Lost in transit
and other ways of working around trade sanctions*

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Abstract

This paper documents multiple strategies deployed to work around trade sanctions imposed on Russia in 2022. These include the use of intermediaries inside and outside the Eurasian Customs Union and probable misclassification of goods subject to sanctions as similar exempt goods. A major contribution comes from a simple, yet little-documented, variety of intermediated trade, whereby goods shipped through the sanctioned economy to the neighbouring economies fail to reach their intended destination. Such trades, not recorded as imports by destination countries, amounted to around half of total "abnormal" exports from the EU/UK to Armenia, Kazakhstan and the Kyrgyz Republic in 2022-23. The incidence of lost-in-transit trade was 30 to 50 percent greater for product groups subject to EU sanctions. Following restrictions on trans-shipment of dual-use goods through Russia introduced in early 2023, the "missing" trade declined somewhat for dual-use goods relative to other goods.

Keywords: sanctions, evasion, transit, intermediated trade, Russia

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1 Introduction

Wars significantly disrupt international trade (Glick and Taylor (2010); Berger et al. (2013); Fisman et al. (2014)), in part because economic sanctions more and more frequently accompany conflict (Hufbauer and Oegg (2009); Kaempfer and Lowenberg (1988)). Although sanctions are typically found to have a negative impact on bilateral trade and the performance of targeted firms (Crozet and Hinz (2020); Ahn and Ludema (2020); Draca et al. (2022)), the evidence on their overall effectiveness is mixed. This is due to partial compliance and various ways in which sanctioned entities and firms can circumvent sanctions by redirecting trade flows or finding alternative suppliers (Bergeijk (1995); Haidar (2017)).

This study sheds light on the channels of sanction evasion by providing evidence consistent with trade intermediated via third countries being used to circumvent sanctions. It also shows that misspecification of the destination country may be widely used to go around sanctions while product misspecification, in aggregate, does not seem to play an important role. A major contribution came from a simple, yet little-documented, variety of intermediated trade whereby goods shipped through the sanctioned economy to the neighbouring economies fail to reach their intended destination.

Our analysis focuses on the European Union (EU) sanctions imposed on Russia in the aftermath of its full-scale invasion of Ukraine on the 24$^{\text{th}}$ of February 2022. It exploits product-level data on bilateral monthly and annual exports where products partially or fully subject to the EU sanctions can be identified.

Comprehensive economic sanctioned imposed on Russia by the EU and other large economies in response to the war on Ukraine present a unique case for studying ways to work around wide-scale economic sanctions. This episode stands out in terms of its size, comprehensive nature and the importance of the targeted economy.[1] Export sanctions covered an extensive yet diverse set of goods, from dual-use technology to luxury consumer goods, and were accompanied by voluntary boycott of the Russian market by a large number of mostly "Western" firms (Sonnenfeld et al. (2022), Hart et al. (2023)). In addition, sanctions were simultaneously upheld by the vast majority of advanced economies, ruling out diversion of

[1]Russia's GDP at market exchange rates in 2021 amounted to US$1.8 trillion making Russia 11$^{\text{th}}$ largest economy in the world.

trade from sanctioning parties towards other advanced economies or close allies of the countries imposing sanctions (as found by Yang et al. (2009) in another context). A swift imposition of sanctions with little or no advance notice also ruled out building up of stocks of imported goods (as documented in other cases by Afesorgbor (2019)).

Our analysis focuses on trade patterns in the aftermath of the sanctions being introduced. It is based on bilateral monthly data on exports at the 6-digit Harmonised System (HS) level of disaggregation, covering the period from January 2017 to December 2023. The disaggregated data allow us to identify products partially or fully subject to the EU sanctions. We focus on exports to Russia as well as to a number of Russia's neighbours. Of particular interest are trade flows to Armenia, Kazakhstan and the Kyrgyz Republic (CCA3). These three countries are part of a customs-free trade bloc with Russia, the Eurasian Economic Union.[2] Goods exported to these economies could potentially be shipped to Russia with minimum checks (akin to shipments, say, within the EU). In addition, Europe's exports to the landlocked CCA3 economies can naturally be shipped through the Russian territory, with a possibility of being lost in transit. We also consider exports to Georgia (providing the only land bridge between Armenia and Russia as the border between Armenia and Azerbaijan remains closed), other neutral economies sharing a land border with the Eurasian Economic Union (and thus plausible candidates for participating in lost-in-transit schemes), and the rest of the world.

We follow a triple-differencing approach comparing (i) exports to Russia (or CCA3) to exports to the rest of the world; (ii) the pre- to the post-sanction period; (iii) various types of sanctioned goods to non-sanctioned goods. We control for importer-month fixed effects to account for fluctuations in the aggregate demand in the importing country, product-month fixed effects to account for seasonality and fluctuations in the product-specific supply and its prices, and product-importer fixed effects to take into account differential demand patterns across importers. Our outcome variables are either the value of exports, an indicator variable capturing non-zero flows of a given product between the two partners in a given month, or the trade 'lost in transit' (for example, the log difference of Armenia's imports from Austria and the Austrian exports to Armenia of a given product). An event-study analysis shows no differential trends in the EU/UK exports of sanctioned vs non-sanctioned products before

[2]Belarus, the remaining member, was also subject to economic sanctions.

March 2022, with new supply routes and schemes emerging within 2-4 months of sanctions being imposed.

Both summary statistics and our regression analysis reveal several striking regularities. After the imposition of economic sanctions on Russia starting in March 2022, the EU/UK (which we consider jointly) exports to Russia more than halved. At the same time, the EU/UK exports to Armenia, Kazakhstan and the Kyrgyz Republic (all members of Eurasian Customs Union alongside Belarus and Russia) increased sharply. The EU/UK exports to these economies relative to exports to the rest of the world exhibit a clear structural break in March 2022, the month when sanctions were introduced, with the divergence increasing further over time before starting to decrease somewhat by mid-2023. Furthermore, the data show a clear increase in exports from CCA3 countries to Russia.

The drop in the EU/UK exports to Russia in the post-sanctions period was much steeper for sanctioned goods than for other goods, while exports of various types of sanctioned goods to CCA3 rose by an extra 20-45 percent relative to other goods. Similarly, the increase in exports from CCA3 countries to Russia was particularly pronounced for goods under EU sanctions. There is no indication of differential trends for sanctioned versus other goods prior to the war.

The analysis further reveals that a large proportion of this intermediated trade involves goods being lost while in transit through Russia. More than half of sanctioned goods exported to certain CCA3 destinations appear to have never reached the recipient stated in the export documents, having been "lost" in transit through Russia. We use triple-differenced specifications and event studies to show that lost-in-transit trade exhibits no pre-trend and it is more pronounced for industrial goods under sanctions as well as for dual-use and luxury goods compared with non-sanctioned goods.

In terms of magnitudes, the increase in the EU/UK exports of sanctioned goods to CCA3, including trade lost in transit, represents a small fraction of the reduction in direct exports of sanctioned goods to Russia in general, on the order of 10 percent. However, the resulting "substitution ratio" can be high for hundreds of specific HS6 product lines. Trade diversion played a relatively more important role in filling the void left by exporters in sanctioning economies. We show that exports from China and Turkiye to Russia increased relative to the

pre-sanctions trend from around the middle of summer of 2022 and additional exports tended to be more pronounced for sanctioned goods.

Following restrictions on trans-shipment of dual-use goods through Russia introduced in February 2023, the differential between abnormal exports of sanctioned and non-sanctioned goods to CCA3 started declining. This decline was observed for all types of goods but was somewhat more pronounced for dual-use goods. For dual-use goods, the differential reduction in lost-in-transit trade is also observed in 2023 relative to 2022 and other types of goods. These patterns are consistent with the increasing threat of secondary sanctions on intermediaries and a clear signal that lost-in-transit technique was noted by policymakers in the sanctioning economies raising the (perceived) costs of such trades. We also show that intermediated trade in sanctioned goods was significantly less pronounced for products that typically rely to a greater extent on trade finance instruments. This points to the role banks can play in reinforcing compliance with trade sanctions.

Some lost-in-transit trade is detectable for other neutral neighbours of the Eurasian Economic Union but on a much smaller scale, plausibly because in those cases a record of whether goods exited Russia / EEU is created at the border. Finally, there is some (albeit less strong) indication that product misclassification may be used to get around sanctions.

Our paper contributes to several strands of the economic literature. First, we contribute to the literature on intermediated (or "entrepot") trade (see, for instance, Ganapati et al. (2024)) by showing that trade routed via third countries can be used to evade economic sanctions. Moreover, it can be lost in transit through the sanctioned economy on a large scale – a simple yet little-documented way of working around sanctions. Intermediated trade has been earlier shown to facilitate evasion of tariffs and taxes (Fisman et al. (2008)) and undermine the effectiveness of trade embargo in the case of Ukraine (Fisman et al. (2024)) while transshipment through third countries can be used to obfuscate the country of origin of goods and obtain preferential treatment at customs (Stoyanov (2012)).

We contribute to the literature on the effectiveness of economic sanctions by providing for the first time evidence, in a triple-differenced setting, consistent with various ways of working around sanctions and highlighting the important role of the "lost-in-transit" method. The existing evidence on the use of third parties to evade sanctions has been mixed. Baronchelli et

al. (2022) study the history of small arms embargoes and do not find evidence of sanction-busting through abnormal trade patterns among sanctioned countries' neighbours. Gutmann and Neumeier (2022) and Frank (2017) find no evidence of sanction busting through diverted trade. Crozet and Hinz (2020) find that the earlier round of sanctions on Russia resulted in a broad-based decline in sanctioning countries' exports to Russia, which can be mostly attributed to increased country risk affecting all transactions with Russia. Tyazhelnikov et al. (2023) show that intermediated trade via Belarus was used to circumvent restrictions on import of food from the EU imposed by Russia in the aftermath of the annexation of Crimea in 2014 while Crozet et al. (2021) show that firms that exported to both Russia and neighbouring countries prior to 2014 reduced their direct sales to Russia by more than other firms in the aftermath of the 2014 round of sanctions. Chupilkin et al. (2024) provide a complementary evidence on the use of an array of intermediaries outside the Eurasian Customs Union to facilitate imports to Russia after 2022. [3]

The rest of the paper is structured as follows. The next section describes the economic sanctions imposed on Russia in 2022 and presents the data sources. Section 3 sets the stage by presenting the broad patterns found in the data. Section 4 lays out our empirical approach. Section 5 presents the results on intermediated trade and trade "lost in transit" putting it in the context of concurrent trade diversion. The following section discusses some broader implications of the analysis. The last section concludes.

2 Setting and Data

2.1 Sanctions on the Russian economy: An overview

Prior to Russia's full-scale invasion of Ukraine in 2022, a narrower set of sanction was already in place. These earlier sanctions were introduced in response to the annexation of Crimea in 2014 and the armed conflict in Eastern Ukraine that started in the same year. Those sanctions predominantly targeted specific companies and individuals. They were accompanied by

[3] There is also a literature focusing on exports of sanctioned countries. Haidar (2017) shows a decline in Iranian non-oil exports to countries that introduced sanctions relative to other countries in the post-sanction period, while Babina et al. (2023) show that Russian oil shipments were largely redirected to alternative markets in response to the EU embargo and G7 price cap on Russian seaborne crude oil, both of which took effect in December 2022. Chupilkin et al. (2023) further documents shifts in the use of currency of invoicing in trade subject to sanctions away from the US dollar and towards the renminbi in response to sanctions.

counter-measures imposed by Russia, notably a ban on import of various food products from the EU, the US and the UK (see Peeva (2019) for an overview). Those sanctions and counter-sanctions were found to result in a broad-based reduction in Russia's trade with the sanctioning countries (Crozet and Hinz (2020)), an increase in prices of the affected goods (Hinz and Monastyrenko (2022)), weaker performance of sanctioned companies (Ahn and Ludema (2020)) and possibly an increased popular support for the government (Peeva (2019)).

