helps account for any common war-related shocks that may affect certain ten-digit products more than others—such as surges in demand for military-related inputs or the imposition of non-trade sanctions (e.g., financial restrictions)—by comparing import behavior just before and after the first sanction date for each product.[20]

Figure 5b reports the estimates. Although somewhat noisier, reflecting the more limited variation in sanction dates at the product level, they continue to reveal a consistent decline of about 0.2 to 0.3 log points. Column (7) of Table C.2 collapses the dynamic estimates into a single post-treatment average. The resulting coefficient implies that, following the earliest imposition of export sanctions on a product, its total monthly import value falls by about 17.8% ($= \exp(-0.196) - 1$).

Robustness. Online Appendix C.1 probes robustness of the product-level estimates. First, we show that the effects are similar when using import weight instead of value. Second, they remain

[20] Specifically, we estimate the following equation:

$$y_{gt} = \sum_{e} \sum_{s \geq e} \beta_{es} \mathbb{1}(E_g = e) \times \mathbb{1}(t = s) + \omega_{h(g)t} + \tau_g + \eta_t + \zeta_{gt} \tag{5}$$

where E_g is the month when first sanctions take effect on product g (for never-sanctioned products, $E_g = \infty$). All remaining notation follows Equation (4), with one important difference: time t is now indexed by month rather than quarter to more precisely capture the dynamics around the introduction of sanctions.

sizable when estimating extensive- and intensive-margin effects separately, indicating insensitivity to outcome transformations. Third, we replicate these estimates using mirror-export data from UN Comtrade. Because these data are reported by exporting countries and available only at the HS6 level, this exercise simultaneously alleviates two concerns: it accounts for possible misclassification across HS10 products within HS6 categories, and it addresses possible omissions or manipulation in Russian import records. The observed average decline in sanctioned imports thus reflects a genuine contraction in trade flows rather than measurement artifacts.

Taken together, our results suggest that while substitution and, in particular, rerouting substantially mitigated the decline in sanctioned country-product import flows, these two adjustment channels did not fully offset the average reduction in total imports of sanctioned products. The remaining shortfall is sizable and persistent over time. This pattern suggests potentially large downstream consequences for firm-level production and supply chains within Russia—an issue we examine in detail in the following section.[21]

6 Results: Impact on Firms

While the results in Section 5 suggest that export sanctions reduced imports of targeted products despite substantial rerouting, it remains an open question whether they caused meaningful disruptions to production and supply chains within the targeted economy. In other words, even with a sustained decline in sanctioned imports, sanctions may have fallen short of their intended objective of economic warfare if domestic producers could readily substitute with locally available inputs or if the government was able to effectively compensate the affected firms. In this section, we leverage the richness of our data to examine the downstream effects of export sanctions on the performance of firms that, prior to the sanctions, had relied on inputs now subject to restrictions.

Empirical Strategy. We construct an annual panel of firms and merge it with the customs data to calculate a firm-specific prewar sanctions exposure. That is, for a given firm f, we combine all of its imports from January 2019 to February 2022 and identify whether it ever imported any country-

[21] In Online Appendix C.3, we also confirm that the negative impact on sanctioned imports is also present in a firm-product-level specification with firm-quarter fixed effects, thereby bridging the results on imports and firms and also mitigating concerns that firm-specific shocks are driving the observed declines in sanctioned imports.

product varieties that were later sanctioned. We then estimate the following DiD specification:

$$y_{ft} = \beta_t \, Exposure_f + \delta_t \mathbf{X}_f + \mu_f + \gamma_t + \epsilon_{ft} \tag{6}$$

where $Exposure_f$ is an indicator for whether a firm f ever imported a soon-to-be-sanctioned country-product variety; y_{ft} represents firm-year outcomes such as yearly revenues; μ_f and γ_t respectively denote the firm and year fixed effects; and $\delta_t \mathbf{X}_f$ controls for year fixed effects interacted with firm characteristics. We cluster the standard errors at the firm level.

The controls $\delta_t \mathbf{X}_f$ are crucial for our identification argument, as they flexibly account for firm characteristics that may be correlated with exposure to export sanctions but could also have an independent time-varying influence on firm outcomes due to heterogenous wartime shocks. In our preferred specification, $\mathbf{X}_f$ includes indicators for whether a firm was ever an importer, an exporter, or subject to targeted sanctions, as well as its two-digit OKVED industry classification. To the extent that, conditional on these controls, treatment variation reflects the impact of export sanctions rather than omitted shocks, and under the conditional parallel-trends assumption, the coefficients of interest are β_t's estimate the causal impact of export sanctions on firm outcomes.

6.1 Impact on Firm Output and Performance

Figure 6 presents the estimates of Equation (6) using firm revenue as the outcome variable. Firms exposed to export sanctions through their prewar imports saw a sharp and persistent 14%–17% decline in revenues following the war's onset, after having their revenues evolve in parallel with firms that never imported sanctioned varieties before the war. The sustained decline through both 2022 and 2023 suggests that any adaptation strategies firms may have employed failed to fully offset the shock, and that the effect was not substantially delayed by preexisting inventories. Beyond their standalone importance, these findings also indirectly validate the import disruptions documented in Section 5, alleviating concerns that the Russian customs data might omit significant volumes of black-market or unregistered transactions.

Table 2 presents the corresponding nondynamic pre-post estimates of the impact of export sanctions on the performance of exposed firms in the target country. Column (1) confirms a significant 12.8% average decline in revenues among exposed firms.

Consistent with the revenue decline reflecting a real contraction in output, we observe similar negative effects across a range of other firm-level outcomes. Figure D.1 in Online Appendix D documents a sharp 15%–17% drop in total cost of goods sold; Figure D.2 shows a 12%–13% decline in gross profits (measured as revenues minus cost of goods sold); while Figure D.3 reports a 9%–11% reduction in value added (measured as revenues minus material expenditures). Table 2 confirms these patterns and further reveals sizable declines in specific input categories: a 6.4% reduction in capital expenditures (column 4), an 9.0% decline in labor expenditures (column 5), and a 13.9% drop in material expenditures (column 6).[22] Additionally, there is a 1.3-percentage-point increase in the likelihood of missing sales data, which may indicate a higher exit rate among exposed firms (column 7). When we impute missing sales as zeroes, we observe a massive 45% ($= \exp^{-0.598} - 1$) decline in exposed firms' sales (column 8). However, caution is warranted in interpreting this magnitude, as some missing data may stem from nonrandom reporting issues rather than firm closures. Taken together, these findings indicate that the export sanctions had substantial and persistent disruptive effects on firm operations across multiple dimensions.

Effects By Industry. Figure 7 displays the estimates for differential changes in firm revenue across different industry subsamples. We find that the downstream impact of export sanctions on firm revenue is present even when focusing exclusively on firms in the manufacturing sector (Panel A), but it is *particularly pronounced for firms in the science and technology sector* (Panel B). Table D.5 provides a tabular representation of these industry-specific heterogeneity patterns, showing that similar effects extend beyond revenue to other key firm outcomes. Similarly, this table further confirms that firms in the science and technology sector are particularly affected compared to other industries, with an estimated 17.6% decline in output ($= \exp^{-0.121-0.072} - 1$) and a nearly 25% decline in material costs, indicative of their reduced ability to import critical inputs. These findings are consistent with one of the key strategic aims of the sanctions regime—*economic warfare*—which aims to disrupt and weaken the target country's industrial and technological capabilities by limiting access to critical manufacturing and high-tech inputs. They also align with the

[22]The lower number of observations in columns (4)–(6) reflects the fact that the more detailed cost items data are available only for firms filing full financial statements. In contrast, smaller firms submit the simplified form report revenues and profits but generally do not provide disaggregated labor or materials expenditures.

stylized facts in Section 4, which show that high-tech and manufacturing inputs rank among the most heavily sanctioned product categories. However, the negative impact is present in the wholesale and transportation sectors, as well as other industries, including, for example, agriculture.

Effects Aggregated by Industry. One concern is that non-exposed firms or new entrants may have quickly replaced the output lost by exposed firms. Not only could this inflate our baseline estimates through control-group contamination, but, more conceptually, it would imply that export sanctions were ultimately ineffective as a tool of economic warfare.

To address this concern, we re-estimate our firm-level analysis at the 5-digit industry level. We construct industry-level exposure as the share of its prewar import value that later became sanctioned, weighted by the prewar revenue generated by importers to downweight industries with few importing firms. We then regress industry-level outcomes, such as total sales, on this aggregated exposure measure while controlling for 5-digit industry and 2-digit-industry-by-year fixed effects. This specification mirrors Equation 6, but implemented at the industry rather than firm level.

The results, shown in Figure 8 and Table D.3, closely parallel the firm-level findings. Figure 8 shows no significant pre-trends prior to 2022, followed by sharp declines in total revenue and operating costs in 2022–2023. Quantitatively, a one-standard-deviation increase in exposure is associated with roughly 10 percent declines in both outcomes. Table D.3 also shows a corresponding decline in the number of reporting firms. If anything, we see a decline in the number of new entrants. Taken together, these industry-level results reinforce our interpretation that export sanctions reduced output among exposed firms, and that any possible gains by non-exposed firms within the same industry were not large enough to offset these losses.

Robustness. We confirm the robustness of our baseline estimates through a series of checks; full details are reported in Online Appendix D.1. First, controlling for time-varying influence of state ownership, foreign ownership, and firm size does not materially affect the results. Second, accounting for firms that may have benefited from export controls—such as those with established rerouting supply chains or competitors of exposed firms—yields similar estimates. Third, the results are not driven by changes in the sample composition: restricting the analysis to a strictly balanced panel or excluding firms that entered during the war or exited in its first year yields sim-

ilar magnitudes. Across all specifications, the coefficients remain large, negative, and precisely estimated, generally corresponding to a 10%–14% decline in revenues among exposed firms.

6.2 Impact on Government Procurement

We further examine whether the disruptions in firm operations caused by export sanctions had downstream effects on Russian government procurement. Table 3 presents the results of estimating a nondynamic version of Equation (6), estimating the impact on the probability of winning at least one government contract (odd-numbered columns) and the log of total value of contracts won (even-numbered columns). Columns (1)–(2) report estimates for the full sample, while columns (3)–(4) restrict the sample to firms that secured government contracts in at least two years of the period and reestimate the same outcomes. Across all specifications, we find large and statistically significant negative effects. Exposed firms became 2.1 to 2.4 percentage points less likely to win any government contract in a given year and experienced a 31% ($= \exp^{-0.372} - 1$) decline in the total value of contracts won after the war's onset. As shown in Table D.2, these declines are not driven by gains among frequent competitors of exposed firms.

These findings not only reinforce the evidence of a contraction in exposed firms' output but also indicate that the government did not compensate these firms through increased procurement spending. This contrasts with Nigmatulina (2021), who documented that Russian firms targeted by post-2014 sanctions received compensatory government support, including through additional procurement contracts. Overall, these results provide further evidence of a substantial pass-through effect: export sanctions not only disrupted firm-level production but also significantly impaired affected firms' ability to compete in public procurement markets and supply the Russian state.

6.3 Impact on Railway Shipments: Domestic Substitution, and Propagation

Next, we leverage detailed firm-to-firm railway shipment data, which allows us to identify a subset of buyers and suppliers for each firm. We then use these data to examine two key questions: (i) whether firms directly exposed to export sanctions exhibited changes in their incoming or outgoing domestic shipments—shedding light on domestic substitution, shifts in demand for domestic inputs, and overall bulk output—and (ii) whether firms indirectly exposed, through connections to buyers or suppliers affected by export sanctions, experienced (additional) declines in their output.

Table 4 addresses the first question by examining whether firms exposed to export sanctions experienced a contraction in their domestic trade, both in terms of volume and number of partners. Specifically, we estimate Equation (6) looking at both measures of trade intensity for firms' in-shipments, out-shipments, and total trade. The results in columns (1)–(3) show a significant 10% decline in total shipment volume, driven entirely by a 16% drop in in-shipments, while out-shipments remain statistically unchanged. Columns (4)–(6) report no differential change in firms' total number of suppliers, buyers, and overall trading partners. While railway data primarily capture shipments of heavy or bulk goods, these findings nevertheless suggest that firms exposed to export sanctions may have been unable to substitute inputs domestically and instead scaled back their in-shipments, consistent with the overall contraction in their production. At the same time, the flat pattern for outbound tonnage would be consistent with these firms producing higher-value, non-bulk products that are not typically shipped by rail.

We next examine whether export sanctions propagated through domestic production networks. Table 5 augments Equation (6) with indicators capturing whether a firm's immediate buyer or supplier (first-degree exposure) or their buyer's or supplier's partners (second-degree exposure) were exposed to export sanctions. All specifications, except the baseline in column (1), control for firms' participation in railway trade interacted with year effects. Columns (3)–(5) show that exposure through suppliers imposes an additional negative impact half the magnitude of the direct effect, while exposure through buyers yields a smaller but still significant impact of about one-fourth. Second-degree effects, reported in columns (6)–(7), are small and imprecise. The baseline coefficient remains stable at about a 14% decline. These results indicate that export sanctions propagated along supply chains, reducing sales not only among directly targeted firms but also among their domestic suppliers and customers, thereby amplifying their aggregate economic impact.

7 Impact on Military Supply Chains

Given that one of the primary objectives of export sanctions was to disrupt military-related production, it is crucial to examine the sanctions' impact specifically on military-related imports and output. We address this question in two steps.

First, we show that export sanctions successfully restricted military-related firms' access to

sanctioned products. For the purpose of this exercise, we define military-related firms using government procurement data as those that ever engaged in contracts under the military procurement law. Following the empirical strategy detailed in Online Appendix C.3, Figure E.1 presents the firm-product-level import estimates specifically for military-related firms and shows negative and significant effects, comparable in magnitude to the estimates for the whole sample.

Second, we examine whether military-related firms experienced differential downstream effects of export sanctions. Table E.1 presents results from a triple-difference specification, augmenting Equation (6) with a triple interaction between a post-2022 indicator, exposure, and a military-related firm indicator, along with year-by-military fixed effects. Column (1) uses the procurement-based definition of military-related firms; column (2) uses an alternative definition, classifying firms located in closed administrative-territorial formations (ZATOs) as military-related; column (3) combines both criteria. In all cases, the estimated triple-interaction terms are small and statistically insignificant, suggesting that exposed military-related firms did not experience differential effects from export sanctions relative to the broader group of exposed firms. In other words, the pass-through effects documented earlier hold robustly for this subsample as well.

Finally, we assess whether export sanctions were effective in curbing imports of a narrow set of products deemed critical for military applications. In both DiD designs, Figures E.2 shows no significant decline in the imports of sanctioned critical components identified by the Main Directorate of Intelligence of Ukraine (2025) as relevant for Russian weapons production. If anything, we observe a relative *increase* in the total value of these flows. Instead, the sharp declines documented in Figure 5 are concentrated in less strategically prioritized product categories. One interpretation is that these critical components faced sharply elevated demand—something difficult to fully control for given the small and specialized nature of the list. However, even under this interpretation, the absence of any observable contraction indicates that Russia was able to continue sourcing these components despite the new restrictions. This pattern highlights an important limitation of the export controls: while the sanctions substantially reduced broader categories of sanctioned imports, they appear less effective at eliminating access to a narrow set of strategically vital components.

Taken together, these findings paint a nuanced picture. While the Russian state appears to have prioritized and preserved access to select critical military components—likely through deliberate

circumvention—export sanctions nonetheless appear to have disrupted broader military supply chains by constraining access to sanctioned inputs and reducing firm-level output.

8 Conclusion

In an era marked by nuclear deterrence and reluctance to engage in direct military confrontation, trade sanctions have become a central tool of economic statecraft. Among these, export sanctions aim to degrade the industrial capacity of a target country by restricting access to critical foreign inputs. Their effectiveness in achieving this goal, however, remains an open question.

We address this question in the context of the unprecedented export sanctions imposed on Russia following its 2022 invasion of Ukraine. Leveraging a unique combination of administrative data—including Russian customs data, firm-level balance sheets, domestic railway shipment records, and government procurement contracts—we provide the most comprehensive causal micro-level assessment of the economic impact of export sanctions to date.

Our findings reveal that sanctioned country-product trade flows fell sharply following the war's onset and continued to decline through the end of 2023. While we observe substantial rerouting through friendly third countries—particularly of sanctioned products originally produced in sanctioning countries—and, to a lesser extent, substitution, these adjustment channels did not fully offset the decline in overall imports of sanctioned products.

At the firm level, export sanctions also had large and persistent effects. Firms with prewar exposure to sanctioned imports experienced sizable declines in sales, cost of goods sold, profits, input expenditures, and government procurement contract volumes, along with increased likelihood of exit. These effects propagated through production networks, with firms linked to exposed trading partners also seeing significant performance declines. The impacts were particularly pronounced in the science and technology sector but extended to manufacturing firms and those engaged in military-related procurement. The declines were not substantially offset by competing firms.

Taken together, our findings challenge the notion that export sanctions on Russia were largely symbolic or easily circumvented. Instead, they led to substantial disruptions to firm-level production and supply chains—including in strategic sectors—thereby constraining the economic and technological capabilities of the Russian economy and serving as instruments of economic warfare.

While our findings provide robust evidence of the disruptive effects of export sanctions, several limitations merit acknowledgment. First, our analysis captures short- to medium-term effects, whereas longer-term responses, such as technological upgrading or innovation,[23] remain outside the scope of this study. Second, our analysis adopts a positive approach, focusing on documenting the impact of sanctions rather than engaging with normative questions around welfare or the optimal sanctions design. Third, we show substantial negative effects on exposed firms carefully accounting for common wartime shocks, and thus explaining the comparatively strong aggregate performance of the Russian economy during this period is outside the scope of the paper. Fourth, the extent to which our results generalize to other sanctioned economies is likely context-dependent: the structure of the targeted economy, its trade dependencies, and the level of international coordination could all shape the efficacy of export sanctions elsewhere. Finally, while we focus on export sanctions, studying the pass-through effects of import sanctions on Russian hydrocarbons and other products is another important avenue for future work.

We view these limitations as opportunities for further research—particularly in tracing firms' long-term adaptation strategies, analyzing the pass-through effects of sanctions on Russian exports, and assessing the broader welfare implications for consumers and workers in both target and sanctioning countries. As sanctions continue to shape the landscape of international conflict and economic diplomacy, understanding their mechanisms and consequences remains a pressing priority for researchers and policymakers alike.

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[23] See Liu et al. (2025); Clayton, Coppola, Maggiori, and Schreger (2025); Flynn, Levy, Moscona, and Wo (2025) for evidence that export controls and foreign political risks can spur R&D and innovation.

