(Trade) War and Peace:
How to Impose International Trade Sanctions

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Abstract

What is the most cost-efficient way to impose trade sanctions against Russia? We build a quantitative model of international trade with input-output connections. Sanctioning countries choose import tariffs to simultaneously maximize their income and minimize Russia's income, with different weights placed on these objectives. We find, first, that for countries with low willingness to pay for sanctions against Russia, the most cost-efficient sanction is an approximately 20% tariff on all Russian products. Second, if countries are willing to pay at least US$0.70 for each US$1 drop in Russian welfare, an embargo on Russia's mining and energy products is the most cost-efficient policy.

Keywords: trade sanctions, tariffs, tariff competition

JEL: F13, O24

1. Introduction

Trade sanctions are a common instrument of diplomacy, with over 100 of them active in 2016. In the wake of Russia's invasion of Ukraine, trade sanctions have once again come into the public spotlight. Countries such as Canada, Japan, and the United Kingdom (UK) responded by imposing import tariffs on Russia, ranging from 8% to 35%. The Western countries jointly removed Russia's "Most Favored Nation (MFN)" status, enabling them to impose arbitrary tariffs on Russia without breaking World Trade Organization (WTO) regulations. Meanwhile, policymakers and politicians have advocated for an embargo on

* This paper benefited from valuable comments from Gadi Barlevy, Dominick Bartelme, Javier Bianchi, David DeRemer, Joakim Gullstrand, Thibault Fally, Gabriel Felbermayr, Marti Mestieri, Dávid Nagy, Justin Pierce, Bengt Söderlund, Robert Staiger, Daniel Xu, and Jing Zhang, as well as seminar participants at Aarhus University, Chicago Fed Brownbag, Jinan University IESR, Kiel Institute, Lund University, University of Luxembourg, and WIFO. The views expressed herein are solely those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Chicago or the Federal Reserve System. All remaining errors are ours. Li gratefully acknowledges support from the HKU Business School Shenzhen Research Institutes (SZRI) under grant number SZRI2023-BRF-13. Corresponding author: haishili@hku.hk (Haishi Li).

Russian oil and gas imports.

Ultimately, trade sanctions are meant to hurt the sanctioned country's economy. However, if the sanctions severely restrict trade, they also hurt the sanctioning countries. This trade-off raises the question: What is the most cost-efficient way to apply trade sanctions? How can a government reduce economic activity in the sanctioned country while minimizing local economic costs? When is an embargo cost-efficient?

We answer these questions using a quantitative model and empirical evidence. We build a model of tariff competition with international trade and input-output connections.[1] In the model, firms produce using labor, locally produced inputs, and inputs from other countries. To import inputs, firms have to pay an import tariff.

Tariffs are chosen by governments trading off two objectives. On the one hand, they want to maximize domestic real income, which is also a measure of household welfare. On the other hand, they want to minimize Russian welfare. If the government has a high willingness to pay for sanctions, it places a greater weight on hurting the Russian economy. As the government is trading off the cost of sanctioning Russia and its own welfare, we refer to these sanctions as cost-efficient sanctions.[2]

To construct reliable counterfactuals, we estimate the model to reproduce the effect of tariffs on Russia's international trade. Using the difference-in-differences strategy introduced in de Souza and Li (2022), we find that a 10% ad-valorem tariff on Russia decreases imports of Russian products by 43% and total imports of the tariffed goods by 15%, showing that both Russia and the sanctioning countries are negatively affected by tariffs. Using the method of de Souza and Li (2022) and tariff variations from all countries, we estimate sectoral trade elasticities to be 6 on average. These elasticities correlate with estimates by Caliendo and Parro (2015) and those we recover using the Feenstra (1994) method.

[1] The model builds on Ossa (2014) and Caliendo and Parro (2015).

[2] In practice, sanctions can take various forms, such as limiting the movement of capital, goods, or people between countries. To narrow down the scope of the problem, we focus on a specific type of trade sanctions: import tariffs, which also include embargoes as a special case. Due to the Lerner Symmetry, sanctions in the form of import tariffs are equivalent to export sanctions.

We highlight four main findings. First, for countries with a low willingness to pay for sanctions, the optimal strategy is to impose a moderate and similar tariff across all products. For example, if the sanctioning countries are prepared to incur a cost of US$0.10 for every US$1 of economic damage inflicted on Russia, the average import tariffs should be set at 20% and applied uniformly across sectors.

Second, if the EU is willing to pay over US$0.70 for each US$1 of real income loss in Russia, an EU embargo on the mining and energy sectors with a 50% tariff on other sectors is cost-efficient.[3] For countries with high willingness to pay for sanctions, the main driver of cost-efficient tariffs is the import share; to cause more harm to Russia, sanctioning countries should target what Russia exports the most, i.e., mining and energy products.

Third, we show that the EU is the group of countries that can hurt the Russian economy the most – not the US or other sanctioning allies (OSA). Russia exports more to the EU than to the US or OSA.[4] Accordingly, tariffs imposed by the US or OSA can, at most, reduce Russian real income by only 0.07% or 0.22%, respectively. By contrast, the EU alone can reduce real income in Russia by as much as 0.8%. Therefore, the burden of trade sanctions against Russia has to be carried by the EU.

Fourth, if Russia retaliates, i.e., if it also chooses to impose tariffs to punish the sanctioning countries, the economic consequences of tariff sanctions against Russia would be more than double. Because the EU is a key importing origin for Russia but Russia is not an important exporting destination for the EU, Russia cannot decrease EU welfare by much through the imposition of high tariffs on the EU; however, these tariffs cause a large decline in Russia's own welfare.

This paper contributes to the literature on tariff competition by studying the problem of a government trading off welfare maximization and diplomatic objectives. The tariff com-

[3]The mining and energy sectors include the extraction of crude oil, natural gas, and other energy products (D05 and D06 in International Standard Industrial Classification (ISIC) Rev. 4) and the coke and refined petroleum sector (D19 in ISIC Rev. 4).

[4]More specifically, Russia's exports to the EU represent 4.85% of the country's total production; its exports to the US represent 0.55%; and its exports to OSA represent 1.63%.

petition literature has investigated optimal trade policy in different settings when countries maximize their own welfare. These settings include tariff cooperation (Ossa 2014), competition on non-tariff trade barriers (Mei 2021), MFN rules (Bagwell et al. 2021), export subsidies (Beshkar and Lashkaripour 2020), and industrial policies (Bartelme et al. 2021). These studies have found that tariffs should be larger on sectors with lower trade elasticities and that there are welfare gains from cooperation.

We contribute to the existing literature by examining countries' trade-offs between sanctions and welfare-maximizing trade policy, enabling us to calculate cost-efficient trade sanctions and contribute to policy debates. Unlike previous research on tariff competition, trade elasticity is not a crucial determinant of cost-efficient sanctions. As countries prioritize harming the Russian economy, optimal tariffs should increase in sectors with larger trade flows. If the willingness to pay exceeds US$0.70 for each US$1 drop in Russian welfare, tariffs should target major Russian export sectors irrespective of their trade elasticities.

Our work contributes to the literature on the economic impacts of sanctions. Sanctions and sanction threats are more effective if they impose more harm on the target and if the sender is more patient (Eaton and Engers 1992, Lacy and Niou 2004). Furthermore, sanctions should optimally trade off between the punishment of the target's leader and the negative impact on the general public (Baliga and Sjöström 2022). Empirical works have shown that the number of sanctions has risen over time(Elliott and Hufbauer 1999, Felbermayr et al. 2020a, 2021, van Bergeijk 2022). In the target country, sanctions exacerbate regional inequality (Lee 2018), induce firm exit (Ahn and Ludema 2020, Crozet et al. 2021), and lower stock market valuation (Draca et al. forthcoming). In the sender country, sanctions also negatively impact firm business (Felbermayr et al. 2020b, Gullstrand 2020, Besedeš et al. 2021). Furthermore, sanctions disrupt international trade (Crozet and Hinz 2020, Miromanova 2021a,b, Kwon et al. 2022).[5]

[5]Recent papers studying sanctions against Russia include Bachmann et al. (2022), Evenett and Muendler (2022a), Evenett and Muendler (2022b), Hinz and Monastyrenko (2022), Itskhoki and Mukhin (2022), Lorenzoni and Werning (2022), Sturm (2022), Chowdhry et al. (2023), and Sturm (2023).

We contribute to the literature on the economic impacts of sanctions by estimating cost-efficient trade sanctions and their economic impact. To the best of our knowledge, this is the first paper to study optimal economic sanctions in a quantitative trade framework. As such, we differ from Eaton and Engers (1992), Lacy and Niou (2004), and Baliga and Sjöström (2022), taking the motivation for sanctions as a given and computing the set of tariffs that hurt the targeted country the most and cost the sanctioning countries the least. Inspired by Baliga and Sjöström (2022), we also calculate cost-efficient sanctions when the sanctioning countries target politically relevant sectors.

2. Empirics

We take advantage of the difference-in-differences strategy introduced by de Souza and Li (2022) to investigate how an increase in tariffs disrupts trade with Russia. We compare Russian products which had an anti-dumping investigation that did not lead to a tariff increase, the control group, to products which had an anti-dumping investigation that concluded with a tariff increase, the treatment group. According to WTO regulations, the decision to impose an anti-dumping tariff should be based on pre-determined characteristics of each product. Because these characteristics are constant overtime, they can be teased out with a product-level fixed effect.

2.1. Institutions

Dumping refers to an act of price discrimination in which an exporter charges a lower price in the destination market than in its home market, adjusted for allowances, trade costs, and currencies in different markets.[6] The WTO allows the destination government to impose AD tariffs to correct for such price differences, but requires that it follows certain procedures.[7] First, a sufficient number of firms in a domestic industry should submit a written request

[6] Experts refer to the home market price, inclusive of these adjustments, as the "normal value". See Section "Fair comparison of normal value and export price" of WTO's technical note on AD (`https://www.wto.org/english/tratop_e/adp_e/adp_info_e.htm`).

[7] See WTO's AD rule (`https://www.wto.org/english/docs_e/legal_e/19-adp_01_e.htm`).

to the government. The request should provide evidence that import competition is doing harm to the domestic industry. It should also show that the foreign exporters are engaging in dumping. Second, upon receipt of the request, the government should establish a committee to investigate the case. Third, using the evidence collected during the investigation and following WTO rules, the committee calculates the normal value of the foreign product and the export price. If the committee finds that the foreign exporter is indeed charging a lower price in the export destination that in its home market, the government will conclude that the foreign exporter is dumping, and it will impose an AD tariff equal to the price difference.[8] If the committee finds otherwise, no AD tariff will be introduced. The committee should reassess the AD duty no later than 5 years after its imposition, which occasionally results in the termination of the AD tariff.

2.1.1. Discussion

Based on the WTO AD rules, two important lessons can be learned about how one should identify the impact of AD tariffs. First, one should not compare the products that are subject to an AD tariff to those that are not. To initiate the imposition of an AD tariff, an investigation committee has to be formed, which can create trade policy uncertainty and disrupt trade even if the investigations do not conclude with tariff changes. Furthermore, as de Souza and Li (2022) show, the investigated products have a lower price, higher trade volume, decreasing price trend, and increasing trade volume trend, compared to the products that are not investigated. Therefore, the sample is composed of only the investigated products.

Second, conditional on an AD investigation, the WTO rules stipulate whether a tariff should be imposed and, if so, that the size of the tariff should depend on the difference in the prices set by the foreign exporter in the origin and destination countries in the pre-

[8] Some investigations have ended with the foreign exporter raising its price to avoid an AD tariff. See WTO Agreements on AD, subsidies, safeguards: contingencies, etc. (`https://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm8_e.htm`). These observations are dropped from both the treatment and control groups.

investigation period. We can use the product–country fixed effects to control for such a difference. Once we do so, the AD tariff should be exogenous to the potential trends of the treatment and control groups.

2.1.2. Data

Our data source for AD investigations is the Global Anti-dumping Database (Bown 2005). The database contains all AD investigations conducted by 31 major economies on all trade partners. For each investigation, the database covers the investigated product and its Harmonized System (HS) code, the exporter and importer, the beginning and end dates of each investigation, and the measures taken. Our data source for international trade is the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). We merge the two datasets on the country–bilateral and HS 6-digit level.[9]

2.2. Empirical Strategy

Following de Souza and Li (2022), we study how AD tariffs affect Russian trade using:

$$\log(y_{p,c,t}) = \theta\tau_{p,c,t} + \beta\mathbb{I}_{p,c,t}\{\text{After AD}\} + \gamma\mathbb{N}_{p,c,t}\{\text{Committee}\} + \eta_{p,c} + \eta_{c,t} + \epsilon_{p,c,t}, \tag{1}$$

where $y_{p,c,t}$ are imports of product p by country c from Russia in year t; $\tau_{p,c,t}$ denotes the AD tariff that country c imposes on product p from Russia in year t, which is equal to zero for the control group; $\mathbb{I}_{p,c,t}\{\text{After AD}\}$ is a dummy after the first AD investigation capturing common trends between treatment and control leading to the investigation. The controls include a set of fixed effects for the number of AD investigations conducted by country c on product p from Russia in the past 5 years, which captures the degree of uncertainty introduced by the AD investigation.[10] Other controls are a product–country fixed effect,

[9] We discuss the summary statistics of these datasets in further detail in Section A.1.

[10] We aggregate AD investigations in the past 5 years because AD tariffs stay for 5 years and are reevaluated. This set of fixed effects ensures that we are comparing treated products to control products within the window of the AD tariff.

$\eta_{p,c}$, and country–year fixed effect, $\eta_{c,t}$.[11] The sample consists of product–country pairs that have at least one AD investigation. Standard errors are clustered at the product–importer level.

We also study the effect of AD tariffs on Russian total exports to all destinations using the following specification:

$$\log(\tilde{y}_{p,t}) = \theta\tau_{p,c,t} + \beta\mathbb{I}_{p,c,t}\{\text{After AD}\} + \gamma\mathbb{N}_{p,c,t}\{\text{Committee}\} + \eta_{p,c} + \eta_{c,t} + \epsilon_{p,c,t}, \tag{2}$$

where $\tilde{y}_{p,t}$ is the exports of product p by Russia in year t to all destinations.

The variable of interest in both specifications is θ, which captures the effect of AD tariffs on trade. As it is common in difference-in-differences, the identifying assumption is of parallel trends between treatment and control groups. To show supportive evidence for this assumption, we test for the existence of parallel trends using:

$$\begin{aligned}\log(y_{p,c,t}) = &\sum_j \theta_j \tau_{p,c,\text{first}}\mathbb{I}_{p,c,t}\{j \text{ Yrs. to AD}\} + \sum_j \beta_j\mathbb{I}_{p,c,t}\{j \text{ Yrs. to AD}\} + \\ &\gamma\mathbb{N}_{p,c,t}\{\text{Committee}\} + \eta_{p,c} + \eta_{c,t} + \epsilon_{p,c,t},\end{aligned} \tag{3}$$

where $y_{p,c,t}$ refers to imports of product p by country c from Russia in year t, and where $\tau_{p,c,\text{first}}$ denotes the first AD tariff that country c imposed on product p from Russia.[12] Moreover, in this equation, the dummy variable $\mathbb{I}_{p,c,t}\{j \text{ Yrs. to AD}\}$ takes 1 if year t is j years to the beginning of the first AD investigation. The coefficient θ_j captures the dynamic effect of AD tariffs in the jth year. Having no pre-trend is equivalent to $\theta_j \approx 0, \forall j < 0$.

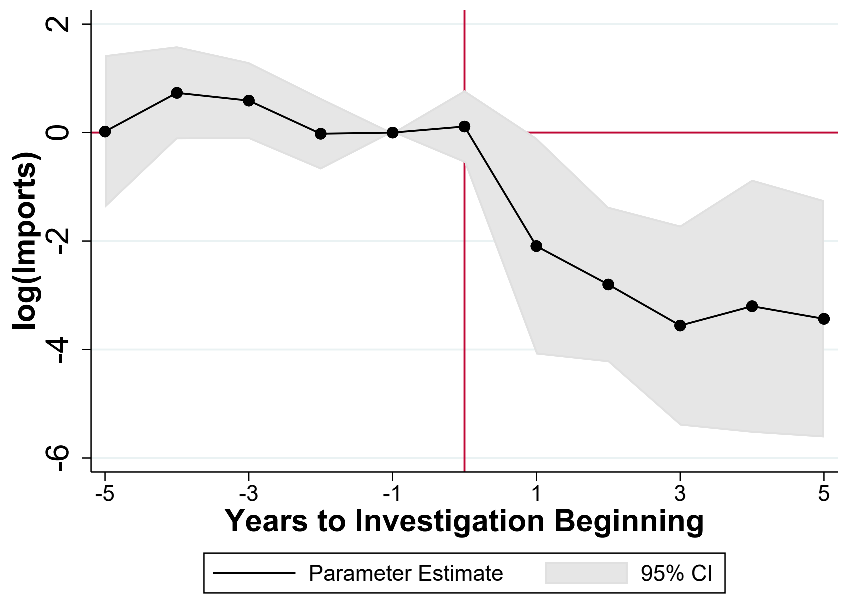
2.3. Results

Figure 1 shows the effect of tariffs on imports from Russia. AD tariffs cause a significant large drop in imports: A 10% increase in AD tariffs is associated with a nearly 40% decline

[11] The number of AD investigations controls for trade policy uncertainty.
[12] In this way, we ensure that there is no other investigation in the pre-period.

in imports of the targeted product. The figure also confirms the nonexistence of a pre-trend; that is, before the increase in tariffs, the treatment and control groups displayed similar import trends.[13]

Figure 1: **Impact of AD Tariffs on Imports**



Description: This figure shows the dynamic impact of AD tariffs on imports using Model 3. The impact on yearly imports is plotted on the y-axis. The number of years to the beginning of the investigation is plotted on the x-axis. We study HS 6-digit level imports. Imports are measured in free on board (FOB), current dollar value terms. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. The sample includes the product–origins that faced at least one AD investigation. The shaded area contains the 95% confidence interval. Standard errors are clustered at the product–country level.

Table 1 shows that tariffs decrease trade and prices of Russian goods. A 10% tariff causes a 43% drop in imports from Russia, with a 36% drop in the quantity imported and a 7% drop in the price of imports. Column 4 suggests that 30% of the tariff is passed to domestic consumers.

Russian total exports of the targeted goods to all destinations experience a decline, as illustrated by Column 5 of Table 1, which estimates Equation 2. A 10% tariff leads to a

[13]Figure A.3 shows the dynamic effect of tariffs on quantity and prices. None of these variables display any pre-period trends. We follow Sequeira (2016) and use log of imports plus one to deal with selection because products in which trade flow went to zero are informative about the effect of tariffs. We show that the outcomes obtained using the baseline estimation strategy are robust to alternative specifications, such as the Poisson Pseudo-Maximum Likelihood (PPML) and the inverse hyperbolic sine transformation of the dependent variable.