On 23 February 2022, the EU expanded its sanctions in response to the recognition of the non-government controlled areas of the Donetsk and Luhansk oblasts of Ukraine and the ordering of Russian armed forces into those areas. The sanctions were further expanded in ten waves, with most in place by the mid-March of 2022. Luxury goods, for instance, were added as part of the fourth package on 15 March 2022, while technology-related goods were added as part of earlier packages. Overall, export prohibitions have covered arms, advanced and dual-use technology, quantum computing, advanced semiconductors, sensitive machinery, transportation and chemicals, goods for use in the oil industry and maritime navigation and goods seen to enhance Russia's industrial production capacity as well as luxury products.

In addition to exports, sanctions have also applied to investments in a number of sectors; use of public funds; imports from Russia of certain goods such as coal, iron and steel, and wood; aviation, Russian freight operators; restrictions on financial services including transactions with Russia's Central Bank; as well as travel bans and financial measures targeting more than 1,200 individuals and 100 companies.

The UK, US, Canada, Japan, Switzerland and a number of other economies adopted their own sanction packages, while China and Turkiye are among Russia's main trading partners that did not impose economic sanctions on Russia.

2.2 Trade sanctions

To identify products or product groups, on which the EU introduced sanctions to export to Russia in the aftermath of the invasion, we use information from the EU Council Regulation 833/2014 and its subsequent amendments[4] as well as from the EU list of dual-technology

[4]https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02014R0833-20221007from=ENtocId108, for instance, Annex II and Annex VII-B

product codes.[5] Product codes are also marked as subject to sanctions in cases when sanctions cover HS6 codes only partially. For example, exports of "luxury" sports equipment or clothing with prices in excess of a certain threshold (typically €300) are subject to sanctions, while cheaper items in the same product group may not be subject to restrictions. In other cases, only a subset of HS8 product codes within an HS6 code may be covered (for example, champagne but not prosecco among sparking wines). Numerous other exemptions may apply, for instance, on health and environmental grounds or in relation to goods required by Russia to fulfil its contractual obligations with respect to deliveries of gas and oil to Europe. Most packages also include provisions for trade covered by pre-existing contracts to be carried out by a certain date, sometimes into the following year. Thus some of the trade in HS6 product groups coded as sanctioned may in fact be covered by such contract wind-down clauses.

For each product line we record the date when sanctions enter into force (see Annex Figure A1). We code the respective HS6 product line as subject to sanctions starting from the next month (for instance, April 2022 for sanctions adopted in mid-March 2022). The list of product groups partially covered by the sanctions is an eclectic mix of 2,182 HS6 codes (as of December 2022) combining: weapons (HS 9301), semi-conductor media (852352), engines and pumps (8412, 8413), containers (860900), aircraft and parts (88), ammonia (281420), steel pipes for oil pipelines (730411), navigation instruments (9014), ski suits (611220), and others.

We also identify product lines that are not necessarily covered by sanctions but are similar to goods that are partially under sanctions (i.e., those nested in the same HS4 code). Those products are of interest since goods covered by sanctions may be intentionally misclassified in customs declarations to avoid detection.[6] By way of example, x-ray apparatus for dentistry and similar medical uses (HS 902213) is not covered by the EU sanctions on Russia, while x-ray apparatus for non-medical uses (HS 902219) is among the sanctioned products. We identify a total of 1,379 "similar" products (as of December 2022).

We use a categorical variable distinguishing dual-use sanctioned goods, industrial sanctioned goods, luxury goods and other goods (a base category comprising the remaining 3,186 HS6 codes, as of December 2022). We also employ a categorical variable to distinguish between

[5] https://trade.ec.europa.eu/doclib/docs/2016/february/tradoc$_1$54240.*pdf*

[6] For instance, Bevan (2008), discusses how arms can be declared as sports arms for customs purposes. The literature has documented product misclassification being frequently used to evade import duties. See for instance, Fisman and Wei (2004), Javorcik and Narciso (2008) and Javorcik and Narciso (2017).

sanctioned goods, similar goods and other goods. Over time, the number of sanctioned and similar product groups increased slightly (see Annex Figure A1). Annex Table A1 summarizes application of sanctions by HS section.

Transit of goods from the EU through Russia to third countries was initially not restricted. Transit of dual-use goods became restricted in February 2023, as part of the 10^{th} sanctions package. In June 2023 restrictions on transit were extended to industrial-capacity goods.

2.3 Bilateral trade data

Driven by our interest in the lost-in-transit trade, our econometric analysis is based on the data reported by the the EU and the UK. We also look at exports of CCA3 as well as major neutral trading partners of Russia, China and Turkiye.

We start by looking at the export flows to Russia and the CCA3 members of the Eurasian Customs Union (Armenia, Kazakhstan and the Kyrgyz Republic), treating the EU/UK as a single aggregate. We will also allow for a differential post-sanction pattern of exports to Georgia (because of its location between Armenia and Russia and thus being an obvious transit route and a possible nominal destination for any goods lost in transit) and other neutral economies that share a land border with the Eurasian Economic Union. The remaining importer is the rest of the world (as an aggregate).

We use monthly values of exports in nominal US dollars for the period January 2017 - December 2023. These are available from the UN Comtrade database at the HS6 level. The data for China come from the China Customs Administration. They are also reported at the HS6 level and disaggregated by the destination country and month. The HS6 level of disaggregation distinguishes, for example, between cotton men's shirts (code 610510) and men's shirts of man-made materials (code 610520), both falling within the same HS4 code 6105. Annex Table A2 summarizes descriptive statistics for trade flows.

We subdivide all products into four broad, mutually exclusive types of goods subject to trade sanctions: Dual-use and military technology; goods that enhance industrial and transport capacity; and luxury goods. We assign goods to types in the order listed. For example,

dual-use technology goods that may enhance industrial capacity are classified as dual-use technology.[7]

3 Intermediated trade: Broad patterns

3.1 Intermediated trade

Russia's invasion of Ukraine in February 2022 and the subsequent introduction of economic sanctions against Russia has led to profound changes in the regional trade patterns. This is clearly visible in Figure 1, which depicts export values denominated in US dollars adjusted for US inflation. It traces trade in goods that subsequently were subject to sanctions (as of end-2022) and other products.

Starting with the top panel, the graphs depict a dramatic drop in the exports from the EU/UK to Russia, accompanied by a substantial increase in exports to CCA3 (Armenia, Kazakhstan and the Kyrgyz Republic). These changes are particularly pronounced for industrial goods and other sanctioned goods, which accounted for majority of exports prior to the war.

Bilateral trade flows should not be considered in isolation. The trajectory of aggregate exports originating from a particular exporter should be considered before drawing conclusions about export reorientation. This is done in Figure 2, which depicts the EU/UK exports to Russia relative to the aggregate EU/UK exports, as well as the EU/UK exports to CCA3 relative to aggregate flows. As clearly visible in the figure, the EU/UK exports to Russia dropped dramatically relative to the exports to the rest of the world, while the EU/UK exports to CCA3 went up in relative terms.

These striking trends suggest that a substantial part of additional exports to Central Asia and the Caucasus may have been re-routed to buyers in Russia. Indeed, CCA3 economies recorded significant increases in exports to Russia during the same period (see Figure 3), though the records of trade within the EEU customs union are likely to be incomplete.

In terms of magnitudes, the rise in the (recorded) trade between the EU and CCA3 corresponds to a small fraction of the drop in direct EU exports to Russia (around 10 per cent

[7] We also separately identify goods goods for use in the oil and gas industry as part of robustness checks.

based on calculations presented in Table 1). Nonetheless, the rerouted trade may be important in case of specific product groups, as discussed later.

The picture is markedly different for exports from Turkiye and China, depicted in the bottom part of Figure 1. After a temporary drop in Turkiye's and China's exports to Russia in March-April 2022, the trade flows resumed, reaching values well above those observed before the sanctions. At the same time, these economies' exports to CCA3 also saw a rapid increase, albeit from a small baseline in absolute terms.

The patterns observed for trade with Russia amount to trade diversion whereby exporters in China, Turkiye and other neutral economies fill in the void left by exporters in the sanctioning economies. The patterns for CCA3 may in part be explained by preference for indirect routing for sales of sensitive goods to Russia, an issue we return to in triple-differenced analysis.

The bottom part of Figure 2 normalizes exports to particular destination by total exports, which may be particularly relevant in the Chinese context, given the disruptions caused in the country by the zero-Covid policy. However, even with this normalization, the broad patterns discussed earlier are confirmed. After a temporary dip in Chinese exports to Russia immediately following the invasion of Ukraine, trade flows recover and grow in importance as a share of total Chinese exports. Similarly, the importance of CCA3 as an export destination increases over time.

Yet another cut of the data is presented in Table 2, which lists export values adjusted for US inflation and normalizes the flows that took place during March-December of 2022 and 2023 by their value value during the corresponding months in 2017-21. The pattern is broadly similar to those discussed earlier: a drop in Western exports to Russia accompanied by an increase in exports to Central Asia and the Caucasus. More specifically, exports from the EU and the UK to Armenia and the Kyrgyz Republic increased several times relative to their 2017-21 average.

3.2 Trade lost in transit

Next, we investigate whether some goods shipped to neighbouring countries may have been "lost in transit", possibly while travelling overland through the territory of Russia. To do so, we look at the annual imports from individual EU economies and the UK as reported by

importing economies and the corresponding exports reported by the EU economies and the UK.[8] Beyond EEU, we also examine EU's trade with other neutral economies bordering the Eurasian Economic Union where shipment through Russia would be logical and at the same time could be used to lose goods in transit. Although none of those economies saw increases in EU exports equivalent to the increases observed for CCA3, EU exports to Georgia and Uzbekistan do exhibit notable increases during the sanctions period (see Table 2).

In the analysis that follows, we use annual flows taking to limit discrepancies arising from normal transit times (as both the exporting country and the importing country record flows as they cross their respective borders). The descriptive statistics based on the annual mirror data for EU's exports and trading partners' imports is presented in Annex Table A3.

Discrepancies between export and import records are common. Besides the transit time, they also stem from the fact that exports are recorded on f.o.b. (free on board) basis, while the import figures include the cost of insurance and freight (so-called c.i.f. basis). Moreover, import flows tend to be monitored more carefully than import flows due to import taxes being collected. Thus typically importing county i would report a higher value of flows from exporting country e, relative to what e would report as trade directed to i.

Hence what we are looking for in the data is a change in the ratio of imports reported by the recipient country (say, Armenia) to exports reported by the sending country coinciding with the timing of sanctions. Such change is indeed abrupt and pronounced for CCA3 economies in 2022. As visible in Figure 4, the log-ratio has been fairly stable during the period 2017-21 and (as expected) close to zero, a pattern also observed for other trading partners of the EU (whereby imports and exports are near-identical for a typical product). In 2022, however, the ratio dropped by more than 40 percentage points, with a further drop in 2023, amounting to more than US$2 billion of trade going "missing" in each of those years. Such drops are not observed for typical trades between the EU and other economies with a land border with the EEU or the rest of the world.

We further separate dual-use sanctioned goods, industrial-capacity goods, luxury goods and non-sanctioned products in each CCA3 economy (see Figure 5). Again, we observe a drop in the ratio of imports to exports in 2022 in each economy and these drops tend to be more

[8] On the exporter side, we exclude Austria, France and Malta due to substantial gaps in data reported in UN Comtrade); on the importer side Tajikistan and Turkmenistan do not publish detailed data on imports.

pronounced for sanctioned goods than for the other products. The picture is similar for the aggregate values of exports and a representative (median) trade at the HS6-exporter-importer level.

The pattern remained broadly similar in 2023, although the reporting gap widened more slowly (or in some cases narrowed) in the case of dual-use goods, coinciding with restrictions imposed on transit of such goods through Russia from March 2023.