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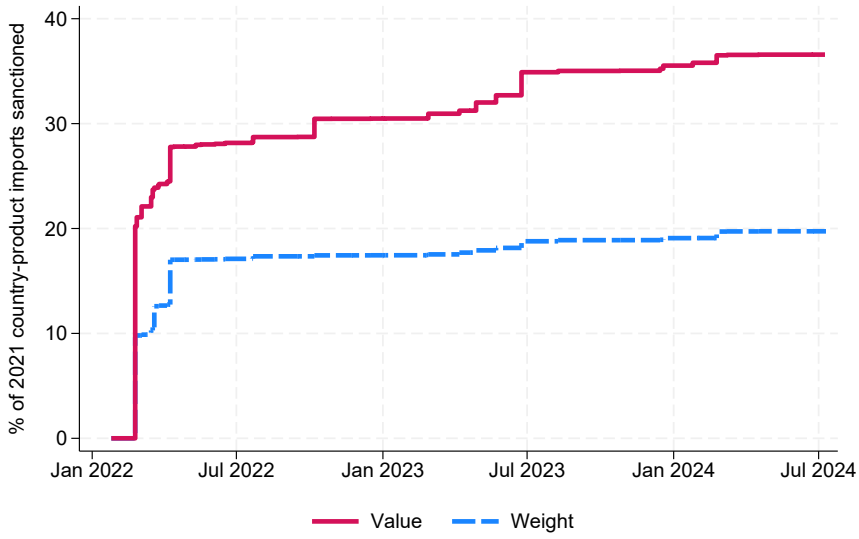
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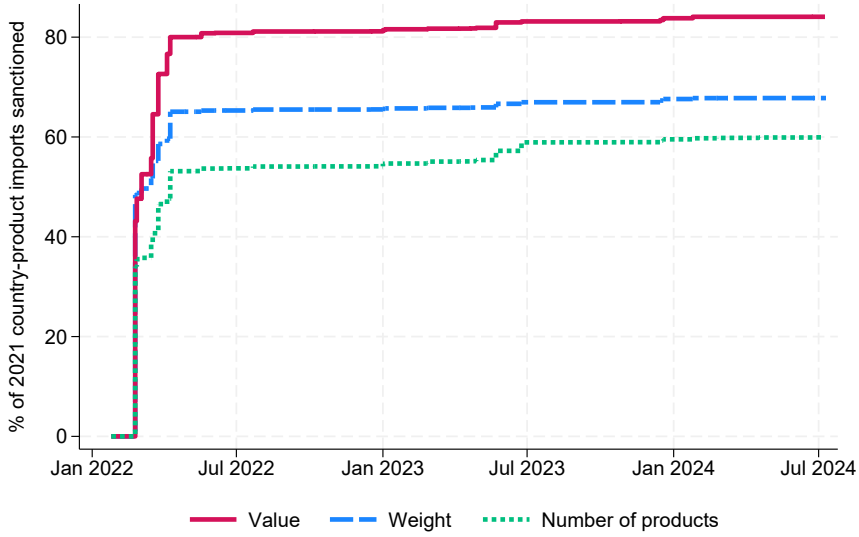
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Figure 1: Timing and Magnitude of Export Sanctions Imposed on Russia, Expressed as a Share of 2021 Russian Import Volume



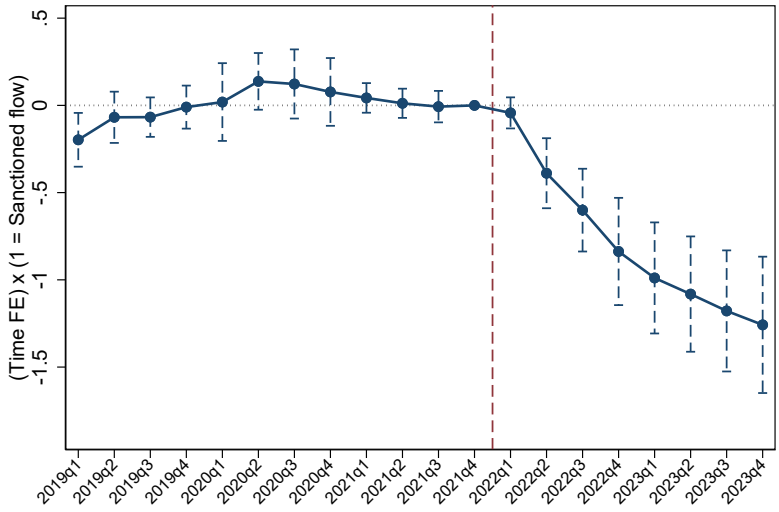
(a) Country–Product-Level Imports



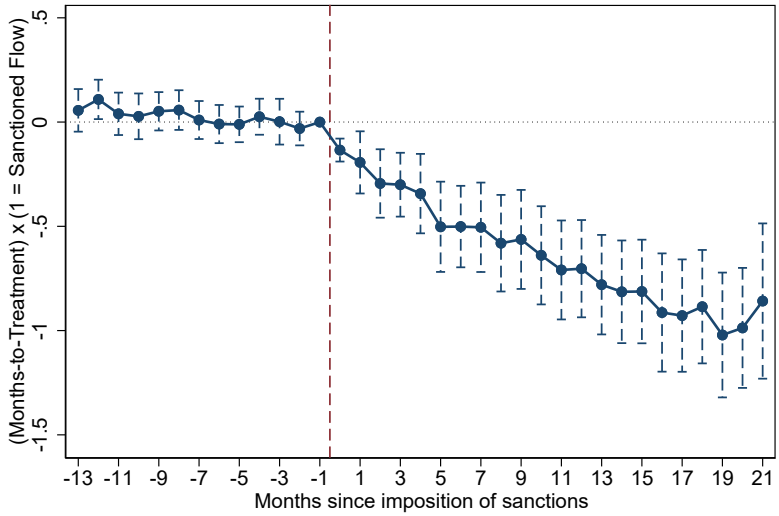
(b) Product-Level Imports

Notes: This figure displays the timing and volume of sanctions imposed on Russia's imports, measured based on their prewar levels. Specifically, for each date from February 2022 to July 2024, we compute the share of Russian imports sanctioned by any country, using 2021 trade data as a baseline. Panel A calculates this share at the country-product level. Panel B calculates this share at the product level, assigning each product the earliest date at which it was sanctioned by any country. The shares are reported across three dimensions: by value (in red), by weight (in blue, long-dashed), and, for Panel B only, by the number of sanctioned HS10 products (in green, short-dashed).

Figure 2: The Impact of Export Sanctions on Sanctioned Country-Product Imports, in Value



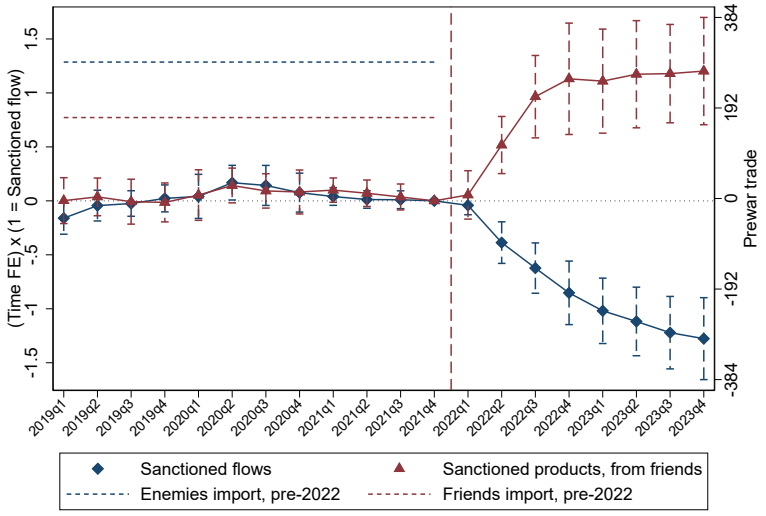
(a) Pre-Post DiD



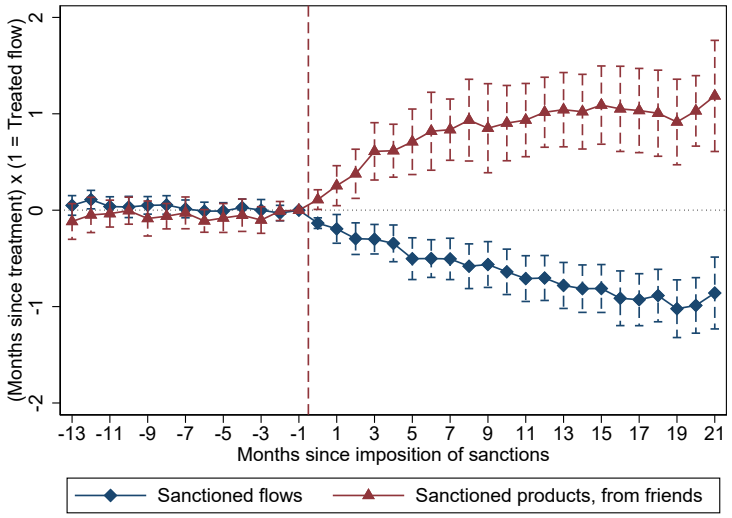
(b) Staggered DiD

Notes: Panel A reports dynamic pre-post DiD estimates from Equation (1), comparing the value of sanctioned country-product imports to nonsanctioned imports before and after the start of the war. Panel B reports dynamic staggered DiD estimates from Equation (2), comparing sanctioned to nonsanctioned country-product imports (in value) before and after sanctions are imposed on a given variety. In both panels, imports of sanctioned products from friendly countries are excluded from the sample. Panel A uses quarterly data, with 2021Q4 as the omitted period. Panel B uses monthly data, and the estimates are aggregated across cohorts by event time. The red vertical line in Panel A marks the start of the war; in Panel B, it marks the imposition of export sanctions on a given country-product variety. The logarithms add 1 to the argument's value to avoid missing values. The bars represent 95% confidence intervals. Standard errors are clustered two-way by country and product. Panel A includes 4,592,360 observations across 9,418 products and 214 countries. Panel B includes 9,043,824 observations across 8,803 products and 197 countries. For the weight-based analogue, see Figure C.2.

Figure 3: Jointly Identifying Rerouting and Substitution via Friendly Countries, in Value



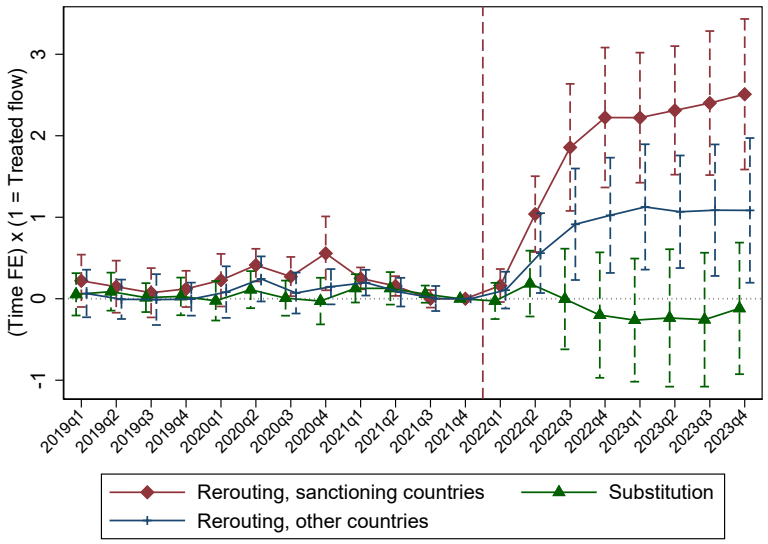
(a) Pre-Post DiD



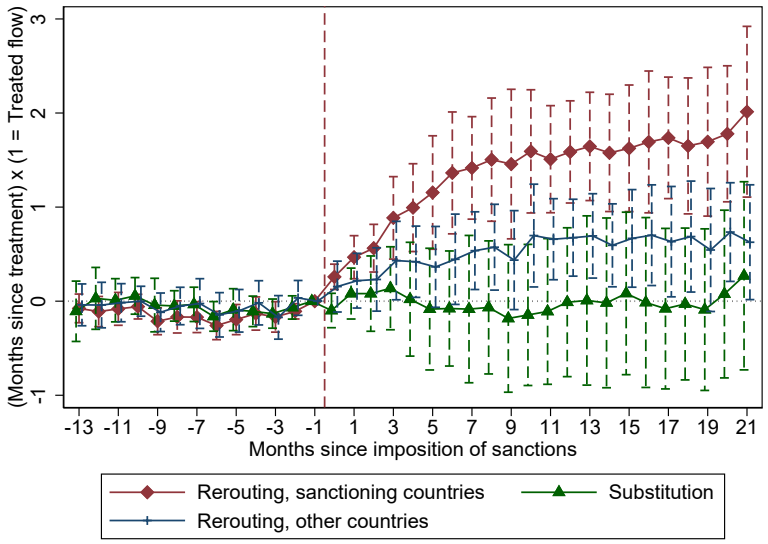
(b) Staggered DiD

Notes: This figure documents the presence of rerouting and substitution. Panel A presents the estimates of Equation (3), comparing the value of sanctioned and nonsanctioned country-product imports, before and after the war's onset, while isolating imports of ever-sanctioned products from the "friendly" countries. *Friendly* countries are those that remained relatively aligned with Russia after the invasion (Armenia, Belarus, China, Georgia, Hong Kong, Kazakhstan, Kyrgyzstan, Serbia, Turkey, and the UAE). *Enemy* countries include all nations that ever imposed trade sanctions on Russia. Panel B reports staggered DiD estimates that combine results from two separate regressions: one measuring the impact of export sanctions on direct sanctioned flows (blue), and the other measuring the impact on imports of sanctioned products from friendly countries (red). In each specification, only one treated group is included, and nonsanctioned imports from neutral third countries are always the control group. Panel A uses quarterly data, with 2021Q4 as the omitted period; Panel B uses monthly data, and the estimates are aggregated across cohorts by event time. The red vertical line in Panel A marks the start of the war; in Panel B, it marks the first sanction imposition for the relevant treated group. The logarithms add 1 to the argument's value to avoid missing values. The short-dashed lines in Panel A plotted on a secondary (right-hand) axis represent the total volume of prewar trade with friendly and enemy countries. The bars represent 95% confidence intervals. Standard errors are clustered two-way by country and product. Panel A includes 5,076,220 observations across 9,486 products and 214 countries. Panel B includes 9,256,464 observations across 8,838 products and 197 countries. For the weight-based analogue, see Figure C.3.

Figure 4: Decomposing Rerouting and Substitution via Friendly Countries, in Value



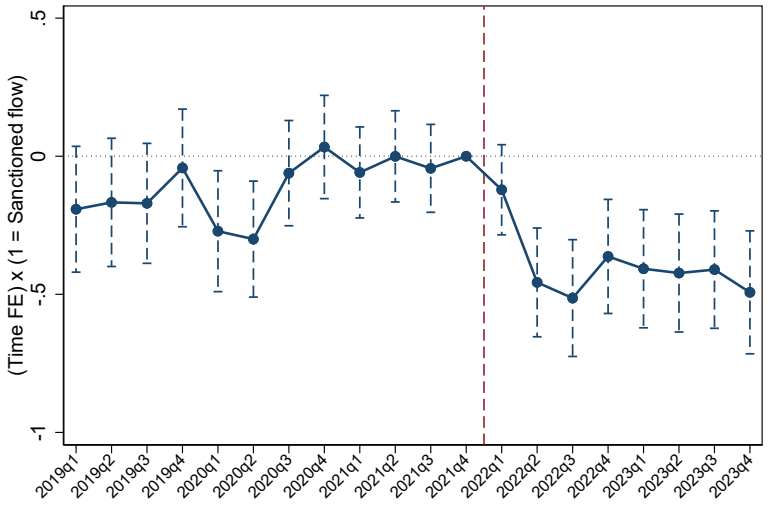
(a) Pre-Post DiD



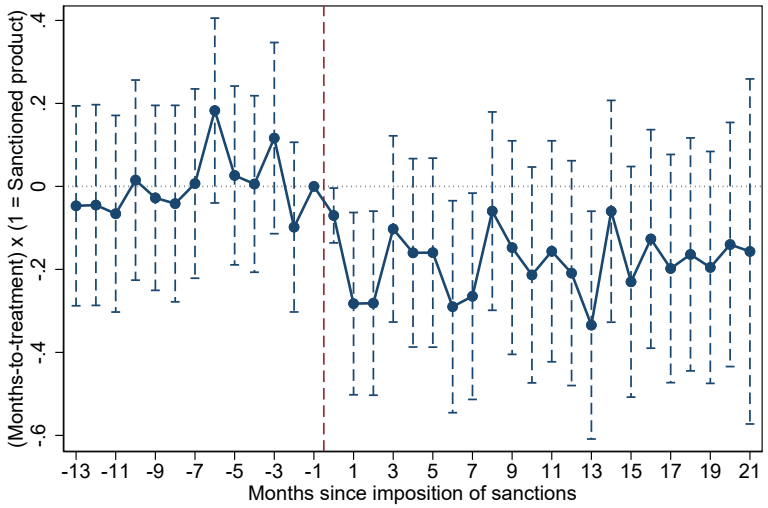
(b) Staggered DiD

Notes: This figure disentangles rerouting and substitution. We separate each import flow of the sanctioned products shipped from friendly countries into three flows: those produced within the same friendly country (*in green*), those produced in sanctioning countries (*in red*), and those produced elsewhere (*in blue*). The impact of export sanctions is then estimated on each of these flow's value, with the nonsanctioned imports from third countries serving as a control group. Directly sanctioned flows from sanctioning countries are excluded from the estimation sample. *Friendly countries* are defined as Armenia, Belarus, China, Georgia, Hong Kong, Kazakhstan, Kyrgyzstan, Serbia, Turkey, and the UAE. Panel A uses a pre-post DiD design; Panel B employs a staggered DiD design. Panel A uses quarterly data, with 2021Q4 as the omitted period; Panel B uses monthly data, and the estimates are aggregated across cohorts by event time. The red vertical line in Panel A marks the start of the war; in Panel B, it marks the first sanction imposition on a given product. The logarithms add 1 to the argument's value to avoid missing values. The bars represent 95% confidence intervals. Standard errors are clustered two-way by country and product. Panel A includes 3,669,220 observations across 8,770 products and 205 countries; Panel B includes 5,479,812 observations across 8,232 products and 185 countries. For the weight-based analogue, see Figure C.4.

Figure 5: The Impact of Export Controls on Russian Imports of Sanctioned Products, in Value



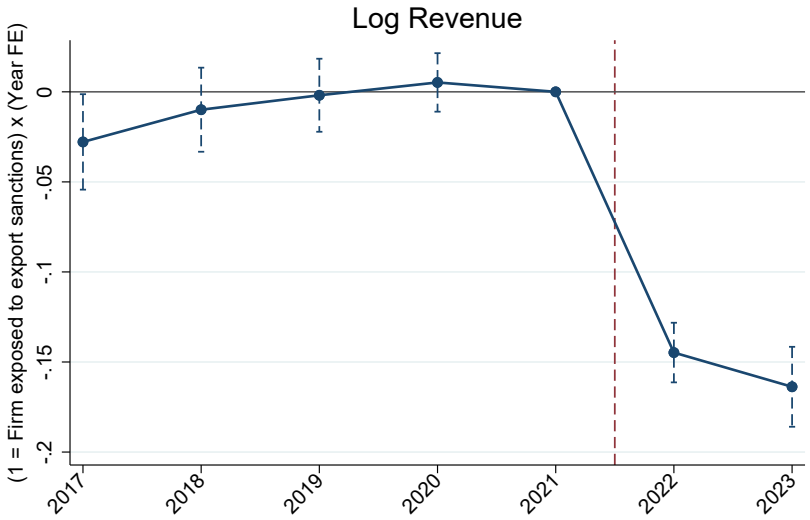
(a) Pre-Post DiD



(b) Staggered DiD

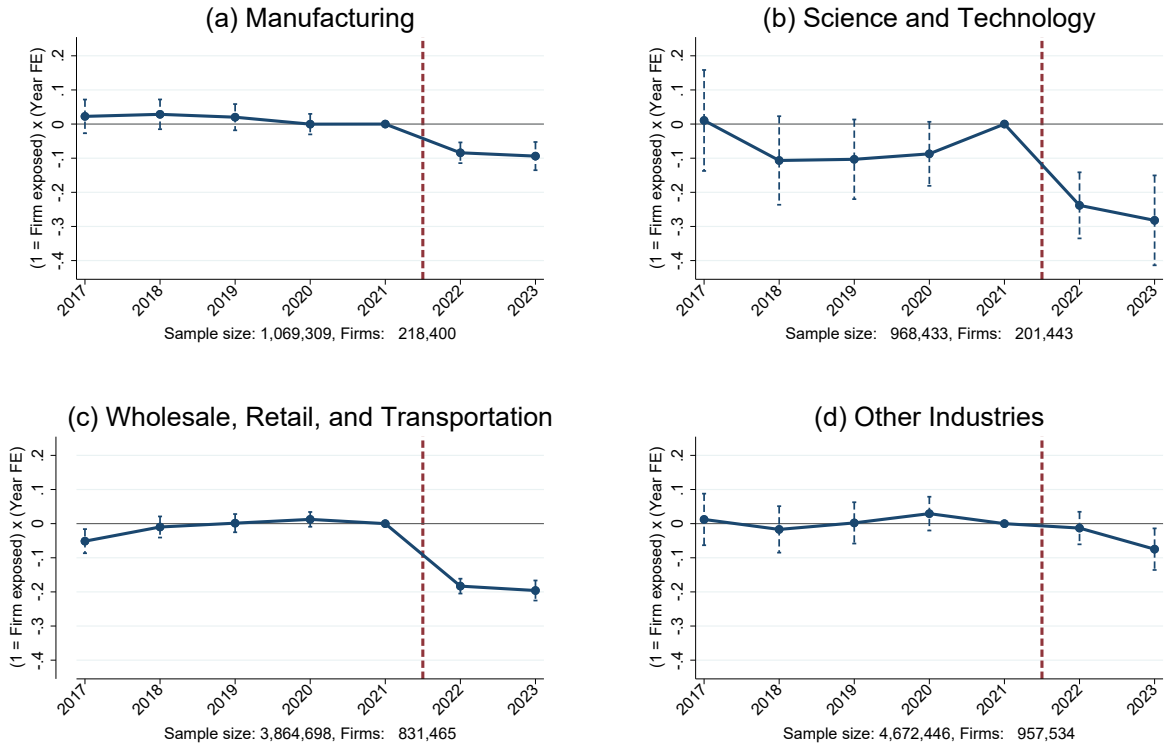
Notes: This figure assesses the impact of sanctions on the total imports of sanctioned products, independent of the identity of countries-importers. Panel A presents the dynamic pre-post DiD estimates from Equation (4), which compares the value of sanctioned and nonsanctioned product imports before and after the war's onset. Panel B displays the dynamic staggered DiD estimates from Equation (5) comparing the import value for sanctioned products to that of nonsanctioned products before and after the imposition of first sanctions on the former. Panel A uses quarterly data, with 2021Q4 as the omitted period; Panel B uses monthly data, and the estimates are aggregated across cohorts by event time. The red vertical line in Panel A marks the start of the war; in Panel B, it marks the first sanction imposition on a given product. Regressions include HS3-product-time fixed effects. The logarithms add 1 to the argument's value to avoid missing values. The bars represent 95% confidence intervals. Standard errors are clustered at the product level. Panel A includes 205,400 observations across 10,270; Panel B includes 465,600 observations across 9,700 products. For the weight-based analogue, see Figure C.5.