Table 1: **Effect of AD Tariffs on Russian Trade**

	(1) Log Value	(2) Log Quantity	(3) Log Price	(4) Log Post-tariff Price	(5) Log Total Exports	(6) Log Total Imports
AD Tariff	-4.306**	-3.605*	-0.701***	0.299	-1.577**	-1.867**
	(1.895)	(1.929)	(0.210)	(0.210)	(0.726)	(0.743)
Observations	1,534	1,534	1,534	1,534	1,534	1,534
R^2	0.807	0.813	0.873	0.875	0.804	0.839

Description: This table presents the impact of AD tariffs that other countries imposed on Russian trade, estimated with Model 1. *Log Value* denotes the log of HS 6-digit level FOB current dollar value imports from Russia. *Log Quantity* denotes the log of the quantity (in metric tons) imported by another country from Russia on the HS 6-digit level. *Log Price* and *Log Post-tariff Price* denote the log of pre- and post-tariff import prices (measured with value per metric ton) by another country from Russia on HS 6-digit level. *Log Total Exports* denotes the log of HS 6-digit level total export value by Russia to all destinations for the same HS 6-digit product for which other countries initiated an AD investigation targeting Russia. *Log Total Imports* denotes the log of HS 6-digit level total imports from all origins by the country that initiated an AD investigation targeting Russia for the same 6-digit product on which the AD tariff is imposed. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. The fixed effects are: product–importer, importer–year, number of AD committees, and after AD investigation. Standard errors are clustered at product–importer level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

15% reduction in Russian total exports of the targeted goods. This finding indicates that Russia cannot fully replace the sanctioning country by supplying the tariffed goods to other nations, resulting in an income loss due to the tariffs.[14]

Total imports of the targeted goods from all origins decline in the sanctioning country, as illustrated by Column 6 of Table 1. A 10% tariff on Russia results in an 18% decrease in total imports of the tariffed good from all origins, including, but not limited to, Russia. This finding suggests that Russian products are not easily replaced. Consequently, the domestic economy faces higher prices, whether producing the product locally or importing it from another country, which ultimately leads to a welfare loss.[15]

These estimated effects of tariffs on Russian trade are robust to several alternative specifications and controls. We leave a detailed discussion of the robustness to Section A.2. Section A.3 discusses heterogeneity of the tariff effect.

[14]Figure A.4a presents the dynamic effects of tariffs on total exports of the targeted products by Russia to all destinations. The figure shows no pre-trend. Table A.11 shows that the exports of Russia to non-sanctioning destinations only slightly increase in response to the tariffs.

[15]Figure A.4b presents the dynamic effects of tariffs on total imports of the targeted goods from all origins in the sanctioning country. The figure shows no pre-trend. Table A.11 shows that the imports of sanctioning countries from other countries except Russia only slightly increase in response to the tariffs.

3. Model

The empirical results indicate that if countries want to sanction Russia, they will hurt the Russian economy at the expense of domestic welfare. Given the degree of willingness to pay for sanctions, how should countries impose tariffs to maximize their own welfare and punish Russia? To answer this question, we present a multi-sector, multi-country quantitative trade model with input-output linkage. The exposition of the model has two sections. In the first section, tariffs are taken as given. In the second section, governments choose tariffs trading off domestic welfare and sanctioning Russia.

3.1. Demographics

The global economy consists of N countries and J sectors. Each country has a mass L_n of households. The preference of country n's households is a Cobb-Douglas function of sector-level consumption goods, C_n^j. The labor supply of households is inelastic.

The household's problem is the following:

$$\max_{\{C_n^j\}_{j=1}^J} U_n = \prod_{j=1}^{J} \left(\frac{C_n^j}{\alpha_n^j} \right)^{\alpha_n^j}, \qquad \text{where} \sum_{j=1}^{J} \alpha_n^j = 1$$
$$\text{s.t.} \sum_{j=1}^{J} P_n^j C_n^j = I_n,$$

where P_n^j denotes the sector j composite goods price in country n. I_n denotes the country's total income. The consumer's problem implies that country n's households face the following consumer price index:

$$P_n^C = \prod_{j=1}^{J} \left(P_n^j \right)^{\alpha_n^j}.$$

3.2. Intermediate Goods Producer

We assume that all markets are competitive. Labor is freely mobile across sectors within a country, but immobile across countries. A representative firm in country n and sector j

produces with labor and intermediate inputs from all sectors with a Cobb-Douglas technology:[16]

$$Y_n^j = A_n^j \left[\frac{L_n^j}{\gamma_n^j}\right]^{\gamma_n^j} \prod_{k=1}^{J} \left[\frac{M_n^{j,k}}{\gamma_n^{j,k}}\right]^{\gamma_n^{j,k}},$$

where A_n^j denotes the total factor productivity (TFP), L_n^j denotes sectoral employment, and $M_n^{j,k}$ denotes the quantity of sector k composite goods used by sector j as an input. γ_n^j and $\gamma_n^{j,k}$ are input-output coefficients with $\gamma_n^j + \sum_{k=1}^{J} \gamma_n^{j,k} = 1$.

Profit maximization implies that the output price equals the marginal cost:

$$p_n^j = \frac{1}{A_n^j} [w_n]^{\gamma_n^j} \prod_{k=1}^{J} [P_n^k]^{\gamma_n^{j,k}}, \tag{4}$$

where w_n denotes the wage of country n.

3.3. Composite Goods

A country's consumers and firms source their composite goods domestically and from other countries. Let Q_n^j be the quantity of composite goods of sector j used in country n:

$$Q_n^j = \left[\sum_{i=1}^{N} (q_{ni}^j)^{(\sigma^j-1)/\sigma^j}\right]^{\sigma^j/(\sigma^j-1)},$$

where q_{ni}^j denotes the quantity of sector j output that country n buys from country i and where σ^j is the elasticity of substitution between countries. Because composite goods are used as consumption and inputs, it must be the case that:

$$Q_n^j = C_n^j + \sum_{k=1}^{J} M_n^{k,j}.$$

[16] In Section C.5.4, we relax the assumption of a Cobb-Douglas production function. Instead, we use a CES production function and test the sensitivity of the results to different elasticities of substitution between inputs.

3.4. Expenditure Share

To get a unit of sector j output from country i, consumers and firms in country n need to pay:

$$p_{ni}^{j} = t_{ni}^{j} k_{ni}^{j} p_{n}^{j},$$

where $t_{ni}^{j} = 1 + \tau_{ni}^{j}$ is 1 plus the ad-valorem tariff that country n imposes on country i and where k_{ni}^{j} denotes the iceberg trade cost to ship one unit of sector j's output from country i to country n.

After country n chooses the quantity to source from each origin country i to minimize the cost of producing Q_{n}^{j}, country n's expenditure share on sector j's output from country i equals:

$$\pi_{ni}^{j} = \frac{(t_{ni}^{j} k_{ni}^{j} p_{i}^{j})^{1-\sigma^{j}}}{\sum_{h=1}^{N} (t_{nh}^{j} k_{nh}^{j} p_{h}^{j})^{1-\sigma^{j}}}.$$

The composite goods price is thus given by:

$$P_{n}^{j} = \left[\sum_{i=1}^{N} (t_{ni}^{j} k_{ni}^{j} p_{i}^{j})^{1-\sigma^{j}} \right]^{1/(1-\sigma^{j})}.$$

From now on, we use $\theta^{j} = \sigma^{j} - 1$ to denote the trade elasticity.

We present the market clearing conditions and equilibrium given tariffs in section B.1.

3.5. Tariff Competition

Import tariffs are chosen by governments. Countries are in three groups according to how they choose tariffs. There are sanctioning countries, the sanctioned country (Russia, in this case), and neutral countries (the rest of the world [ROW]). The sanctioning countries choose tariffs, trading off between two objectives. On the one hand, they want to maximize their domestic households' welfare. On the other hand, they want to minimize Russian welfare.

Russia also chooses tariffs to maximize its own welfare and reduce the sanctioning countries' welfare. We assume that the neutral countries do not change tariffs.[17]

Before we formally define the problem of a sanctioning country, let $\boldsymbol{\tau_{nR}}$ be the vector of sectoral tariffs that country n imposes on Russia. Let $\boldsymbol{\tau_{-nR}}$ be all global tariffs except what n imposes on Russia. Use $G_n(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}})$ to denote the equilibrium welfare in country n under tariff policy $(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}})$:

$$G_n(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}) = \frac{I_n(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}})}{P_n^C(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}})}, \tag{5}$$

where $I_n(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}})$ denotes household income (Equation B.6) and $P_n^C(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}})$ denotes the consumer price index (Equation B.4).

Conditional on $\boldsymbol{\tau_{-nR}}$, the objective of sanctioning country n is:

$$\begin{aligned} g_n(\boldsymbol{\tau_{-nR}}) \in argmax_{\{\boldsymbol{\tau_{nR}}\}} \rho G_n(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}) - (1-\rho) G_R(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}), \qquad (6) \\ \text{s.t. Equilibrium Conditions B.1-B.8,} \end{aligned}$$

where ρ is the willingness to pay for sanctions against Russia. In other words, the domestic government is willing to pay US\$$\frac{1-\rho}{\rho}$ for every US\$1 of consumption forgone in Russia. This specification nests two special cases. When $\rho = 1$, country n maximizes its own real income, and when $\rho = 0$, country n minimizes Russia's real income without consideration for its own welfare.[18]

Russia, the sanctioned country, trades off maximizing its own welfare and retaliating against the countries imposing the sanctions. Use $\boldsymbol{S}$ to denote the set of sanctioning coun-

[17] In Section C.4.2, we study the case in which neutral countries join the sanctioning allies. In Section C.5.3, we also consider the case in which Russia keeps its tariffs constant.

[18] In Section C.7, we consider an alternative cost-efficient sanction problem whereby the sanctioning countries minimize Russia's welfare but require that their own welfare does not decrease.

tries. Russia's problem is as follows:

$$g_R(\boldsymbol{\tau_{-RS}}) \in argmax_{\{\boldsymbol{\tau_{RS}}\}} \rho G_R(\boldsymbol{\tau_{RS}}, \boldsymbol{\tau_{-RS}}) - (1-\rho) \sum_{n \in S} \frac{G_n(\boldsymbol{\tau_{RS}}, \boldsymbol{\tau_{-RS}})}{N_S} \tag{7}$$

s.t. Equilibrium Conditions B.1-B.8,

where $G_R(\boldsymbol{\tau_{RS}}, \boldsymbol{\tau_{-RS}})$ is the equilibrium welfare in Russia and $\sum_{n \in S} \frac{G_n(\boldsymbol{\tau_{RS}}, \boldsymbol{\tau_{-RS}})}{N_S}$ is the average real income of the sanctioning countries (N_S denotes the number of sanctioning countries, $\boldsymbol{\tau_{RS}}$ denotes the set of tariffs that Russia imposes on the sanctioning countries, and $\boldsymbol{\tau_{-RS}}$ denotes all global tariffs except what Russia imposes on the sanctioning countries). As with sanctioning countries, ρ captures the willingness to pay for tariff retaliation against sanctioning countries.[19] We call the equilibrium tariffs that are a solution to Problems 6 and 7 cost-efficient sanctions.

Equilibrium with Sanctions. Given $\{\{\tau^j_{ni}\}_{j,n \in S, i \neq R}, \{\tau^j_{Ri}\}_{j, i \notin S}, \{\tau^j_{ni}\}_{j, n \notin S, i \neq R}\}$, *an equilibrium with optimal sanctions is given by tariffs imposed on Russia by sanctioning countries,* $\{\boldsymbol{\tau_{nR}}\}_{n \in \boldsymbol{S}}$, *tariffs imposed on sanctioning countries by Russia,* $\{\boldsymbol{\tau_{Rn}}\}_{n \in \boldsymbol{S}}$, *a set of sectoral prices,* $\{P^j_n\}_{n,j}$, *and wages,* $\{w_n\}_n$, *such that*

1. *given tariffs* $\{\tau^j_{ni}\}_{j,n,i}$, $\{\{P^j_n\}_{n,j}, \{w_n\}_n\}$ *is an equilibrium;*
2. *sanctioning countries and Russia optimally choose their tariffs:*

$$\boldsymbol{\tau_{nR}} = g_n(\boldsymbol{\tau_{-nR}}), \forall n \in \boldsymbol{S};$$
$$\boldsymbol{\tau_{RS}} = g_R(\boldsymbol{\tau_{-RS}}).$$

To solve a counterfactual equilibrium, we rewrite the model in changes. In this way, we

[19] In the baseline scenario in Section 5, we assume that Russia has the same ρ as the sanctioning countries. In Section C.5.3, we also consider that Russia retaliates by always maximizing its own welfare $\rho_{RUS} \equiv 1$ and by always minimizing the sanctioning countries' welfare $\rho_{RUS} \equiv 0$. We show that sanctioning countries' strategies and their real income changes are not significantly affected by Russia's retaliation strategy.

eliminate the fundamentals that are invariant to tariff changes and are difficult to calibrate (for example, non-tariff trade barriers $\{k_{ni}^{j}\}_{j,n,i}$). We present the sanction equilibrium in changes in Section B.2.

4. Calibration

To calibrate our model, we rely on two main data sources: 1) the OECD ICIO Database and 2) our estimates of the trade elasticities. We calibrate the baseline global economy to its levels in 2018, the latest year for which a world input-output table is available. We let each sector $j \in \{1, 2, ..., 22\}$ denote the 22 goods sectors considered in OECD ICIO and $j = 23$ denotes a merged service sector.[20] Countries $i, n \in \{\text{EUN,OSA,ROW,RUS,USA}\}$ denote the EU, other sanctioning countries, ROW, Russia, and the US.[21] The EU and the US are the two largest economies that are sanctioning Russia. Other sanctioning countries include Australia, Canada, Israel, Japan, South Korea, New Zealand, Norway, Singapore, Switzerland, Taiwan, and the UK, which are the economies that had joined sanctions on Russia by March 31, 2022.[22] We combine these other sanctioning economies because of the collaborative nature of the sanctions, and we reduce the number of countries for which we have to show the optimal sanctioning tariffs.[23] ROW includes all other economies that are covered by OECD ICIO. These countries have not imposed sanctions on Russia and will thus not change their tariffs throughout our analysis. Therefore, we combine them into one economy. We calibrate country-bilateral and sector-level expenditure shares, π_{ni}^{j}, country-

[20] See Table A.7 for the list of OECD ICIO sectors and their correspondence with the International Standard Industrial Classification (ISIC) Rev. 4 sectors.

[21] The EU countries that are covered by OECD ICIO are as follows: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Morocco, Netherlands, Poland, Portugal, Romania, Slovakia, Spain, and Sweden.

[22] See `https://graphics.reuters.com/UKRAINE-CRISIS/SANCTIONS/byvrjenzmve/` for the evolving list of countries that have sanctioned Russia.

[23] Section C.2 discusses the statistics of Russian trade. We show that the EU depends on Russia for mining and energy imports, while Russia views the EU as a significant sales market. Russia relies on sanctioning countries for input imports, but is not a crucial sales destination for them. We explore the implications of these trade patterns for cost-efficient sanctions.

level input-output coefficients, $\gamma_n^{k,j}$, country-level value added, $w_n L_n$, and country-level trade deficit, D_n, directly to their data counterparts in OECD ICIO.

We use AD tariffs that all countries impose on all their trade partners to identify the trade elasticity at the sector level. The estimated elasticities are presented in Table C.1. They range from 1.36 to 8.98. The average trade elasticity is 6.09. Results are consistent with the intuition that sectors less substitutable across countries, such as minerals and manufactured products, have lower trade elasticities than those that are more substitutable, such as energy and chemical products. Our estimates of the sectoral trade elasticities are correlated with those of Caliendo and Parro (2015) and the ones estimated with the Feenstra (1994) method. We leave a comprehensive analysis of the estimation of sectoral trade elasticities to Section C.1.

5. Results

Cost-Efficient Sanctions. In this section, we discuss the cost-efficient sanctions imposed by the EU. Figure 2 shows the statistics relating to the optimal sanctions imposed by the EU according to the different levels of willingness to pay for sanctions, ρ. The left panel plots the cost-efficient sanctions for selected sectors. The right panel plots the change in imports in the EU implied by different sanctioning schemes.

The EU should increase tariffs and decrease trade with Russia, even if the willingness to pay for sanctions is zero ($\rho = 1$), as shown in Figure 2. This is because higher tariffs on Russia lead to a decrease in the price of imported goods relative to exported ones, resulting in an increase in the EU's real income.[24] This result suggests that, to a certain degree, sanctioning countries can improve their own welfare and harm the Russian economy simultaneously.

Even when there is low willingness to pay for sanctions, imports from Russia should drop by more than 80%. When the EU's willingness to pay for sanctions is positive, it decreases trade with Russia by more than 60%. When there is a willingness to pay only US$0.40 per

[24] This is the traditional terms-of-trade effect discussed in, for example, Bagwell and Staiger (1990).

US$1 decline in Russian income, i.e., $\rho = 0.7$, the EU imposes tariffs that decrease imports from Russia by 95%.

Cost-efficient sanctions are small and uniform across sectors when there is low willingness to pay for sanctions, as shown in to Figure 2. If the EU is willing to pay US$0.10 for each US$1 decline in Russian income, i.e., $\rho = 0.9$, tariffs should average about 20% for all sectors. Tariffs increase with a higher willingness to pay, but the dispersion across sectors is small.[25]

If the EU is willing to pay over US$0.70 for each US$1 decline in Russian income, i.e., ρ is below 0.6, an EU embargo of Russian mining and energy products is optimal. Figure 3 extends the horizontal axis of Figure 2 to $\rho = 0.4$, according to which the EU is willing to pay US$1.50 for each US$1 decline in Russian income, and shows the optimal tariffs and trade flow changes accordingly. If the EU pays US$0.70 to reduce Russian real income by US$1, tariffs on mining and energy products are especially high, as shown in Figure 4. The tariff on energy extraction sector products, including crude oil and natural gas, is above 300%, and the tariff on petroleum is above 200%. In this case, an embargo on Russian oil and gas combined with high tariffs on other sectors is the most cost-efficient policy. When the willingness to pay rises to US$1.50, tariffs on all sectors are above 80% and an embargo on all sectors is optimal.