4 Triple-differencing analysis: Empirical specifications

4.1 Intermediated trade

Next, we investigate intermediated trade in a triple-differenced setting. Our specification for a single exporting country takes the following form:

$$log(Exp_{pit}) = \beta PostSanctions_{pt} * ProductType_p * CountryGroup_i + \alpha_{pi} + \alpha_{pt} + \alpha_{it} + \epsilon_{pit} \tag{1}$$

where the dependent variable is defined as (the logarithm of) the value of exports of HS6 product p exported in month t to the importing country i. The coefficients of interest are those on the triple interaction terms between a categorical variable for groups of products subject to sanctions (*Prod*, with non-sanctioned goods serving as a base category), the post-sanctions period (product-specific, *Post*) and a particular group of importers (Russia or CCA3, with other economies serving as a base group).[9]

The specification includes several sets of fixed effects. Product-importer (α_{pi}) fixed effects capture differences in demand for a specific product across various importers related, for instance, to differences in tastes or domestic production capacity. In single-exporter specification, they also capture factors affecting the bilateral trading relationships such as distance, linguistic proximity, historical links or common border and allow for a differential

[9]Belarus has been subject to its own set of EU sanctions over its role in the invasion of Ukraine. For more information on the Eurasian Customs Union see Isakova et al. (2016).

impact of these factors across products. Product-month (α_{pt}) fixed effects pick up general trends in trade in particular goods, including price fluctuations or shocks to the product supply. Importer-month (α_{it}) fixed effects account for fluctuations in the business cycle in the importing country, its exchange rate, or anything else that may affect the aggregate demand for imports. These fixed effects would subsume broad trends in trade in the aftermath of the imposition of sanctions – a drop in exports to Russia and an increase in exports to Armenia or the Kyrgyz Republic, or an overall decline in exports of a particular product in a particular year – but not differences in bilateral trade in specific products within a given month.

Half or more of observations on bilateral monthly trade at this high level of disaggregation are zeros. With this in mind, it is also useful to look at the extensive margin of trade – the probability that exports in a given month are positive for a given pair of trade partners and a given HS6 product code. Specifications similar to those for the intensive margin of trade (Equation 1) are estimated as a linear probability model, where the dependent variable takes a value of one for positive trade values and zero otherwise.

To combine the estimates on the extensive and the intensive margins of trade, we use Poisson Pseudo-Maximum Likelihood estimation (PPML, see Silva and Tenreyro (2006)) as well as the inverse hyperbolic sine transformation of the values of trade, $log(Exp + \sqrt{Exp^2 + 1})$ (see MacKinnon and Magee (1990)). The latter transformation approximates the logarithmic transformation for large trade volumes while assigning the value of zero to zero trade rather than discarding zero observations.

4.2 Lost in transit trade

We first investigate trade "lost in transit" in a difference-in-difference setting where each observation corresponds to bilateral trade between an EU member country or the UK and an importer for a particular HS6 product group in a given year. The dependent variable is the logarithm of the ratio of bilateral imports (as reported by an importer) to the corresponding bilateral exports (as reported by an EU/UK exporter). The sample covers all importers where data are available in UN Comtrade. In these specifications we distinguish between the sanctions regime (2022-23) and pre-sanctions regime.

The difference-in-difference specifications (Equation 2) include product-exporter-importer and product-exporter-year fixed effects. The interaction term of interest is between the post-sanctions period and the categorical variable for various types of importers (CCA3 economies or other neutral economies sharing a land border with the EEU), with the rest of the world representing the base group.

$$Log(Imp_{peit}/Exp_{peit}) = \gamma PostSanctions_{pt} * ImporterType_i + \alpha_{pet} + \alpha_{pei} + \epsilon_{peit} \quad (2)$$

The triple-differenced specifications (Equation 3) focus on the interaction term between the post-sanctions period, the type of importer and the type of product (with non-sanctioned goods forming the base category). The battery of fixed effects additionally include exporter-importer-year fixed effects that take into account the overall drop in import-export ratios observed in trade between the EU and CCA3 thus zooming in on any differential trends by product group.

$$Log(Imp_{peit}/Exp_{peit}) = \gamma PostSanctions_{pt} * ProductType_p * ImporterType_i + \alpha_{eit} + \alpha_{pet} + \alpha_{pei} + \epsilon_{peit} \quad (3)$$

5 Results: Intermediated trade and trade "lost in transit"

5.1 EU exports of sanctioned products

We begin our econometric analysis by considering the EU/UK exports (EU-27 plus UK) to Russia, CCA3, selected other neighbouring economies and the rest of the world. We focus on the differential patterns of trade between products that were fully or partially subject to sanctions versus all other products. And in particular, we are interested in whether exports of these products to Russia and CCA3 exhibited a differential pattern.

The results, presented in Column 1 of Table 3, suggest that once sanctions have been imposed, the EU/UK exports to Russia of fully or partially sanctioned goods were 0.3 to 2.2 log points lower compared to exports of other goods and to what could have been expected based on patterns observed prior to the imposition of sanctions. This very large difference is statistically significant at the 1 percent level and comes on top of the overall drop in EU exports to Russia (subsumed in the respective fixed effect). It is largest for industrial goods and smallest for luxury goods under sanctions.

At the same time, from March 2022 onwards the EU/UK exports of dual-use, industrial and luxury sanctioned goods to CCA3 were around 25-45 percent higher than exports of non-sanctioned goods.

Similar patterns are observed on the extensive margin. For instance, for industrial sanctioned goods the probability of observing EU/UK exports to Russia declined by an additional 53 percentage points while the probability of EU/UK exports to CCA3 increased by an additional 3 percentage points (see Column 2). PPML and hyperbolic sine specifications yield estimates qualitatively similar to those obtained for the logarithm of trade.

The very striking patterns documented so far are consistent with a scenario under which Western firms cut direct trading relationships with Russia but scale up trade with entities located in the CCA3 countries. It is possible that these CCA3 intermediaries then re-export products to Russia, not necessarily with the knowledge of the Western exporter.

5.2 EU exports of goods similar to sanctioned goods

As mentioned earlier, the existing literature has documented frequent and extensive misclassification of imported products and found evidence consistent with such misclassification being used to evade import taxes (Fisman et al. (2008); Javorcik and Narciso (2008); Javorcik and Narciso (2017)). Thus in this section we additionally distinguish between goods that are similar to sanctioned products. These are products that belong to the same HS4 digit product group as thus could plausibly be used to hide sensitive imports.[10]

[10]Recall the example of x-ray apparatus for dentistry and similar medical uses (HS 902213) not being covered by the EU sanctions on Russia, while x-ray apparatus for non-medical uses (HS 902219) being subject to sanctions.

The results are presented in Table 4. They are qualitatively similar to those for sanctioned products, though the estimates tend to be somewhat smaller in magnitude. For instance, the EU exports of similar-to-sanctioned goods to Russia declined more substantially than those of other goods, although the observed differential is 4-5 times smaller than that for the sanctioned goods (obtained in the same specifications). Moreover, the results reveal an additional increase in the probability of exports of similar goods from EU to CCA3, statistically significant at the 1 percent level.

The pattern observed with respect to exports to Russia may have to do with the ambiguity of sanctions and compliance complexity (the burden of proof that shipment is distinct from a similar shipment that would be subject to sanctions). The results may also reflect voluntary withdrawal by firms supplying such "similar" goods, which may have, for instance, higher technological content (see Sonnenfeld et al. (2022), Hart et al. (2023) and Chupilkin et al. (2024) on voluntary withdrawals versus decisions to continue supplying the Russian market).

When it comes to the increase in (new) exports to CCA3, although this pattern may reflect inaccurate declaration of goods shipped to those economies, it may also pickup a genuine increase in trade in "similar" goods on account of the corresponding decline in direct exports of those goods to Russia. We return to this point later when discussing the cumulative magnitudes of the detected trade patterns and their implications.

In sum, there is no indication that misclassification, in aggregate, played an important role as a method of working around trade sanctions.

5.3 Event study analysis

The mostly-unanticipated nature of the war and the clear-cut timing of sanctions means that our setting lends itself well to an event-study analysis. The underlying econometric specifications are similar to those considered earlier, except for an additional battery of interaction terms between the sanctions dummy and the dummy variables for each month before and after the introduction of sanctions. January 2022 serves as the base (omitted) period. In this exercise we maintain consistent treatment and control samples over time, that is, samples of sanctioned and other goods using regulations in place as of end-2022.

$$Log(Exp_{pit}) = \sum_t \beta_t Month_t * ProductType_p * CountryGroup_i + \alpha_{pi} + \alpha_{pt} + \alpha_{it} + \epsilon_{pit} \quad (4)$$

While monthly trade is volatile and standard errors are larger, a number of distinctive patterns emerge from this analysis (see Figure 6). Up until February 2022, the differences between the EU/UK exports of subsequently sanctioned goods to Russia and those of other goods were broadly stable, with no differential trends. In March 2022, the EU/UK exports of sanctioned goods to Russia dropped dramatically relative to exports of other goods. This differential kept increasing between March and mid-summer 2022, stabilizing thereafter.

In contrast, a statistically significant increase in the EU/UK exports of sanctioned goods to CCA3 (above an increase /in exports of other goods) is observed from April 2022 onwards, increasing steadily through the end of the summer and then stabilizing before starting to narrow gradually from March 2023 onwards. Again, there is no strong evidence of differential pre-trends. This pattern is suggestive of new supply chains via Armenia, Kazakhstan and the Kyrgyz Republic being set up within weeks of the imposition of sanctions and taking several months to scale up.

While the differential between excess exports of sanctioned and non-sanctioned progressively narrowed through the last three quarters of 2023, it remained sizable and statistically significant throughout the period. The inversion of the trend coincided with the introduction of restrictions on transit of goods through Russia, initially for dual-use goods – a point we investigate further when zooming in on trade lost in transit.

5.4 Exports from CCA3 to Russia

Next, we look at the exports from CCA3 to Russia and other trading partners. We estimate an equation similar to Equation 1 with all fixed effects additionally interacted with each exporter (for instance, creating product-exporter-importer fixed effects, see Equation 5).

$$Log(Exports_{peit}) = \beta PostSanctions_{pt} * ProductType_p * Rus_i + \alpha_{pei} + \alpha_{pet} + \alpha_{iet} + \epsilon_{peit} \quad (5)$$

The results, presented in Table 5, are consistent with trade in sanctioned goods being intermediated by CCA3 countries. CCA3's exports of sanctioned goods to Russia increased by an additional 1.2 log points relative to other goods, with large differentials observed for dual-use goods under sanctions. These large differential effects are observed both on the intensive and on the extensive margin of trade. The probability of observing exports increased by an additional 4-6 percentage points for goods that were put on the sanctions list. Overall, these results are also consistent with the emergence of intermediated trade in sanctioned goods.

5.5 Trade diversion

To put intermediated trade via CCA3 into context, we document broader shifts in patterns of Russia's imports following the imposition of sanctions, consistent with diversion of trade towards neutral partners. Triple-differencing analysis reveals that after the imposition of international sanctions, China's exports of dual-use goods to Russia increased significantly more than exports of non-sanctioned goods. These effects are large and are observed both on the intensive and on the extensive margins. In addition, China's exports of dual-use goods to CCA3 increased by an extra 17-57v percentage points relative to exports of non-sanctioned goods (see Table 6). Looking at examples of specific products, exports of heavy-duty trucks from China to Russia increased markedly in 2022.

Similar patterns are observed for Turkiye's exports to Russia (see Table 7), again, with larger increases in exports of dual-use and industrial goods under sanctions, both to Russia directly and to CCA3 economies, compared with exports of non-sanctioned goods.

5.6 Trade lost in transit

Some media reports further suggested that goods shipped to CCA3 countries through Russia may not physically enter the destination economies. Various transshipment schemes have been

previously shown to be used to evade tariffs (for instance, Rotunno et al. (2013)). Indeed, as discussed earlier, the gap between exports reported by the EU/UK and the respective imports reported by the economies in the Caucasus and Central Asia indeed widened in 2022 and 2023.

The regression analysis looks at changes in import-to-export ratios observed in bilateral trade between the EU member states and their trading partners after the imposition of economic sanctions on Russia. The results of difference-in-difference analysis comparing patterns observed for CCA3, other neutral economies sharing a land border with the EEU and the rest of the world are presented in Table 8.

Across CCA3, the reported imports of sanctioned goods declined by an extra 60 percentage points in 2022-23 relative to the corresponding reported exports and relative to the ratios observed for other economies. These effects are statistically significant at the 1 percent level and observed for all types of goods, with a larger coefficient for industrial-capacity goods and a smaller coefficient for non-sanctioned goods (Column 6). Similar patterns are observed in trade with other neutral economies sharing a land border with the EEU although the estimated effect is an order of magnitude smaller (at around 6 percent).