Figure 6: The Impact of Export Sanctions on Exposed Firms' Sales



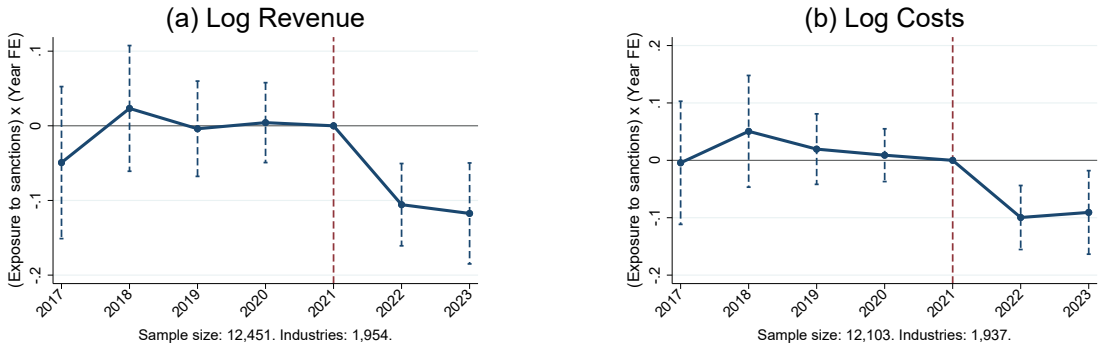
Notes: This figure examines the impact of export sanctions on the revenues of firms that, prior to the war, imported any country-product variety that was later sanctioned. Specifically, it presents the dynamic DiD estimates of Equation (6), which compares firm revenues between firms with and without prewar exposure to future export sanctions, before and after the war's onset. The outcome data are presented at the yearly level, with 2021 serving as the baseline period. The red vertical line indicates the start of the war. The bars represent 95% confidence intervals. Standard errors are clustered at the firm level. Sample size: 10,608,115; firms: 2,183,481.

Figure 7: The Impact of Export Sanctions on Exposed Firms' Sales, by Industry



Notes: This figure examines the impact of export sanctions on the revenues of exposed firms by industry. Specifically, the plots display the dynamic DiD estimates of Equation (6), comparing firm revenues between firms with and without prewar exposure to future export sanctions, before and after the war's onset. A firm is considered exposed if, prior to the war, it imported any country-product variety that was later sanctioned. The revenue data come at the yearly level, with 2021 serving as the baseline period. The red vertical line indicates the start of the war. The bars represent 95% confidence intervals. Standard errors are clustered at the firm level.

Figure 8: The Impact of Export Sanctions on Total Sales and Costs of 5-Digit Industries



Notes: This figure examines the impact of export sanctions on industry-level sales and costs. The dataset is collapsed at the 5-digit industry level. The exposure to export sanctions at the industry level is calculated as the share of prewar soon-to-be-sanctioned import flows weighted by the revenues in an industry earned by importers. The exposure is then normalized by its standard deviation. The plots display the dynamic DiD estimates analogous to Equation (6) but implemented at the industry rather than firm level, comparing industry revenues between 5-digit industries more versus less exposed to the export sanctions, before and after the war's onset. Both regressions control for 2-digit industry-by-year FE and 5-digit-industry FE. The revenue and costs data come at the yearly level, with 2021 serving as the baseline period. The red vertical line indicates the start of the war. The bars represent 95% confidence intervals. Standard errors are clustered at the 5-digit industry level.

Table 1: The Impact of Export Sanctions on Total Russian Imports of Sanctioned Products

	(1) Log Total Value	(2) Log Total Weight	(3) Log Unit Price	(4) Log Total Value	(5) Log Total Weight	(6) Log Unit Price
Post-War × Sanctioned Product	-0.273***	-0.168***	-0.074***	-0.310***	-0.273***	0.010
	(0.049)	(0.043)	(0.015)	(0.073)	(0.063)	(0.022)
Quarter FE	✓	✓	✓			
Product FE	✓	✓	✓	✓	✓	✓
3-Digit Product-Quarter FE				✓	✓	✓
Mean Dep. Var.	10.24	8.49	3.24	10.24	8.49	3.24
SD Dep. Var.	6.00	5.49	2.53	6.00	5.49	2.53
Observations	205,460	205,460	160,127	205,460	205,460	160,127
Number of Products	10,273	10,273	9,417	10,273	10,273	9,417

Notes: This table examines whether total imports of sanctioned products into Russia, independent of country-exporter, declined following the onset of Russia's 2022 invasion of Ukraine. Specifically, it presents the estimates of Equation (4) modified by replacing θ_t with a single postwar indicator. The outcome variable in columns (1) and (4) is the log of total value imported; in columns (2) and (5), log of total weight imported; and in columns (3) and (6), log-unit price, defined as value per weight calculated for each transaction and then averaged at the product-code level weighted by the transaction's value. The logarithms add 1 to the argument's value to avoid missing values. The time span is from 2019Q1 through 2023Q4. *Product* refers to ten-digit (or lower, if specified) HS codes, unless they were aggregated due to changes in HS classification, following Pierce and Schott (2012). Standard errors in parentheses are clustered at the product level. * p<0.1, ** p<0.05, *** p<0.01.

Table 2: The Impact of Export Sanctions on Exposed Russian Firms

	(1) Log Sales	(2) Log Total Production Costs	(3) Log Gross Profit	(4) Log Capital Costs	(5) Log Labor Costs	(6) Log Materials Costs	(7) 𝟙[Sales Missing]	(8) Log Sales (zeroes if missing)
Post-2022 × Exposed to Export Sanctions	-0.137***	-0.147***	-0.108***	-0.067***	-0.094***	-0.150***	0.013***	-0.598***
	(0.010)	(0.009)	(0.011)	(0.013)	(0.012)	(0.016)	(0.002)	(0.048)
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Importer FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Exporter FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Industry FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Target Sanctioned FE	✓	✓	✓	✓	✓	✓	✓	✓
Mean Dep. Var.	15.91	15.85	13.98	14.40	15.38	17.14	0.24	11.06
SD Dep. Ver.	2.29	2.24	2.40	2.59	2.37	2.72	0.43	7.57
Observations	10,597,168	9,881,593	8,447,082	4,620,059	1,377,628	1,433,613	15,247,428	15,245,129
Number of Firms	2,178,204	2,063,893	1,922,658	979,529	323,064	338,753	2,178,204	2,178,202

Notes: This table examines the impact of export sanctions on the performance of the exposed Russian firms. Specifically, it presents the nondynamic version of the estimates of Equation (6), comparing revenues (and other financials) of firms exposed (and not exposed) to the export sanctions, before and after the war's onset. A firm is considered exposed if, prior to the war, it imported any country-product variety that was later sanctioned. With the exception of the missing sales indicator, all dependent variables are in logarithms of Russian rubles. The firm outcome variables come at the yearly level from 2017 through 2023. Standard errors in parentheses are clustered at the firm level. * p<0.1, ** p<0.05, *** p<0.01.

Table 3: The Impact of Export Sanctions on Exposed Firms' Government Procurement Contracts

	(1)	(2)	(3)	(4)
	𝟙[Won At Least One Contract]	Log Value of Contracts Won	𝟙[Won At Least One Contract]	Log Value of Contracts Won
Post-2022 × Exposed to Export Sanctions	-0.024***	-0.372***	-0.021***	-0.373***
	(0.002)	(0.024)	(0.007)	(0.102)
Firm FE	✓	✓	✓	✓
Year-Importer FE	✓	✓	✓	✓
Year-Exporter FE	✓	✓	✓	✓
Year-Industry FE	✓	✓	✓	✓
Year-Target Sanctioned FE	✓	✓	✓	✓
Only Firms With Contracts In > 2 Years			✓	✓
Mean Dep. Var.	0.11	1.58	0.63	9.45
SD Dep. Ver.	0.31	4.63	0.48	7.46
Observations	10,597,168	10,597,167	1,552,070	1,552,070
Number of Firms	2,178,204	2,178,204	261,981	261,981

Notes: This table examines the impact of export sanctions on the government procurement activity of the exposed Russian firms, estimated using a pre-post version of Equation (6). A firm is considered exposed if, prior to the war, it imported any country-product variety that was later sanctioned. Columns (1) and (3) present estimates for the likelihood that a firm won at least one government contract in a given year. Columns (2) and (4) report the effects on the (log of one plus) total value of contracts won (in rubles). Columns (3) and (4) restrict the sample to firms that secured contracts in at least two years of the sample. The government procurement outcome variables are aggregated at the firm-year level from 2017 through 2023. Standard errors in parentheses are clustered at the firm level. * p<0.1, ** p<0.05, *** p<0.01.

Table 4: The Impact of Export Sanctions on Exposed Firms' Railway Shipments

	(1) Log In-Shipments	(2) Log Out-Shipments	(3) Log Total Shipments	(4) Log # Suppliers	(5) Log # Buyers	(6) Log # Partners
Post-2022 × Firm Exposed to Export Sanctions	-0.175***	0.031	-0.106***	-0.003	0.004	-0.012
	(0.039)	(0.055)	(0.036)	(0.019)	(0.032)	(0.019)
Firm FE	✓	✓	✓	✓	✓	✓
Year-Importer FE	✓	✓	✓	✓	✓	✓
Year-Exporter FE	✓	✓	✓	✓	✓	✓
Year-Industry FE	✓	✓	✓	✓	✓	✓
Mean Dep. Var.	7.73	8.18	8.10	1.21	1.48	1.44
SD Dep. Ver.	2.53	2.66	2.60	1.10	1.35	1.26
Observations	106,165	53,288	127,925	106,219	53,323	127,962
Number of Firms	23,224	12,009	27,710	23,240	12,021	27,719

Notes: This table examines the impact of export sanctions on railway shipments of exposed Russian firms, estimated using a pre-post version of Equation (6). Columns (1)–(3) report effects on the (log of one plus) total weight of incoming, outgoing, and combined shipments, respectively. Columns (4)–(6) present results for the log number of suppliers, buyers, and total trading partners. A firm is considered exposed if, before the war, it imported any country-product variety that was later sanctioned. The railway outcome variables are aggregated at the firm-year level from 2017 through 2023. Standard errors in parentheses are clustered at the firm level. * p<0.1, ** p<0.05, *** p<0.01.

Table 5: Propagation of Export Sanctions Through Supply Chain Linkages

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Log Sales						
Post-2022 ×	-0.137***	-0.143***	-0.143***	-0.143***	-0.143***	-0.143***	-0.143***
× Firm Exposed to Export Sanctions	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Post-2022 ×			-0.076***		-0.074***	-0.044*	-0.040
× Supplier Exposed to Export Sanctions			(0.016)		(0.016)	(0.024)	(0.027)
Post-2022 ×				-0.037**	-0.033*	-0.057*	-0.076**
× Buyer Exposed to Export Sanctions				(0.018)	(0.018)	(0.031)	(0.037)
Post-2022 × Supplier's						-0.039	
Partner Exposed to Export Sanctions						(0.024)	
Post-2022 × Buyer's						0.028	
Partner Exposed to Export Sanctions						(0.030)	
Post-2022 × Supplier's							-0.004
Supplier Exposed to Export Sanctions							(0.043)
Post-2022 × Supplier's							-0.040
Buyer Exposed to Export Sanctions							(0.039)
Post-2022 × Buyer's							0.000
Supplier Exposed to Export Sanctions							(0.043)
Post-2022 × Buyer's							0.048
Buyer Exposed to Export Sanctions							(0.050)
Firm FE	✓	✓	✓	✓	✓	✓	✓
Year-Importer FE	✓	✓	✓	✓	✓	✓	✓
Year-Exporter FE	✓	✓	✓	✓	✓	✓	✓
Year-Industry FE	✓	✓	✓	✓	✓	✓	✓
Year-Target Sanctioned FE	✓	✓	✓	✓	✓	✓	✓
Year-Railway Trader FE		✓	✓	✓	✓	✓	✓
Mean Dep. Var.	15.91	15.91	15.91	15.91	15.91	15.91	15.91
SD Dep. Ver.	2.29	2.29	2.29	2.29	2.29	2.29	2.29
Observations	10,597,168	10,597,168	10,597,168	10,597,168	10,597,168	10,597,168	10,597,168
Number of Firms	2,178,204	2,178,204	2,178,204	2,178,204	2,178,204	2,178,204	2,178,204

Notes: This table examines the impact of export sanctions on the performance of directly and indirectly exposed Russian firms. Specifically, it extends the baseline estimates in Table 2 by also examining whether firm revenues were affected by whether a given firm's buyers or suppliers were exposed to export sanctions and, in turn, whether their buyers or suppliers were. Data on firm-to-firm connections come from data on railway shipments within Russia. A firm is considered exposed if, prior to the war, it imported any country-product variety that was later sanctioned. The dependent variable in all columns is the logarithm of yearly sales in Russian rubles from 2017 through 2023. Standard errors in parentheses are clustered at the firm level. * p<0.1, ** p<0.05, *** p<0.01.

Online Appendix for "Trade Sanctions" **(not for publication)**

Konstantin Egorov, Vasily Korovkin, Alexey Makarin, Dzhamilya Nigmatulina

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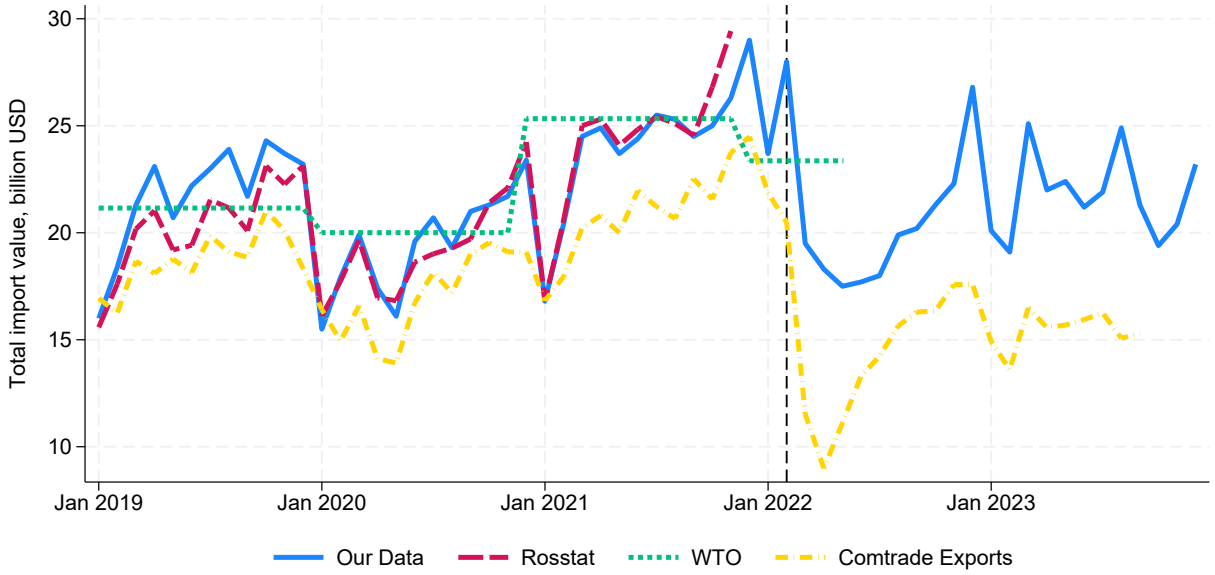
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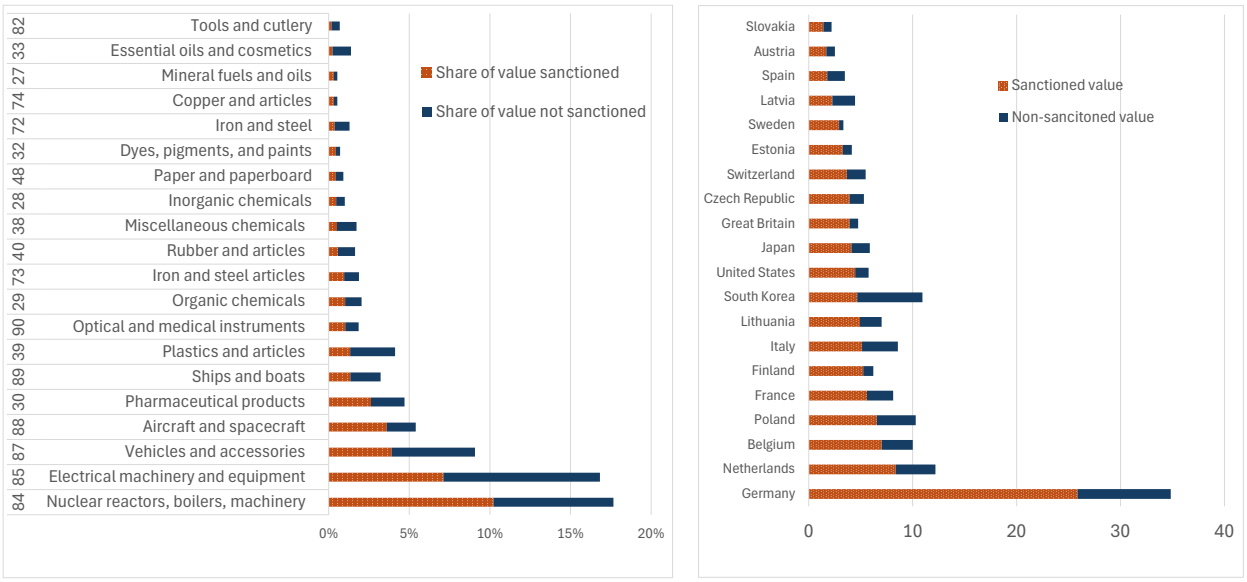
A Additional Stylized Facts and Summary Statistics

Figure A.1: Aggregate Trends in Russia's Imports



Notes: This figure depicts the total value of goods imported by Russia from January 2019 to December 2023 (in USD), as specified by various data sources: (i) our transaction-level customs data, aggregated to the monthly level, with imports of physical cash excluded (blue, solid line); (ii) official data from the Russian Statistical Service (red, long-dashed); (iii) data from the WTO (green, short-dashed); and (iv) UN Comtrade mirror data, reported by other countries (yellow, dashed). The gray vertical line indicates the start of the war.