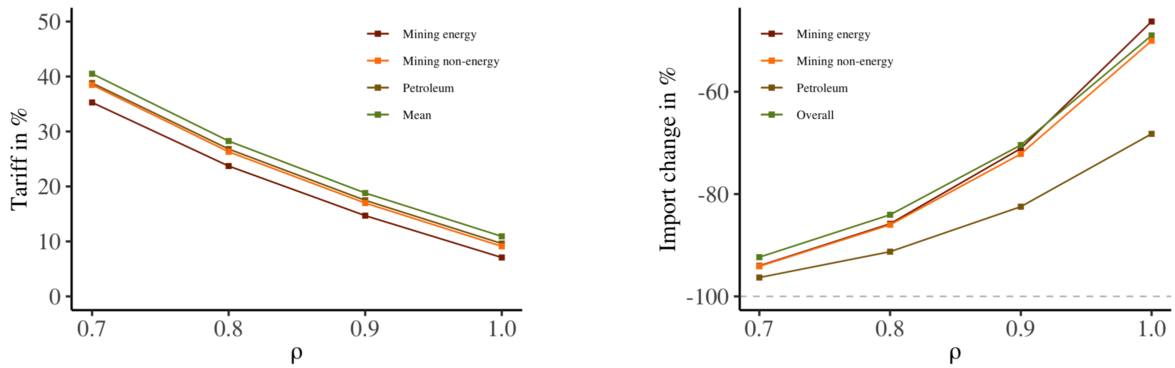
Conditional on the willingness to pay for sanctions, trade elasticities and initial import share are important determinants of tariffs. If the sanctioning country's main goal is to maximize domestic welfare, tariffs should target products with a low trade elasticity and a low import share from Russia. In this case, countries use tariffs to manipulate the terms of trade, i.e., to raise the export price relative to the import price.[26] The products in which the terms of trade are more affected by tariffs are the ones with lower demand elasticity and lower import share.

[25]In Section C.7, we solve the alternative cost-efficient sanction problem where the sanctioning countries minimize Russia's welfare while not decreasing their own welfare. We find that those cost-efficient sanction tariffs resemble the optimal tariffs under low willingness to pay for sanctions.

[26]See, for example, Bagwell and Staiger (1990).

Figure 2: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the EU,** $\rho \in [0.7, 1.0]$

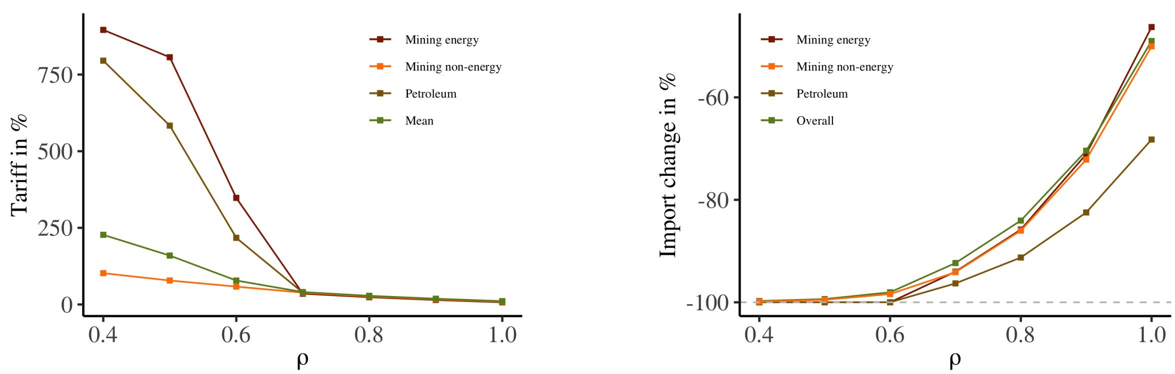
(a) Tariff (b) Change in Imports



Description: This figure shows the statistics for the EU under cost-efficient sanctions against Russia that vary by the level of willingness to pay for them. ρ ranges from 0.7 to 1.0. Figure 2a plots the cost-efficient sanctions on mining energy, mining non-energy, petroleum, and the average tariff across sectors by different levels of willingness to pay for sanctions, ρ. Figure 2b plots the percentage change in imports in the EU for different sectors by different levels of willingness to pay for sanctions, ρ.

Figure 3: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the EU,** $\rho \in [0.4, 1.0]$

(a) Tariff (b) Change in Imports

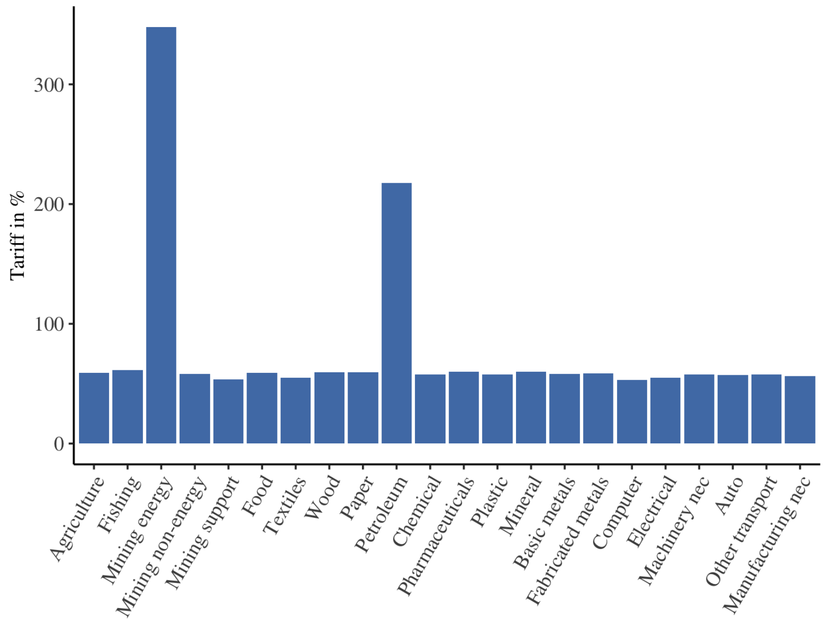


Description: This figure shows the statistics for the EU under cost-efficient sanctions against Russia that vary by the level of willingness to pay for them. ρ ranges from 0.4 to 1.0. Figure 3a plots the cost-efficient sanctions on mining energy, mining non-energy, petroleum, and the average tariff across sectors by different levels of willingness to pay for sanctions, ρ. Figure 3b plots the percentage change in imports in the EU for different sectors by different levels of willingness to pay for sanctions, ρ.

When there is a high enough willingness to pay for sanctions, tariffs should target sectors with a large import share from Russia and with a high trade elasticity. Sanctioning these sectors can divert more Russian exports to other countries, reduce Russian output further, and cause more economic damage in Russia. Section C.3 discusses these intuitions in detail.

Cost-efficient sanctions in the US and OSA exhibit a similar pattern, which varies accord-

Figure 4: **Cost-Efficient Sanctions in the EU for** $\rho = 0.6$



Description: This figure shows the cost-efficient sectoral tariffs that the EU imposes on Russia at $\rho = 0.6$ – the EU is willing to pay US\$0.7 for US\$1 real income loss in Russia.

ing to each country's willingness to pay for sanctions, as shown in Figures C.29 and C.30. In both cases, cost-efficient sanctions are small and uniform across sectors for low willingness to pay for sanctions, but they still cause a large drop in trade with Russia. Figure C.31 shows that as the willingness to pay increases, US optimal tariffs increase uniformly across sectors. The reason is that, as Figure C.4a shows, the share of US expenditure on Russia is small and similar across sectors. Figure C.32 shows that for other sanctioning countries, an embargo on mining and energy sectors is optimal if they would like to pay US\$1 to reduce Russia's income by US\$1. If the willingness to pay rises to US\$1.50, an embargo by all sanctioning countries on all Russian products is optimal.

5.1. The Welfare Cost of Sanctions

The Welfare Cost of Sanctions for Russia. How much welfare loss can sanctions cause in Russia? To answer this question, Figure 5 shows the welfare changes for Russia and the sanctioning countries under two scenarios: with and without Russian retaliation. In the case with retaliation, similar to the sanctioning countries, Russia chooses tariffs based on

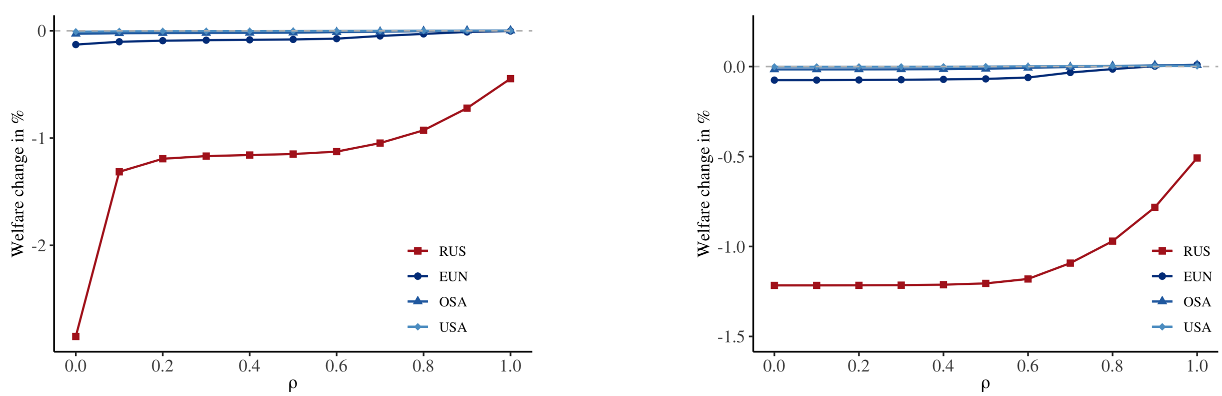
Problem 7. In the case without Russian retaliation, Russian tariffs are constant at the calibrated values.

As shown in Figure 5, sanctions can decrease Russian welfare by between 0.5% and 3%. Without Russian retaliation, i.e., if Russian tariffs are constant at the calibrated values, the welfare loss in Russia ranges from 0.5% to 1.2%, depending on the willingness to pay of the sanctioning countries. If Russia retaliates, the welfare cost of sanctions can be as large as 3% due to the the economic size difference between Russia and the sanctioning countries. The sanctioning countries are an important sourcing origin for Russia, whereas Russia is not an important exporting destination for the sanctioning countries.[27] Because of this, restricting imports from the sanctioning countries can have little impact on the sanctioning countries' income, but it induces a large price increase and real income loss in Russia.[28]

Figure 5: **Welfare Changes with and without Russian Retaliation**

(a) With Russian Retaliation

(b) Without Russian Retaliation

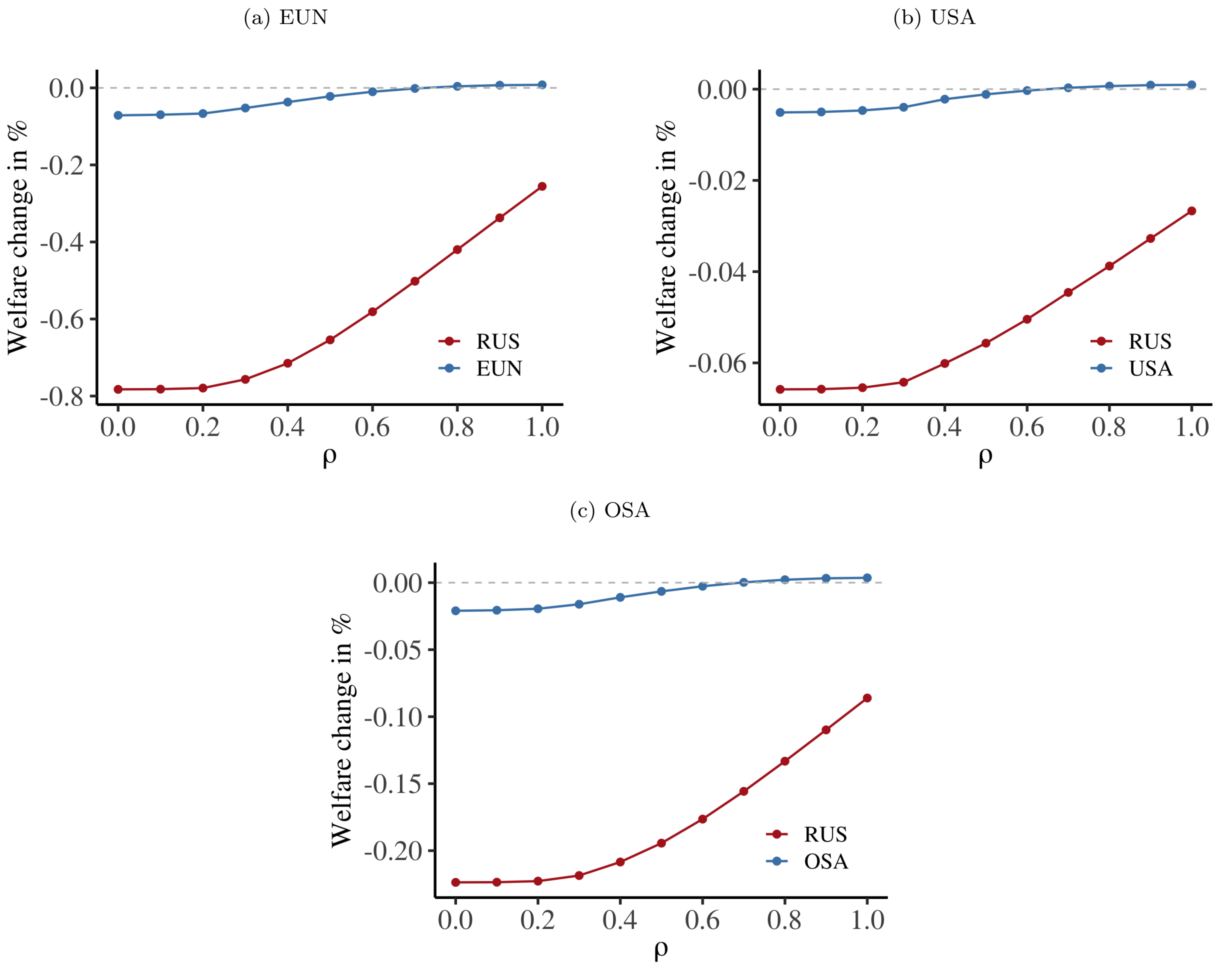


Description: This figure shows the welfare change by the different levels of willingness to pay for sanctions, ρ, under two variations of the model discussed in Section 3. Figure 5a displays the welfare changes for Russia, the EU, OSA, and the US when Russia also changes its tariffs to affect the welfare of the sanctioning countries. Figure 5b displays the welfare change in Russia, the EU, OSA, and the US under the assumption that Russia keeps its tariffs constant. Welfare refers to the equilibrium real income. Changes are calculated by comparing the resulting equilibrium from the new tariffs to the equilibrium with initial, pre-sanction tariffs.

[27] Russia spends 5.2% of its total expenditures on the sanctioning countries. The sanctioning countries sell 0.2% of their output to Russia. See Figures C.4c and C.4d.

[28] This finding also indicates that, as long as Russia cares about domestic welfare ($\rho_{RUS} > 0$), Russia should not impose high retaliatory tariffs on the sanctioning countries, and the consequences of sanctions are similar both with and without Russian retaliation. In Section C.5.3, we elaborate on this point further. We show that the sanctioning countries' optimal tariffs are not significantly affected by Russia's retaliation strategies.

Figure 6: **Welfare Changes with Individual Sanctions**



Description: This figure shows the welfare change for different willingness to pay for sanctions, ρ, under the equilibrium tariffs of the model with individual sanctions. Figure 6a shows the welfare change if the EU chooses tariffs on Russia to maximize 6 while all the other countries hold tariffs constant. Figure 6b shows the welfare change if the US chooses tariffs on Russia to maximize 6 while all the other countries hold tariffs constant. Figure 6c shows the welfare change if OSA chooses tariffs on Russia to maximize 6 while all the other countries hold tariffs constant. Welfare refers to the equilibrium real income. Changes are calculated comparing the equilibrium to the current tariffs.

The Welfare Cost of Sanctions on Sanctioning Countries. How much do sanctions cost the sanctioning countries? As shown in Figure 5, the welfare cost of sanctions is small. The sanctioning countries face a welfare loss ranging from 0.1% to 0.2%, depending on Russia's response to the sanctions. Additionally, Figure 5 highlights that imposing sanctions on Russia can benefit the sanctioning allies. If the sanctioning allies are not willing to pay for sanctions but choose tariffs on Russia to maximize their own welfare, i.e., $\rho = 1$, their welfare increases by 0.01%, 0.003%, and 0.003% in the EU, US, and OSA, respectively. Given the sanctioning allies' significant size and wealth advantage over Russia, they can alter the terms of trade in their favor, which harms Russia's economy while benefiting the sanctioning countries.

This finding is especially significant because it emphasizes the impact of revoking Russia's MFN status, which was one of the initial sanction measures imposed on Russia. With the implementation of this new regime, countries that are part of the WTO have the freedom to impose arbitrary tariffs on Russia. Therefore, even if these countries do not intend to harm Russia's economy, they can still inflict severe losses on Russia by selecting tariffs that enhance their own welfare (consistent with the theoretical predictions in Sturm 2022 and Sturm 2023).

To understand which of the sanctioning countries can have a greater impact on Russia, we consider the case where the EU, the US, and OSA individually set tariffs to target Russia's real income. For simplicity, we assume that Russia keeps its tariffs constant. Figure 6 shows the welfare changes for Russia and the sanctioning countries under unilateral sanctions. Each of the three sub-figures plots the counterfactual equilibrium in which one country chooses tariffs on Russian imports based on Problem 6, while Russia and all the other countries keep their tariffs constant.

According to Figure 6, the EU is the sanctioning group most affected by sanctions against Russia. If $\rho = 0$, i.e., tariffs against Russia are chosen to minimize Russian welfare, the EU has a welfare loss of 0.1%. Since the US and OSA trade much less with Russia than the EU, they suffer a welfare loss of only 0.01% and 0.02%, respectively.

The EU is also the trade partner that can cause the largest welfare damage to Russia. The EU alone can reduce the welfare in Russia by 0.26% to 0.78%, whereas US sanctions can only reduce Russian welfare by no more than 0.1%.

5.2. Extensions

Effect of Sanctions on Non-Sanctioning Countries. The ROW gains from the trade conflict between Russia and the sanctioning countries. As they raise tariffs against one another, Russia and the sanctioning allies import more from the ROW, a phenomenon known as trade diversion. Section C.4.1 examines the impact of various sanction policies on the exports, imports, and welfare of the ROW.

A Larger Coalition. What would be the implications of the ROW joining the current sanctioning countries in imposing cost-efficient sanctions on Russia? Section C.4.2 demonstrates that if the ROW were to participate in the sanctions, the EU and other sanctioning allies could effectively implement an embargo on Russia, even with a low willingness to pay for sanctions. Furthermore, the resulting welfare impacts on Russia would be significantly amplified.