The last column presents the results of triple-differenced analysis comparing drops in import-to-export ratios observed for various types of goods. It reveals a differential drop of around 30 percent in the ratio of reported imports to exports for industrial goods (and 18 percent for dual-use goods), on top of the drop observed for non-sanctioned goods traded between the EU and CCA3.

In some cases, imports are recorded against zero corresponding exports from the EU or, conversely, no imports are recorded against non-zero exports. We create dummy variables for those cases and look at differential patterns in incidence of such discrepancies after the imposition of sanctions on Russia (see Annex Tables A4). The picture is similar: under sanctions, zero imports become around 6 percentage points more likely to be recorded by CCA3 economies against non-zero exports from the EU, with differentially larger effect for dual-use goods. Imports became around 10 percentage points less likely to be recorded against zero exports and "misclassification" into dual-use or industrial goods became differentially less likely under sanctions.

Next, we conduct an event study similar to the one conducted earlier for intermediated trade. First, in a difference-in-difference framework we interact the categorical variable for the type of importer with year dummy variables, with 2021 being the base year. The results presented in Figure 7 show no pre-trends prior to 2022, followed by a sharp drop in the import-to-export ratio in 2022 and a further widening of the gap in 2023. The widening, in part, reflects the fact that the 2022 effect is only underpinned by trade in 9-10 out of 12 months of the year while the 2023 coefficient captures the full-year effect.

In a triple-differenced setting, we further interact the product type and importer type with the year dummies. The results are presented in Figure 8. For dual-use goods, the incidence of trade being lost-in-transit appears to have declined in 2023 compared with a counterfactual based on trends for non-sanctioned goods (and other economies). This trend is different from the ones observed for industrial goods and luxury goods under sanctions. This suggests that while the February 2023 sanctions package did not eliminate loss of dual-use goods in transit, it raised the (perceived) costs associated with lost-in-transit trade in dual-use goods and meaningfully restricted such trades relative to a plausible counterfactual.

5.7 Economic sanctions and trade finance

In the next subsection we provide indirect evidence on the role of banks in upholding sanctions. To do so, we identify products that are more likely to require letters of credit – a type of trade finance instrument provided by a bank in importer country and confirmed by a bank in exporter country. Crozet et al. (2022) show that reliance on letters of credit is beneficial for cross-border trade at times of increased uncertainty but harmful at times of financial turmoil. Both the issuing bank and the confirming bank are required to run know-your-customer compliance checks. Being tightly regulated entities, banks had been previously subjected to large fines for failing to comply with sanctions. For instance, Berthou (2023) show that French firms working with banks that were likely to be more concerned about sanctions enforcement by the US authorities were significantly less likely to invoice their exports to Russia in US dollars after the 2014 round of sanctions.

For these reasons, dependence on letters of credit may affect trade in goods covered by sanctions differentially from trade in other goods. An index of letter-of-credit]intensity is

available at the HS4 level from Crozet et al. (2022) and is applied to all HS6 product groups within HS4. We look at the subsample of product groups with above-median letter-of-credit intensity and those with below-median intensity. The results are reported in Table 9.

The additional increase in EU exports of sanctioned goods to CCA3 economies is substantially higher for goods that typically do not require trade finance, both on the intensive margin and on the extensive margin of trade. For trade-finance-intensive goods the coefficient on the sanctions variable is also positive but smaller and its statistical significance depends on the estimation method (being not significant in PPML regressions). The difference in the extent of intermediated trade between the two groups of products is likely explained by stricter compliance checks accompanying trade backed by letters of credit.

We return to the role of trade finance provided by banks when discussing policy options for responding to the rise of lost-in-transit trade and other forms of intermediated trade in sanctioned goods.

5.8 Unit values

Next, we investigate if the average unit values of exports of sanctioned products to Russia and CCA3 changed relative to those of other products once sanctions have been imposed. Average unit values are calculated by dividing the nominal value of exports by the quantity of exports (the unit of measurement being specific to an HS6 product group). The data on shipments in physical terms is also obtained from UN Comtrade.

In general, additional compliance costs or other costs associated with trade in sanctioned goods are likely to be at least partially passed on to the consumer, leading to an increase in the average unit value of exports. In addition, cheaper, non-differentiated, generic products may be easier to substitute from other suppliers, for instance, those in China. Such substitution within a product group can also drive up the average unit value of EU's exports.

However, for luxury goods where sanctions apply to items above a certain threshold value (for instance, €300 for most items of apparel, €750 for mobile phones or €1,500 for pianos), one could also observe a shift towards cheaper items within the same HS6 product group, i.e., towards those priced below the sanctions threshold. The reported price of some items may

even be artificially lowered to a value below the cut-off point. This may result in a lower average unit value of exports in response to sanctions. In the light of these opposing effects, as before, we distinguish between HS6 product lines containing luxury goods, where application of sanctions depends on the unit value, and other goods subject to sanctions.

In the difference-in-difference analysis, we estimate the coefficient on the interaction term between the categorical variable for the importers of interest and the post-sanctions period, as detailed in Equation 6. The specification include importer-product fixed effects (capturing specificities of unit costs of a particular product group imported from the EU by, say, CCA3 economies) and product-time fixed effects (capturing, say, global trends in unit costs of EU's exports of a particular product). The results are reported in Table 10.

$$log(UnitValue_{pit}) = \beta PostSanctions_t * CountryGroup_i + \alpha_{pi} + \alpha_{pt} + \epsilon_{pit} \tag{6}$$

The average unit value of EU exports to Russia increased by an additional 11 percent under sanctions compared to what could be expected based on trends before sanctions and concurrent exports to other destinations. Unit values of EU exports to CCA3 increased by around 3 percent. When it comes to China's exports to Russia, no significant change is observed for goods exported to Russia directly while the unit value of shipments to CCA3 increased by extra 7 percent relative to a plausible counterfactual. For Turkiye (not shown in the table), larger increases are observed both for direct shipments to Russia and for shipments to CCA3, of an order of 20 and 11 percent, respectively.

In the triple-differencing analysis, we further interact the term of interest with a categorical variable for product types and saturate regressions with importer-time fixed effects which capture any change in prevailing unit costs for exports to Russia or CCA3 during the post-sanctions period (Equation 7). These regressions thus zoom in on any differences in pricing of various types of sanctioned goods shipped to Russia or CCA3 compared with non-sanctioned goods. The results are presented in the last columns in Table 10).

$$log(UnitValue_{pit}) = \beta PostSanctions_{pt} * ProductType_{p} * CountryGroup_{i} + \alpha_{pi} + \alpha_{pt} + \alpha_{it} + \epsilon_{pit} \quad (7)$$

Under sanctions, the average unit value of EU exports to Russia differentially increased by an additional 8 percent in the case of dual-use goods and 27 percent for industrial goods compared with non-sanctioned goods. For luxury goods, the average unit values declined by around 30 percent relative to what could otherwise be expected. The latter finding is in line with some degree of compliance with the sanctions thresholds. When we further consider shipments from the EU/UK to CCA3 countries, there are no significant differences in unit value changes across types of products.

Unit values of CCA3 exports to Russia increased by around 70 percent, with larger differential increases for dual-use goods and smaller increases for luxury goods (likely a reflection of the costs passed on by intermediaries as well as composition effects within product groups). Unit values of China's exports to Russia differentially increased for dual-use and industrial goods, with extra increases of 10-15 percent, likely reflecting the market power of China's exporters as well as movements upmarket within product groups, into niches previously occupied by trademarks from sanctioning economies.

Overall, there is indication of higher average prices of exports to Russia, and in particular exports of sanctioned goods, which may reflect additional costs associated with indirect routing or an increased number of intermediaries. For exporters from neutral economies, these increases in part reflect increased market power of exporters and possibly pricing of risks associated with secondary sanctions.

At the same time, unit value mark-ups at the point of exports analyzed in this paper appear to be modest. This may in part reflect relatively modest mark-ups for trade lost-in-transit relative to other types of intermediated trade. It should also be noted that increases in import prices at the Russian border may be considerably greater. For instance, Chupilkin et al. (2024) document a sizable increase in unit costs at the point of imports for intermediated trade, in particular for imports of dual-use goods (via indirect routings) under trademarks registered to intellectual property owners in sanctioning economies. Hinz and Monastyrenko (2022) provide

further evidence of increased consumer prices in response to the earlier rounds of sanctions and counter-sanctions in Russia.

5.9 The magnitudes of intermediated trade and trade lost-in-transit

In total, the increase in exports of fully or partially sanctioned goods from the EU, the UK and the US to CCA3 amounted to around US$5 billion over the period March-December 2022-23 (compared with the same period in 2017-21 and adjusted for inflation). Several observations emerge.

First, around 50-60 percent of trade likely involving intermediaries in CCA economies may have been simply lost in transit (based on the ratios of the reported imports and exports as well as the magnitudes of exports reported by the EU). Those shipments may not have involved (relatively expensive) physical movement of goods to landlocked Central Asia or Armenia and back to Russia.

Second, trade intermediated through CCA amounts to less than 10 percent of the decline in the direct exports of fully or partially sanctioned goods from the EU and the UK to Russia over the same period (see Table 1). In aggregate, trade diversion – increases in exports from China, Turkiye and other neutral economies – played a more important role in filling the void left by the sanctioning trading partners.

At the same time, the extent of rerouting appears to be high for particular product groups. This can be seen by calculating "substitution ratios" – the ratios of abnormal increase in exports to CCA3 in 2022-23 relative to the average in 2017-21 (adjusted for inflation) to the drop in direct exports of the same product to Russia. These substitution ratios exceed 50 percent for a diverse mix of more than 450 product lines. In some cases, amounts are small while for a handful of product lines abnormal trade is in excess of US$ 100 million.

By way of example, for large-engine internal-combustion vehicles (870324), the increase in exports to CCA3 amounts to US§274 million (from virtually nil) compared with a drop of US$ 606 million in direct exports to Russia, yielding a substitution ratio of 45 percent. For portable computers (847130), the substitution ratio is well in excess of 100 percent, with a US$ 84 million increase in exports to CCA3. Similarly, a substitution ratio of around 60 percent is

observed for printers (844331), with patterns extending to other consumer electronics and parts. For porcelain tableware (691110) the substitution ratio is also around 60 percent. These patterns are, in turn, consistent with evidence in Avdeenko et al. (2023) who show that Western brands were widely sold online in Russia via websites tracked by Google Analytics.

Among those goods, those that appear to be lost in transit in large quantities include tractors (870120), vehicles and vehicle parts, computers, printers (844331) and mobile phones (851712). For example, in 2017-21 the ratio of imports of vehicle parts (HS code 870830) as reported by Armenia and the Kyrgyz Republic relative to the exports to those countries reported by the EU/UK was between 89 and 110 percent. However, in 2022 it dropped to 30 percent suggesting that about 2/3 of exports have "gone missing" in transit. In the case of various engine parts (HS code 840999), the ratio dropped from 95 percent in 2021 to 17 percent in 2022.

Third, while the total additional trade from selected advanced economies via Armenia, Kazakhstan and the Kyrgyz Republic (in sanctioned and non-sanctioned goods) is a small percentage of the decline in direct exports to Russia, the amounts involved are large for the intermediary economies. In the Kyrgyz Republic and Armenia, they were equivalent to 8 to 11 per cent of their GDP (annualized) in 2022, rising much further if additional imports from China and Turkiye are included (to up to 90 per cent of GDP, annualized, for the Kyrgyz Republic).

The logistics and intermediation services associated with increased exports would have made a sizeable contribution to these economies' GDP and capital inflows. As a result, the currencies of economies providing intermediary services performed better than most emerging market currencies in 2022; in some cases, they appreciated against the US dollar notwithstanding dollar's overall strength during that period. The cost of various intermediary services is effectively billed to end-consumers in Russia who face significantly higher prices for imported goods (see Hinz and Monastyrenko (2022) for evidence of price increases following the earlier round of sanctions and counter-sanctions in Russia and Chupilkin et al. (2024) for evidence on price increases at the point of import in 2022-23).