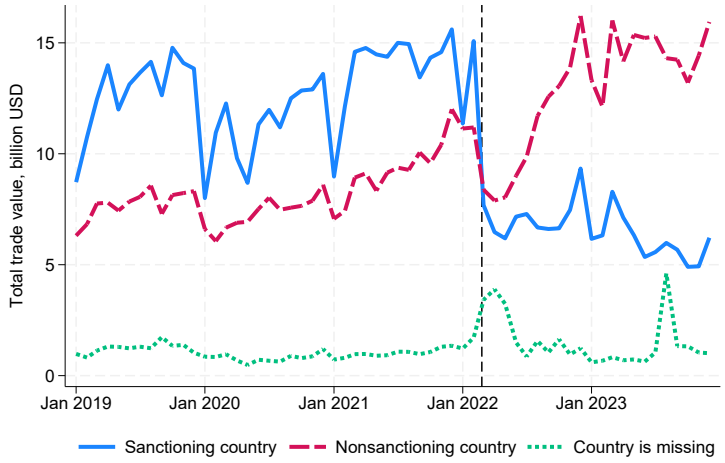
Figure A.2: Sanctioned Volume of Russian Imports: Top-20 Product Categories and Countries



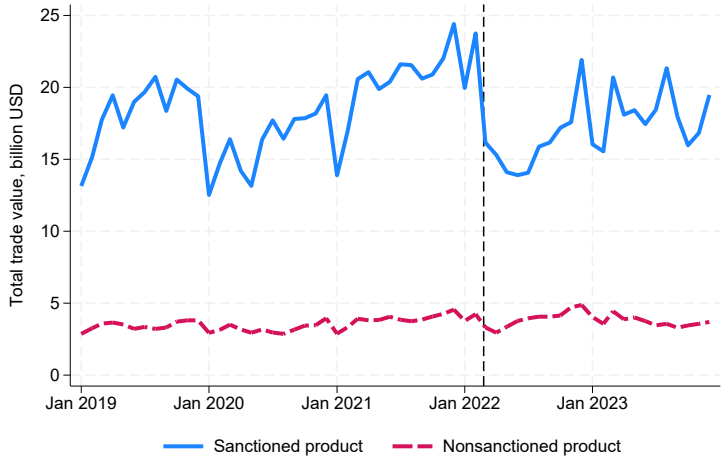
(a) Most Sanctioned Products (% of 2021 Imports) (b) Most Sanctioning Countries (in Bln USD)

Notes: Panel A displays the top-20 sanctioned 2-digit product categories. Each bar shows the share of a category in Russia's total 2021 imports by value, with the first segment (in orange) indicating the portion of the category that was sanctioned. Panel B displays the top-20 countries with the highest value of sanctioned exports to Russia. The total length of each bar represents the size of each country's 2021 exports to Russia (in billion USD), while the first segment (in orange) highlights the sanctioned portion of its export value.

Figure A.3: Dynamics of the Total Value of Russian Imports (2018–2023), by Country and Product Sanction Status



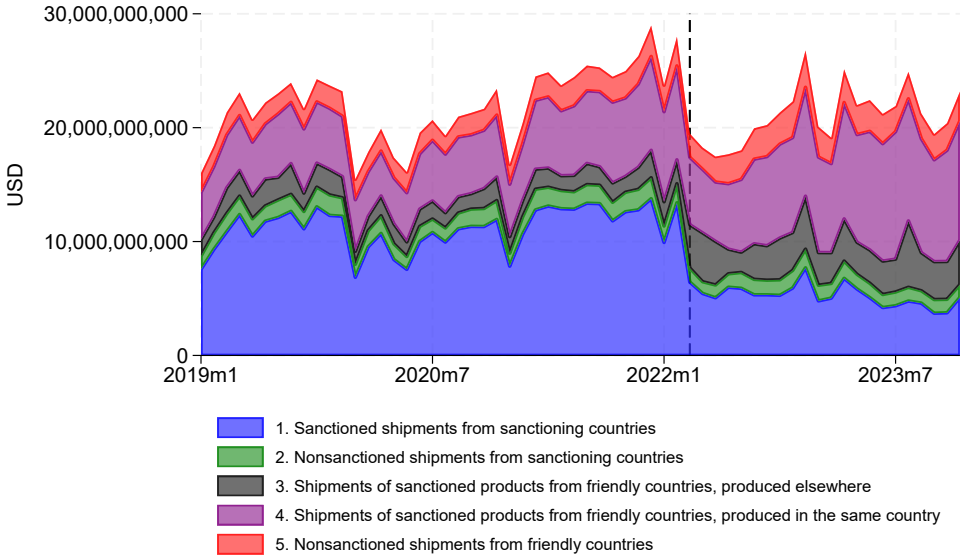
(a) Total Value of Imports: Sanctioning vs. Nonsanctioning Countries



(b) Total Value of Imports: Ever-Sanctioned vs. Never-Sanctioned Products

Notes: This figure displays the evolution of Russia's total import value from January 2019 to December 2023. The gray vertical line indicates the start of the war. In Panel A, the data are broken down by whether the exporting country imposed any sanctions or was missing from the data. In Panel B, the data are broken down by whether the product was sanctioned by any country for export to Russia. The gray vertical line indicates the start of the war.

Figure A.4: Total Import Flows by Type



Notes: This figure displays import value flows by their sanctioned status and categories of country of origin and country of shipment from January 2019 to December 2023. The gray vertical line indicates the start of the war.

Table A.1: Summary Statistics: Russian Imports

	Observations	Mean	SD	Min	Max
Panel A: Country-Product-Quarter Imports					
Number of transactions	7,128,940	19	248	0	101,874
Total value, USD '000	7,128,940	250	5,385	0	4,715,639
Total net weight, tons	7,128,940	70.8	4,588	0	5,477,937
Log total value	7,128,940	3.65	5.09	0	22
Log total weight	7,128,940	2.55	4	0	22
$\mathbb{1}$[Ever sanctioned]	7,128,940	0.28	0.45	0	1
$\mathbb{1}$[Sanctioned at t by c]	7,128,940	0.07	0.24	0	1
$\mathbb{1}$[Critical component]	7,128,940	0.09	0.29	0	1
Panel B: Product-Quarter Imports					
Number of transactions	287,644	470	3,232	0	282,139
Total value, USD '000	287,644	6,200	50,233	0	4,873,493
Total net weight, tons	287,644	1,754	27,164	0	5,477,937
Unit value, USD '000	227,052	146	22,177	0	7,218,129
Log total value	287,644	10.3	5.94	0	22
Log total weight	287,644	8.57	5.45	0	22
$\mathbb{1}$[Ever sanctioned]	287,644	0.60	0.49	0	1
$\mathbb{1}$[Critical component]	287,644	0.04	0.19	0	1

Notes: This table displays the summary statistics for Russian imports. Panel A depicts the summary statistics for country-product quarterly import flows from 2019Q1 through 2023Q4. Panel B depicts the summary statistics for product-level quarterly import flows from 2019Q1 through 2023Q4. Unit value is not defined for quarters with zero imports of a particular product. *Product* refers to ten-digit HS codes, unless they were aggregated due to changes in HS classification, following Pierce and Schott (2012).

Table A.2: Summary Statistics: Russian Firms

	Observations	Mean	SD	Min	Max
Panel A: Accounting Outcomes					
Sales, Rub '000 000	10,597,168	168	7,542	6.0e-06	7,979,027
Costs of Goods Sold, Rub '000 000	10,210,547	140	5,728	0	4,815,225
Gross Profits , Rub '000 000	10,210,547	32.8	3,357	-3,833,100	3,640,459
Capital Costs, Rub '000 000	7,046,326	86.2	12,853	-720	14,596,295
Material Costs, Rub '000 000	2,609,932	405	10,154	0	4,820,694
Labour Costs, Rub '000 000	2,572,321	34.9	1,010	-123,851	536,828
Log of Sales	10,597,168	15.9	2.29	1.8	30
Panel B: Measures of Exposure, Firm Characteristics					
𝟙[Firm Exposed to Export Sanctions]	2,178,204	0.025	0.155	0	1
Firm Exposure to Export Sanctions	2,178,204	0.014	0.105	0	1
𝟙[Buyer Exposed to Export Sanctions]	2,178,204	0.003	0.057	0	1
𝟙[Supplier Exposed to Export Sanctions]	2,178,204	0.007	0.084	0	1
𝟙[Importer]	2,178,204	0.044	0.206	0	1
𝟙[Exporter]	2,178,204	0.023	0.148	0	1
𝟙[Railway Trader]	2,178,204	0.010	0.101	0	1
𝟙[Firm Is Target-Sanctioned]	2,178,204	0.002	0.044	0	1
𝟙[Industry=Manufacturing]	2,178,204	0.098	0.294	0	1
𝟙[Industry=Wholesale]	2,178,204	0.318	0.462	0	1
𝟙[Industry=Transportation]	2,178,204	0.060	0.235	0	1
𝟙[Industry=Science and Technology]	2,178,204	0.091	0.285	0	1
𝟙[Industry=Other]	2,178,204	0.434	0.492	0	1
Panel C: Railway Shipments					
In-Shipments Weight, Tons	146,292	57.4	745	0	56,932
Out-Shipments Weight, Tons	146,292	61.3	855	0	70,587
Total Shipments Weight, Tons	146,292	119	1,330	0	92,236
Num. of Suppliers	146,292	5.69	15.6	0	895
Num. of Buyers	146,292	5.83	33.8	0	1,890
Total Partners	146,292	8.09	43.3	0	2,363

Notes: This table presents summary statistics for Russian firms. Panel A provides summary statistics for firm-level yearly accounting outcomes spanning the years 2017 to 2023. Panel B reports various measures of firms' exposure to export sanctions based on their prewar import flows and firm characteristics. Buyers and suppliers are identified using railway shipment data. Panel C summarizes firms' yearly railway shipments from 2017 to 2023.

Table A.3: Correlation of Sanctioned Product Lists Across Countries

	AU	CA	CH	EU	GB	JP	KR	TW	US
AU: Australia	1								
CA: Canada	0.4490	1							
CH: Switzerland	0.5453	0.3011	1						
EU: European Union	0.1214	0.1517	0.4934	1					
GB: Great Britain	0.1722	0.2072	0.5252	0.8855	1				
JP: Japan	0.3234	0.4139	0.2948	0.5025	0.4915	1			
KR: South Korea	0.2402	0.2607	0.2926	0.4584	0.4555	0.5318	1		
TW: Taiwan	0.1567	0.1791	0.1457	0.1613	0.1619	0.1973	0.3350	1	
US: United States	0.4189	0.4496	0.2787	0.5033	0.5248	0.7522	0.5633	0.1901	1

Notes: This table displays pairwise correlations between the sets of 10-digit HS product codes that contain products eventually sanctioned by different countries. Each correlation coefficient is calculated based on the correlation between two binary variables, where each variable indicates whether a specific 10-digit HS product code was sanctioned by a particular country or bloc. These variables are defined over the universe of 10-digit codes imported by Russia in 2021.

B Case Studies: Semiconductors and Critical Components.

This appendix illustrates how our granular data allow us to track import flows of specific product categories along the various routes through which goods enter Russia, while highlighting the limitations of such descriptive trade patterns. We focus on two categories of particular relevance to wartime production: semiconductors and critical components.

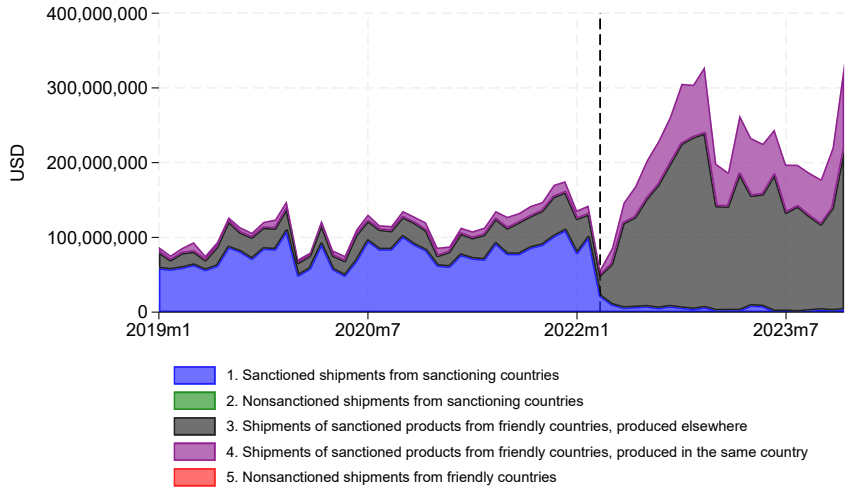
Figure B.1a examines import flows of semiconductors and related products (HS codes starting with 8541 and 8542), disaggregated by route type. Following the invasion, imports of sanctioned semiconductors from sanctioning countries (blue area) collapsed to nearly zero. In contrast, imports shipped from nonsanctioning countries surged, eventually pushing total semiconductor imports to roughly twice their 2021 level. For most of these flows, the country of origin differed from the country of shipment (grey area), consistent with rerouting through third countries. A meaningful share, however, originated and was shipped from the same nonsanctioning country (purple area), indicating direct substitution in production.

Figure B.1b extends the analysis to a broader list of "critical components" directly used in weapons production.[1] Here too, imports from sanctioning countries fell sharply. But compared to semiconductors, rerouting and substitution patterns appear more modest. Imports of critical components produced and shipped from the same friendly country remained stable across the war period, while rerouted flows increased only gradually. However, despite the growth in these alternative supply routes, the total value of critical component imports remained somewhat lower than in 2021, in stark contrast to the trends observed for semiconductors.

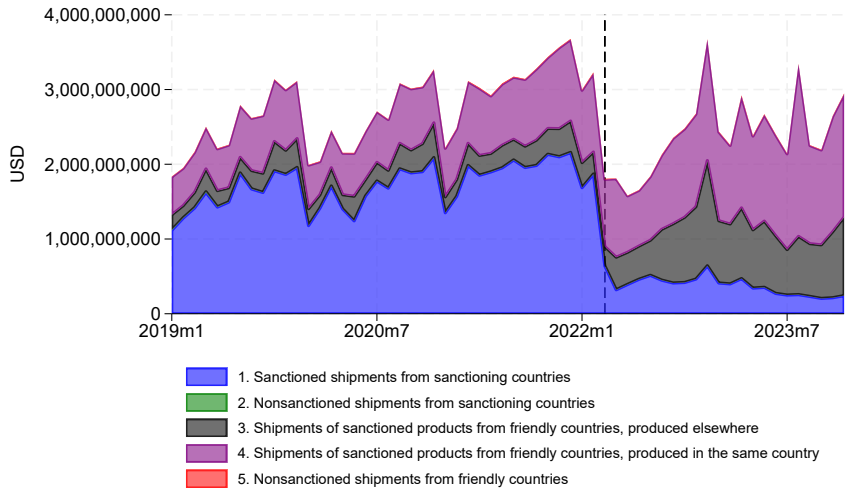
Together, these patterns highlight the granularity of our data and underscore two key points. First, Russia's access to high-tech and war-related imports in the post-sanctions period varied significantly across product categories, reflecting differences in demand, supply availability, and rerouting feasibility. Second, descriptive trends alone can be misleading, as they may confound the impact of export sanctions with changes in underlying demand—especially for goods with heightened wartime importance, such as semiconductors. Our econometric approach, presented in the main text, is thus key to separating these confounding factors and isolating the causal effects of export sanctions.

[1] The list is drawn from two lists, "Components in Weapons" and "Instruments of War," categorized in the Main Directorate of Intelligence of Ukraine (2025). These items were either recovered from the battlefield or identified by investigators as machinery used in weapons production. The associated product descriptions and models were then matched to the closest 6-digit HS codes manually and with the help of GPT-4o.

Figure B.1: Case Studies: Imports of Semiconductors and Critical Components, by Route Type



(a) Imports of Semiconductors



(b) Imports of Critical Components

Notes: This figure displays imported value flows of products by their sanctioned status and categories of country of origin and country of shipment from January 2019 to December 2023. The gray vertical line indicates the start of the war. In Panel A, the sample is restricted to semiconductors or related products, identified by HS codes starting with 8541 and 8542. In Panel B, the sample is restricted to the HS10 list of critical components drawn from two lists, "Components in Weapons" and "Instruments of War," classified in the Main Directorate of Intelligence of Ukraine (2025), matched to the closest 6-digit HS code manually and with the help of GPT-4o.

C Impact on Trade: Robustness and Additional Results

C.1 Robustness Checks

This appendix discusses in greater detail the robustness checks for the impact of sanctions on the sanctioned imports introduced in Section 5.

First, we re-estimate our baseline first stage (Figure 2) on the full sample, now including imports of sanctioned products from friendly countries that were excluded in the baseline to prevent contamination of the control group. Figure C.1 shows the results. Consistent with rerouting and substitution now biasing the baseline coefficients away from zero, the estimated declines are now somewhat larger, raising the average drop from 55% to 62% in the pre-post design. Nevertheless, the overall patterns remain similar.

Second, we replicate all estimates in Section 5 using import weight as the outcome instead of import value. Figures C.2–C.5 present the corresponding analogs for Figures 2–5. The estimates remain both qualitatively and quantitatively similar, confirming that the observed declines reflect changes in import volumes rather than price effects.

Third, we address the concern that our definition of countries friendly to the Russian regime may be too narrow and may miss certain countries that may be important for exports of sanctioned products following the war's onset. As such, we repeat our analysis in Sections 5.1 and 5.2 extending the list of friendly countries to include all BRICS members. Specifically, we add Brazil, Egypt, Ethiopia, India, Indonesia, Iran, and South Africa to the list. Figure C.6 repeats the analysis in Figures 2a and 3a with the expanded list of friendly countries and shows that the results remain largely unchanged, with estimates of similar magnitude.

Fourth, we address the concern that not including certain countries in our sanctions dataset may bias our baseline estimates. Table C.4 shows that this is not the case. Columns (1)–(2) exclude all imports from Ukraine; columns (3)–(4) classify Norway as a sanctioning country applying EU-equivalent measures; columns (5)–(6) exclude imports of sanctioned products from countries that Russia officially designates as "unfriendly" but for which we do not have official sanctions data; and columns (7)–(8) exclude all imports from these countries entirely.[1] Consistent with the imports from these countries being small, these sample changes do not materially change our estimates.

[1] Sanctions data are unavailable for the following countries that Russia officially considers unfriendly (Government of the Russian Federation, 2022): Albania, Andorra, Anguilla, Bahamas, Bermuda, British Indian Ocean Territory, British Virgin Islands, Cayman Islands, Falkland Islands, Gibraltar, Guernsey, Iceland, Isle of Man, Jersey, Liechtenstein, Monaco, Montenegro, New Zealand, North Macedonia, Norway, Pitcairn Islands, San Marino, Singapore, Turks and Caicos Islands, and the U.S. Virgin Islands. (We treat Ukraine separately, as Russia-Ukraine trade has been nearly eliminated after the 2022 invasion irrespective of product type.) Before the war, these countries accounted for only 0.78% of Russian total imports and 0.75% of imports of ever-sanctioned products (both in value).

Fifth, we verify that our baseline results are not sensitive to the transformation of the outcome variable. In our main specification, we apply a log-plus-one transformation to retain country-product-quarter cells with zero trade while ensuring computational feasibility. Columns (2)–(3) of Table C.5 show that the country-product-level estimates remain large and negative when using a simple logarithm transformation that omits zero trade flows: column (2), for instance, implies a 34% reduction in sanctioned imports ($= \exp^{-0.413} - 1$), which is comparable to our baseline estimate of 55%. Column (1) further shows a large effect at the extensive margin, with the likelihood of observing positive imports of a sanctioned variety in a given quarter falling by 5.9 percentage points. Columns (4)–(6) repeat this extensive-intensive margin decomposition for product-level imports (Table 1), again yielding negative and economically sizable estimates throughout.

Sixth, we examine whether our country-product staggered DiD results are driven primarily by the first cohort of sanctioned varieties, which coincided with the outbreak of the war. If true, this would limit the ability of the staggered design to address the possibility of complex confounding war-related shocks. However, as shown in columns (3)–(4) of Table C.2, excluding the first cohort leaves our estimates largely unchanged—and if anything, the magnitude of the effect increases.

Seventh, we address possible violations of the no-anticipation assumption in the country-product staggered design. While Figure 2a documents flat pretrends prior to the war—supporting this assumption for early sanctions—subsequent cohorts and sanction waves may have been at least partially anticipated. To correct for this, we augment Equation (2), where for each treated flow we add additional cohort-specific coefficients for each period after February 2022 and before the month when sanctions take effect.[2] This ensures that the omitted category consists only of prewar months (and specifically excludes months where sanctions could have been anticipated) for all treated flows. Table C.2, columns (5)–(6), shows that the results remain robust. Aggregated to a single average, the dynamic effects of sanctions in column (5) boil down to a 61% reduction in sanctioned trade flows ($= \exp^{-0.946} - 1$), which is nearly identical to our baseline estimate of 59%.