Political Weights. If sanctions aim at sectors with greater political relevance in Russia, an embargo on Russian mining and energy sectors becomes cost-efficient, even for countries with low willingness to pay for sanctions. To assess political relevance, we connect each Russian individual sanctioned by the US, UK, or EU (referred to as an oligarch) to their associated companies in Russia. By examining the company's revenue, we compute the revenue share of oligarch-owned firms by sector. If sanctioning countries are willing to pay US$0.10 for each US$1 decrease in Russian oligarch consumption, tariffs on the Russian mining and energy sectors should exceed 80%, resulting in nearly a 100% reduction in mining and energy product imports. Section C.4.3 discusses the model with political weights in greater detail.

5.3. Robustness

Alternative Trade Elasticities. In Sections C.5.1 and C.5.2, we discuss the cost-efficient sanctions using the trade elasticities estimated by Caliendo and Parro (2015) and our estimates of the long-run trade elasticities. The results are not quantitatively different from the baseline calibration because the elasticities estimated in Section C.1 are close to the long-run trade elasticities and are positively correlated with those acquired by Caliendo and Parro (2015).

Russian Retaliation Strategies. The cost-efficient sanctions are also robust to Russian retaliation strategies. The reason is that, as Russia is a relatively small export destination for the sanctioning countries (Figure C.4c), Russia's retaliation on the sanctioning countries' exports should not strongly affect the latter group's output, income, or incentives to impose sanctions.[29] Section C.5.3 provides a comprehensive analysis of the impacts of various Russian retaliation strategies.

CES Production Function. The elasticity of substitution between inputs may play an important role in the impact of sanctions. For instance, if petroleum can be easily replaced with other inputs or labor, sanctions on Russia would minimally affect domestic production. Section C.5.4 shows that our primary findings hold true across various input substitution elasticities.

6. Conclusion

Trade sanctions serve as a prevalent tool for diplomatic retaliation. To inform present and future policies, we develop a quantitative model of tariff competition to determine the most cost-efficient approach for implementing trade sanctions against Russia. In this model, governments choose tariffs based on two objectives: maximizing domestic welfare and minimizing Russian welfare. When a government has a high willingness to pay for sanctions, it places greater emphasis on damaging the Russian economy.

Our research reveals four significant findings. First, for countries with a low willingness to pay for sanctions, the optimal strategy is to impose a modest tariff on all Russian products. Second, if the EU is willing to pay over US$0.70 for each US$1 of real income loss in Russia, a cost-efficient approach would be an EU embargo on the mining and energy sectors, combined with a 50% tariff on other sectors. Third, the EU holds the greatest potential to harm the Russian economy – not the US or OSA. Lastly, if Russia retaliates by imposing tariffs to punish the sanctioning countries, the welfare loss in Russia would more than double, with minimal consequences for the sanctioning allies.

[29] This is also corroborated by Figure 5, which shows that the sanctioning countries' real income is not significantly affected by ρ – the willingness to pay to minimize the opponent's real income in both the the sanctioning countries and Russia.

These findings validate current sanction policies and offer guidance for future sanctions. Our results suggest that most countries impose trade sanctions of around 20% against Russia due to their limited willingness to pay for sanctions. Furthermore, our analysis indicates that, when there is a high willingness to pay for sanctions, tariffs should target the primary export product of the sanctioned country.

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A. Empirics

A.1. Summary Statistics

Table A.1 shows the summary statistics for AD investigations targeting Russia. During the sample period (1995–2020), Russia faced 393 AD investigations, of which 298 (75%) concluded with an affirmative ruling, and 150 products that Russia exported faced AD investigations, of which 112 were subject to tariff increases.[30] Twenty countries imposed AD tariffs on Russia. Conditional on an investigation that led to an AD tariff increase, the average tariff was 123% and the median tariff was 43%. Figure A.1a shows the number of AD investigations and affirmative investigations by year. Figure A.1b shows that, conditional on an investigation with an affirmative ruling, the average AD tariff was the highest on the metal and machinery sectors.

Table A.2 shows the summary statistics, by country, for the AD investigations targeting Russia. The US conducted the most AD investigations, followed by the EU, Canada, and Ukraine. Conditional on an affirmative investigation, the AD tariff rate imposed by the US was the highest (497%).

Table A.3 shows the summary statistics for AD investigations that all countries imposed on their trade partners. There were a total of 15,131 AD investigations, of which 10,370 (68%) concluded with an affirmative ruling; 1,585 products faced AD investigations, of which 1,298 were subject to tariff increases. Conditional on an investigation that led to an AD tariff increase, the average tariff was 128% and the median tariff was 55%. Figure A.2a shows the number of global AD investigations and affirmative investigations by year. Figure A.2b shows that, on the world level, conditional on an investigation with an affirmative ruling, the average AD tariff was the highest on the mining (non-energy), mining support, and automobile sectors. Tables A.4 and A.5 show the summary statistics for global AD investigations by the investigating country and the exporting country.

[30] A product refers to an HS 6-digit code.

Table A.1: **Statistics for AD Investigations Targeting Russia**

	Tariff Increase	**No Tariff Chg**	**All**
# Investigations	298	105	393
# Products	112	74	150
# Countries	20	11	20
Avg. Tariff	1.23	0	0.90
Med. Tariff	0.43	0	0.33

Notes: This table presents the statistics for the AD investigations targeting Russia between 1995 and 2020. Each investigation was conducted on a product from Russia. The average and median tariffs are the simple average and the median across investigations. The investigation-level tariff is computed in ad-valorem terms.

Table A.2: **AD Investigations Targeting Russia by Country**

	Investigations		**Treated**		**All**	
Country	**# Investigations**	**% Treated**	**Avg. Tariff**	**Med. Tariff**	**Avg. Tariff**	**Med. Tariff**
United States	76	52.63%	4.97	3.13	2.62	1.57
European Union	68	82.35%	0.54	0.35	0.45	0.33
Canada	43	79.07%	1.44	0.87	1.14	0.86
Ukraine	32	90.63%	0.39	0.34	0.36	0.32
India	25	48.00%	0.71	0.68	0.34	0.00
Argentina	22	63.64%	0.82	0.60	0.52	0.60
China	22	100.00%	0.26	0.18	0.26	0.18
Philippines	21	42.86%	0.15	0.15	0.06	0.00
Venezuela	15	100.00%	0.64	0.64	0.64	0.64
Mexico	12	83.33%	0.49	0.34	0.41	0.30
Indonesia	11	100.00%	0.35	0.29	0.35	0.29
Pakistan	9	100.00%	0.29	0.28	0.29	0.28
Turkey	9	44.44%	0.17	0.10	0.08	0.00
Colombia	7	100.00%	1.35	0.50	1.35	0.50
Brazil	6	66.67%	0.24	0.29	0.16	0.16
South Korea	5	100.00%	0.25	0.30	0.25	0.30
South Africa	5	100.00%	0.78	0.78	0.78	0.78
Taiwan	3	33.33%	0.39	0.39	0.13	0.00
Australia	1	100.00%	0.29	0.29	0.29	0.29
Peru	1	100.00%	0.07	0.07	0.07	0.07

Description: This table presents summary statistics for the AD investigations targeting Russia by the country that initiated the investigation. The table shows the number of investigations, the fraction of the investigations that led to a tariff increase, the average tariff rate conditional on an affirmative investigation, and the average tariff rate of all investigations. The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020.

Table A.3: **Statistics for Global AD Investigations**

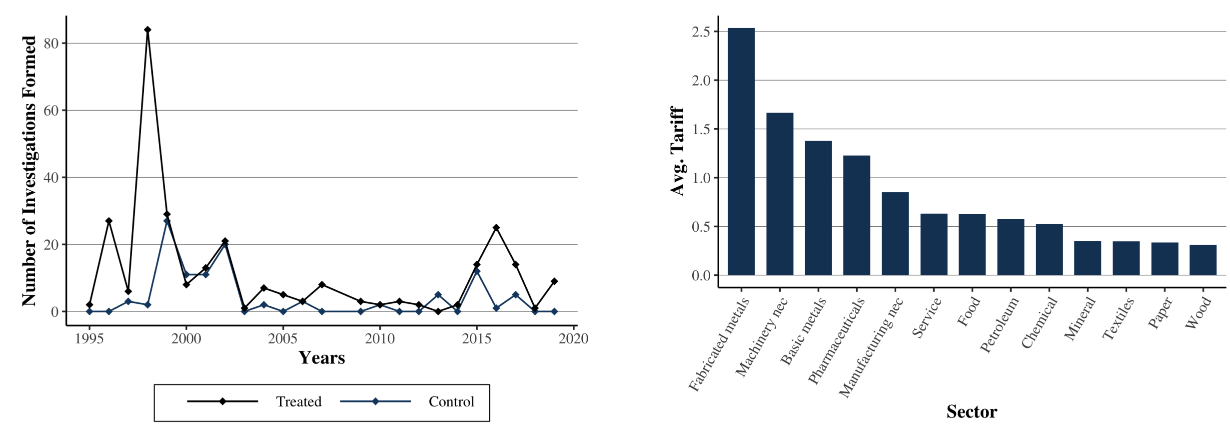
	Tariff Increase	No Tariff Chg	All
# Investigations	10370	4761	15131
# Products	1298	808	1585
# Countries inv	31	31	31
# Countries exp	95	89	106
Avg. Tariff	1.28	0	0.88
Med. Tariff	0.55	0	0.29

Notes: This table presents the statistics for the AD investigations targeting Russia between 1995 and 2020. Each investigation was conducted on a product from Russia. The average and median tariffs are the simple average and the median across investigations. The investigation-level tariff is computed in ad-valorem terms.

Figure A.1: **Summary Statistics for AD Investigations Targeting Russia**

(a) Number of AD Investigations by Year

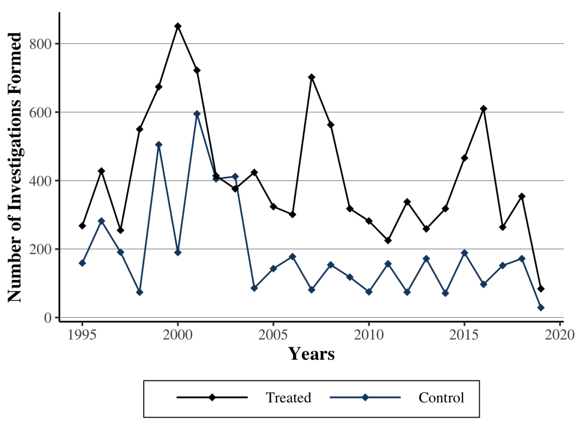
(b) Ave. AD Tariff Rate by Sector



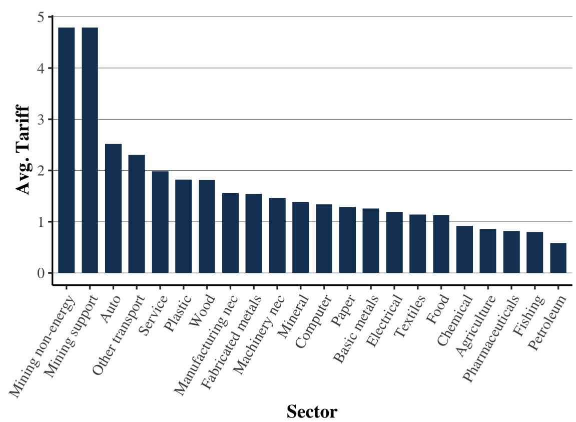
Description: This figure shows the summary statistics for the AD investigations and AD tariffs targeting Russia. The left panel shows the number of AD investigations with affirmative and negative rulings by year. The right panel shows, by sector, the average tariff rate across AD investigations conditional on an affirmative ruling. The same sector classification is used as in the 2018 OECD Inter-country Input-output Database (OECD ICIO 2018). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020.

Figure A.2: **Summary Statistics for Global AD Investigations**

(a) Number of AD Investigations by Year



(b) Ave. AD Tariff Rate by Sector



Description: This figure shows the summary statistics for the AD investigations and AD tariffs that all countries imposed on their trade partners. The left panel shows the number of AD investigations with affirmative and negative rulings by year. The right panel shows, by sector, the average tariff rate across AD investigations conditional on an affirmative ruling. The same sector classification is used as in the 2018 OECD ICIO. The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020.

Table A.4: **Global AD Investigations by Investigating Country**

	Investigations		**Treated**		**All**	
Country	**# Investigations**	**% Treated**	**Avg. Tariff**	**Med. Tariff**	**Avg. Tariff**	**Med. Tariff**
United States	3611	66.46%	2.17	0.90	1.44	0.37
India	1997	81.47%	0.80	0.51	0.65	0.50
European Union	1875	60.27%	0.92	0.56	0.56	0.23
Canada	1250	63.76%	1.91	1.09	1.22	0.49
Argentina	885	71.75%	1.24	0.62	0.89	0.50
Brazil	681	48.31%	1.42	0.76	0.69	0.00
Turkey	652	75.31%	1.59	0.45	1.20	0.29
China	624	98.40%	0.44	0.29	0.43	0.29
Australia	544	64.34%	0.28	0.15	0.18	0.07
Sourh Africa	383	63.71%	0.54	0.45	0.34	0.28
South Korea	366	68.03%	0.32	0.28	0.22	0.15
Indonesia	320	65.63%	0.27	0.21	0.18	0.11
Peru	310	64.19%	2.35	0.44	1.51	0.29
Mexico	275	83.64%	1.41	0.81	1.18	0.75
Pakistan	259	81.08%	0.39	0.28	0.32	0.22
Russia	164	59.76%	0.34	0.23	0.20	0.15
Malaysia	150	55.33%	0.19	0.13	0.11	0.06
Colombia	132	52.27%	1.93	0.77	1.01	0.10
Venezuela	120	84.17%	1.42	2.04	1.19	0.95
New Zealand	102	33.33%	1.05	0.58	0.35	0.00
Taiwan	96	51.04%	0.44	0.22	0.22	0.14
Ukraine	91	91.21%	0.89	0.45	0.81	0.41
Israel	83	46.99%	2.24	1.18	1.05	0.00
Philippines	44	40.91%	0.31	0.15	0.13	0.00
Trinidad and Tobago	28	82.14%	1.76	1.92	1.44	1.92
Chile	26	57.69%	0.31	0.23	0.18	0.10
Japan	19	89.47%	0.38	0.40	0.34	0.29
Jamaica	16	93.75%	0.51	0.22	0.48	0.22
Uruguay	10	30.00%	0.63	0.55	0.19	0.00
Costa Rica	9	77.78%	0.98	0.13	0.76	0.13
Ecuador	9	11.11%	0.30	0.30	0.03	0.00

Description: This table presents summary statistics for global AD investigations by the country that initiated the investigation. The table shows the number of investigations, the fraction of the investigations that led to a tariff increase, the average tariff rate conditional on an affirmative investigation, and the average tariff rate of all investigations. The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020.

Table A.5: **Global AD Investigations by Exporting Country**

	Investigations		Treated		All	
Country	**# Investigations**	**% Treated**	**Avg. Tariff**	**Med. Tariff**	**Avg. Tariff**	**Med. Tariff**
China	3791	79.87%	2.01	0.99	1.60	0.61
South Korea	1258	62.80%	0.50	0.24	0.32	0.08
Taiwan	837	71.92%	0.97	0.37	0.70	0.24
Japan	689	64.01%	0.98	0.60	0.63	0.29
India	628	63.85%	1.80	0.40	1.15	0.15
United States	522	72.22%	0.84	0.47	0.61	0.36
Indonesia	498	69.48%	0.67	0.50	0.46	0.20
Thailand	442	72.85%	0.57	0.33	0.41	0.20
Brazil	407	69.78%	1.04	0.73	0.73	0.37
Russia	393	73.54%	1.23	0.43	0.90	0.33
Viet Nam	349	65.04%	2.82	0.76	1.84	0.26
Malaysia	327	64.83%	0.49	0.29	0.32	0.15
Germany	307	65.80%	0.65	0.39	0.43	0.21
Ukraine	295	83.39%	1.17	0.68	0.98	0.47
France	266	45.49%	0.97	0.60	0.44	0.00
South Africa	255	73.33%	1.07	0.79	0.79	0.38
Turkey	239	45.61%	1.04	0.46	0.47	0.00
European Union	224	78.57%	0.65	0.40	0.51	0.35
Italy	180	68.89%	0.89	0.45	0.61	0.18
Spain	171	51.46%	0.81	0.46	0.42	0.07
United Kingdom	165	73.33%	1.14	0.77	0.84	0.49
Mexico	162	75.31%	0.93	0.56	0.70	0.37
Romania	149	79.87%	1.13	0.66	0.91	0.43
Hong Kong	134	48.51%	0.88	0.63	0.42	0.00
Canada	130	49.23%	0.40	0.28	0.20	0.00
Pakistan	127	66.93%	0.31	0.33	0.21	0.12
Singapore	119	66.39%	0.59	0.36	0.39	0.17
Argentina	116	44.83%	0.92	0.85	0.41	0.00
Kazakhstan	104	84.62%	1.90	0.81	1.61	0.77
Belgium	101	63.37%	0.54	0.41	0.34	0.24
Slovakia	97	61.86%	1.03	0.62	0.64	0.24
Australia	96	51.04%	1.43	0.70	0.73	0.29
Netherlands	94	62.77%	0.47	0.12	0.30	0.05
Egypt	83	20.48%	0.20	0.20	0.04	0.00
New Zealand	74	8.11%	0.14	0.11	0.01	0.00
Saudi Arabia	73	28.77%	0.53	0.30	0.15	0.00
Chile	71	73.24%	0.56	0.28	0.41	0.14
United Arab Emirates	70	77.14%	0.85	0.56	0.66	0.37
Peru	60	48.33%	0.49	0.50	0.23	0.00
Austria	57	66.67%	1.01	0.54	0.67	0.54
Bulgaria	57	94.74%	1.65	0.63	1.57	0.63
Poland	57	75.44%	0.69	0.51	0.52	0.43
Iran	54	55.56%	0.41	0.29	0.23	0.15
Macao	53	5.66%	0.23	0.23	0.01	0.00
Sweden	43	39.53%	0.44	0.27	0.17	0.00
Venezuela	40	20.00%	2.07	1.44	0.41	0.00
Belarus	39	66.67%	2.44	1.09	1.63	0.49
Israel	37	54.05%	0.47	0.53	0.26	0.34
Macedonia	36	69.44%	2.38	1.26	1.65	0.63
Hungary	34	50.00%	1.14	1.57	0.57	0.07
Philippines	33	69.70%	1.05	0.45	0.73	0.45
Finland	30	53.33%	1.10	0.41	0.59	0.12
Czechia	28	82.14%	1.71	0.91	1.40	0.78
Oman	22	59.09%	0.58	0.46	0.34	0.09
Greece	21	80.95%	0.89	0.55	0.72	0.45
Uruguay	21	42.86%	0.44	0.34	0.19	0.00
Switzerland	20	35.00%	1.37	0.72	0.48	0.00
Luxembourg	20	0.00%			0.00	0.00
Lithuania	18	33.33%	0.13	0.11	0.04	0.00
Colombia	15	66.67%	0.38	0.28	0.25	0.28
Moldova	14	50.00%	9.48	11.07	4.74	0.20
Sri Lanka	13	76.92%	0.30	0.25	0.23	0.25
Portugal	13	76.92%	0.98	1.03	0.76	0.59
Denmark	12	83.33%	2.27	1.67	1.89	0.76
Malawi	12	100.00%	1.10	1.10	1.10	1.10
Croatia	11	90.91%	0.69	0.53	0.63	0.46
Trinidad and Tobago	11	45.45%	0.43	0.56	0.20	0.00
Bahrain	10	0.00%			0.00	0.00
Libya	10	20.00%	1.03	1.03	0.21	0.00
Norway	10	80.00%	0.33	0.38	0.27	0.32
Dominican Republic	9	88.89%	0.22	0.22	0.20	0.22
Ireland	9	88.89%	0.13	0.08	0.11	0.08
Paraguay	9	100.00%	0.28	0.28	0.28	0.28
Bangladesh	6	100.00%	0.27	0.31	0.27	0.31
Estonia	6	66.67%	0.40	0.40	0.27	0.06
Faroe Islands	6	50.00%	0.55	0.55	0.27	0.27
Liechtenstein	6	0.00%			0.00	0.00
Guatemala	5	20.00%	0.52	0.52	0.10	0.00
Latvia	5	100.00%	0.14	0.17	0.14	0.17
Bosnia and Herzegovina	4	75.00%	0.34	0.28	0.25	0.28
Nepal	4	100.00%	0.18	0.18	0.18	0.18
North Korea	4	0.00%			0.00	0.00
Qatar	4	100.00%	0.45	0.45	0.45	0.45
Cuba	3	66.67%	0.21	0.21	0.14	0.21
Slovenia	3	33.33%	0.46	0.46	0.15	0.00
Uzbekistan	3	33.33%	0.13	0.13	0.04	0.00
Algeria	2	100.00%	0.13	0.13	0.13	0.13
Georgia	2	100.00%	0.38	0.38	0.38	0.38
Kyrgyzstan	2	100.00%	0.26	0.26	0.26	0.26
Kuwait	2	100.00%	0.20	0.20	0.20	0.20
Laos	2	0.00%			0.00	0.00
Nigeria	2	100.00%	0.40	0.40	0.40	0.40
Serbia	2	100.00%	0.29	0.29	0.29	0.29
Armenia	1	100.00%	0.37	0.37	0.37	0.37
Costa Rica	1	0.00%			0.00	0.00
Ecuador	1	100.00%	0.04	0.04	0.04	0.04
Jordan	1	100.00%	0.34	0.34	0.34	0.34