5.10 Discussion

The analysis documents the important role of "lost-in-transit" method deployed to work around comprehensive trade sanctions. It is simple, relatively inexpensive and little documented in the literature.

A number of policy tools are potentially available to counter the effectiveness of this simple and inexpensive method of working around sanctions. Transshipment through the sanctioned economy could, in principle, be prohibited (a partial prohibition was indeed put in place by the EU in February 2023). This may, however, result in considerable logistical complications for legitimate importers in third countries that are often landlocked (Armenia, the Kyrgyz Republic, Tajikistan, Uzbekistan), semi-landlocked (Kazakhstan and Azerbaijan border the Caspian Sea) and / or have difficult relationships with other neighbours (in the case of Armenia). Options for land transshipment between Europe and Asia bypassing both Iran and Russia are naturally limited.

Enforcing such regulations also requires upgrades to information management systems, for instance, when it comes to trade finance. The analysis in the paper provides evidence supportive of banks subjecting potential trade finance operations to additional scrutiny: intermediated trade is much less likely to be observed for products traditionally relying on trade finance instruments. Yet bank systems are not typically designed to record the routing or unit values of trade and may need to be upgraded to accommodate comprehensive trade sanctions regimes covering routes, unit values or any other relevant variables.

5.11 Robustness checks

We run a number of robustness checks. First, we repeat the analysis performed for aggregate EU exports looking at exports of individual EU member states (with all fixed effects additionally interacted with each exporter). The results are qualitatively and quantitatively similar to those discussed earlier.

Next, we aggregate trade during March-December of each year. In 2022, this approach yields trade in the aftermath of Russia's invasion of Ukraine. Looking at the same period in each

year alleviates concerns related to seasonality in trade patterns while aggregated flows tend to be less volatile. Again, the results for intermediated trade are qualitatively similar to those reported earlier.

We further conduct placebo tests for trade lost in transit by looking at EU's trade with India, an important trading partner of the EU and Russia that does not share a land border with the EEU. The results do not indicate any significant pick-up in lost trade in 2022 or 2023.

Additional specifications use time-invariant sanctions variable (for instance, as of December 2022) interacted with a dummy variable for the post-sanctions period; other specifications include different sets of fixed effects. These produce similar results. In specifications without product-importer fixed effects, the interaction terms of interest are included and estimated separately for the pre-sanctions and post-sanctions periods, with the difference between the two being most comparable to the earlier estimates. The combination of the two interaction terms produce qualitatively and quantitatively similar results.

When we look at the types of sanctions, we specifically identify a subset of goods essential for the capacity of the oil and gas industry, given the importance of these sectors for Russia's fiscal revenues and export receipts (oil and gas account for around 55 percent of exports directly and perhaps up to 70 percent counting proximate energy-intensive exports such as fertilizer). This is a fairly narrow set of around 30 HS6 product lines, and a large chunk of those products had been traditionally imported into Russia from the United States. We find that exports of these goods from the United States have virtually ceased, with no other statistically significant patterns given the small size of this sample. In the main analysis these HS6 lines are subsumed in the broader category of goods essential for the industrial capacity.

We also run additional analysis that looks at various product types – for example, final versus intermediate goods or differentiated vs non-differentiated products – and the results (available upon request) are consistent with the expected patterns of intermediated trade.

6 Conclusion

Using bilateral monthly and annual exports at the HS6 level of disaggregation, we document a number of striking patterns in trade of Russia and its neighbours in the aftermath of Russia's invasion of Ukraine. The EU/UK exports to Russia dropped sharply following the introduction of economic sanctions in March 2022. At the same time, the EU/UK exports to Armenia, Kazakhstan and the Kyrgyz Republic (CCA3, all members of Eurasian Customs Union alongside Belarus and Russia) increased markedly. These patterns consistent with rerouting of trade to Russia were more pronounced for product groups where goods are at least partially subject to sanctions and, to a lesser extent, for goods that are similar to sanctioned ones.

A large proportion of this intermediated trade appears to be accounted for shipments from the EU to CCA3, presumably lost in transit through Russia, as they have never been recorded as imports at CCA3 customs. Difference-in-difference and triple-difference analysis shows that the emergence of this lost-in-transit trade is specific to the post-sanctions period and CCA3 economies with much smaller effects, if any, observed for other neutral economies sharing a land border with Russia or the EEU.

The increase in exports of sanctioned goods to CCA3, including trade lost in transit, represents a small fraction of the reduction in direct exports of sanctioned goods to Russia (around 10 percent) but can be large for specific product groups. New supply routes took around 2-4 months to set up.

The evidence points to a simple and inexpensive – yet little-documented – way to circumvent economic sanctions by using spurious transshipment arrangements. Such trade has been earlier shown to be a tool of evading tariffs, taxes and country-of-origin rules. Trade lost in transit, intermediated trade and probable misclassification of goods complement patterns of trade diversion in Russia's direct trade with neutral trading partners, notably China and Turkiye. Countering the effectiveness of lost-in-transit trade may require additional regulations on transshipment and updates to information management systems used to record financing of trade transactions as the analysis shows that financial institutions can play an important role in upholding trade sanctions.

Following restrictions on trans-shipment of dual-use goods through Russia introduced in February 2023, the difference between lost-in-transit trade in dual-use goods and non-sanctioned goods has narrowed. While the February 2023 sanctions package did not eliminate loss of dual-use goods in transit, it appears to have raised the (perceived) costs associated with lost-in-transit trade in dual-use goods and meaningfully restricted such trades relative to a plausible counterfactual. More generally, the differential between EU's exports of sanctioned and non-sanctioned goods to CCA3 started narrowing from March 2023.

The patterns of trade summarized in this paper rely on official exporter data (and, in the case of trade lost in transit, also on official importer data). They do not pick up any (other) illicit activities such as smuggling of sanctioned or non-sanctioned goods. We are also limited by the nature of the data (aggregated at the HS6 product group level), which does not cover actual goods, their unit costs, traders or trademark owners. This often creates ambiguity as to the extent to which such trade, were it to take place between the EU and Russia directly, would be covered by trade sanctions. At the same time, by revealing some of the complex shifts in trade following the imposition of comprehensive packages of trade restrictions, the paper invites further research into ways in which supply chains respond to sanctions.

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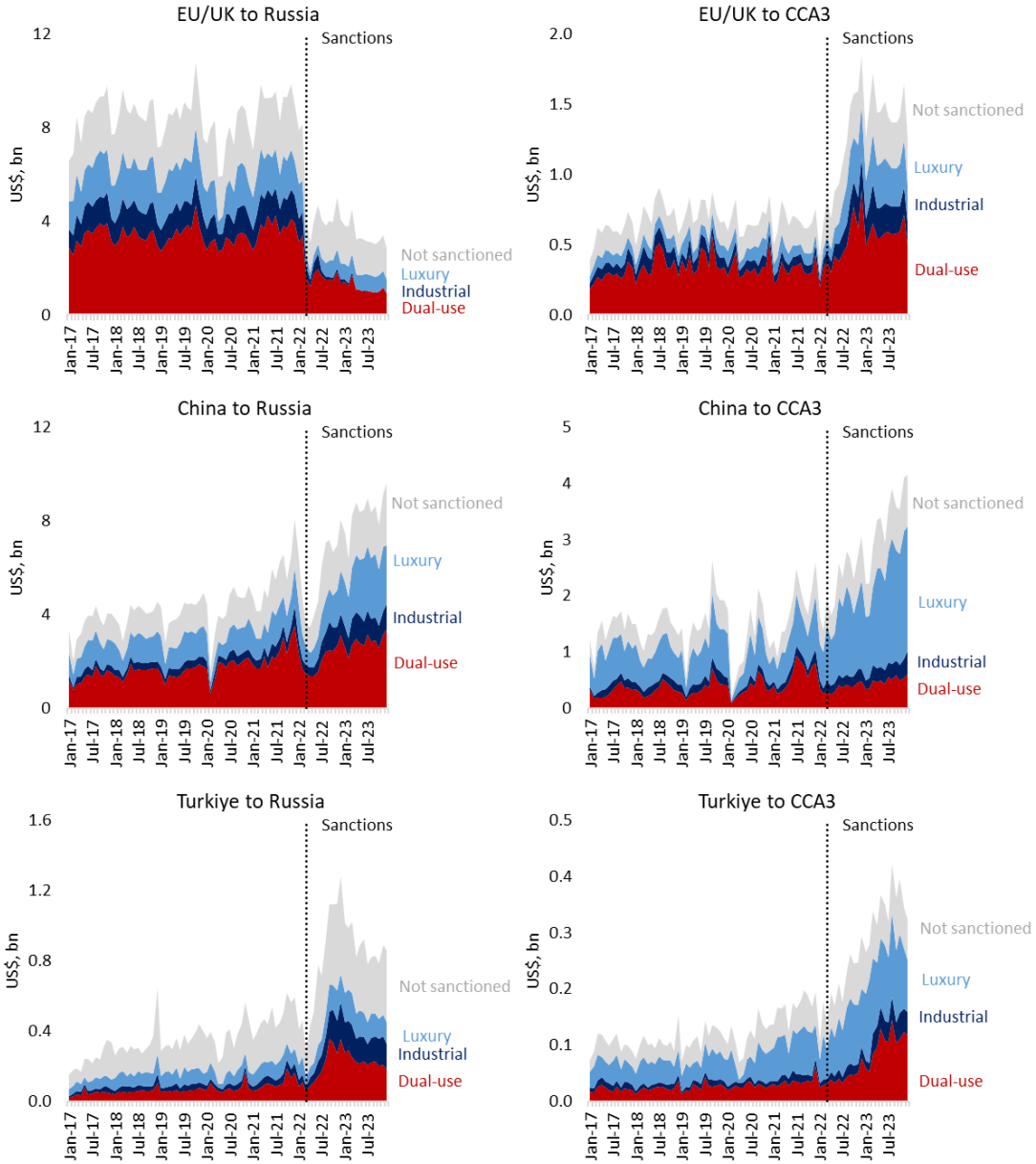
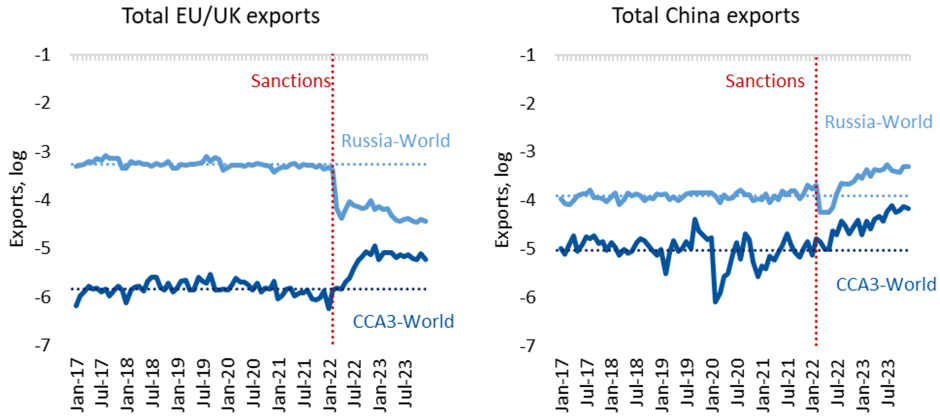
Figure 1: Exports to Russia and CCA, by exporter and type of goods



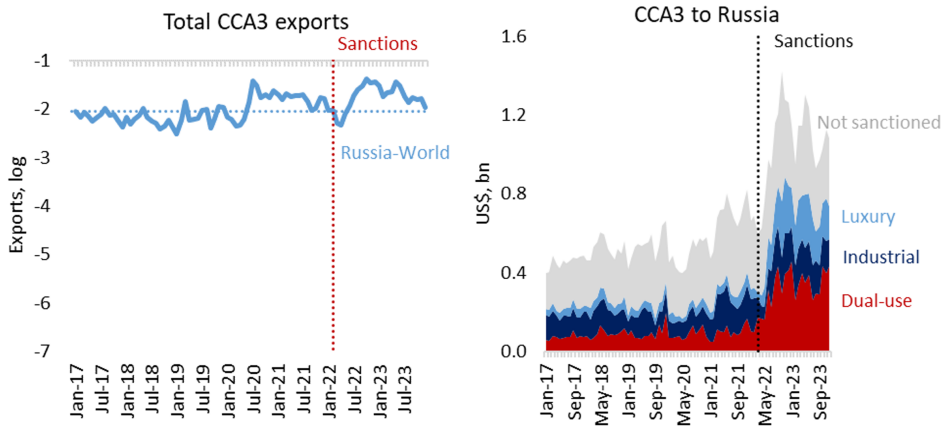
Source: Authors' calculations based on UN Comtrade and China Customs Administration.
Note: Based on trade reported by exporters. Trade in nominal US dollars is adjusted for US inflation. EU total is inclusive of the UK. Sanctioned refers to HS6 product lines where EU sanctions apply at least partially as of end-2022. CCA3 comprises Armenia, Kazakhstan and the Kyrgyz R.