C.2 Replicating Main Results Using UN Comtrade Data

Our baseline estimates rely on Russian customs data. This dataset has several key advantages: its granularity allows analysis at the ten-digit product-code level, helping us residualize highly specific shocks to a product's demand or supply, and at the firm-product level, helping us account

[2] Specifically, we estimate

$$y_{gct} = \sum_{e} \sum_{t^* < s < e} \alpha_{es} \mathbb{1}(E_{gc} = e) \times \mathbb{1}(t = s) + \sum_{e} \sum_{s \geq e} \beta_{es} \mathbb{1}(E_{gc} = e) \times \mathbb{1}(t = s) + \tau_{gc} + \eta_{gt} + \omega_{ct} + \zeta_{gct} \quad \text{(C1)}$$

where t^* denotes February 2022 and $\{\alpha_{es}\}$ is the set of additional coefficients.

for possible omitted firm-specific shocks (see Appendix Section C.3). Its detailed variables also allow us to distinguish between the country of shipment and the country of production, and to analyze shipment weight in addition to shipment value. A limitation, however, is the incomplete coverage of trade flows with some members of the Eurasian Economic Union (EAEU), such as Belarus and Kazakhstan. Given the role of these countries in rerouting sanctioned shipments, one might be concerned that our results are significantly biased by this omission.

To address this concern, we turn to UN Comtrade data. Although more aggregated—available only at the HS6 level—and with vastly incomplete reporting of shipment weights, UN Comtrade includes trade flows within the EAEU. Russia ceased reporting to UN Comtrade after the invasion; we therefore use mirror export data, as reported by exporting countries to Russia. We process these data by converting HS6 codes into synthetic product codes, following Pierce and Schott (2012), to account for the 2022 HS classification changes, and we merge them with our sanctions dataset, treating a synthetic "six-digit" product code as sanctioned whenever at least one of its constituent HS10 codes is sanctioned by any country. We then reestimate our baseline specifications in Equations (1) and (4) using these mirror export data to assess whether our main results are replicated.[3]

Figures C.8 and C.9 present the UN-Comtrade-based analogs of Figures 2a and 5a, respectively. Both the country–product-level and product-level estimates are fully replicated. If anything, the magnitudes of the updated estimates are slightly larger than in the main figures, corresponding to roughly 86% ($\exp^{-2}-1$) and 39% ($\exp^{-0.5}-1$) declines in sanctioned country-product and product-level imports by 2023Q4, respectively. Overall, these results indicate that our main trade-related findings—the negative impact on imports of sanctioned products despite substantial rerouting—are not driven by the absence of within-EAEU flows in the Russian customs data. Moreover, since the UN Comtrade data are available only at the HS6 level, the results further indicate that potential within-HS6 spillovers, such as relabeling toward nearby lower-digit product categories, do not materially bias our estimates.

C.3 Impact on Firm-Level Imports of Sanctioned Products

Before estimating the pass-through of export sanctions onto Russian firms, one may want to assess whether these sanctions negatively affected *firm-level* imports. This exercise serves two key purposes. First, it establishes a firm-level first stage, crucial for interpreting the firm-level regressions. Second, it provides an additional robustness check by incorporating firm-time fixed effects, thereby addressing concerns that export sanctions may have coincided with other industry-specific shocks affecting firms that import certain types of products.

[3]The only other necessary modification to Equation (4) is that, given the higher level of aggregation in the UN Comtrade data, we include HS1–quarter (rather than HS3–quarter) fixed effects.

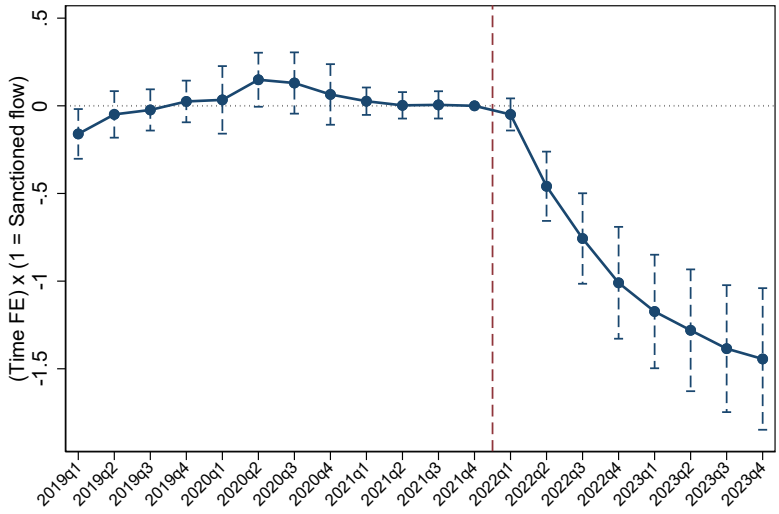
We estimate the impact of export sanctions on firms' imports via the following DiD equation:

$$y_{fgt} = \theta_t \, ImportedSanctioned_{fg(c)} + \tau_{fg} + \eta_{gt} + \omega_{ft} + \zeta_{fgt} \tag{C2}$$

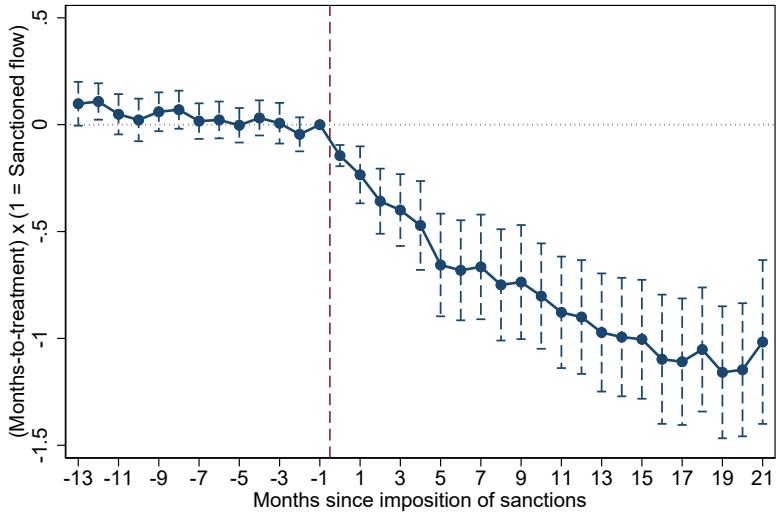
where y_{fgt} represents the total (log-)imports of product g by a Russian firm f in quarter t, measured either by total value or by total weight shipped; $ImportedSanctioned_{fg(c)}$ is an indicator that equals 1 if, before the war, a firm f imported product g from a country c that later imposed sanctions on its exports of that product to Russia. The specification includes firm-product fixed effects (τ_{fg}), product-quarter fixed effects (η_{gt}), and firm-quarter fixed effects (ω_{ft}), with the latter accounting for any firm-level shocks that may influence its imports independent of the product type. The standard errors are clustered at the product-firm level.

Figure C.10 presents the results. Following the war's onset, the firm's total imports of products where at least some of the firm-product flow came from country-product varieties that were later sanctioned decreased by 10%–15% in value and 5%–10% in weight relative to other firm-product import flows. These estimates suggest that exposed firms were unable to fully compensate for the increased difficulty of importing sanctioned products. As a result, we may indeed expect export sanctions to have a nonnegligible pass-through effect on domestic production.

Figure C.1: The Impact of Export Sanctions on Sanctioned Country-Product Imports, Full Sample



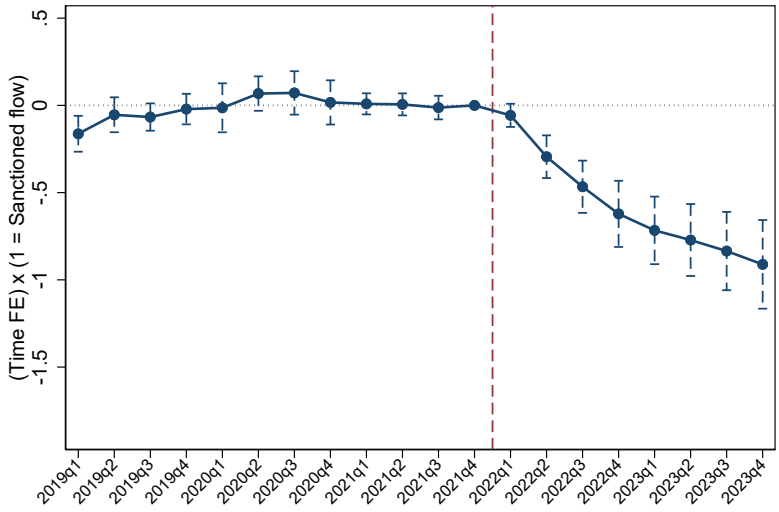
(a) Pre-Post DiD



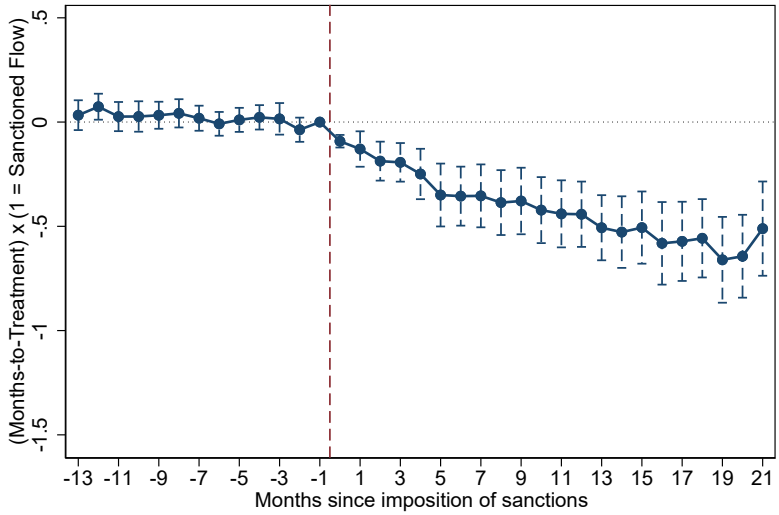
(b) Staggered DiD

Notes: This figure replicates Figure 2 on the full sample, including imports of sanctioned products from friendly countries. Panel A reports dynamic pre-post DiD estimates from Equation (1), comparing the value of sanctioned country-product imports to nonsanctioned imports before and after the start of the war. Panel B reports dynamic staggered DiD estimates from Equation (2), comparing sanctioned to nonsanctioned country-product imports (in value) before and after export sanctions are imposed on a given variety. Panel A uses quarterly data, with 2021Q4 as the omitted period. Panel B uses monthly data, and the estimates are aggregated across cohorts by event time. The red vertical line in Panel A marks the start of the war; in Panel B, it marks the imposition of export sanctions on a given country-product variety. The logarithms add 1 to the argument's value to avoid missing values. The bars represent 95% confidence intervals. Standard errors are clustered two-way by country and product. Panel A includes 5,076,220 observations across 9,486 products and 214 countries. Panel B includes 10,132,992 observations across 8,930 products and 197 countries.

Figure C.2: The Impact of Export Sanctions on Sanctioned Country-Product Imports, in Weight



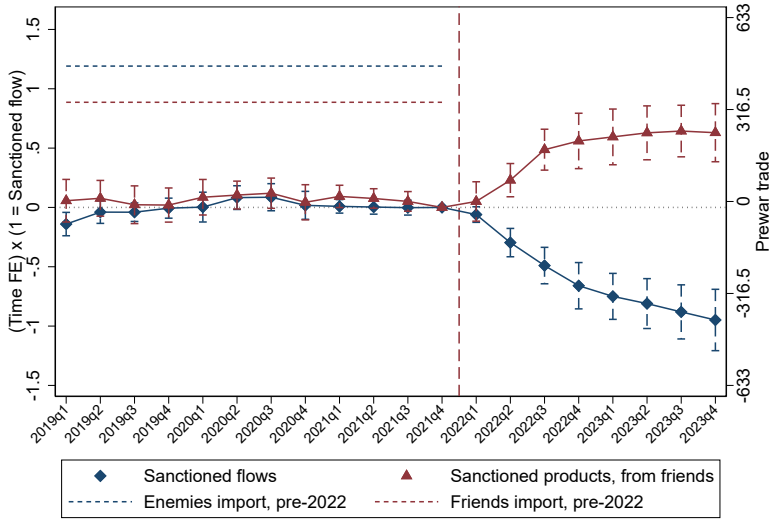
(a) Pre-Post DiD



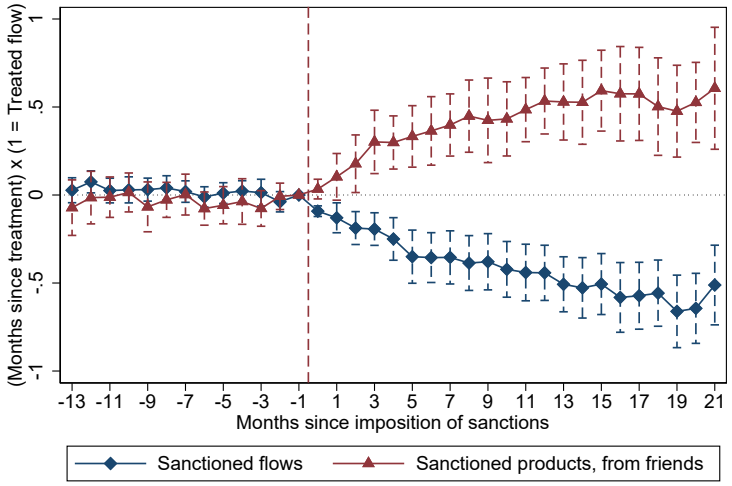
(b) Staggered DiD

Notes: Panel A reports dynamic pre-post DiD estimates from Equation (1), comparing the weight of sanctioned countryproduct imports to nonsanctioned imports before and after the start of the war. Panel B reports dynamic staggered DiD estimates from Equation (2), comparing sanctioned to nonsanctioned country-product imports (in weight) before and after export sanctions are imposed on a given variety. In both panels, imports of sanctioned products from friendly countries are excluded from the sample. Panel A uses quarterly data, with 2021Q4 as the omitted period. Panel B uses monthly data, and the estimates are aggregated across cohorts by event time. The red vertical line in Panel A marks the start of the war; in Panel B, it marks the imposition of export sanctions on a given country-product variety. The logarithms add 1 to the argument's value to avoid missing values. The bars represent 95% confidence intervals. Standard errors are clustered two-way by country and product. Panel A includes 4,592,360 observations across 9,418 products and 214 countries. Panel B includes 9,043,824 observations across 8,803 products and 197 countries. For the value-based analogue, see Figure 2.

Figure C.3: Jointly Identifying Rerouting and Substitution via Friendly Countries, in Weight



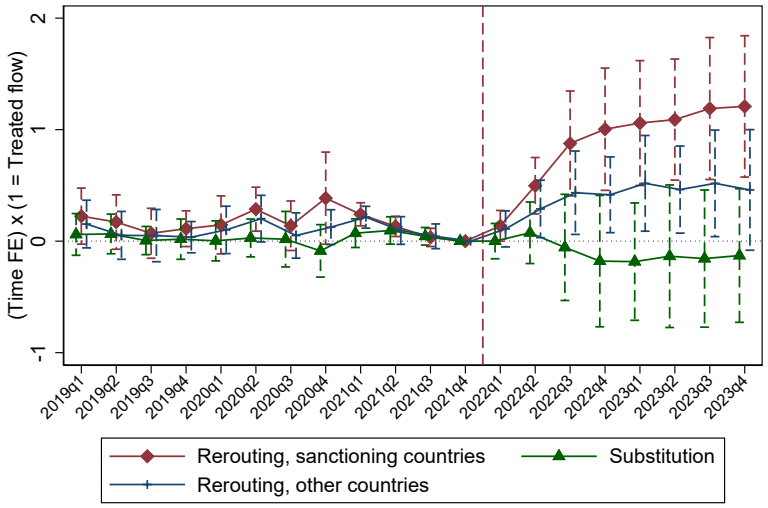
(a) Pre-Post DiD



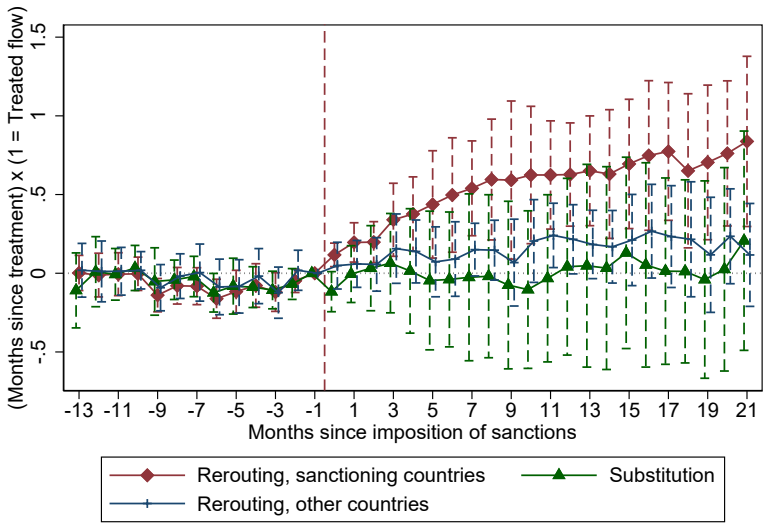
(b) Staggered DiD

Notes: This figure documents the presence of rerouting and substitution. Panel A presents the estimates of Equation (3), comparing the weight of sanctioned and nonsanctioned country-product imports, before and after the war's onset, while isolating imports of ever-sanctioned products from the "friendly" countries. *Friendly* countries are those that remained relatively aligned with Russia after the invasion (Armenia, Belarus, China, Georgia, Hong Kong, Kazakhstan, Kyrgyzstan, Serbia, Turkey, and the UAE). *Enemy* countries include all nations that ever imposed trade sanctions on Russia. Panel B reports staggered DiD estimates that combine results from two separate regressions: one measuring the impact of export sanctions on direct sanctioned flows (blue), and the other measuring the impact on imports of sanctioned products from friendly countries (red). In each specification, only one treated group is included, and nonsanctioned imports from neutral third countries are always the control group. Panel A uses quarterly data, with 2021Q4 as the omitted period; Panel B uses monthly data, and the estimates are aggregated across cohorts by event time. The red vertical line in Panel A marks the start of the war; in Panel B, it marks the first sanction imposition for the relevant treated group. The logarithms add 1 to the argument's value to avoid missing values. The short-dashed lines in Panel A plotted on a secondary (right-hand) axis represent the total volume of prewar trade with friendly and enemy countries. The bars represent 95% confidence intervals. Standard errors are clustered two-way by country and product. Panel A includes 5,076,220 observations across 9,486 products and 214 countries. Panel B includes 9,256,464 observations across 8,838 products and 197 countries. For the value-based analogue, see Figure 3.

Figure C.4: Decomposing Substitution and Rerouting via Friendly Countries, in Weight



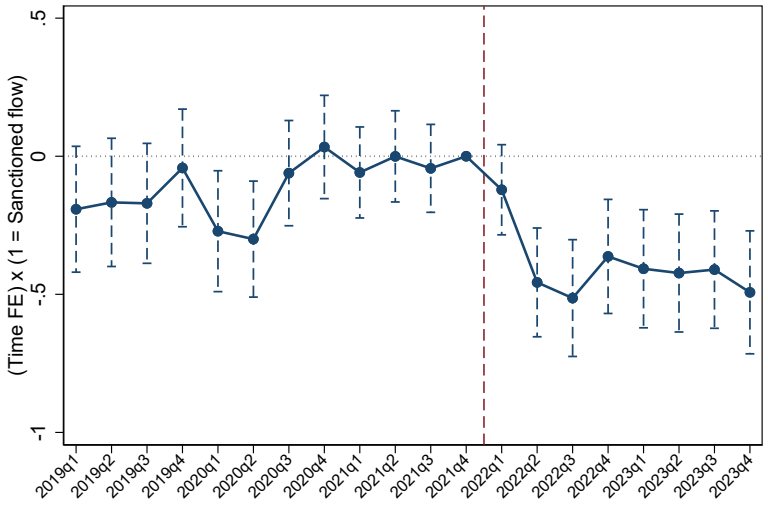
(a) Pre-Post DiD



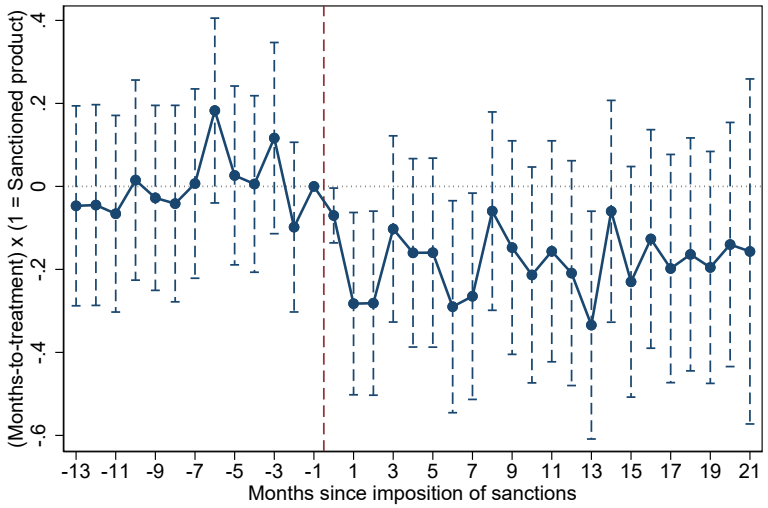
(b) Staggered DiD

Notes: This figure disentangles rerouting and substitution. We separate each import flow of the sanctioned products shipped from friendly countries into three flows: those produced within the same friendly country (*in green*), those produced in sanctioning countries (*in red*), and those produced elsewhere (*in blue*). The impact of export sanctions is then estimated on each of these flow's weight, with the nonsanctioned imports from third countries serving as a control group. Directly sanctioned flows from sanctioning countries are excluded from the estimation sample. *Friendly countries* are defined as Armenia, Belarus, China, Georgia, Hong Kong, Kazakhstan, Kyrgyzstan, Serbia, Turkey, and the UAE. Panel A uses a pre-post DiD design; Panel B employs a staggered DiD design. Panel A uses quarterly data, with 2021Q4 as the omitted period; Panel B uses monthly data, and the estimates are aggregated across cohorts by event time. The red vertical line in Panel A marks the start of the war; in Panel B, it marks the first sanction imposition on a given product. The logarithms add 1 to the argument's value to avoid missing values. The bars represent 95% confidence intervals. Standard errors are clustered two-way by country and product. Panel A includes 3,669,220 observations across 8,770 products and 205 countries; Panel B includes 5,479,812 observations across 8,232 products and 185 countries. For the value-based analogue, see Figure 4.