Description: This table presents summary statistics for the global AD investigations by the exporting country. The table shows the number of investigations, the fraction of the investigations that led to a tariff increase, the average tariff rate conditional on an affirmative investigation, and the average tariff rate of all investigations. The AD data are from the Global Anti-dumping Database. The sample runs from 1995 to 2020.

Table A.6: **Summary Statistics of the Difference-in-Differences Regression by Sector**

Sector	No. Obs	No. Prods	No. Importer	No. Exporter	Mean Ave Tariff	Mean Log Value	Sd. Ave Tariff	Sd. Mean Log Value
Agriculture	1959	10	6	7	0.03	8.68	0.07	6.70
Fishing	304	5	2	3	0.01	4.66	0.05	9.12
Mining non-energy	124	3	2	2	0.03	5.98	0.07	3.52
Mining support	72	3	2	2	0.03	6.35	0.08	3.43
Food	6048	87	21	37	0.03	4.95	0.07	7.46
Textiles	22568	212	18	30	0.03	-2.96	0.07	10.24
Wood	3629	64	15	25	0.03	2.08	0.07	9.53
Paper	8738	97	20	38	0.03	2.60	0.07	9.01
Petroleum	10041	140	19	45	0.04	2.86	0.08	9.00
Chemical	25126	259	23	61	0.04	3.04	0.07	8.79
Pharmaceuticals	784	21	11	12	0.05	6.38	0.09	5.81
Plastic	8502	100	22	32	0.03	4.42	0.07	8.19
Mineral	4415	69	22	29	0.04	3.18	0.08	8.27
Basic metals	100308	203	21	58	0.03	-0.48	0.07	10.15
Fabricated metals	5039	90	22	31	0.04	5.24	0.08	7.56
Computer	11945	111	21	38	0.03	4.30	0.07	8.15
Electrical	7533	95	22	33	0.03	4.25	0.07	8.61
Machinery n.e.c.	13712	229	24	44	0.04	5.37	0.08	7.60
Auto	1148	29	13	14	0.04	6.18	0.08	7.73
Other transport	1986	40	13	13	0.04	5.85	0.08	7.70
Manufacturing n.e.c.	35834	353	27	52	0.03	4.88	0.07	7.90
Service	1559	29	8	19	0.04	1.62	0.08	9.96

Description: This table presents summary statistics for the variables used in the difference-in-differences regressions used to estimate sectoral trade elasticities (Model C.1). The AD data are from the Global Anti-dumping Database. The sample runs from 1995 to 2020.

Table A.7: **OECD ICIO Sectors and International Standard Industrial Classification (ISIC) Revision 4 Sectors**

Sector	OECD ICIO	ISIC Rev. 4
Agriculture	Agriculture, hunting, forestry	1-2
Fishing	Fishing and aquaculture	3
Mining energy	Mining and quarrying, energy producing products	5-6
Mining non-energy	Mining and quarrying, non-energy producing products	7-8
Mining support	Mining support service activities	9
Food	Food products, beverages and tobacco	10-12
Textiles	Textiles, textile products, leather and footwear	13-15
Wood	Wood and products of wood and cork	16
Paper	Paper products and printing	17-18
Petroleum	Coke and refined petroleum products	19
Chemical	Chemical and chemical products	20
Pharmaceuticals	Pharmaceuticals, medicinal chemical and botanical products	21
Plastic	Rubber and plastics products	22
Mineral	Other non-metallic mineral products	23
Basic metals	Basic metals	24
Fabricated metals	Fabricated metal products	25
Computer	Computer, electronic and optical equipment	26
Electrical	Electrical equipment	27
Machinery n.e.c.	Machinery and equipment, nec	28
Auto	Motor vehicles, trailers and semi-trailers	29
Other transport	Other transport equipment	30
Manufacturing n.e.c.	Manufacturing nec; repair and installation of machinery and equipment	31-33
Service	Electricity, gas, steam and air conditioning supply	35
	Water supply, sewerage, waste management and remediation activities	36-39
	Construction	41-43
	Wholesale and retail trade; repair of motor vehicles	45-47
	Land transport and transport via pipelines	49
	Water transport	50
	Air transport	51
	Warehousing and support activities for transportation	52
	Postal and courier activities	53
	Accommodation and food service activities	55-56
	Publishing, audiovisual and broadcasting activities	58-60
	Telecommunications	61
	IT and other information services	62-63
	Financial and insurance activities	64-66
	Real estate activities	68
	Professional, scientific and technical activities	69-75
	Administrative and support services	77-82
	Public administration and defence; compulsory social security	84
	Education	85
	Human health and social work activities	86-88
	Arts, entertainment and recreation	90-93
	Other service activities	94-96
	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	97-98

Description: This table shows the relationship between the OECD ICIO sectors that we consider and the International Standard Industrial Classification (ISIC) Rev. 4 sectors.

A.2. Robustness

Tables A.8, A.9, and A.10 show that the effects of tariffs on imports from Russia, Russian total exports, and total imports are robust across various alternative specifications. Column 1 of these tables presents the baseline estimates. Column 2 clusters standard errors at the 4-digit product and importer level. Column 3 employs a dummy variable indicating whether an investigation committee is formed (as opposed to the number of committees) to control for the impact of AD investigations. Column 4 includes separate product, importer, and year fixed effects. Column 5, building upon the baseline, further incorporates 4-digit product–time fixed effects. Column 6, on top of the baseline, further controls for product–level total number of investigations that other countries conduct on a product from Russia. Column 7 of Tables A.8 and A.10 controls for product–time fixed effects.[31] Column 8 of Tables A.8 and A.10 and Column 7 of Table A.9 apply the Poisson Pseudo Maximum Likelihood (PPML) estimator (Silva and Tenreyro 2006). Column 9 of Table A.8 estimates the PPML model with product–year fixed effects. Column 10 of Table A.8, Column 9 of Table A.10 and Column 8 of Table A.9 utilize the inverse hyperbolic sine of trade value as the outcome variable.[32]

[31]The product–time fixed effects capture all variations in Russia's product–level total exports, so the results with product–time fixed effects are not reported in Table A.9. Additionally, it is important to note that the number of observations decreases substantially in Column 7 of Tables A.8 and A.10 when product–time fixed effects are included. Once these fixed effects are controlled for, the estimation of the tariff coefficient relies on variations across investigating countries. However, Figure A.5 indicates that approximately 80% of investigations against Russia are conducted by a unique country, leading to the exclusion of these observations when product–time fixed effects are considered. Furthermore, at most two countries investigate the same product from Russia in the same year.

[32]See Bellemare and Wichman (2020). The inverse hyperbolic sine of $y_{p,c,t}$ can be expressed as: $\text{Arsinh}(y_{p,c,t}) = \log(y_{p,c,t} + (y_{p,c,t} + 1)^{1/2})$. This transformation offers an alternative method for estimating elasticities when the dependent variable contains zeros or small values.

Table A.8: **Robustness Test: Effect of AD Tariffs on Russian Trade**

	(1) Log Value	(2) Log Value	(3) Log Value	(4) Log Value	(5) Log Value	(6) Log Value	(7) Log Value	(8) Value	(9) Value	(10) Arsinh(Value)
AD Tariff	-4.306**	-4.306**	-4.479**	-3.976**	-3.571*	-4.250**	-5.057**	-3.020***	-1.631***	-4.394*
	(1.895)	(1.921)	(1.997)	(1.907)	(1.793)	(1.925)	(2.136)	(0.801)	(0.137)	(2.297)
Observations	1534	1534	1534	1638	1300	1534	312	1302	250	1404
R^2	0.807	0.807	0.804	0.688	0.931	0.809	0.907	NA	NA	0.884
Product X Importer FE	X	X	X		X	X	X	X	X	X
Importer X Year FE	X	X	X		X	X		X		X
Product X Year FE							X		X	
4-digit X Year FE					X					X
Product FE				X						
Importer FE				X						
Year FE				X						
PPML								X	X	
Number of AD committees	X	X		X	X	X	X	X	X	X
Product–year level number of AD committees						X				
Dummy for AD committee			X							
After AD investigation	X	X	X	X	X	X	X	X	X	X
Std error clustering	Product X Importer	4-digit X Importer	Product X Importer	Product X Importer	Product X Importer	Product X Importer	Product X Importer	Product X Importer	Product X Importer	Product X Importer

Description: This table presents the impact of AD tariffs imposed on Russia by other countries on the log of imports from Russia by the country that initiated the AD investigation. We study HS 6-digit level imports. Imports are measured in FOB, current dollar value terms. The coefficients are estimated with Model 1. Different columns include different combinations of fixed effects and controls. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. Standard errors are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.010.

Table A.9: **Robustness Test: Effect of AD Tariffs on Total Exports**

	(1) Log Total Exports	(2) Log Total Exports	(3) Log Total Exports	(4) Log Total Exports	(5) Log Total Exports	(6) Log Total Exports	(7) Total Exports	(8) Arsinh(Value)
AD Tariff	-1.577**	-1.577*	-1.445*	-1.013	-0.992	-1.516*	-1.182**	-1.863
	(0.726)	(0.796)	(0.741)	(0.989)	(0.765)	(0.773)	(0.540)	(2.030)
Observations	1534	1534	1534	1638	1300	1534	1302	1404
R^2	0.804	0.804	0.803	0.657	0.913	0.804	NA	0.819
Product X Importer FE	X	X	X		X	X	X	X
Importer X Year FE	X	X	X		X	X	X	X
4-digit X Year FE					X			X
Product FE				X				
Importer FE				X				
Year FE				X				
Number of AD committees	X	X		X	X	X	X	X
Product–year level number of AD committees						X		
Dummy for AD committee			X					
After AD investigation	X	X	X	X	X	X	X	X
PPML							X	
Std error clustering	Product X Importer	4-digit X Importer	Product X Importer	Product X Importer	Product X Importer	Product X Importer	Product X Importer	Product X Importer

Description: This table presents the impact of AD tariffs imposed on Russia by other countries on the log of HS 6-digit level total exports by Russia to all destinations. The coefficients are estimated with Model 1. Total exports refers to total exports of the HS 6-digit level product by Russia to all destinations; these exports are of the same 6-digit products for which other countries initiated an AD investigation on Russia. Different columns include different combinations of fixed effects and controls. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. Standard errors are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.010.

Table A.10: **Robustness Test: Effect of AD Tariffs on Total Imports**

	(1) Log Total Imports	(2) Log Total Imports	(3) Log Total Imports	(4) Log Total Imports	(5) Log Total Imports	(6) Log Total Imports	(7) Log Total Imports	(8) Total Imports	(9) Arsinh(Value)
AD Tariff	-1.867**	-1.867**	-1.890**	-1.499*	-1.708	-1.910**	-1.233	-0.974**	-2.445
	(0.743)	(0.764)	(0.826)	(0.871)	(1.074)	(1.074)	(0.798)	(0.396)	(2.318)
Observations	1534	1534	1534	1638	1300	1534	312	1302	1404
R^2	0.839	0.839	0.837	0.738	0.922	0.840	0.910	NA	0.847
Product X Importer FE	X	X	X		X	X	X	X	X
Importer X Year FE	X	X	X		X	X	X	X	X
Product X Year FE									
4-digit X Year FE					X				X
Product FE				X					
Importer FE				X					
Year FE				X					
Number of AD committees	X	X		X	X	X	X	X	X
Product–year level number of AD committees						X			
Dummy for AD committee			X						
After AD investigation	X	X	X	X	X	X	X	X	X
PPML								X	
Std error clustering	Product X Importer	4-digit X Importer	Product X Importer	Product X Importer	Product X Importer	Product X Importer	Product X Importer	Product X Importer	Product X Importer

Description: This table presents the impact of AD tariffs imposed on Russia by other countries on the log of HS 6-digit level total imports by another country from all origins. The coefficients are estimated with Model 1. Total imports refers to the total imports of the HS 6-digit level product from all origins by the country that initiated an AD investigation on Russia; these imports are of the same 6-digit products on which the AD tariffs have been imposed. Different columns include different combinations of fixed effects and controls. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

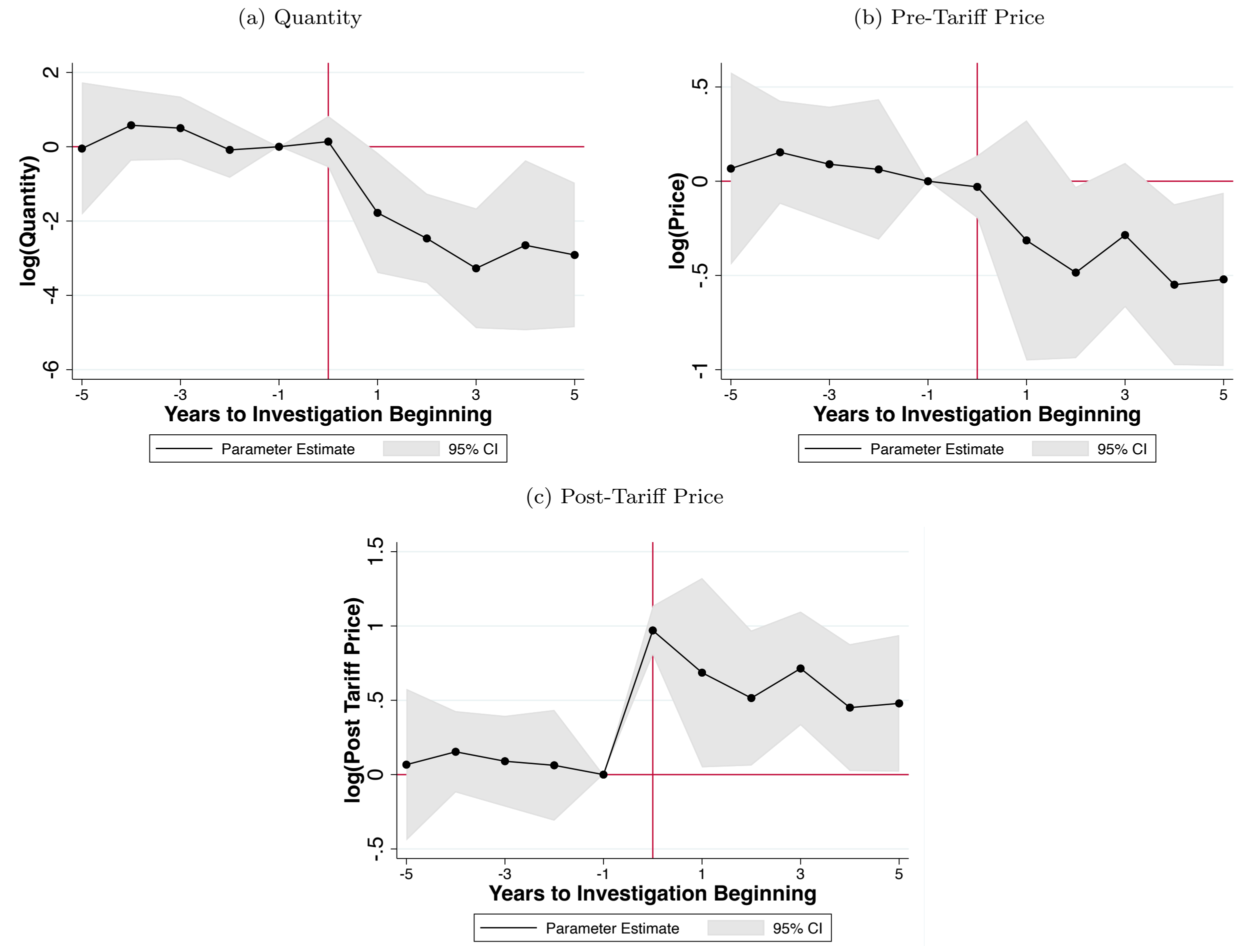
A.3. Heterogeneity

The following specification estimates heterogeneity in the effect of tariffs against Russia:

$$\begin{aligned}\log(y_{p,c,t}) =& \theta\tau_{p,c,t} + \theta_H \tau_{p,c,t} \times \log(y^{pre}_{p,c}) + \beta \mathbb{I}_{p,c,t}\left\{\text{After AD}\right\} + \\ & \gamma \mathbb{N}_{p,c,t}\left\{\text{Committee}\right\} + \eta_{p,c} + \eta_{c,t} + \epsilon_{p,c,t},\end{aligned} \tag{A.1}$$

where $y^{pre}_{p,c}$ is the pre-investigation trade flow. All other notations remain the same. θ_H captures the effect of AD tariffs on countries with larger initial imports from Russia.