Figure 2: Difference-in-difference: Share of exports to Russia and CCA3 in total exports, log



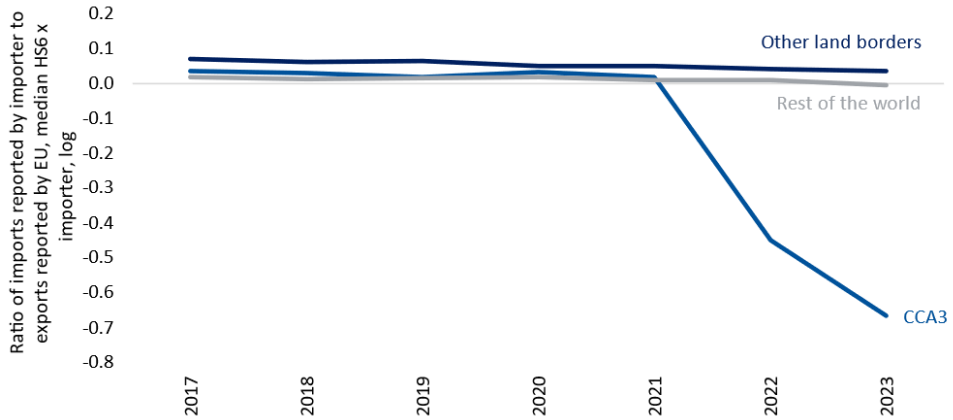
Source: Authors' calculations.
Note: The figure shows the log-difference between exports to Russia (or CCA3) and exports to the rest of the world in a given month. CCA3 comprises Armenia, Kazakhstan and the Kyrgyz R.

Figure 3: Exports from CCA3 to Russia



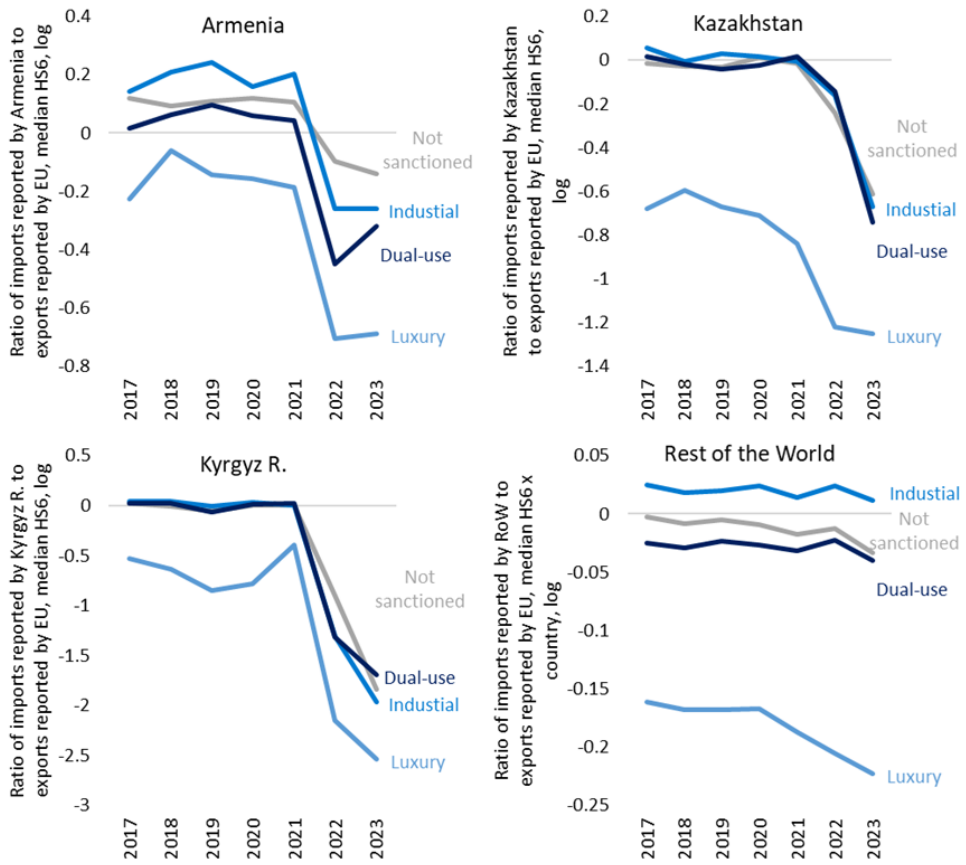
Source: Authors' calculations based on UN Comtrade, Refinitiv Eikon and Kazakhstan customs statistics.
Note: Based on trade reported by exporters. Trade in nominal US dollars is adjusted for US inflation.

Figure 4: Lost in transit: Median ratio of imports recorded by CCA3 to exports recorded by EU/UK, log



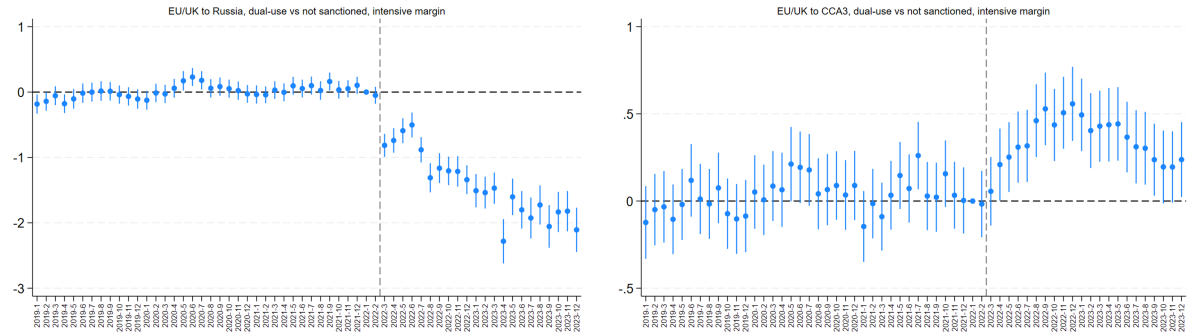
Source: Authors' calculations based on UN Comtrade.
Note: Based on bilateral trade at the HS6 level each year. Logarithm of median ratio of imports as reported by an importer to the corresponding exports as reported by EU member states and the UK, across HS6 products and importers.

Figure 5: Lost in transit: Median ratio of imports to exports recorded by EU/UK, log, by type of product



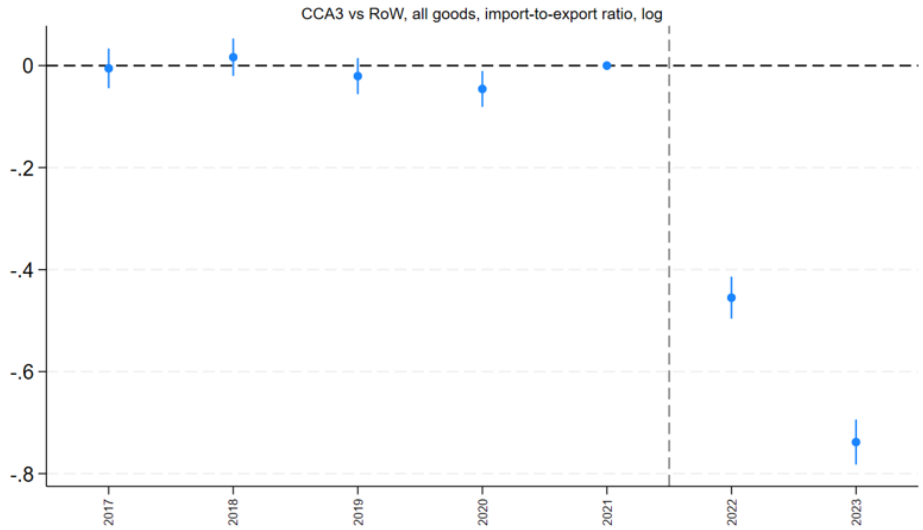
Source: Authors' calculations based on UN Comtrade.
Note: Based on bilateral trade at the HS6 level each year. Log the median ratio of imports as reported by an importer to the corresponding exports as reported by EU member states and the UK, by CCA3 economy and type of products under sanctions.

Figure 6: Event study: Exports of sanctioned vs non-sanctioned goods



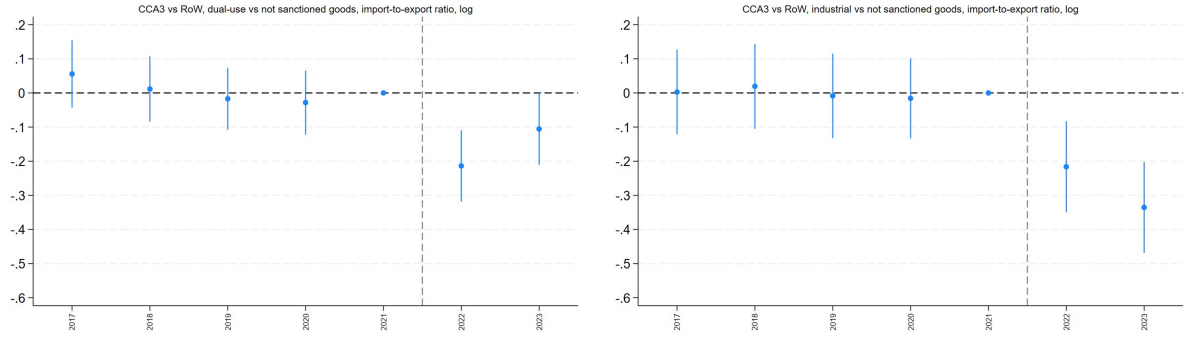
Source: Authors' calculations.
Note: The figure shows coefficients on the interaction terms between month dummy variables, the dummy for sanctioned products and Russia (or CCA3) as importer. The dependent variable is the logarithm of monthly bilateral exports from the EU/UK in a given HS6 product group. Standard errors are clustered on products; 95% confidence intervals are shown. Sanctioned products are based on EU legislation and include HS6 groups where sanctions apply in a subset of cases as of end-2022. CCA3 comprises Armenia, Kazakhstan and the Kyrgyz R.

Figure 7: Event study: Lost in transit trade, difference-in-difference



Source: Authors' calculations.
Note: The figure shows coefficients on the interaction terms between year dummy variables and the categorical variable for CCA3 (other land borders; rest of the world) as importer. The dependent variable is the logarithm of the ratio of bilateral annual imports as reported by importers to bilateral exports reported by the EU member states and the UK for a given HS6 product group. 2021 serves as a base year. Standard errors are clustered on products; 95% confidence intervals are shown. CCA3 comprises Armenia, Kazakhstan and the Kyrgyz R.

Figure 8: Event study: Lost in transit trade, triple difference



Source: Authors' calculations.
Note: The figure shows coefficients on the interaction terms between year dummy variables, the categorical variable for CCA3 (other land borders; rest of the world) as importer and categorical variable for product types. The dependent variable is the logarithm of the ratio of bilateral annual imports as reported by importers to bilateral exports reported by the EU member states and the UK for a given HS6 product group. 2021 serves as a base year. Standard errors are clustered on products; 95% confidence intervals are shown. CCA3 comprises Armenia, Kazakhstan and the Kyrgyz R.