Figure C.5: The Impact of Export Controls on Russian Imports of Sanctioned Products, in Weight



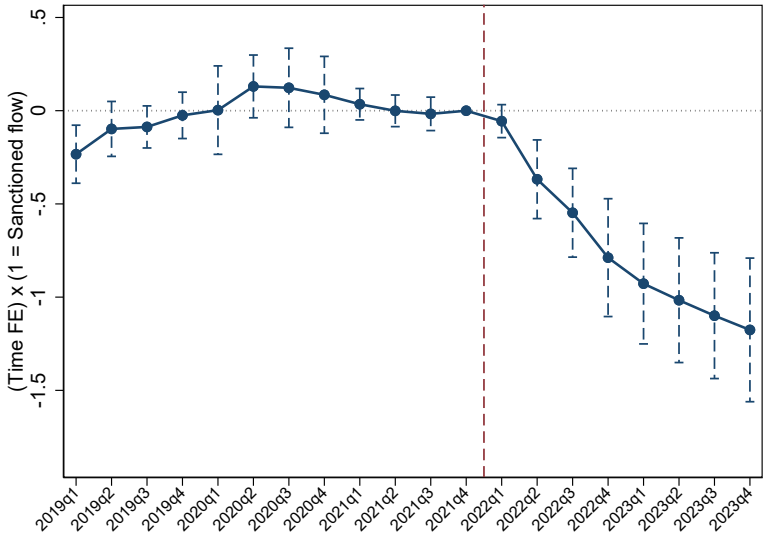
(a) Pre-Post DiD



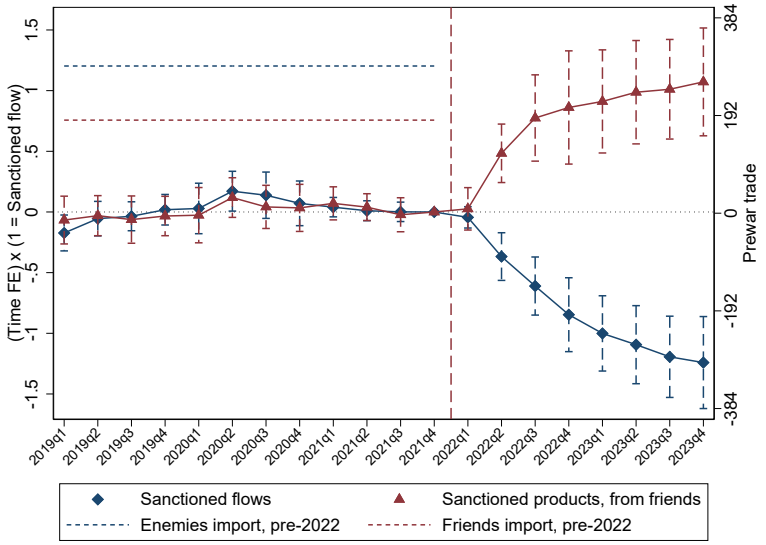
(b) Staggered DiD

Notes: This figure assesses the impact of sanctions on the total imports of sanctioned products, independent of the identity of countries-importers. Panel A presents the dynamic pre-post DiD estimates from Equation (4), which compares the weight of sanctioned and nonsanctioned product imports before and after the war's onset. Panel B displays the dynamic staggered DiD estimates from Equation (5) comparing the import weight for sanctioned products to that of nonsanctioned products before and after the imposition of first sanctions on the former. Panel A uses quarterly data, with 2021Q4 as the omitted period; Panel B uses monthly data, and the estimates are aggregated across cohorts by event time. The red vertical line in Panel A marks the start of the war; in Panel B, it marks the first sanction imposition on a given product. Regressions include HS3-product-time fixed effects. The logarithms add 1 to the argument's value to avoid missing values. The bars represent 95% confidence intervals. Standard errors are clustered at the product level. Panel A includes 205,400 observations across 10,270; Panel B includes 465,600 observations across 9,700 products. For the value-based analogue, see Figure 5.

Figure C.6: Export Sanctions and Russian Imports of Sanctioned Country-Product Varieties: Including BRICS in the List of Friendly Countries



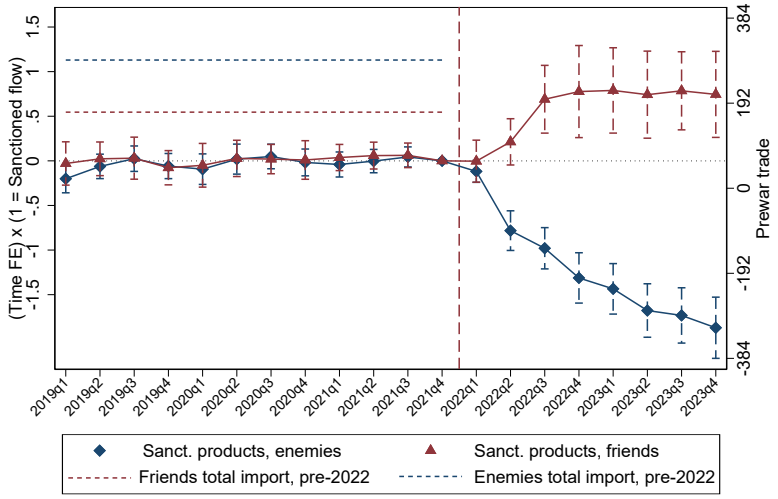
(a) First Stage



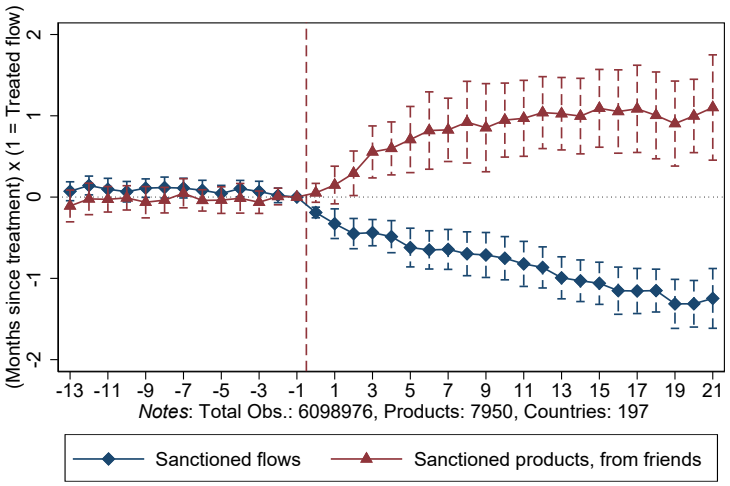
(b) Rerouting and Substitution

Notes: This figure assesses the robustness of our baseline trade results to expanding the list of "friendly" countries to include BRICS members. In Panel A, the sample excludes imports of sanctioned products from both "friendly" and BRICS countries. In Panel B, we re-estimate Equation (3), distinguishing imports of ever-sanctioned products from "friendly" and BRICS countries. "Friendly" countries are Armenia, Belarus, China, Georgia, Hong Kong, Kazakhstan, Kyrgyzstan, Serbia, Turkey, and the UAE; the BRICS set augments this list with Brazil, Egypt, Ethiopia, India, Indonesia, Iran, South Africa. Both panels use quarterly data with 2021Q4 as the omitted period. The red vertical line marks the start of the war. The logarithms add 1 to the argument's value to avoid missing values. In Panel B, the short-dashed lines plotted on a secondary (right-hand) axis represent the total prewar trade volumes with friendly/BRICS and sanctioning countries. The bars represent 95% confidence intervals. Standard errors are clustered two-way by country and product. Panel A includes 4,417,540 observations across 9,401 products and 214 countries. Panel B includes 5,076,220 observations across 9,486 products and 214 countries.

Figure C.7: Jointly Identifying Rerouting and Substitution: Accounting for Imports of Sanctioned Products from Sanctioning Countries that Did Not Explicitly Sanction Them



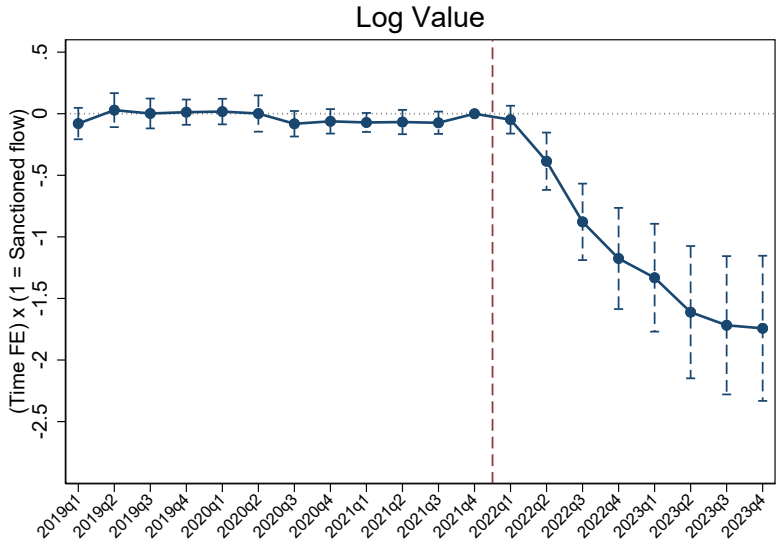
(a) Pre-Post DiD



(b) Staggered DiD

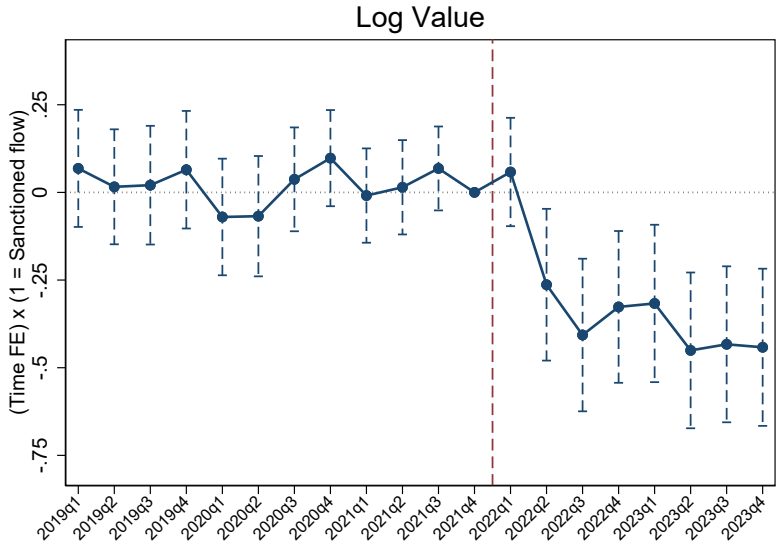
Notes: This figure presents a robustness check for the joint rerouting and substitution estimates, dropping from the sample the imports of sanctioned products from those sanctioning countries that never sanctioned them. Panel A presents the estimates of an extended version of Equation (3). This specification compares the value of sanctioned and nonsanctioned country-product imports, before and after the war's onset, while isolating imports of ever-sanctioned products from the "friendly" countries and imports of the same products from those sanctioning countries that never sanctioned them. *Friendly* countries are those that remained relatively aligned with Russia after the invasion (Armenia, Belarus, China, Georgia, Hong Kong, Kazakhstan, Kyrgyzstan, Serbia, Turkey, and the UAE). *Enemy* countries include all nations that ever imposed trade sanctions on Russia. Panel B reports staggered DiD estimates that combine results from several separate regressions: those measuring the impact of export sanctions on direct sanctioned flows (blue), and on imports of sanctioned products from friendly countries (red), and on imports of the same products from those sanctioning countries that never sanctioned them (not shown). Panel A uses quarterly data, with 2021Q4 as the omitted period; Panel B uses monthly data, and the estimates are aggregated across cohorts by event time. The red vertical line in Panel A marks the start of the war; in Panel B, it marks the first sanction imposition for the relevant treated group. The logarithms add 1 to the argument's value to avoid missing values. The short-dashed lines in Panel A plotted on a secondary (right-hand) axis represent the total volume of prewar trade for each treated group. The bars represent 95% confidence intervals. Standard errors are clustered two-way by country and product. Panel A includes 5,076,220 observations across 9,486 products and 214 countries. Panel B includes 9,256,464 observations across 8,838 products and 197 countries.

Figure C.8: The Impact on Sanctioned Country-Product Imports, UN Comtrade



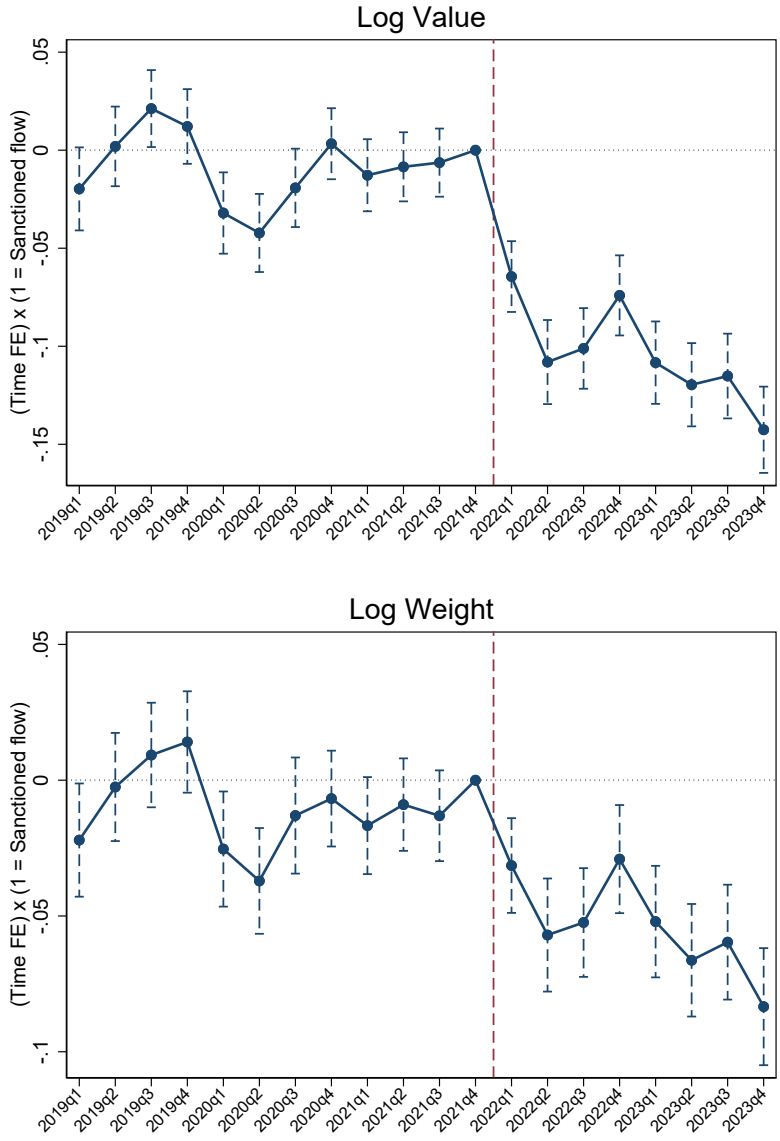
Notes: This figure assesses the impact of sanctions on the imports of sanctioned country-product varieties, using mirror export data from UN Comtrade instead of the Russian customs data. It presents the dynamic DiD estimates of Equation (1), comparing the volume of sanctioned country-product imports to that of nonsanctioned imports before and after the war's onset. Here, *Products* refers to *six*-digit HS codes (the lowest level of aggregation in the UN Comtrade data) unless they were aggregated due to changes in HS classification, following Pierce and Schott (2012). Imports of sanctioned products from friendly countries are excluded from the sample. The data are aggregated quarterly, with 2021Q4 serving as the baseline period. The red vertical line indicates the start of the war. This figure uses the total import value of a given product in a given quarter as an outcome; a net-weight counterpart is omitted due to reporting inconsistencies in the UN Comtrade data. The logarithms add 1 to the argument's value to avoid missing values. The bars represent 95% confidence intervals. Standard errors are clustered two-way by country and product. Total observations 2,973,780; products: 5,286; countries: 139.

Figure C.9: The Impact on Russian Imports of Sanctioned Products, UN Comtrade



Notes: This figure assesses the impact of sanctions on the total imports of sanctioned products, using mirror export data from UN Comtrade instead of the Russian customs data. Specifically, it presents the dynamic DiD estimates of Equation (4), comparing the volume of sanctioned product imports to that of nonsanctioned imports before and after the war's onset. Here, *Products* refers to *six*-digit HS codes (the lowest level of aggregation in the UN Comtrade data) unless they were aggregated due to changes in HS classification, following Pierce and Schott (2012). The regression accounts for HS1-quarter fixed effects. The data are aggregated at the quarterly level, with 2021Q4 serving as the baseline period. The red vertical line indicates the start of the war. This figure uses the total import value of a given product in a given quarter as an outcome; a net-weight counterpart is omitted due to reporting inconsistencies in the UN Comtrade data. The logarithms add 1 to the argument's value to avoid missing values. The bars represent 95% confidence intervals. Standard errors are clustered at the product level. Total observations 108,920; products: 5,446.

Figure C.10: The Impact on Russian Firm-Level Imports of Sanctioned Products



Notes: This figure assesses the impact of sanctions on the imports of exposed products for each specific firm. Specifically, it displays the estimates comparing the import volume for exposed firm-products to that of nonexposed firm-products before and after the first quarter of 2022. Exposed firm-products are those later-sanctioned ten-digit HS codes that a firm imported from a sanctioning country at least once prior to 2022. An HS code that was always imported from a nonsanctioning country is not exposed. This specification controls for any firm-level shocks that take place at the same time as the sanctions; it also controls for product-by-time fixed effects. The data are at the quarterly level. The red vertical line indicates the start of the war. The top (bottom) panel uses the total import value (net weight) of a given product in a given quarter as an outcome. The logarithms add 1 to the argument's value to avoid missing values. The bars represent 95% confidence intervals. Standard errors are clustered at the product-by-firm level. Total observations: 10,489,566; firms: 69,185; products: 7,917.