Figure A.3: **Impact of AD Tariffs on Quantity and Prices**



Description: This figure shows the dynamic impact of AD tariffs on the quantity, pre-tariff price, and post-tariff price of imports using Model 3. The impact on yearly import quantity and price is plotted on the y-axis. The number of years to the beginning of the investigation is plotted on the x-axis. The import quantity is measured with HS 6-digit level metric tons imported from Russia by the country that initiated the AD investigation. HS 6-digit level price is measured with the value per metric ton. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. The sample includes the product–origins that faced at least one AD investigation. The shaded area contains the 95% confidence interval. Standard errors are clustered at the product–country level.

According to results in Table A.12, larger initial trade flows are associated with a reduced magnitude of the impact resulting from AD tariffs.

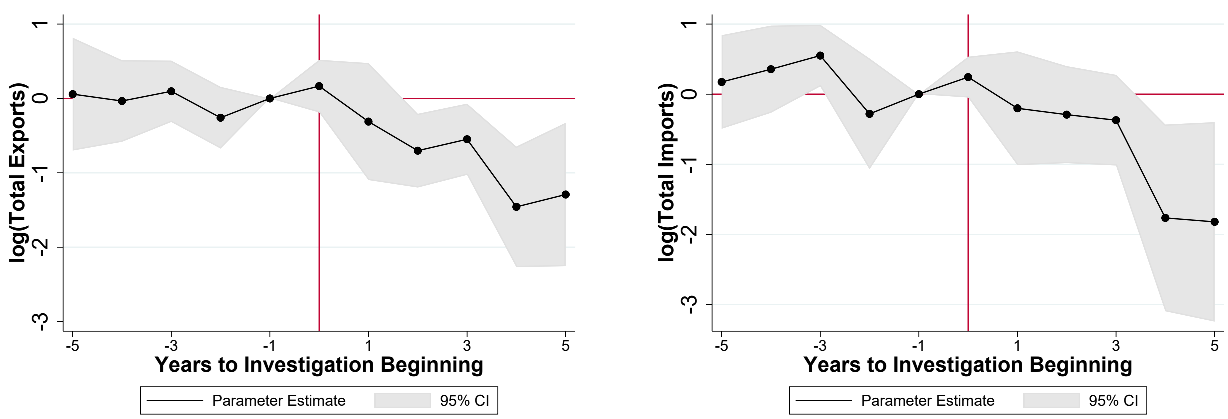
We also estimate heterogeneity of the response to tariffs using the following model:

$$\begin{aligned} \log(y_{p,c,t}) =& \theta\tau_{p,c,t} + \theta_H \tau_{p,c,t} \times \mathbf{1}(\text{Large Tariff})_{p,c} + \beta \mathbb{I}_{p,c,t}\{\text{After AD}\} + \\ & \gamma \mathbb{N}_{p,c,t}\{\text{Committee}\} + \eta_{p,c} + \eta_{c,t} + \epsilon_{p,c,t}, \end{aligned} \tag{A.2}$$

Figure A.4: **Impact of AD Tariffs on Product-level Total Exports and Total Imports**

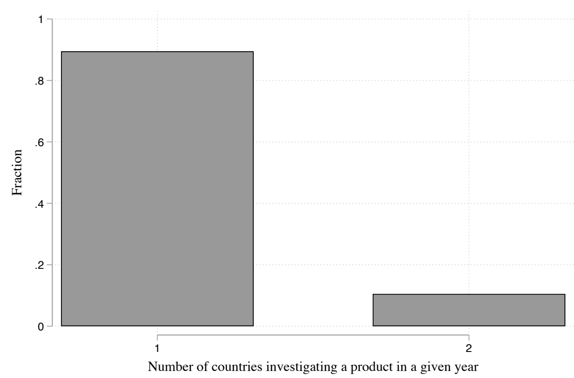
(a) Exports to All Destinations

(b) Imports from All Origins



Description: This figure shows the dynamic impact of AD tariffs on total exports and total imports using Model 3. The impact on total imports and total exports is plotted on the y-axis. The number of years to the beginning of the investigation is plotted on the x-axis. Total exports refers to the total exports of the HS 6-digit level product by Russia to all destinations; these exports are of the same 6-digit product for which other countries initiated an AD investigation targeting Russia. Total imports refers to the imports of the HS 6-digit level product from all origins by the country that initiated an AD investigation targeting Russia; these imports are of the same 6-digit product on which the AD tariff has been imposed. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. The sample includes the product–origins that faced at least one AD investigation. The shaded area contains the 95% confidence interval. Standard errors are clustered at the product–country level.

Figure A.5: **Distribution of the Number of Countries Investigating the Same Product from Russia in the Same Year**



Description: This figure illustrates the distribution of the number of countries involved in an AD investigation against Russia. An investigation is defined as a product being investigated in a year.

where $\mathbf{1}(\text{Large Tariff})_{p,c}$ is a dummy that takes one if the AD tariff is among the top 25% of all AD tariffs against Russia. It captures the difference in the response to the average AD tariff and the large AD tariffs. All other notations remain the same.

Table A.12 demonstrates that the magnitude of trade elasticity in response to larger AD tariffs exceeds the trade elasticity in response to the average tariff.

Table A.11: **Effect of AD Tariffs on Trade Diversion**

	(1) Log Exports to Other Destinations	(2) Log Imports from Other Origins	(3) Log Imports of Other Products
AD Tariff	0.202	0.112	-0.214
	(0.525)	(0.372)	(0.344)
Observations	1,063	1,062	1,064
R^2	0.888	0.908	0.901

Description: This table presents the impact of AD tariffs imposed on Russia by other countries on the trade diversion to other destinations, origins, and products, estimated with Model 1. *Log Exports to Other Destinations* denotes the log of exports of HS 6-digit level products by Russia to all destinations except the country that imposed the AD tariff on the same 6-digit product from Russia (for which an AD investigation was initiated). *Log Imports from Other Origins* denotes the log of HS 6-digit level imports by the country that imposed the AD tariff on the same 6-digit product from Russia (for which an AD investigation was initiated). *Log Imports of Other Products* denotes the imports from Russia of all HS 6-digit level products within the same HS 2-digit category except the HS 6-digit product that faces an AD investigation by another country. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. The fixed effects are: product–importer, importer–year, number of AD committees, and after AD investigation. Standard errors are clustered at product–importer level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.12: **Heterogeneity Analysis of AD Tariffs on Russian Trade: Pre-investigation Trade Flows and Large Tariffs**

	(1) Log Value	(2) Log Value	(3) Log Value	(4) Log Value	(5) Value	(6) Value	(7) Value	(8) Value
AD Tariff	-12.86***	-13.95	-15.49**	-0.997	-6.952***	-13.56**	-7.882**	-1.569
	(1.895)	(8.805)	(6.028)	(1.679)	(1.334)	(6.370)	(3.799)	(1.292)
AD Tariff x Log Value 1-yr before Investigation	1.329***				0.578**			
	(0.330)				(0.264)			
AD Tariff x Log Value 5-yr before Investigation		1.440				1.311**		
		(0.977)				(0.636)		
AD Tariff x Log Value 10-yr before Investigation			1.384				0.612	
			(0.820)				(0.500)	
AD Tariff x Top 25% Tariffs				-7.460***				-2.921**
				(1.566)				(1.242)
Observations	1300	1040	858	1534	1268	1034	855	1302
R-squared	0.761	0.722	0.704	0.813	NA	NA	NA	NA
PPML					X	X	X	X

Description: This table presents how the impact of AD tariffs on the sanctioning country's trade with Russia of the targeted products depends on pre-investigation trade flow values and the tariffs' magnitudes, estimated with the difference-in-differences method. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. The fixed effects are: product–importer, importer–year, number of AD committees, and after AD investigation. Standard errors are clustered at destination–product level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

B. Model

B.1. Market Clearing and Equilibrium Conditions

Define the price of sector j output in country i as follows:

$$p_n^j = \frac{1}{A_n^j} \left[w_n\right]^{\gamma_n^j} \prod_{k=1}^{J} \left[P_n^k\right]^{\gamma_n^{j,k}}. \tag{B.1}$$

Country n's expenditure share on sector j's output from country i equals:

$$\pi_{ni}^j = \frac{(t_{ni}^j k_{ni}^j p_i^j)^{1-\sigma^j}}{\sum_{h=1}^N (t_{nh}^j k_{nh}^j p_h^j)^{1-\sigma^j}}. \tag{B.2}$$

The price of sector j composite goods in country n is given by:

$$P_n^j = \left[\sum_{i=1}^{N} (t_{ni}^j k_{ni}^j p_i^j)^{1-\sigma^j}\right]^{1/(1-\sigma^j)}. \tag{B.3}$$

From now on, we use $\theta^j = \sigma^j - 1$ to denote the trade elasticity.

The consumer price index is defined as:

$$P_n^C = \prod_{j=1}^{J} \left(P_n^j\right)^{\alpha_n^j}. \tag{B.4}$$

Let $X_n^j = P_n^j Q_n^j$ denote country n's total expenditure on sector j's composite goods. The market clearing condition for the composite goods implies that:

$$X_n^j = \sum_{k=1}^{J} \gamma_n^{k,j} \sum_{i=1}^{N} \frac{X_i^k \pi_{in}^k}{t_{in}^k} + \alpha_n^j I_n, \tag{B.5}$$

where the first term is country n's demand for inputs from sector j and the second term is the consumer's demand.

Household income, I_n, must be equal to labor income, tax revenue, and the trade deficit:

$$I_n = w_n L_n + R_n + D_n, \tag{B.6}$$

where $w_n L_n$ is labor income, R_n is tariff revenue, and D_n is the trade deficit. Tariff revenue can be written as:

$$R_n = \tau^j_{ni} \sum_{i=1}^{N} \frac{X^k_i \pi^k_{in}}{t^k_{in}}. \tag{B.7}$$

Using Equation B.5 and the definition of the trade deficit, we can write the labor market clearing condition:

$$w_n L_n = \sum_{j=1}^{J} \gamma^j_n \sum_{i=1}^{N} \frac{X^j_i \pi^j_{in}}{t^j_{in}}. \tag{B.8}$$

With that, we are ready to define an equilibrium given tariffs.

Equilibrium given Tariffs. Given tariffs $\{\tau^j_{ni}\}_{j,n,i}$*, an equilibrium is defined as a set of sectoral prices ,*$\{P^j_n\}_{n,j}$*, and wages,* $\{w_n\}_n$*, such that*

1. *firms maximize profit (Equation B.1);*
2. *the price index satisfies Equations B.2 and B.3;*
3. *the goods markets clear, satisfying Equations B.5 and B.6;*
4. *the government budget constraint (Equation B.7) holds;*
5. *the labor market clears, satisfying Equation B.8.*

B.2. Equilibrium in Changes

Using the "exact hat algebra" technique popularized by Dekle et al. (2007), we can express the equilibrium conditions in terms of changes from the baseline equilibrium, given changes in tariffs $\left\{\hat{t}^j_{ni}\right\}_{j,n,i}$ ($\hat{t}^j_{ni} = (1+\tau^{j\prime}_{ni})/(1+\tau^j_{ni})$):

$$\hat{c}^j_n = (\hat{w}_n)^{\gamma^j_n} \prod_{k=1}^{J} (\hat{P}^k_n)^{\gamma^{k,j}_n} \tag{B.9}$$

$$\hat{P}^j_n = \left[\sum_{i=1}^{N} \pi^j_{ni} (\hat{t}^j_{ni} \hat{c}^j_i)^{-\theta^j}\right]^{-1/\theta^j} \tag{B.10}$$

$$\hat{\pi}^j_{ni} = \left(\frac{\hat{c}^j_i \hat{t}^j_{ni}}{\hat{P}^j_n}\right)^{-\theta^j} \tag{B.11}$$

$$X^{j\prime}_n = \sum_{k=1}^{J} \gamma^{j,k}_n \sum_{i=1}^{N} \frac{\pi^{k\prime}_{in}}{t^{k\prime}_{in}} X^{k\prime}_i + \alpha^j_n I^\prime_n \tag{B.12}$$

$$I^\prime_n = \hat{w}_n w_n L_n + D^\prime_n + \sum_{j=1}^{J} \sum_{i=1}^{N} \tau^{j\prime}_{ni} \frac{X^{j\prime}_n \pi^{j\prime}_{ni}}{t^{j\prime}_{ni}} \tag{B.13}$$

$$\hat{w}_n = \sum_{j=1}^{J} \gamma^j_n \sum_{i=1}^{N} X^{j\prime}_i \frac{\pi^{j\prime}_{in}}{t^{j\prime}_{in} w_n L_n}. \tag{B.14}$$

To compute the counterfactuals, we only need data on bilateral trade shares π^j_{ni}, the share of value added in production γ^j_n, value added $w_n L_n$, incumbent tariffs τ^j_{ni}, the share of intermediate consumption $\gamma^{k,j}_n$, consumption shares α^s_n, and sectoral trade elasticity θ^j.

We follow Ossa (2014) and Caliendo and Parro (2015) to construct a trade flow matrix without trade imbalance using the approach introduced in Dekle et al. (2007). All later calculations of welfare changes given counterfactual tariffs will treat this purged trade flow data as the factual equilibrium.

Equilibrium in Changes Given Tariff Changes. Given changes in tariffs $\left\{\hat{t}^j_{ni}\right\}_{j,n,i}$*, an equilibrium is defined as changes in sectoral prices,* $\{\hat{P}^j_n\}_{n,j}$*, and wages,* $\{\hat{w}_n\}_n$*, such that*

1. *firms maximize profit (Equation B.9);*
2. *the price index satisfies Equations B.10 and B.11;*
3. *the goods markets clear, satisfying Equations B.12 and B.13;*
4. *the labor market clears, satisfying Equation B.14.*

Tariff Competition with Equilibrium in Changes. Following the notations in Section 3.5, we denote changes in the sectoral tariffs that country n imposes on Russia with $\hat{\mathbf{t}}_{\mathbf{nR}}$, and all other tariffs – changes in tariffs imposed on Russia by all countries except country n and those that country n imposes on all other countries except Russia – with $\hat{\mathbf{t}}_{-\mathbf{nR}}$.

The change in country n's welfare equals the following:

$$\hat{G}_n(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}) = \frac{\hat{I}_n(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})}{\hat{P}_n^C(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})}, \tag{B.15}$$

where $\hat{I}_n(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})$ denotes the change in country n's income and $\hat{P}_n^C(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})$ denotes the change in country n's consumer price index.

Conditional on $\hat{\mathbf{t}}_{-\mathbf{nR}}$, the objective of sanctioning country n is to both maximize its own welfare (real income, or GNI) and minimize Russian welfare in the counterfactual equilibrium:

$$g_n(\hat{\mathbf{t}}_{-\mathbf{nR}}) \in argmax_{\{\hat{\mathbf{t}}_{\mathbf{nR}}\}} \rho G_n \hat{G}_n(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}) - (1-\rho) G_R \hat{G}_R(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}), \tag{B.16}$$
$$\text{s.t. Equilibrium Conditions B.9-B.14,}$$

where G_n and G_R denote country n's and Russia's real income in the baseline equilibrium. We calibrate them to the country's purchasing power parity (PPP) adjusted GNI in 2018, the same year as the OECD ICIO data.[33]

Russia, when it retaliates, maximizes a weighted average of its own welfare and the loss in the allies' welfare, both in the counterfactual equilibrium:

$$g_R(\hat{\mathbf{t}}_{-\mathbf{RS}}) \in argmax_{\{\hat{\mathbf{t}}_{\mathbf{RS}}\}} \rho G_R \hat{G}_R(\hat{\mathbf{t}}_{\mathbf{RS}}, \hat{\mathbf{t}}_{-\mathbf{RS}}) - (1-\rho) \sum_{n \in S} \frac{G_n \hat{G}_n(\hat{\mathbf{t}}_{\mathbf{RS}}, \hat{\mathbf{t}}_{-\mathbf{RS}})}{N_S} \tag{B.17}$$
$$\text{s.t. Equilibrium Conditions B.9-B.14.}$$

[33] The data source is the World Bank. See https://data.worldbank.org/indicator/NY.GNP.MKTP.PP.CD?locations=1W-EU-RU-US.

Equilibrium in Changes with Sanctions. Given changes in all tariffs except what the sanctioning countries impose on Russia and Russia imposes on sanctioning countries, $\{\hat{t}^j_{ni}\}_{j,n,i} \setminus \left\{\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{\mathbf{Rn}}\right\}_{n\in\mathbf{S}}$, an equilibrium with optimal sanctions is given by tariffs imposed on Russia by sanctioning countries, $\{\hat{\mathbf{t}}_{\mathbf{nR}}\}_{n\in\mathbf{S}}$, tariffs imposed on the sanctioning countries by Russia, $\{\hat{\mathbf{t}}_{\mathbf{Rn}}\}_{n\in\mathbf{S}}$, a set of sectoral prices, $\{\hat{P}^j_n\}_{n,j}$, and wages, $\{\hat{w}_n\}_n$, such that

1. *given tariffs $\{\hat{t}^j_{ni}\}_{j,n,i}$, $\left\{\{\hat{P}^j_n\}_{n,j}, \{\hat{w}_n\}_n\right\}$ is an equilibrium;*
2. *sanctioning countries and Russia optimally choose changes in their tariffs:*

$$\hat{\mathbf{t}}_{\mathbf{nR}} = g_n(\hat{\mathbf{t}}_{-\mathbf{nR}}), \forall n \in \mathbf{S}$$
$$\hat{\mathbf{t}}_{\mathbf{RS}} = g_R(\hat{\mathbf{t}}_{-\mathbf{RS}})$$

C. Quantitative Analysis

C.1. Estimation of Sector-level Trade Elasticity

To estimate trade elasticities, we pool together variation from all AD tariffs against any trade partner. We estimate trade elasticity for each goods sector listed in the 2018 OECD Inter-country Input-Output Database (OECD ICIO 2018).[34] We use a specification similar to Equation 1:

$$\begin{aligned}\log(y_{p,d,o,t}) = &\sum_{j=1}^{J} \theta^j \mathbf{1}(p \in j)\tau_{p,d,o,t} + \beta \mathbb{I}_{p,d,o,t}\left\{\text{After AD}\right\} + \gamma \mathbb{N}_{p,d,o,t}\left\{\text{Committee}\right\} \\ &+ \eta_{p,t} + \eta_{p,d} + \eta_{p,o} + \eta_{d,t} + \eta_{o,t} + \epsilon_{p,d,o,t}, \end{aligned} \tag{C.1}$$

where $y_{p,d,o,t}$ denotes the imports of product p from country o by country d in year t. j

[34]To ensure that there is sufficient cross-product variation, we pool together the agriculture sector (D01-D02 of ISIC Rev. 4) and food sector (D10-D12 of ISIC Rev. 4), and pool together all mining and energy sectors (D05-D09 and D19 of ISIC Rev. 4).

represents a sector and $\mathbf{1}(p \in j)$ takes one if product p belongs to sector j. $\tau_{p,d,o,t}$ is the AD tariff that d imposes on product p from country o in year t. $\mathbb{I}_{p,d,o,t}\{\text{After AD}\}$ takes 1 if year t is after the first AD investigation that country d conducts on product p from country o; it accounts for trends leading to the first investigation. $\mathbb{N}_{p,d,o,t}\{\text{Committee}\}$ stands for fixed effects for the number of AD investigations conducted by country c on product p from Russia in the past 5 years, which captures the degree of uncertainty introduced by the AD investigation. $\eta_{p,t}$ is a product–year fixed effect, $\eta_{p,d}$ is a product–destination fixed effect, $\eta_{p,o}$ is a product–origin fixed effect, $\eta_{d,t}$ is a destination–year fixed effect, and $\eta_{o,t}$ is an origin–year fixed effect.