Table 1: Change in export volumes, Mar-Dec 2022-23 relative to the average of Mar-Dec 2017-21, in US$ billion

	Total		Dual-use		Industrial		Luxury		Not sanctioned	
	Russia	CCA3	Russia	CCA3	Russia	CCA3	Russia	CCA3	Russia	CCA3
EU/UK	-65.2	5.3	-28.3	1.6	-11.7	0.8	-13.3	1.7	-11.8	1.2
USA	-5.7	0.4	-2.1	0.1	-0.6	0.1	-0.8	0.1	-2.2	0.1
China	20.4	11.4	4.3	-0.3	4.8	0.7	6.2	8.6	5.0	2.4
Turkiye	4.3	1.4	1.3	0.5	1.0	0.2	0.4	0.6	1.6	0.3
CCA3	4.2		2.2		0.2		1.4		0.4	

Source: Authors calculations based on UN Comtrade and China Customs Administration.

Note: Based on trade reported by exporters. Trade in nominal US dollars adjusted for US inflation. Sanctioned refers to HS6 product lines where EU sanctions apply at least partially. CCA3 is Armenia, Kazakhstan and the Kyrgyz R.

Table 2: Average monthly cross-border trade flows in March-December 2022-23, in percent of the March-December average in 2017-21

From	World	CCA3	ARM	KAZ	KGZ	RUS	BLR	AZE	CHN	GEO	MNG	PRK	TJK	TKM	UZB
EU + UK	102	178	213	154	573	38	85	68	88	138	115	56	121	69	148
of which:															
EU	102	181	212	158	570	39	88	76	83	138	117	56	120	69	148
Germany	96	195	215	171	771	32	88	107	84	155	98		130	74	137
UK	101	108	262	90	715	21	7	48	131	145	75	20	122	73	129
China	112	184	94	144	277	153	221	78		47	161	67	179	182	186

Source: Authors' calculations based on UN Comtrade and China Customs Administration.

Note: Based on trade reported by exporters. Trade in nominal US dollars is adjusted for US inflation. CCA3 refers to Armenia, Kazakhstan, and Kyrgyzstan.

Table 3: EU exports of sanctioned vs other goods: Triple-differenced analysis

Dep. var.:	*Trade, log*	*0-1*	*Trade, hyp*	*Trade, PPML*
Dual-use under sanctions x CCA3	0.322***	0.0377***	0.948***	0.0472
	(0.0453)	(0.00606)	(0.0971)	(0.0672)
Industrial under sanctions x CCA3	0.429***	0.0298***	0.580***	0.255**
	(0.0591)	(0.00703)	(0.0910)	(0.107)
Luxury under sanctions x CCA3	0.236***	0.0404***	0.842***	0.431***
	(0.0496)	(0.00775)	(0.105)	(0.140)
Dual-use under sanctions x Russia	-1.213***	-0.173***	-2.681***	-0.518***
	(0.0652)	(0.0105)	(0.140)	(0.174)
Industrial under sanctions x Russia	-2.242***	-0.528***	-7.039***	-1.813***
	(0.110)	(0.0105)	(0.151)	(0.130)
Luxury under sanctions x Russia	-0.334***	0.0438***	0.0707	-0.486***
	(0.0610)	(0.0100)	(0.124)	(0.139)
Observations	1,093,793	1,898,484	1,898,484	1,882,183
R^2	0.931	0.774	0.895	

Source: Authors' calculations.

Note: Standard errors are clustered on products. All regressions include importer-month, product-month and product-importer fixed effects. *, **, *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The dependent variable is (the logarithm of) bilateral trade in a given month in a given product group at the HS6 level; 0-1 variable for trade taking place or the inverse hyperbolic sine transformation of trade. Importer economies comprise Armenia, Kazakhstan, Kyrgyz R., Russia and the rest of the world (aggregated). Sanctioned refers to HS6 product lines where EU sanctions apply at least partially. CCA3 is Armenia, Kazakhstan and the Kyrgyz R.

Table 4: Exports of sanctioned vs similar vs other goods

Dep. var.:	*Trade, log*	*0-1*	*Trade, hyp*	*Trade, PPML*
Goods under sanctions x CCA3	0.319***	0.0420***	0.907***	0.221***
	(0.0396)	(0.00513)	(0.0720)	(0.0780)
Similar goods x CCA3	0.0520	0.0183***	0.261***	0.125
	(0.0463)	(0.00547)	(0.0702)	(0.0774)
Goods under sanctions x Russia	-1.078***	-0.235***	-3.437***	-0.640***
	(0.0513)	(0.00864)	(0.111)	(0.115)
Similar goods x Russia	-0.239***	-0.0470***	-0.628***	-0.0329
	(0.0452)	(0.00804)	(0.0932)	(0.0834)
Observations	1,093,793	1,898,484	1,898,484	1,882,183
R^2	0.931	0.771	0.893	

Source: Authors' calculations.

Note: Standard errors are clustered on products. All regressions include importer-month, product-month and product-importer fixed effects. *, **, *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The dependent variable is (the logarithm of) bilateral trade in a given month in a given product group at the HS6 level. Importer economies comprise Armenia, Kazakhstan, Kyrgyz R., Russia and the rest of the world (aggregated). Sanctioned refers to HS6 product lines where EU sanctions apply at least partially, all sanctioned product lines are classified into the presented mutually exclusive categories. Similar goods are not sanctioned but fall within the same HS4 as sanctioned goods. CCA3 is Armenia, Kazakhstan and the Kyrgyz R.

Table 5: Exports of sanctioned vs other goods from CCA3

Dep. var.:	*Trade, log*	*0-1*	*Trade, hyp*	*Trade, PPML*
Dual-use under sanctions x Russia	1.239***	0.0599***	1.060***	1.233***
	(0.116)	(0.0105)	(0.119)	(0.173)
Industrial under sanctions x Russia	0.683***	0.0518**	0.756***	0.00942
	(0.157)	(0.0125)	(0.141)	(0.304)
Luxury under sanctions x Russia	0.176	0.0336***	0.555***	1.443***
	(0.116)	(0.0119)	(0.130)	(0.386)
Observations	188,084	734,664	734,664	385,130
R^2	0.849	0.779	0.826	

Source: Authors' calculations.

Note: Standard errors are clustered on products. All regressions include exporter-importer-month, product-exporter-month and product-exporter-importer fixed effects. *, **, *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The dependent variable is (the logarithm of) bilateral trade in a given month in a given HS6 product group. Importer economies comprise Russia and the rest of the world (aggregated). Exporters are Armenia, Kazakhstan and the Kyrgyz R. Sanctioned refers to HS6 product lines where EU sanctions apply at least partially.

Table 6: China's exports of sanctioned vs other goods: Triple-differenced analysis

Dep. var.:	*Trade, log*	*0-1*	*Trade, hyp*	*Trade, PPML*
Dual-use under sanctions x CCA3	0.228***	0.0366***	0.571***	0.167**
	(0.0426)	(0.00693)	(0.111)	(0.0742)
Industrial under sanctions x CCA3	-0.109*	0.00817	-0.209**	-0.0206
	(0.0561)	(0.00658)	(0.0865)	(0.116)
Luxury under sanctions x CCA3	0.301***	0.0235***	0.498***	0.278***
	(0.0521)	(0.00761)	(0.108)	(0.0976)
Dual-use under sanctions x Russia	0.493***	0.0397***	0.961***	0.182**
	(0.0397)	(0.00760)	(0.0971)	(0.0823)
Industrial under sanctions x Russia	0.560***	0.0763***	1.004***	0.261**
	(0.0571)	(0.0106)	(0.131)	(0.112)
Luxury under sanctions x Russia	-0.131***	0.0101	0.0140	0.137
	(0.0449)	(0.00836)	(0.0955)	(0.113)
Observations	806,513	1,534,680	1,534,680	1,492,993
R^2	0.921	0.768	0.879	

Source: Authors' calculations.

Note: Standard errors are clustered on products. All regressions include importer-month, product-month and product-importer fixed effects. *, **, *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The dependent variable is (the logarithm of) bilateral trade in a given month in a given product group at the HS6 level; 0-1 variable for trade taking place or the inverse hyperbolic sine transformation of trade. Importer economies comprise Armenia, Kazakhstan, Kyrgyz R., Russia and the rest of the world (aggregated). Sanctioned refers to HS6 product lines where EU sanctions apply at least partially. CCA3 is Armenia, Kazakhstan and the Kyrgyz R.

Table 7: Turkiye's exports of sanctioned vs other goods: Triple-differenced analysis

Dep. var.:	*Trade, log*	*0-1*	*Trade, hyp*	*Trade, PPML*
Dual-use under sanctions x CCA3	0.411***	0.0560***	0.767***	0.172
	(0.0565)	(0.00773)	(0.101)	(0.132)
Industrial under sanctions x CCA3	0.489***	0.0163*	0.259**	0.188
	(0.0768)	(0.00835)	(0.101)	(0.205)
Luxury under sanctions x CCA3	0.387***	0.0243***	0.509***	0.240*
	(0.0593)	(0.00873)	(0.102)	(0.125)
Dual-use under sanctions x Russia	0.528***	0.0782***	1.186***	0.216
	(0.0646)	(0.0104)	(0.120)	(0.162)
Industrial under sanctions x Russia	0.641***	0.0369***	0.713***	0.686***
	(0.0912)	(0.0118)	(0.138)	(0.106)
Luxury under sanctions x Russia	-0.177***	0.00469	-0.0489	-0.154
	(0.0634)	(0.0114)	(0.117)	(0.115)
Observations	516,348	1,366,260	1,366,260	1,244,383
R^2	0.902	0.760	0.860	

Source: Authors' calculations.

Note: Standard errors are clustered on products. All regressions include importer-month, product-month and product-importer fixed effects. *, **, *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The dependent variable is (the logarithm of) bilateral trade in a given month in a given product group at the HS6 level; 0-1 variable for trade taking place or the inverse hyperbolic sine transformation of trade. Importer economies comprise Armenia, Kazakhstan, Kyrgyz R., Russia and the rest of the world (aggregated). Sanctioned refers to HS6 product lines where EU sanctions apply at least partially. CCA3 is Armenia, Kazakhstan and the Kyrgyz R.

Table 8: Lost in transit: Difference-in-difference and triple-difference analysis

	1	2	3	4	5	6
Dependent variable:	Ratio of CCA imports from the EU/UK to EU/UK exports to CCA, log					
	All goods	Dual-use	Industrial	Luxury	Not sanctioned	Triple difference
Post-sanctions x CCA3	-0.613***	-0.680***	-0.840***	-0.666***	-0.481***	
	(0.0166)	(0.0326)	(0.0459)	(0.0431)	(0.0223)	
Post-sanctions x OLB	-0.0687***	-0.102***	-0.144***	-0.0168	-0.0464***	
	(0.00729)	(0.0142)	(0.0218)	(0.0170)	(0.0106)	
Post-sanctions x CCA3 x Dual-use						-0.175***
						(0.0392)
Post-sanctions x OLB x Dual-use						-0.0495***
						(0.0178)
Post-sanctions x CCA3 x Industrial						-0.309***
						(0.0501)
Post-sanctions x OLB x Industrial						-0.0933***
						(0.0239)
Post-sanctions x CCA3 x Luxury						-0.218***
						(0.0469)
Post-sanctions x OLB x Luxury						0.0285
						(0.0202)
Observations	15,214,036	3,866,976	1,889,780	2,331,169	7,126,111	15,212,703
R^2	0.628	0.597	0.621	0.672	0.629	0.632
Product-exporter-importer FE	✓	✓	✓	✓	✓	✓
Product-exporter-time FE	✓	✓	✓	✓	✓	✓
Exporter-importer-time FE						✓

Source: Authors' calculations.

Note: Standard errors are clustered on products. *, **, *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The dependent variable is the logarithm of the ratio of bilateral annual imports as reported by the importer to the corresponding bilateral exports, as reported by EU/UK at the HS6 level. Sanctioned refers to HS6 product lines where EU sanctions apply at least partially. Post-sanctions period refers to 2022-23.CCA3 is Armenia, Kazakhstan and the Kyrgyz R. OLB are all other not sanctioning land borders of Russia.