Table C.1: The Impact on Russian Imports of Sanctioned Country-Product Varieties

	(1) Log Total Value	(2) Log Total Weight	(3) Log Total Value	(4) Log Total Weight	(5) Log Total Value	(6) Log Total Weight	(7) Log Total Value	(8) Log Total Weight
Post-War × Sanctioned Flow	-2.155***	-1.551***	-1.833***	-1.249***	-0.765***	-0.546***	-0.802***	-0.571***
	(0.164)	(0.116)	(0.328)	(0.229)	(0.083)	(0.066)	(0.123)	(0.080)
Product-Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Product-Quarter FE			✓	✓			✓	✓
Country-Quarter FE					✓	✓	✓	✓
Mean Dep. Var.	3.45	2.37	3.45	2.37	3.45	2.37	3.45	2.37
SD Dep. Ver.	4.97	3.86	4.97	3.86	4.97	3.86	4.97	3.86
R^2	0.64	0.66	0.67	0.70	0.66	0.68	0.69	0.71
Observations	4,609,600	4,609,600	4,592,500	4,592,500	4,609,460	4,609,460	4,592,360	4,592,360
Number of Countries	221	221	221	221	214	214	214	214
Number of Products	10,273	10,273	9,418	9,418	10,273	10,273	9,418	9,418

Notes: This table presents the estimates of Equation (1) studying whether imports into Russia at the country-product-quarter level declined following the onset of Russia's 2022 invasion of Ukraine, depending on whether that product-country variety was later sanctioned. We exclude all ever-sanctioned flows originating from friendly countries, so while these products are sanctioned, the corresponding trade flows themselves are not. The outcome variable in the odd-numbered columns is the log of total value imported, while in the even-numbered columns, it is the log of total weight imported. The logarithms add 1 to the argument's value to avoid missing values. The time span is from 2019Q1 through 2023Q4. *Product* refers to ten-digit HS codes, unless they were aggregated due to changes in HS classification, following Pierce and Schott (2012). Standard errors in parentheses are two-way clustered at the country and product levels. * p<0.1, ** p<0.05, *** p<0.01.

Table C.2: The Impact on Russian Imports of Sanctioned Country-Product Varieties or Sanctioned Products, Staggered Design

	(1) Log Total Value	(2) Log Total Weight	(3) Log Total Value	(4) Log Total Weight	(5) Log Total Value	(6) Log Total Weight	(7) Log Total Value	(8) Log Total Weight
Post-Treatment × Treated Flow	-0.895***	-0.571***	-1.057***	-0.802***	-0.946***	-0.617***	-0.196**	-0.182*
	(0.134)	(0.093)	(0.102)	(0.102)	(0.139)	(0.092)	(0.078)	(0.094)
Product-Country FE	✓	✓	✓	✓	✓	✓		
Product-Month FE	✓	✓	✓	✓	✓	✓		
Country-Month FE	✓	✓	✓	✓	✓	✓		
No First Cohort			✓	✓				
Anticipation Allowed					✓	✓		
Product FE							✓	✓
3-Digit Product-Month FE							✓	✓
Observations	9,043,824	9,043,824	7,099,152	7,099,152	6,782,868	6,782,868	465,600	465,600
Number of Products	8,803	8,803	8,344	8,344	8,803	8,803	9,700	9,700
Number of Countries	197	197	197	197	197	197	—	—

Notes: This table examines the effect of sanctions on imports of sanctioned country-product varieties (columns 1–6), as well as the effect of sanctions on the imports of sanctioned products from any country (columns 7 and 8). In the Country-Product specifications, we exclude all ever-sanctioned flows originating from friendly countries, so while these products are sanctioned, the corresponding trade flows themselves are not. Specifically, the first two columns present the estimates of Equation (2), and the last two columns present the estimates of the corresponding product-level equation. Columns (3) and (4) estimate Equation (2) without the first cohort, and columns (5) and (6) estimate the more conservative Equation (C1) from footnote 2, where sanctions are allowed to be anticipated after February 2022. All estimates are aggregated across cohorts and months into a single nondynamic average coefficient. For the last two columns, the first date of imposed sanctions is used as the treatment date for a product. The outcome variable in the odd-numbered columns is the log of total value imported, while in the even-numbered columns, it is the log of total weight imported. The logarithms add 1 to the argument's value to avoid missing values. *Product* refers to ten-digit HS codes, unless they were aggregated due to changes in HS classification, following Pierce and Schott (2012). Standard errors in parentheses are two-way clustered at the country and product levels. * p<0.1, ** p<0.05, *** p<0.01.

Table C.3: The Impact on Russian Imports of Sanctioned Country-Product Varieties, Jointly Identifying Rerouting and Substitution via Friendly Countries

	(1) Log Total Value	(2) Log Total Weight	(3) Log Total Value	(4) Log Total Weight	(5) Log Total Value	(6) Log Total Weight	(7) Log Total Value	(8) Log Total Weight
Post-War × Sanctioned Flow	-2.155***	-1.551***	-1.796***	-1.240***	-0.765***	-0.546***	-0.841***	-0.610***
	(0.164)	(0.116)	(0.312)	(0.219)	(0.083)	(0.066)	(0.120)	(0.082)
Post-War × Sanctioned Product × × Friendly Country	1.767***	1.023***	2.258***	1.410***	0.927***	0.516***	0.867***	0.416***
	(0.358)	(0.237)	(0.443)	(0.291)	(0.124)	(0.050)	(0.154)	(0.066)
Product-Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Product-Quarter FE			✓	✓			✓	✓
Country-Quarter FE					✓	✓	✓	✓
Mean Dep. Var.	3.55	2.46	3.56	2.46	3.55	2.46	3.56	2.46
SD Dep. Ver.	5.06	3.96	5.06	3.96	5.06	3.96	5.06	3.96
Observations	5,092,100	5,092,100	5,076,360	5,076,360	5,091,960	5,091,960	5,076,220	5,076,220
Number of Countries	221	221	221	221	214	214	214	214
Number of Products	10,273	10,273	9,486	9,486	10,273	10,273	9,486	9,486

Notes: This table examines whether imports into Russia at the country-product-quarter level declined following the onset of Russia's 2022 invasion of Ukraine, even accounting for substitution and rerouting through countries that remained relatively friendly to the Russian regime. Specifically, it presents the estimates of Equation (1), modified to include an additional interaction term capturing whether a given country-product import flow involved a product that was ever sanctioned and originated from a "friendly" country, interacted with a postwar indicator. *Friendly countries* are defined as Armenia, Belarus, China, Georgia, Hong Kong, Kazakhstan, Kyrgyzstan, Serbia, Turkey, and the UAE. The outcome variable in the even-numbered columns is the log of total value imported, while in the odd-numbered columns, it is the log of total weight imported. The logarithms add 1 to the argument's value to avoid missing values. The time span is from 2019Q1 through 2023Q4. Product codes refer to ten-digit HS codes, unless they were aggregated due to changes in HS classification, following Pierce and Schott (2012). Standard errors in parentheses are two-way clustered at the country and product levels. * p<0.1, ** p<0.05, *** p<0.01.

Table C.4: Alternative Specifications for the Impact of Export Sanctions on Russian Imports of Sanctioned Country-Product Varieties

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Log Total Value	Log Total Weight	Log Total Value	Log Total Weight	Log Total Value	Log Total Weight	Log Total Value	Log Total Weight
Post-War × Sanctioned Flow	-0.829***	-0.591***	-0.797***	-0.567***	-0.808***	-0.570***	-0.808***	-0.570***
	(0.125)	(0.080)	(0.123)	(0.080)	(0.127)	(0.082)	(0.127)	(0.082)
Product-Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Product-Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓
Country-Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓
Mean Dep. Var.	3.46	2.37	3.45	2.37	3.51	2.42	3.52	2.42
SD Dep. Ver.	4.98	3.86	4.97	3.86	5.00	3.89	5.00	3.90
R^2	0.69	0.72	0.69	0.71	0.69	0.71	0.69	0.71
Observations	4,507,380	4,507,380	4,592,360	4,592,360	4,464,120	4,464,120	4,432,460	4,432,460
Number of Countries	213	213	214	214	211	211	190	190
Number of Products	9,399	9,399	9,418	9,418	9,416	9,416	9,399	9,399
Robustness Check	Exclude Ukraine		Impute Norway		Exclude 'unfriendly', sanctioned products		Exclude 'unfriendly', all imports	

Notes: This table examines the robustness of the estimates for export controls' impact on sanctioned country-product imports to addressing the issues with completeness of our sanctions database. We exclude all ever-sanctioned flows originating from friendly countries, so while these products are sanctioned, the corresponding trade flows themselves are not. Columns (1)–(2) reproduce the baseline from Table C.1 excluding all imports from Ukraine across all years. Columns (3)–(4) instead code Norway as a sanctioning country applying EU-equivalent measures. Columns (5)–(6) exclude flows of sanctioned products (sanctioned by any of the countries for which sanctions data are available) from countries that Russia officially designated unfriendly but for which data on export sanctions are missing. Columns (7)–(8) exclude all imports from unfriendly countries lacking sanctions data. Separate data export sanctions are unavailable for the following *unfriendly* countries: Albania, Andorra, Anguilla, Bahamas, Bermuda, British Indian Ocean Territory, British Virgin Islands, Cayman Islands, Falkland Islands, Gibraltar, Guernsey, Iceland, Isle of Man, Jersey, Liechtenstein, Monaco, Montenegro, New Zealand, North Macedonia, Norway, Pitcairn Islands, San Marino, Singapore, Turks and Caicos Islands, and the U.S. Virgin Islands. Note that before the war, these countries accounted for only 0.78% of Russian total imports and 0.75% of imports of ever-sanctioned products (both in value). The outcome variable in the even-numbered columns is the log of total value imported, while in the odd-numbered columns, it is the log of total weight imported. The logarithms add 1 to the argument's value to avoid missing values. The time span is from 2019Q1 through 2023Q4. *Product* refers to ten-digit HS codes, unless they were aggregated due to changes in HS classification, following Pierce and Schott (2012). Standard errors in parentheses are two-way clustered at the country and product levels. * p<0.1, ** p<0.05, *** p<0.01.

Table C.5: The Impact on Russian Imports of Sanctioned Country-Product Varieties or Sanctioned Products, Extensive and Intensive Margins

	(1)	(2)	(3)	(4)	(5)	(6)
	Country-Product Level			Product Level		
	𝟙[Import>0]	Log Total Value (If Nonzero)	Log Total Weight (If Nonzero)	𝟙[Import>0]	Log Total Value (If Nonzero)	Log Total Weight (If Nonzero)
Post-War × Sanctioned Flow	-0.059***	-0.413***	-0.376***			
	(0.011)	(0.103)	(0.108)			
Post-War × Sanctioned Product				-0.017**	-0.137***	-0.142***
				(0.006)	(0.031)	(0.036)
Product-Country FE	✓	✓	✓			
Product-Quarter FE	✓	✓	✓			
Country-Quarter FE	✓	✓	✓			
Product FE				✓	✓	✓
2-Digit Product-Quarter FE				✓	✓	✓
Mean Dep. Var.	0.36	9.76	6.59	0.78	13.11	10.85
SD Dep. Var.	0.48	2.97	3.90	0.41	2.93	3.66
Observations	4,592,360	1,566,450	1,564,848	205,460	160,184	160,136
Number of Countries	214	172	172	–	–	–
Number of Products	9,418	7,818	7,815	10,273	9,419	9,417

Notes: This table examines whether the observed decline in sanctioned imports is driven primarily by the extensive or intensive margin. In the Country-Product specifications, we exclude all ever-sanctioned flows originating from friendly countries, so while these products are sanctioned, the corresponding trade flows themselves are not. Columns (1)–(3) present the analysis at the country-product level, while columns (4)–(6) focus on the product-level estimates. Columns (1) and (4) repeat the baseline estimation at their respective levels but use indicators for nonzero imports in a given quarter as the outcome variables. Columns (2)–(3) and (5)–(6) restrict the sample to only periods with nonzero imports, omitting observations where imports were entirely absent. The logarithms add 1 to the argument's value to avoid missing values. *Product* refers to ten-digit HS codes, unless they were aggregated due to changes in HS classification, following Pierce and Schott (2012). Standard errors, reported in parentheses, are two-way clustered at the country and product levels in columns (1)–(3) and at the product level in columns (4)–(6). * p<0.1, ** p<0.05, *** p<0.01.

D Impact on Exposed Firms: Robustness and Additional Results

D.1 Robustness Checks

This appendix discusses in greater detail the robustness checks for the impact of export sanctions on exposed Russian firms introduced in Section 6.

First, we further assuage concerns that the estimates might be biased due by omitted heterogeneous shocks induced by the war. Specifically, the estimated effects could reflect not firms' exposure to export sanctions per se, but rather wartime shocks that disproportionately affected firms of certain type—which also happened to be exposed to export sanctions. Our baseline specification already accounts for several such sources of omitted heterogeneity, including firm-specific sanctions, yearly shocks to exporters and importers, and broad industry-year changes. Columns (1)–(3) in Table D.1 extend this analysis to also control for differential wartime effects associated with state-owned and foreign-owned firms, as well as year-specific effects by firm size. The results remain robust to these additional controls.

Second, a key concern is that the estimated decline in sales among exposed firms may be overstated, or even mechanically driven, by simultaneous sales gains among firms in the control group, which may have taken advantage of export controls. We address this concern in two steps.

We first identify firms that imported sanctioned products produced in sanctioning countries but shipped from friendly countries before or during the war—that is, firms engaged in rerouting—as they may have benefited from the export sanctions. We add separate postinvasion interaction terms for these firms, effectively removing them from the control group. The results in columns (4)–(5) of Table D.1 confirm that such firms experienced a substantial postinvasion increase in sales. However, accounting for these firms, if anything, leads to larger estimated negative effects on exposed firms, indicating that those unable to reroute before or after the invasion experienced the sharpest output contractions. Specifically, column (5) shows that among exposed firms, those that did not engage in post-invasion rerouting suffered revenue losses of approximately 21.7%, compared with the baseline estimate of 12.8%, underscoring the mitigating role of rerouting documented in Section 5.2.

Next, we identify competitors that may have benefited the most from the decline of exposed firms. We use the Marker database, which, for each government contract lists not only the firm that signed the contract, but also all the firms that also bid for that contract. We add separate postinvasion interaction terms for all firms listed as competitors to at least one exposed firm and, in a separate specification, for all firms ranked among the top ten competitors by frequency to at least one exposed firm. The results in columns (6)–(7) of Table D.1 indicate that these firms indeed performed slightly better after the invasion relative to the control group. However, their exclusion

from the control group does not materially affect our baseline impact on firms exposed to export sanctions. Table D.2 includes analogous controls in the government procurement specification and shows that, although competitor substitution inflates the baseline negative effects by roughly one third in this case, the estimated impacts remain large and statistically significant.

These results are consistent with the industry-level evidence in Table D.3 introduced in Section 6.1. Across industries, we see greater revenue declines postinvasion in 5-digit industries with higher exposure to export sanctions, suggesting limited compensatory expansion by non-exposed firms. In other words, while some competitors benefit at the margin, the aggregate pattern does not support substantial offsetting growth among non-exposed firms in affected industries.

In addition to the checks above, we further probe robustness to alternative sample definitions, addressing concerns that our baseline estimates may in part be driven by the changing sample composition and firms' entry and exit. Columns (1)–(2) of Table D.4 present the baseline specification; columns (3)–(4) restrict the sample to a balanced panel of firms with nonmissing revenue data in every year from 2017 to 2023; columns (5)–(6) exclude firms that entered the dataset only after the war; columns (7)–(8) exclude firms that exited in the first year of the war (i.e., those with no observations in 2022 or 2023). Across all sample definitions, we continue to find a large and statistically significant negative effect of export sanctions on firm revenue and total cost of goods sold. The coefficient estimates range from –0.101 to –0.150, corresponding to a 9.6%–13.9% decline in firm output, depending on the outcome and subsample considered.

Table D.1: The Impact of Export Sanctions on Exposed Firms' Output, Robustness to Flexibly Controlling for Firm Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent Variable: Log Sales							
	State Owned	Foreign Owned	Size Above Median	Rerouted Before Invasion	Rerouted After Invasion	Competitor of Exposed Firms	Competitor of Exposed Top-10	Multiple Controls
Post-2022 × Exposed to Export Sanctions	-0.133***	-0.126***	-0.130***	-0.140***	-0.245***	-0.134***	-0.133***	-0.135***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Post-2022 × X (see columns)	-0.198***	-0.160***	-0.125***	0.320***	0.685***	0.031***	0.015**	
	(0.008)	(0.009)	(0.002)	(0.020)	(0.011)	(0.005)	(0.008)	
Post-2022 × State Owned								-0.155***
								(0.018)
Post-2022 × Rerouted Before								0.326***
								(0.020)
Post-2022 × Competitor								0.060***
								(0.005)
Post-2022 × Foreign Owned								-0.151***
								(0.009)
Post-2022 × Pre-Size > Median								-0.127***
								(0.002)
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Importer FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Exporter FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Industry FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Target Sanctioned FE	✓	✓	✓	✓	✓	✓	✓	✓
Mean Dep. Var.	15.91	15.91	15.93	15.91	15.91	15.91	15.91	15.93
SD Dep. Ver.	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29
Observations	10,505,517	10,505,517	10,070,839	10,505,517	10,505,517	10,505,517	10,505,517	10,070,839
Number of Firms	2,146,579	2,146,579	1,931,316	2,146,579	2,146,579	2,146,579	2,146,579	1,931,316

Notes: This table probes the robustness of the impact of export sanctions on the revenue of exposed Russian firms to accounting for heterogeneous war-induced shocks across a range of firm characteristics. Column (1) accounts for the war's differential impact on state-owned enterprises. Column (2) accounts for the war's differential impact on foreign-owned firms. Column (3) accounts for the war's differential impact on firms above the median in size by prewar (2019–2021) revenue. Columns (4) and (5) account for the war's differential impact on firms that were involved in re-routing sanctioned products through friendly countries either before (January 2021 to February 2022) or during the war (February 2022 onward), respectively. Columns (6) and (7) control for the war's heterogeneous effect on firms that were competitors of sanctioned firms in the government procurement data: column (6) uses an indicator for ever being a competitor of exposed firms, while column (7) focuses on firms that were top-10 competitors of exposed firms. Column (8) includes several of these controls jointly. A firm is considered exposed to export sanctions if, before the war, it imported any country-product variety that was later sanctioned. Revenues are in logarithms of Russian rubles. The firm-level outcome variables come at the yearly level from 2017 through 2023. Standard errors in parentheses are clustered at the firm level. * p<0.1, ** p<0.05, *** p<0.01.

Table D.2: The Impact of Export Sanctions on Exposed Firms' Government Procurement Contracts, Robustness to Flexibly Accounting for Competitors

	(1)	(2)	(3)	(4)
	𝟙[Won At Least One Contract]	Log Value of Contracts Won	𝟙[Won At Least One Contract]	Log Value of Contracts Won
Post-2022 × Exposed to Export Sanctions	-0.017***	-0.267***	-0.021***	-0.363***
	(0.002)	(0.024)	(0.007)	(0.102)
Post-2022 × Competitor FE	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓
Year-Importer FE	✓	✓	✓	✓
Year-Exporter FE	✓	✓	✓	✓
Year-Industry FE	✓	✓	✓	✓
Year-Target Sanctioned FE	✓	✓	✓	✓
Only Firms With Contracts In >2 Years			✓	✓
Mean Dep. Var.	0.11	1.58	0.63	9.44
SD Dep. Ver.	0.31	4.64	0.48	7.46
Observations	10,505,517	10,505,516	1,547,049	1,547,049
Number of Firms	2,146,579	2,146,579	260,447	260,447

Notes: This table examines the impact of export sanctions on the government procurement activity of the exposed Russian firms, controlling for pre-invasion competitor firms, to determine if the effect on contracts disappears. The control variable is an indicator for ever being a competitor of exposed firms interacted with Post-2022 dummy variable. A firm is considered exposed if, prior to the war, it imported any country-product variety that was later sanctioned. Columns (1) and (3) present estimates for the likelihood that a firm won at least one government contract in a given year. Columns (2) and (4) report the effects on the (log of one plus) total value of contracts won (in rubles). Columns (3) and (4) restrict the sample to firms that secured contracts in at least two years of the sample. The government procurement outcome variables are aggregated at the firm-year level from 2017 through 2023. Standard errors in parentheses are clustered at the firm level. * p<0.1, ** p<0.05, *** p<0.01.