Trade elasticities are identified with within-sector and cross product–origin–destination–time tariff variation. The parameter θ^j captures the effect of tariffs on imports of products of sector j.[35]

Table C.1 shows our estimated trade elasticities by sector. These elasticities range from 1.36 (other non-metallic mineral products) to 8.98 (mining and energy products). After all sectors are pooled together, the estimated average trade elasticity is 6.09. Consistent with our intuition, sectors that are perceived as less substitutable across countries, for example, minerals and manufactured products, have lower trade elasticities than those that are perceived as more substitutable across countries, for example, energy and chemical products.

Figure C.3 shows that our estimated elasticities are correlated with the estimates of Caliendo and Parro (2015) and the values that we estimate using the Feenstra (1994) method.[36] On average, our estimates are lower than those found in Caliendo and Parro (2015) (in Figure C.3a more than half of the sectors are below the 45-degree line, and their

[35] Table A.6 displays the summary statistics for the variables included in this regression. Table A.7 displays the correspondence between the sectors considered in this paper, the sectors included in the OECD ICIO Database, and ISIC Rev. 4 sectors.

[36] The method relies on time series variation in prices and market shares of imported varieties of goods. The identifying assumption is that shocks to import demand and export supply are uncorrelated, which serves as the moment condition. The trade value and quantity data are from the BACI Database of CEPII (Gaulier and Zignago 2010), covering the time period 1995–2019.

average estimate across all sectors is 9.1).[37] Our estimates are higher than those that we estimate using the Feenstra (1994) method (in Figure C.3b, most sectors are above the 45-degree line).[38]

Table C.1: **Estimated Sectoral Trade Elasticities, θ^j**

Sector	Estimate	Standard Err	p-value	Sector	Estimate	Standard Err	p-value
Agriculture	5.18	1.17	0.000	Plastic	5.56	1.06	0.000
Fishing	6.96	1.34	0.000	Mineral	1.36	1.69	0.423
Mining energy	8.98	1.47	0.000	Basic metals	6.59	1.20	0.000
Mining non-energy	8.98	1.47	0.000	Fabricated metals	5.19	1.11	0.000
Mining support	8.98	1.47	0.000	Computer	4.97	1.11	0.000
Food	5.18	1.17	0.000	Electrical	5.44	1.29	0.000
Textiles	6.96	1.34	0.000	Machinery n.e.c.	5.22	1.05	0.000
Wood	6.01	1.48	0.000	Auto	5.98	1.46	0.000
Paper	4.44	1.71	0.010	Other transport	5.33	1.17	0.000
Petroleum	8.98	1.47	0.000	Manufacturing n.e.c.	4.55	1.09	0.000
Chemical	7.45	1.26	0.000	Service	4.17	1.27	0.001
Pharmaceuticals	5.80	1.27	0.000				
All	6.09	0.86	0.000	**Observations**			269,950

Description: This table presents the sector-level trade elasticities that we estimate using the difference-in-differences method based on Model C.1. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. The fixed effects are: product–time, product–exporter, product–importer, exporter–time, importer–time, number of AD committees, and after AD investigation. Standard errors are clustered at origin–destination–product level.

C.1.1. Robustness Tests

Alternative specifications. Our trade elasticity estimates remain robust under alternative empirical specifications. Table C.2 displays the average trade elasticity across sectors estimated with different methods. Column 1 presents the baseline estimate (which is also reported in Table C.1). Column 2 accounts for the exporter–importer–year fixed effect. Column 3 incorporates both the exporter–importer–year fixed effect and the product–exporter–importer fixed effect. Column 4 presents the results using the PPML estimation method. Finally, Column 5 shows the outcome when employing the inverse hyperbolic sine of the trade flow

[37] The reason why our estimates are lower than those recovered in Caliendo and Parro (2015) is likely the role of trade policy uncertainty. de Souza and Li (2022) show that our treatment and control groups faced similar trade policy uncertainty before a tariff was imposed. However, Caliendo and Parro (2015) do not control for trade policy uncertainty in their regressions. As trade policy uncertainty is likely positively correlated with tariffs (Handley and Limão 2017), this can exaggerate the estimates.

[38] Using the Feenstra (1994) method, the average elasticity across all sectors is 2.6. The reason why our estimates are higher than those estimated with the Feenstra (1994) method is likely that they rely on price changes rather than on the larger time variations in tariffs.

values as the dependent variable.

Figure C.1 presents the sectoral trade elasticities estimated with alternative empirical specifications. Corresponding to the columns in Table C.2, we re-estimate Model C.1 by incorporating origin–destination–year fixed effects, product–origin–destination fixed effects, and estimating the model using PPML as well as the inverse hyperbolic sine of the trade flow values as the dependent variable. Sectors with high trade elasticities in the baseline also exhibit high trade elasticities under alternative specifications.

Unique investigating country. Our estimates remain robust even when the sample is limited to AD investigations involving a unique investigating country. Figure C.2 displays the distribution of the number of countries investigating the same product from the same country within the same year. Approximately 80% of AD investigations are conducted by only one country. Table C.3 presents the average trade elasticity across sectors for the sample containing only investigations conducted by a unique country, considering different fixed effect combinations, PPML, and using the inverse hyperbolic sine of the trade flow as the dependent variable. The estimates continue to be robust.

Heterogeneity analysis. Readers may be interested in whether the impact of tariffs is influenced not only by sectors, but also by country characteristics and tariff attributes. We examine this heterogeneity from two perspectives: pre-investigation trade flows and tariff sizes.

Table C.4 shows that the effect of tariffs decreases with pre-investigation trade flow values. We interact the tariff with the log of the trade flow value from the investigated country to the investigating country for the investigated product 1, 5, and 10 years before the investigation. Columns 1 to 3 show that tariffs have a smaller effect (in terms of elasticity) if countries traded more, suggesting that stronger trade linkages are more resilient to tariff shocks. Columns 4 to 6 demonstrate that these effects are robust when using the PPML estimation strategy.

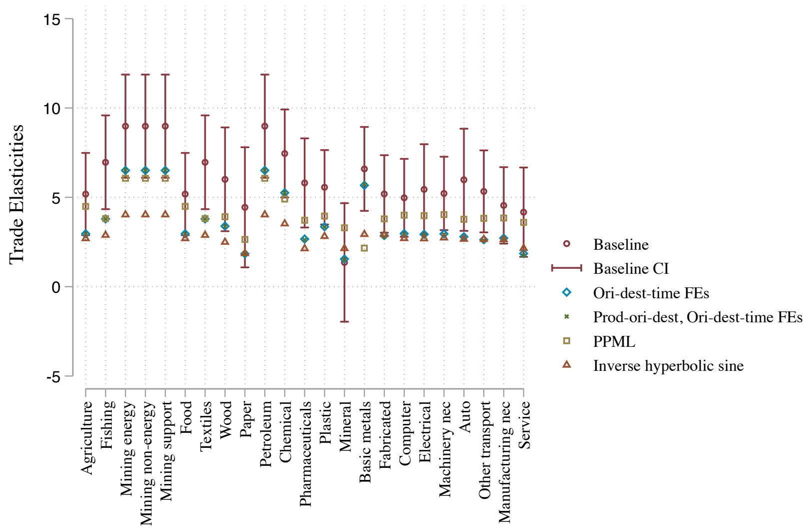
Additionally, Table C.5 indicates that the effect of tariffs is larger for larger tariffs. We interact the tariff with a dummy variable denoting whether the tariff is among the top 5%, top 10%, and top 25% of all AD tariffs in Columns 1, 2, and 3, respectively. The interaction term is significant, negative, and greater in magnitude if the tariff is in more top percentiles. Columns 4 to 6 report the estimates using the PPML strategy, and these patterns remain robust.

Table C.2: **Robustness Test: Alternative Specifications**

	(1) Log Value	(2) Log Value	(3) Log Value	(4) Value	(5) Arsinh(Value)
AD Tariff	-6.094***	-4.359***	-4.365***	-3.547***	-3.595***
	(0.862)	(0.903)	(0.900)	(0.426)	(0.408)
Observations	269950	268938	268938	236927	269950
R^2	0.834	0.865	0.866	NA	0.875
Product X Year FE	X	X	X	X	X
Product X Exporter FE	X	X		X	X
Product X Importer FE	X	X		X	X
Exporter X Year FE	X			X	X
Importer X Year FE	X			X	X
Exporter X Importer X Year FE		X	X		
Product X Exporter X Importer FE			X		
PPML				X	
Number of AD committees	X	X	X	X	X
After AD investigation	X	X	X	X	X

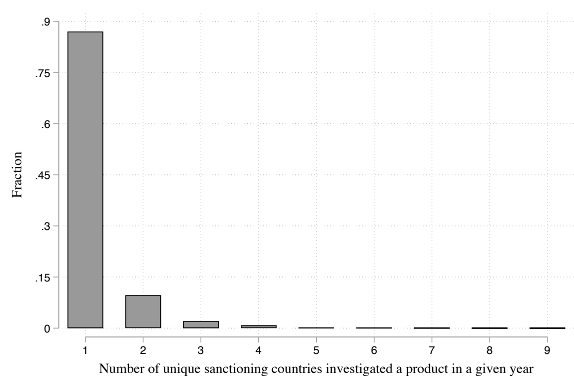
Description: This table presents the average trade elasticity across sectors estimated using the difference-in-differences method and different fixed effect combinations and estimation strategies. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. Standard errors are clustered at origin–destination–product level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Figure C.1: **Robustness Test: Sectoral Trade Elasticities Estimated with Different Specifications**



Description: This figure displays the sector-level trade elasticities estimated using Model C.1 and alternative empirical specifications. These specifications correspond to the different columns in Table C.2. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. Standard errors are clustered at origin–destination–product level.

Figure C.2: **Distribution of the Number of Countries that Investigate the Same Product from the Same Country in the Same Year**

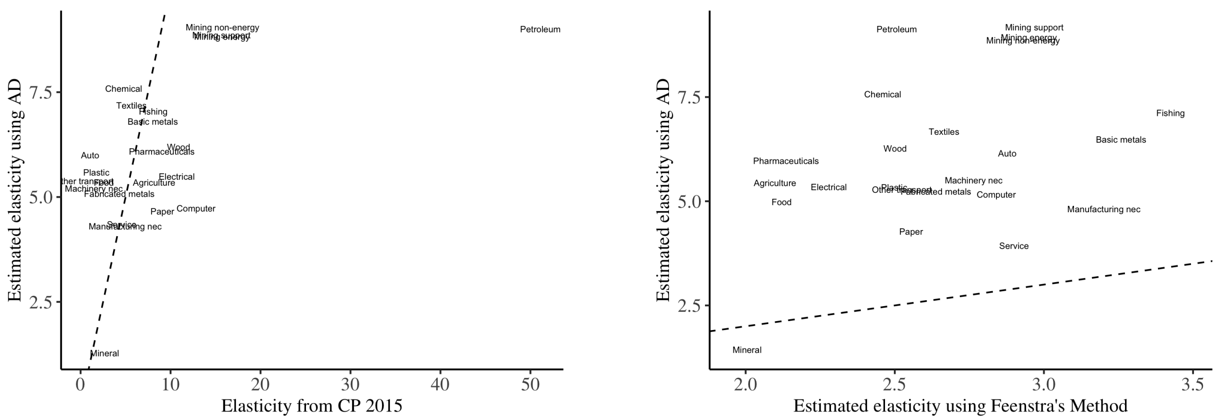


Description: This figure illustrates the distribution of the number of countries involved in an AD investigation. An investigation is characterized by a specific product from a certain country being examined in a year.

Figure C.3: **Correlation between Trade Elasticities Estimated with Difference-in-Differences and the Estimated Values (1) in Caliendo and Parro (2015) and (2) using the Feenstra (1994) Method**

(a) Correlation with Caliendo and Parro (2015) elasticities

(b) Correlation with the elasticities that we estimate with the Feenstra (1994) method



Description: This figure shows the sector-level trade elasticities that we estimate with the difference-in-differences method and those estimated in the literature. The left panel shows the correlation between our elasticities and those that Caliendo and Parro (2015) find. The right panel shows the correlation between our elasticities and those we estimate using the Feenstra (1994) method at the same level of sectors.

Table C.3: **Robustness Test: Unique Investigating Country**

	(1) Log Value	(2) Log Value	(3) Log Value	(4) Value	(5) Arsinh(Value)
AD Tariff	-4.633***	-2.539*	-2.541*	-3.885***	-2.691***
	(1.221)	(1.347)	(1.327)	(0.479)	(0.563)
Observations	126287	124668	124644	110378	126287
R^2	0.859	0.888	0.888	NA	0.899
Product X Year FE	X	X	X	X	X
Product X Exporter FE	X	X		X	X
Product X Importer FE	X	X		X	X
Exporter X Year FE	X			X	X
Importer X Year FE	X			X	X
Exporter X Importer X Year FE		X	X		
Product X Exporter X Importer FE			X		
PPML				X	
Number of AD committees	X	X	X	X	X
After AD investigation	X	X	X	X	X

Description: This table presents the average trade elasticity across sectors, estimated using the difference-in-differences method and different estimation strategies. The sample is composed of the investigations that involve a unique investigating country. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. Standard errors are clustered at origin–destination–product level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table C.4: **Heterogeneity Analysis: Pre-investigation Trade Flows**

	(1) Log Value	(2) Log Value	(3) Log Value	(4) Value	(5) Value	(6) Value
AD Tariff	-13.06***	-11.81***	-7.900***	-7.615***	-6.688***	-3.761***
	(1.841)	(2.152)	(2.655)	(0.991)	(0.879)	(1.178)
AD Tariff x Log Value 1-yr before Investigation	0.939***			0.392***		
	(0.184)			(0.107)		
AD Tariff x Log Value 5-yr before Investigation		0.757***			0.294***	
		(0.221)			(0.102)	
AD Tariff x Log Value 10-yr before Investigation			0.550**			0.143
			(0.264)			(0.124)
Observations	218420	158629	86769	213092	154172	83935
R^2	0.776	0.803	0.854	NA	NA	NA
Product X Year FE	X	X	X	X	X	X
Product X Exporter FE	X	X	X	X	X	X
Product X Importer FE	X	X	X	X	X	X
Exporter X Year FE	X	X	X	X	X	X
Importer X Year FE	X	X	X	X	X	X
PPML				X	X	X
Number of AD committees	X	X	X	X	X	X
After AD investigation	X	X	X	X	X	X

Description: This table presents how the impact of AD tariffs depends on pre-investigation trade flow values, estimated with the difference-in-differences method. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. Standard errors are clustered at origin–destination–product level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table C.5: **Heterogeneity Analysis: Large Tariffs**

	(1) Log Value	(2) Log Value	(3) Log Value	(4) Value	(5) Value	(6) Value
AD Tariff	-5.518***	-5.390***	-5.116***	-4.034***	-4.175***	-4.225***
	(1.025)	(1.040)	(1.081)	(0.496)	(0.514)	(0.553)
AD Tariff X Top 5%	-8.282***			-2.232***		
	(1.833)			(0.719)		
AD Tariff X Top 10%		-5.097***			-0.271	
		(1.407)			(0.558)	
AD Tariff X Top 25%			-3.331***			0.0490
			(1.249)			(0.474)
Observations	208059	208059	208059	180651	180651	180651
R^2	0.832	0.832	0.832	NA	NA	NA
Product X Year FE	X	X	X	X	X	X
Product X Exporter FE	X	X	X	X	X	X
Product X Importer FE	X	X	X	X	X	X
Exporter X Year FE	X	X	X	X	X	X
Importer X Year FE	X	X	X	X	X	X
PPML				X	X	X
Number of AD committees	X	X	X	X	X	X
After AD investigation	X	X	X	X	X	X

Description: This table presents how the impact of AD tariffs depends on the tariffs' magnitudes, estimated with the difference-in-differences method. The import data are from the United Nations Comtrade Database, acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data are from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020. Standard errors are clustered at origin–destination–product level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