Table 9: Exports of sanctioned vs other goods, by letter-of-credit intensity

Dep. var.: Exports	Trade, log		0-1		Trade, PPML	
Type of good	LC intensive	LC not intensive	LC intensive	LC not intensive	LC intensive	LC not intensive
Goods under sanctions x CCA3	0.191***	0.439***	0.0136**	0.0588***	0.0606	0.248***
	(0.0442)	(0.0539)	(0.00564)	(0.00733)	(0.0866)	(0.0806)
Goods under sanctions x Russia	-0.801***	-1.200***	-0.221***	-0.203***	-0.664***	-0.696***
	(0.0592)	(0.0786)	(0.0106)	(0.0128)	(0.0812)	(0.170)
Observations	594,995	492,377	1,055,796	828,660	1,048,613	819,652
R^2	0.928	0.934	0.774	0.767		

Source: Authors' calculations.

Note: Standard errors are clustered on products. All regressions include importer-month, product-month and product-importer fixed effects. *, **, *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The dependent variable is (the logarithm of) bilateral trade in a given month in a given product group at the HS6 level. Importer economies comprise Armenia, Kazakhstan, Kyrgyz R., Russia and the rest of the world (aggregated). Sanctioned refers to HS6 product lines where EU sanctions apply at least partially. Letter-of-credit-intensive products are those with the median or above intensity index based on Crozet et al. (2022), non-intensive products are the rest. CCA3 is Armenia, Kazakhstan and the Kyrgyz R.

Table 10: Unit value of exports: Difference-in-difference and triple-difference analysis

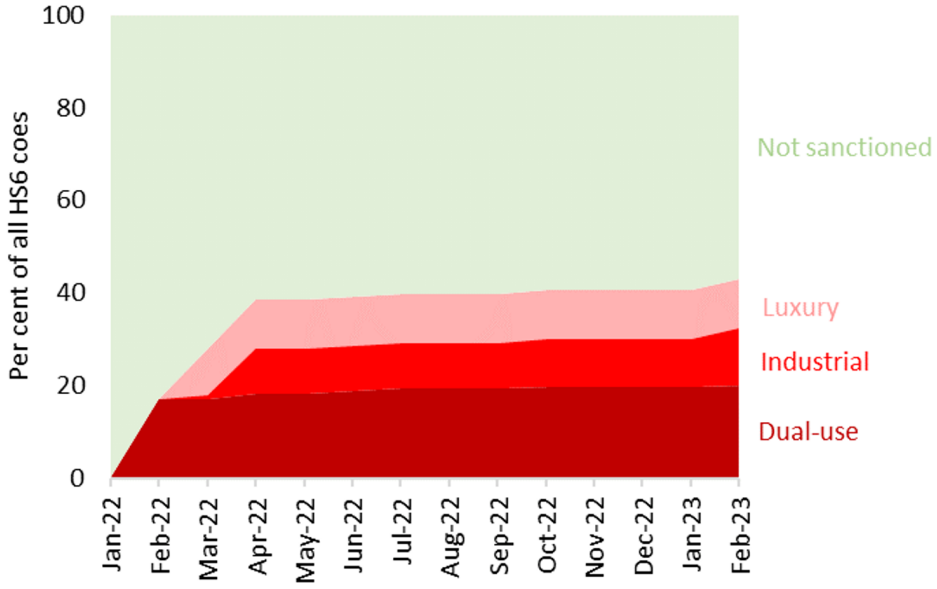
	Difference-in-difference			Triple difference		
Exporters	EU	China	CCA3	EU	China	CCA3
Post-sanctions x CCA3	0.0341***	-0.00655				
	(0.00926)	(0.00850)				
Post-sanctions x Russia	0.105***	0.0722***	0.700***			
	(0.0113)	(0.00766)	(0.0317)			
Post-sanctions x CCA3 x Dual-use				-0.0206	-0.0370	
				(0.0244)	(0.0245)	
Post-sanctions x Russia x Dual-use				0.0820**	0.107***	0.551***
				(0.0359)	(0.0213)	(0.0928)
Post-sanctions x CCA3 x Industrial				-0.0416	0.00882	
				(0.0280)	(0.0262)	
Post-sanctions x Russia x Industrial				0.267***	0.153***	0.0942
				(0.0513)	(0.0244)	(0.105)
Post-sanctions x CCA3 x Luxury				-0.0111	0.0771***	
				(0.0266)	(0.0204)	
Post-sanctions x Russia x Luxury				-0.297***	0.0274	-0.213***
				(0.0319)	(0.0197)	(0.0804)
Observations	1,023,815	775,978	174,474	1,023,815	775,978	174,474
R^2	0.933	0.948	0.881	0.934	0.948	0.884
Product-importer FE	✓	✓	✓	✓	✓	✓
Product-time FE	✓	✓	✓	✓	✓	✓
Importer-time FE				✓	✓	✓

Source: Authors' calculations.

Note: Standard errors are clustered on products. *, **, *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The dependent variable is the logarithm of the average unit value of bilateral trade in a given month in a given product group at the HS6 level (nominal value divided by quantity). Where exporter is EU/UK, China or Turkiye, the Importer economies comprise Armenia, Kazakhstan, Kyrgyz R., Russia and the rest of the world (aggregated). Where exporter economies are CCA3 (Armenia, Kazakhstan and the Kyrgyz R.), importer economies are Russia and the rest of the world (aggregated). Sanctioned refers to HS6 product lines where EU sanctions apply at least partially.

7 Annex: Additional Figures and Tables

Figure A1: Number of sanctioned product groups



Source: EU and authors' calculations.
Note: HS6 product group is marked as sanctioned from the month following the adoption of the corresponding package.

Table A1: Sanctioned products, by HS section, product type, and sanction type

N	*HS section*	Number of HS6 product lines: Part-sanctioned	Similar	Other
		By HS section		
I	Animal products	2	2	367
II	Vegetable products	10	29	269
III	Animal and vegetable oils	0	0	48
IV	Prepared food, beverages and tobacco	29	23	165
V	Mineral products	48	28	73
VI	Chemicals	379	363	124
VII	Plastics and rubber	105	83	21
VIII	Leather and fur skins	21	0	48
IX	Wood and articles of wood	16	35	70
X	Wood pulp and paper	62	43	35
XI	Textiles and textile articles	308	234	252
XII	Footwear, headgear, umbrellas, etc.	33	2	12
XIII	Articles of stone and glass	71	45	23
XIV	Precious or semi-precious stones, jewellery	45	1	7
XV	Base metals and articles of base metal	232	159	170
XVI	Machinery and electrical equipment	494	204	79
XVII	Vehicles, aircraft, vessels	120	17	6
XVIII	Optical, precision, medical and other instruments	136	40	31
XIX	Arms and ammunition	20	0	0
XX	Miscellaneous manufacturing	44	36	42
XXI	Works of art	7	0	0
	Total	2182	1344	1842
		By product type		
	Capital	409	185	103
	Intermediate	1230	1039	964
	Consumption	534	120	775
	Generic	732	445	465
	Specific	875	740	318
	Non-durable	66	57	626
	Durable	468	63	149
	Non-differentiated	591	592	939
	Differentiated	1582	752	904
		By sanction type		
	Luxury goods	570		
	Industrial/transport capacity	536		
	Oil and gas	13		
	Dual-use and military technology	1063		

Source: Authors' calculations.

Note: Number of HS6 product lines where EU sanctions apply at least partially as of end-2022. Similar goods are those not sanctioned but within the same HS4 as sanctioned. Differentiated products as defined in Rauch (1999), other classifications are based on Broad Economic Categories classification version 5.

Table A2: Descriptive statistics: Intermediated trade

	EU/UK exports to Russia					China exports to Russia				
*V*ariable	Mean	Median	St. dev.	Min	Max	Mean	Median	St. dev.	Min	Max
Trade, log	11.78	12.06	2.86	-1.82	20.81	11.99	12.30	2.61	0.00	20.47
Trade, hyperbolic	9.43	11.60	5.91	0.00	21.50	8.78	11.48	6.24	0.00	21.16
Trade, non-zero	0.76	1.00	0.43	0.00	1.00	0.69	1.00	0.46	0.00	1.00
	EU/UK exports to CCA3					China exports to CCA3				
*V*ariable	Mean	Median	St. dev.	Min	Max	Mean	Median	St. dev.	Min	Max
Trade, log	9.06	9.19	2.72	-1.52	19.30	10.35	10.59	2.73	0.00	19.24
Trade, hyperbolic	4.07	0.00	5.12	0.00	19.99	4.08	0.00	5.58	0.00	19.94
Trade, non-zero	0.42	0.00	0.49	0.00	1.00	0.37	0.00	0.48	0.00	1.00
	EU/UK exports to rest of the world					China exports to rest of the world				
*V*ariable	Mean	Median	St. dev.	Min	Max	Mean	Median	St. dev.	Min	Max
Trade, log	15.24	15.52	2.57	-6.93	23.31	15.23	15.62	2.73	0.00	23.73
Trade, hyperbolic	15.57	16.15	3.48	0.00	24.00	14.48	15.99	5.26	0.00	24.42
Trade, non-zero	0.98	1.00	0.15	0.00	1.00	0.91	1.00	0.29	0.00	1.00

Source: Authors' calculations based on UN Comtrade and China Customs Administration.

Note: Unit of observation is bilateral exports at HS6 level in a given month from January 2017 to December 2023. Observations with zero trade in all month for a given country pair and HS6 product group are not included. CCA3 is Armenia, Kazakhstan and the Kyrgyz R.

Table A3: Descriptive statistics: Lost-in-transit trade

Variable	Mean	Median	St. dev.	Min	Max
Ratio of imports to exports, log	-0.03	-0.001	2.19	-23.28	21.65
Zero imports and positive exports	0.20	0.00	0.40	0.00	1.00
Zero exports and positive imports	0.24	0.00	0.43	0.00	1.00

Source: Authors' calculations based on UN Comtrade.

Note: Unit of observation is bilateral annual imports / exports at the HS6 level in 2017-23. Exporters are EU member states and the UK; importers are all their trading partners that report imports to UN Comtrade.

Table A4: Lost in transit: Difference-in-difference and triple-difference analysis of zero import and zero export records

	Zero imports and positive exports reported			Zero exports and positive imports reported		
	All goods	Dual-use	Triple difference	All goods	Dual-use	Triple difference
Post-sanctions x CCA3	0.0622***	0.0546***		-0.0955***	-0.111***	
	(0.00158)	(0.00303)		(0.00173)	(0.00331)	
Post-sanctions x OLB	0.0194***	0.0152***		-0.0207***	-0.0144***	
	(0.000821)	(0.00162)		(0.000879)	(0.00170)	
Post-sanctions x CCA3 x Dual-use			-0.0125***			-0.0131***
			(0.00367)			(0.00407)
Post-sanctions x OLB x Dual-use			-0.00453**			0.00819***
			(0.00202)			(0.00212)
Post-sanctions x CCA3 x Industrial			-0.00115			-0.0253***
			(0.00467)			(0.00574)
Post-sanctions x OLB x Industrial			0.00550**			0.00248
			(0.00256)			(0.00299)
Post-sanctions x CCA3 x Luxury			-0.000916			0.0248***
			(0.00441)			(0.00445)
Post-sanctions x OLB x Luxury			0.00259			-0.00722***
			(0.00235)			(0.00241)
Observations	29,432,653	7,097,156	29,432,387	29,432,653	7,097,156	29,432,387
R^2	0.637	0.614	0.645	0.689	0.672	0.693
Product-exporter-importer FE	✓	✓	✓	✓	✓	✓
Product-exporter-time FE	✓	✓	✓	✓	✓	✓
Exporter-importer-time FE			✓			✓

Source: Authors' calculations.

Note: Standard errors are clustered on products. *, **, *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The dependent variables are dummy variables for cases where non-zero imports are reported against zero exports reported by EU member states or the UK and cases where zero imports are reported against non-zero exports. Estimated using linear probability model with fixed effects as shown. Sanctioned refers to HS6 product lines where EU sanctions apply at least partially. Post-sanctions period refers to 2022-23.