Table D.3: The Impact of Export Sanctions on Exposed Industries

	(1)	(2)	(3)	(4)	(5)	(6)
	Log Sales	Log Costs	N of Entrants	N of Exits	N of Firms with Nonmissing Revenue	N of Reporting Firms
Post-2022 × Normalized Exposure to Export Sanctions	-0.108***	-0.110***	-0.056***	0.012	-0.318**	-0.430**
	(0.036)	(0.035)	(0.016)	(0.031)	(0.144)	(0.197)
5-Digit-Industry FE	✓	✓	✓	✓	✓	✓
Year-2-Digit-Industry FE	✓	✓	✓	✓	✓	✓
Mean Dep. Var.	19	18.7	.541	2.16	19.6	27
SD Dep. Ver.	3.04	3.04	3.93	10.6	89.4	125
Observations	12,451	12,103	17,857	17,857	17,857	17,857
Number of Industries	1,954	1,937	2,551	2,551	2,551	2,551

Notes: This table examines the impact of export sanctions on industry-level outcomes. The dataset is collapsed at the 5-digit industry level. The exposure to sanctions at the industry level is calculated as the share of prewar soon-to-be-sanctioned import flows weighted by the revenues in an industry earned by importers. The exposure is then normalized by its standard deviation. The estimates are then from a nondynamic equivalent of Equation (6) but at the industry rather than firm level, comparing outcomes of 5-digit industries more versus less exposed to the export sanctions, before and after the war's onset. The outcome variables are: total revenue, total operation costs, the number of entrants (first-time reporters), the number of exits (last-time reporters), the number of reporting firms with nonmissing sales, and the number of reporting firms. Data come at the yearly level from 2017 through 2023. Standard errors are clustered at the 5-digit industry level. * p<0.1, ** p<0.05, *** p<0.01.

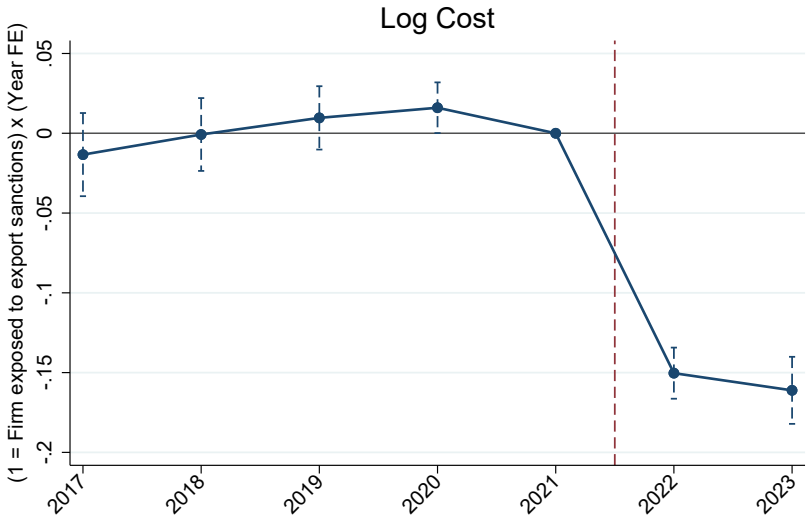
Table D.4: The Impact of Export Sanctions on Exposed Firms' Output, Robustness to Various Sample Definitions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline Sample		Balanced Panel		No Entrants		No Exiteers	
	Log Sales	Log Total Cost of Goods Sold	Log Sales	Log Total Cost of Goods Sold	Log Sales	Log Total Cost of Goods Sold	Log Sales	Log Total Cost of Goods Sold
Post-2022 × Exposed to Export Sanctions	-0.137***	-0.147***	-0.101***	-0.109***	-0.137***	-0.147***	-0.139***	-0.150***
	(0.010)	(0.009)	(0.010)	(0.010)	(0.010)	(0.009)	(0.010)	(0.009)
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Importer FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Exporter FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Industry FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Target Sanctioned FE	✓	✓	✓	✓	✓	✓	✓	✓
Mean Dep. Var.	15.91	15.85	16.35	16.22	15.92	15.86	16.06	15.97
SD Dep. Ver.	2.29	2.24	2.12	2.12	2.29	2.24	2.23	2.19
Observations	10,597,168	9,881,593	5,404,462	5,100,393	10,388,120	9,685,123	8,690,711	8,149,879
Number of Firms	2,178,204	2,063,893	772,066	748,058	2,073,680	1,965,658	1,542,394	1,481,566

Notes: This table examines the robustness of the impact of export sanctions on the performance of the exposed Russian firms to focusing on alternative sample definitions. Specifically, it presents the nondynamic version of the estimates of Equation (6), comparing revenues and cost of goods sold of firms exposed (and not exposed) to the export sanctions, before and after the war's onset. A firm is considered exposed if, prior to the war, it imported any country-product variety that was later sanctioned. All dependent variables are denominated in the logarithm of Russian rubles. Columns (1) and (2) show the results for the baseline sample. Columns (3) and (4) focus on the fully balanced panel of firms that reported revenue each year in 2017–2023. Columns (5) and (6) drop all firms that have observations only after the war starts. Finally, columns (7) and (8) drop the firms that exited after the war, i.e., do not have observations after the war's onset. Standard errors in parentheses are clustered at the firm level. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

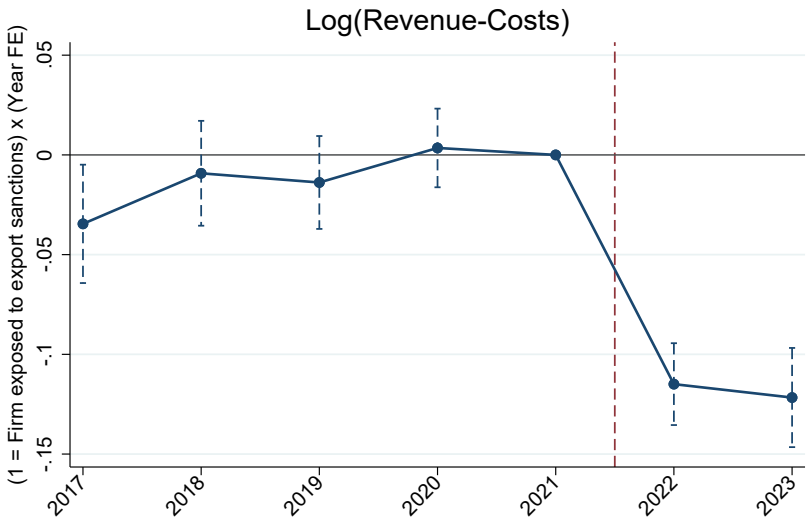
D.2 Additional Results

Figure D.1: The Impact of Export Sanctions on Exposed Firms' Total Cost of Goods Sold



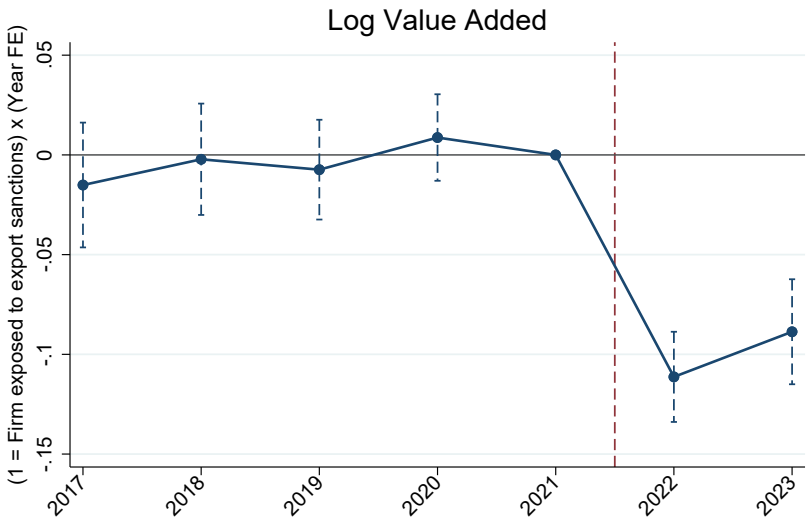
Notes: This figure examines the impact of export sanctions on the total cost of goods sold of firms that, prior to the war, imported any country-product variety that was later sanctioned. Specifically, it presents the dynamic DiD estimates of Equation (6), which compares total cost of goods sold between firms with and without prewar exposure to future export sanctions, before and after the war's onset. The outcome data are presented at the yearly level, with 2021 serving as the baseline period. The red vertical line indicates the start of the war. The bars represent 95% confidence intervals. Standard errors are clustered at the firm level. Sample size: 9,891,479; firms: 2,068,666.

Figure D.2: The Impact of Export Sanctions on Exposed Firms' Gross Profits



Notes: This figure examines the impact of export sanctions on gross profits (revenues minus cost of goods sold) of firms that, prior to the war, imported any country-product variety that was later sanctioned. Specifically, it presents the dynamic DiD estimates of Equation (6), which compares gross profits between firms with and without prewar exposure to future export sanctions, before and after the war's onset. The outcome data are presented at the yearly level, with 2021 serving as the baseline period. The red vertical line indicates the start of the war. The bars represent 95% confidence intervals. Standard errors are clustered at the firm level. Sample size: 8,454,308; firms: 1,926,146.

Figure D.3: The Impact of Export Sanctions on Exposed Firms' Value Added



Notes: This figure examines the impact of export sanctions on the value added (calculated from revenues minus material costs) of firms that, prior to the war, imported any country-product variety that was later sanctioned. Specifically, it presents the dynamic DiD estimates of Equation (6), which compares value added between firms with and without prewar exposure to future export sanctions, before and after the war's onset. The outcome data are presented at the yearly level, with 2021 serving as the baseline period. The red vertical line indicates the start of the war. The bars represent 95% confidence intervals. Standard errors are clustered at the firm level. Sample size: 8,344,456; firms: 1,913,583.

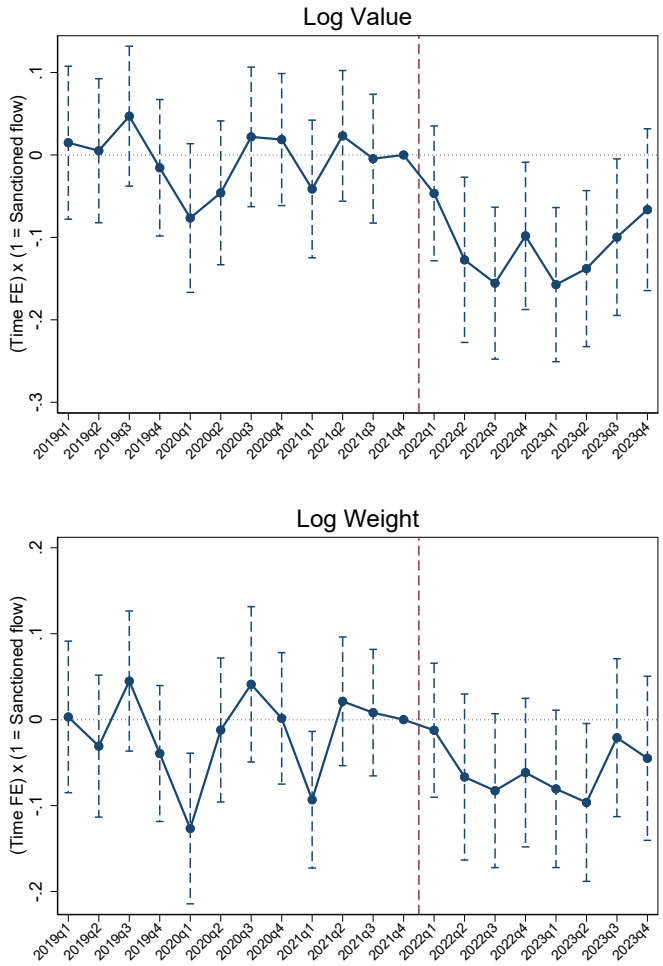
Table D.5: The Impact of Export Sanctions on Exposed Firms, by Industry

	(1) Log Sales	(2) Log Total Cost of Goods Sold	(3) Log Gross Profit	(4) Log Capital Costs	(5) Log Labor Costs	(6) Log Materials Costs	(7) 𝟙[Sales Missing]	(8) Log Sales (zeroes if missing)
Post-2022 × Exposed to Export Sanctions	-0.121***	-0.123***	-0.210***	-0.143***	-0.037*	-0.117***	-0.012***	-0.088
	(0.020)	(0.020)	(0.022)	(0.023)	(0.021)	(0.026)	(0.005)	(0.093)
Post-2022 × Exposed to Export Sanctions × Manufacturing	0.058***	0.029	0.124***	0.043*	-0.021	0.033	0.089***	-1.656***
	(0.022)	(0.021)	(0.024)	(0.024)	(0.022)	(0.028)	(0.005)	(0.113)
Post-2022 × Exposed to Export Sanctions × Wholesale	-0.046**	-0.056***	0.117***	0.121***	-0.090***	-0.074***	0.003	-0.122
	(0.020)	(0.020)	(0.022)	(0.025)	(0.021)	(0.027)	(0.005)	(0.095)
Post-2022 × Exposed to Export Sanctions × Transportation	0.015	0.058*	0.085**	0.042	-0.159***	-0.065	0.034***	-0.409**
	(0.035)	(0.034)	(0.041)	(0.046)	(0.036)	(0.050)	(0.008)	(0.166)
Post-2022 × Exposed to Export Sanctions × Science and Tech	-0.072*	-0.041	0.038	0.106**	-0.075*	-0.168***	0.049***	-1.068***
	(0.038)	(0.037)	(0.043)	(0.047)	(0.043)	(0.054)	(0.009)	(0.179)
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Importer FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Exporter FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Industry FE	✓	✓	✓	✓	✓	✓	✓	✓
Year-Target Sanctioned FE	✓	✓	✓	✓	✓	✓	✓	✓
Mean Dep. Var.	15.91	15.85	13.98	14.40	15.38	17.14	0.24	11.06
SD Dep. Ver.	2.29	2.24	2.40	2.59	2.37	2.72	0.43	7.57
Observations	10,597,168	9,881,593	8,447,082	4,620,059	1,377,628	1,433,613	15,247,428	15,245,129
Number of Firms	2,178,204	2,063,893	1,922,658	979,529	323,064	338,753	2,178,204	2,178,202

Notes: This table examines the impact of export sanctions on the performance of exposed Russian firms, allowing for heterogeneity across five industry groups: manufacturing, wholesale, transportation, science and technology, and all others (the omitted category). The estimates are based on a triple-difference specification that builds on Equation (6), adding interactions between a post-2022 indicator and industry group indicators. Year-by-industry fixed effects are included as part of the baseline specification. A firm is considered exposed if prior to the war, it imported any country-product variety that was later sanctioned. With the exception of the missing sales indicator, all dependent variables are in logarithms of Russian rubles. The firm outcome variables come at the yearly level from 2017 through 2023. Standard errors in parentheses are clustered at the firm level. * p<0.1, ** p<0.05, *** p<0.01.

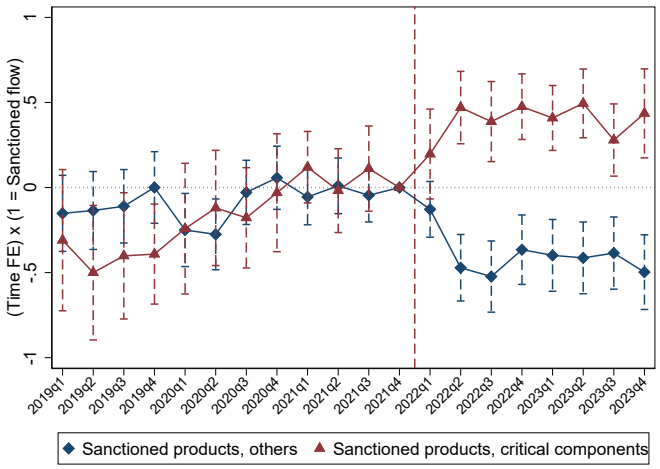
E Impact on Military Supply Chains: Figures and Tables

Figure E.1: The Impact on Russian Firm-Level Imports of Sanctioned Products, Firms That Are Part of Military Supply Chains

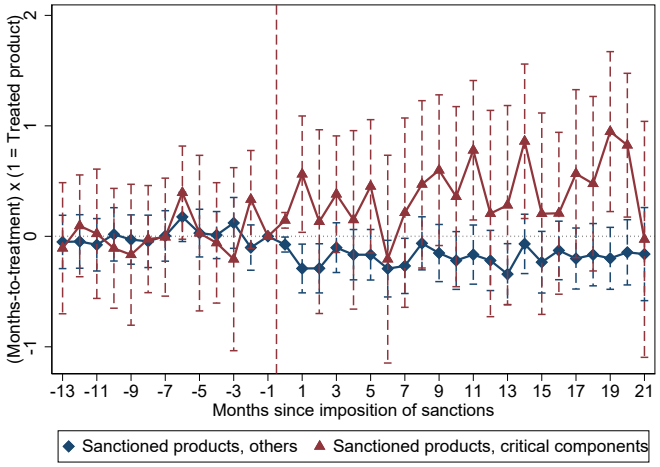


Notes: This figure assesses the impact of sanctions on the imports of exposed products for each specific firm. The sample is restricted to a list of firms that were part of military supply chains. This list is created by taking all buyers and sellers of procurement contracts that feature *Military Procurement* or related keywords in the contract wording. Specifically, they display the estimates comparing the import volume for exposed firm-products to that of nonexposed firm-products before and after the first quarter of 2022. Exposed firm-products are those later-sanctioned ten-digit HS codes that a firm imported from a sanctioning country at least once prior to 2022. An HS code that was always imported from a nonsanctioning country is not exposed. This specification controls for any firm-level shocks that take place at the same time as sanctions; it also controls for product-by-time fixed effects. The data are at the quarterly level. The red vertical line indicates the start of the war. The top (bottom) panel uses the total import value (net weight) of a given product in a given quarter as an outcome. The logarithms add 1 to the argument's value to avoid missing values. The bars represent 95% confidence intervals. Standard errors are clustered at the product-by-firm level. Total observations: 558,824; firms: 2,500; products: 3,835.

Figure E.2: The Impact on Russian Imports of Sanctioned Products, Critical Components vs. Others, in Value



(a) Pre-Post DiD



(b) Staggered DiD

Notes: This figure assesses the impact of export sanctions on the total imports of sanctioned products, independent of the importing country's identity, distinguishing between critical components and other sanctioned goods. Critical components are drawn from two lists, "Components in Weapons" and "Instruments of War," classified in the Main Directorate of Intelligence of Ukraine (2025), matched to the closest 6-digit HS code manually and with the help of GPT-4o. Panel A presents dynamic DiD estimates from a modified version of Equation (4), comparing the import value of sanctioned critical and noncritical products against nonsanctioned imports before and after the war's onset. Panel B displays the dynamic staggered DiD estimates from Equation (5) comparing the import value for sanctioned products to that of nonsanctioned products before and after the imposition of first sanctions on the former. Panel A data are aggregated at the quarterly level, with 2021Q4 serving as the baseline period. Panel B data are aggregated at the monthly level, and the estimates are aggregated across cohorts at the time level. The red vertical line in Panel A indicates the start of the war. The red vertical line in Panel B indicates the introduction of first sanctions on a given product. Regressions include HS3-product-time fixed effects. In both panels, the outcome is import value; the logarithms add 1 to the argument's value to avoid missing values. Bars represent 95% confidence intervals. Standard errors are clustered at the product level. Panel A: total observations 205,460; critical products 166; other products 10,107. Panel B: total observations 465,696; critical products 160; other products 9,540.

Table E.1: The Impact on Exposed Military-Related Firms

	(1)	(2)	(3)
	Dependent Variable: Log Sales		
	Military Procurement	ZATO	Either
Post-2022 × Firm Exposed to Export Sanctions	-0.136***	-0.136***	-0.136***
	(0.010)	(0.010)	(0.010)
Post-2022 × Firm Exposed to Export Sanctions ×	0.011	-0.047	0.015
× Firm is Part of Military Supply Chains	(0.027)	(0.138)	(0.026)
Firm FE	✓	✓	✓
Year-Importer FE	✓	✓	✓
Year-Exporter FE	✓	✓	✓
Year-Industry FE	✓	✓	✓
Year-Target Sanctioned FE	✓	✓	✓
Year-Military FE	✓	✓	✓
Mean Dep. Var.	15.92	15.92	15.92
SD Dep. Ver.	2.29	2.29	2.29
Observations	10,594,522	10,594,522	10,594,522
Number of Firms	2,177,779	2,177,779	2,177,779

Notes: This table assesses the impact of export sanctions on the sales of military-related Russian firms. The estimates are based on a triple-difference specification that builds on Equation (6), adding an interaction between a post-2022 indicator and a military-related firm indicator, as well as year-by-military fixed effects. Column (1) defines military-related firms (using government procurement data) as those that ever engaged in procurement under the military procurement law. Column (2) uses an alternative definition, identifying military-related firms as those located in closed administrative-territorial formations (ZATOs). Column (3) combines both definitions, classifying a firm as military-related if it meets either criterion. The sales data are at the firm-year level from 2017 through 2023. Standard errors, shown in parentheses, are clustered at the firm level. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.