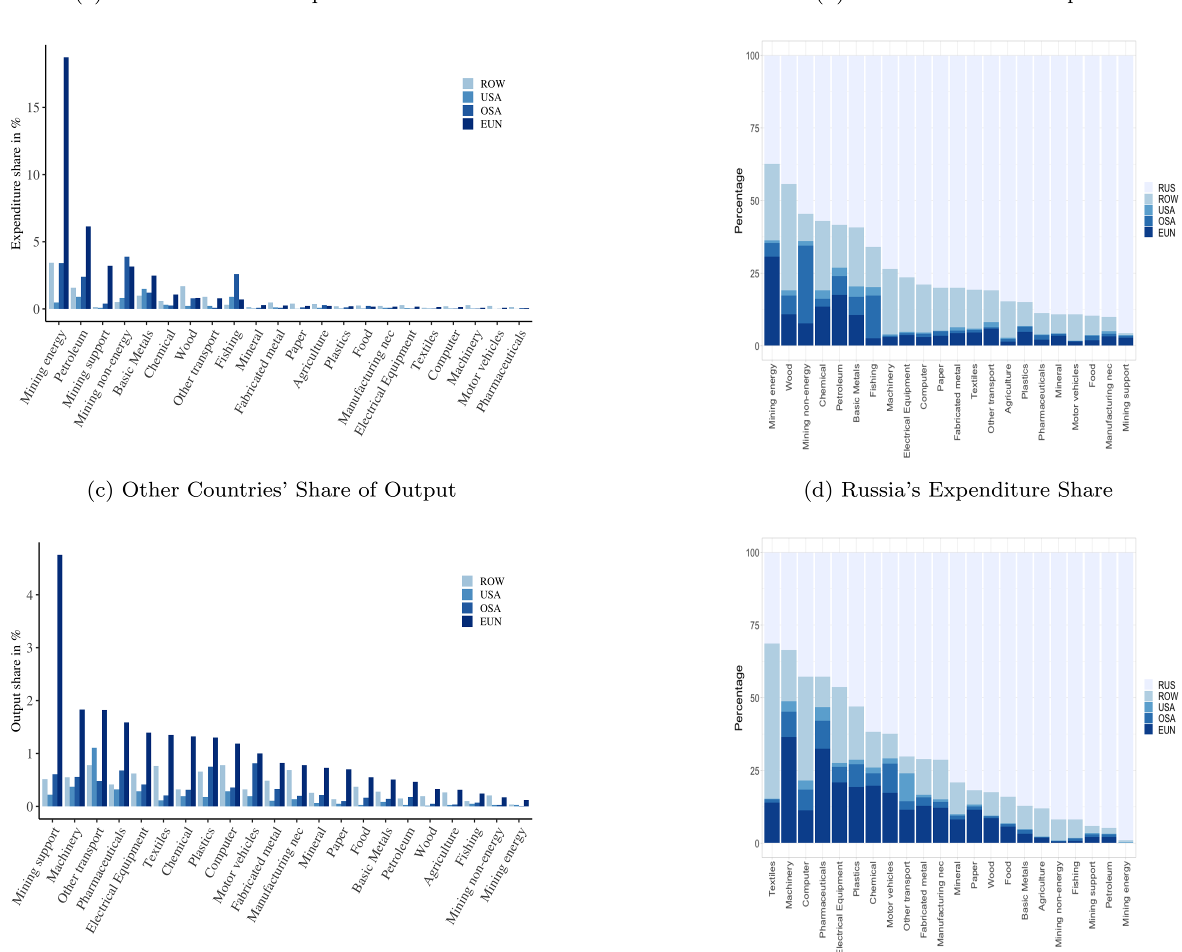
C.2. Sectoral Trade Statistics with Russia

In Figure C.4, we highlight two findings from analyzing the sanctioning countries' trade statistics with Russia. First, Russia's exports of mining and energy products to the EU are important for both the EU's consumption and Russia's production. Mining and energy sector products from Russia account for about 20% of the EU's total expenditure on these products (Figure C.4a), and exports of these products to the EU account for more than a quarter of Russia's total output (Figure C.4b). This suggests that among all sanctioning countries, the EU plays a pivotal role.[39] If the EU sanctions mining and energy products from Russia, it may cause significant economic losses in Russia, but it may also hurt the EU's welfare.

Second, the sanctioning countries are a major importing origin for Russia. However, Russia is not a major exporting destination for the sanctioning countries. Figure C.4d shows that when it comes to imports from sanctioning countries, Russia allocates approximately 50% of its total expenditure on machinery and pharmaceutical products, and over a quarter of its spending on electrical equipment and chemicals. However, the share of exports to Russia in the sanctioning countries' sectoral output never exceeds 5% (Figure C.4c). This suggests that tariff retaliation by Russia may not cause substantial harm to the income of sanctioning countries. Rather, it can significantly reduce Russia's welfare. If Russia cares about its own welfare, it is optimal to not impose high retaliatory tariffs.

[39] The EU accounts for 36% of Russia's total exports (5% of Russia's total output) and 39% of Russia's total imports (4% of Russia's total expenditure). The US accounts for 4% of Russia's total exports (1% of Russia's total output) and 5% of Russia's total imports (0.5% of Russia's total expenditure). Other sanctioning countries account for 12% of Russia's total exports (2% of Russia's total output) and 11% of Russia's total imports (1% of Russia's total expenditure).

Figure C.4: **Trade Statistics with Russia by Sector**



(a) Other Countries' Expenditure Share

(b) Russia's Share of Output

(c) Other Countries' Share of Output

(d) Russia's Expenditure Share

Description: This figure shows, by country and sector, the trade statistics with Russia. Figure C.4a shows Russia's share of total expenditure on the sector's products. Figure C.4b shows the share of output sold to each country in Russia's sectoral total output. Figure C.4c shows the share of output sold to Russia in other countries' sectoral total output. Figure C.4d show other countries' shares in Russia's total expenditure on the sector's product.

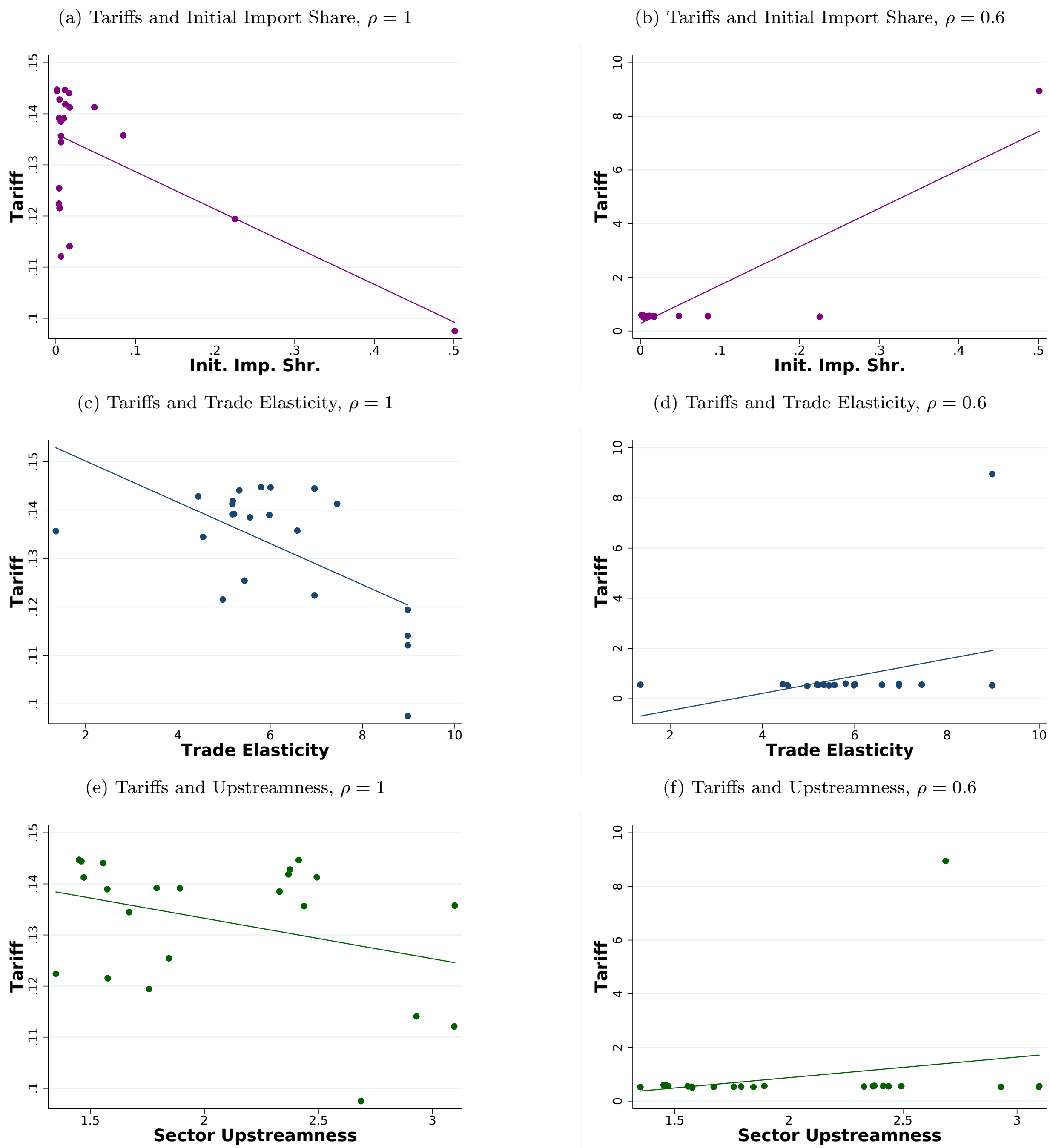
C.3. Cost-Efficient Sanctions and Fundamentals

To study the relationship between optimal sectoral tariffs imposed on Russia and sectoral characteristics, we use the following regression:

$$\tau_{s,\rho} = \beta_{imp,\rho} ImpShr_s + \beta_{\sigma,\rho}\sigma_s + \beta_{ups,\rho} upstreamness_s + \epsilon_{s,\rho}, \tag{C.2}$$

where $\tau_{s,\rho}$ is the optimal tariff imposed by the EU on sector s imports from Russia when the EU's willingness to pay is governed by ρ. σ_s is the trade elasticity of sector s. $upstreamness_s$ measures sector s's upstreamness (Antràs et al. 2012) – the average number of sectors through

Figure C.5: **Correlations between Sectoral Cost-Efficient Sanction Tariffs and Fundamentals: Sectoral Import Shares from Russia, Trade Elasticities, and Sector Upstreamness**



(a) Tariffs and Initial Import Share, $\rho = 1$

(b) Tariffs and Initial Import Share, $\rho = 0.6$

(c) Tariffs and Trade Elasticity, $\rho = 1$

(d) Tariffs and Trade Elasticity, $\rho = 0.6$

(e) Tariffs and Upstreamness, $\rho = 1$

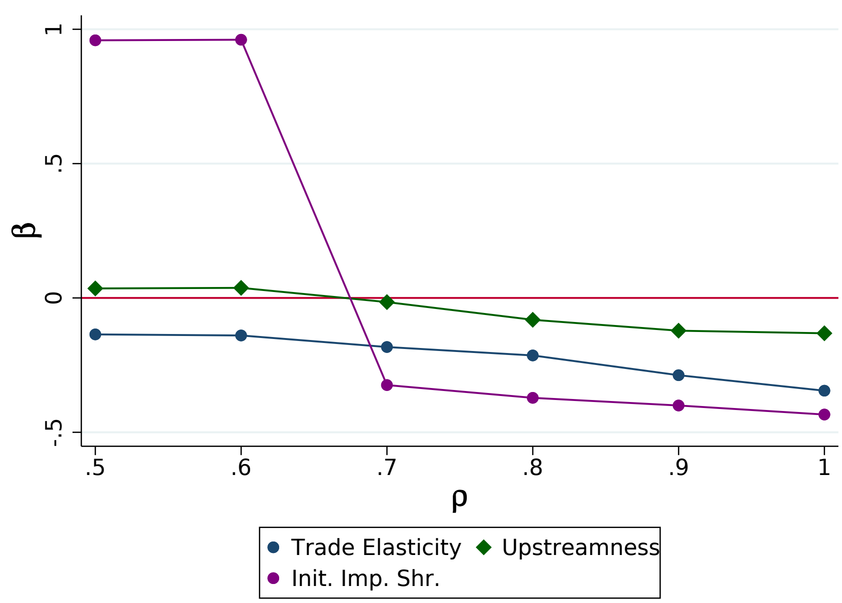
(f) Tariffs and Upstreamness, $\rho = 0.6$

Description: This figure shows the correlations between the optimal sectoral tariffs imposed on Russia by the EU and different sector-level fundamentals under $\rho = 0$ and $\rho = 0.6$.

which US\$1 of sector s output goes until it reaches the final consumer. $ImpShr_s$ is the share of imports from Russia in total sector s's imports by the EU in the baseline economy. To make each variable comparable, they are normalized to have a mean of 0 and a variance of 1.

In Figure C.5, we plot the raw correlations between optimal sectoral tariffs by the EU and individual sector characteristics for $\rho = 1$ and $\rho = 0.6$. In Figure C.6, we plot how the partial correlations change with ρ. For low willingness to pay for sanctions, i.e., when ρ is large, higher tariffs should be set on sectors that have small import shares, have lower trade elasticities, and are more downstream. For example, when $\rho = 1$, a sector whose import share is 1 standard deviation lower should be targeted by a tariff that is 0.5 standard deviation higher. Similarly, a sector whose trade elasticity is 1 standard deviation higher should face a tariff that is 0.4 standard deviation lower. These relationships change when ρ falls below 0.7, i.e., when the EU places greater weight on punishing Russia. When there is higher willingness to pay, sectors with larger import shares and higher trade elasticities are targeted with higher tariffs.

Figure C.6: **Correlations between Tariffs with Different Fundamentals for Different ρs**



Description: This figure shows the partial correlations between the optimal sectoral tariffs imposed on Russia by the EU and different sector-level fundamentals under different ρs (estimated with Equation C.2).

C.4. Extensions

C.4.1. Effect of Sanctions on Non-Sanctioning Countries

Figure C.7a shows that the ROW boosts its exports in reaction to sanctions placed on Russia. As sanctioning countries raise tariffs against Russia, sanctioning countries substitute imports from Russia with those from the ROW. This pattern, referred to as the trade diversion effect, leads to an increase in ROW exports to the sanctioning countries and overall.[40]

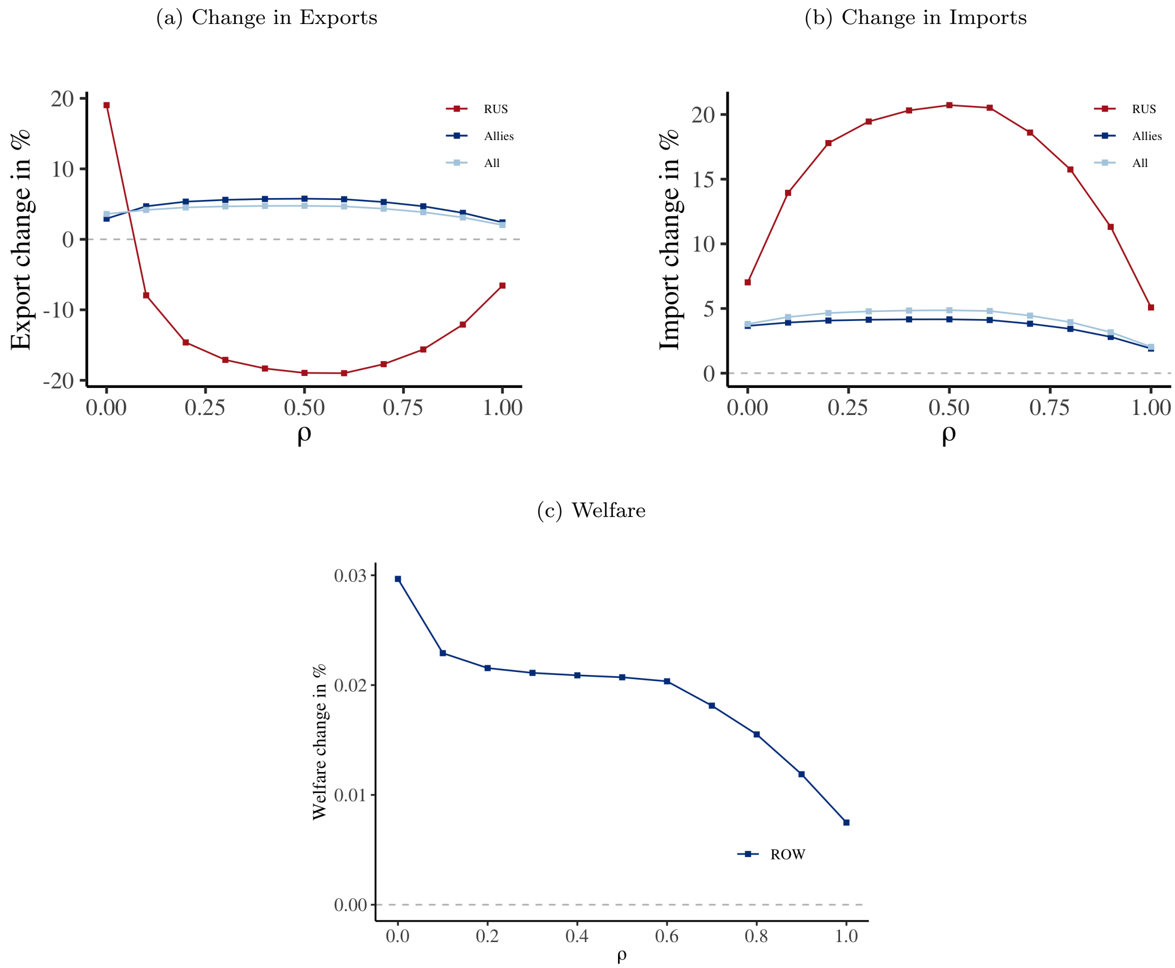
The relationship between ROW's exports to Russia and the willingness to pay for sanctions is non-monotonic, influenced by two key forces: the income effect and the trade diversion effect. Russia experiences a significant income loss even at low levels of willingness to pay for sanctions, causing its imports from the ROW to initially decrease. The trade diversion effect, which occurs when Russia imposes high tariffs against sanctioning countries, reduces imports from them, and increases imports from the ROW, only becomes dominant when $\rho = 0$ and Russia closes its border to trade with allied nations.

Figure C.7b shows that sanctions against Russia increase imports by the ROW. As the sanctioning allies and Russia impose tariffs on each other, the prices of exported goods in both countries decrease, which motivates the ROW to import more of those goods. However, this effect is not monotonic. High willingness to pay for sanctions causes tariffs to raise the marginal cost of production in Russia, leading to a lower level of imports by the ROW from Russia when trade sanctions are intensified.

Trade sanctions increase welfare for the ROW, as shown in Figure C.7c. The ROW benefits from the sanctions because it positively impacts their terms of trade. The trade diversion effect results in an increase in the price of exported goods, while the price of imported goods decreases. This leads to an overall increase in welfare for the ROW.

[40] As Russia's demand for ROW's exports peaks at the highest willingness to pay for sanctions, ROW's exports initially destined for the sanctioning countries are redirected to Russia. Consequently, when the willingness to pay for sanctions is high, the increase in ROW's exports to the sanctioning countries is not as substantial.

Figure C.7: **Effect of Cost-Efficient Sanctions in the ROW**



Description: This figure shows the statistics for the ROW under cost-efficient sanctions against Russia that vary by the level of willingness to pay for sanctions. We assume that the ROW keeps all its tariffs constant. Figure C.7a plots the percentage change in exports from the ROW to the sanctioning countries, to Russia, and in total. Figure C.7b plots the percentage change in imports by the ROW from the sanctioning countries, from Russia, and in total. Figure C.7c plots the percentage change in welfare in the ROW.

C.4.2. A Larger Coalition

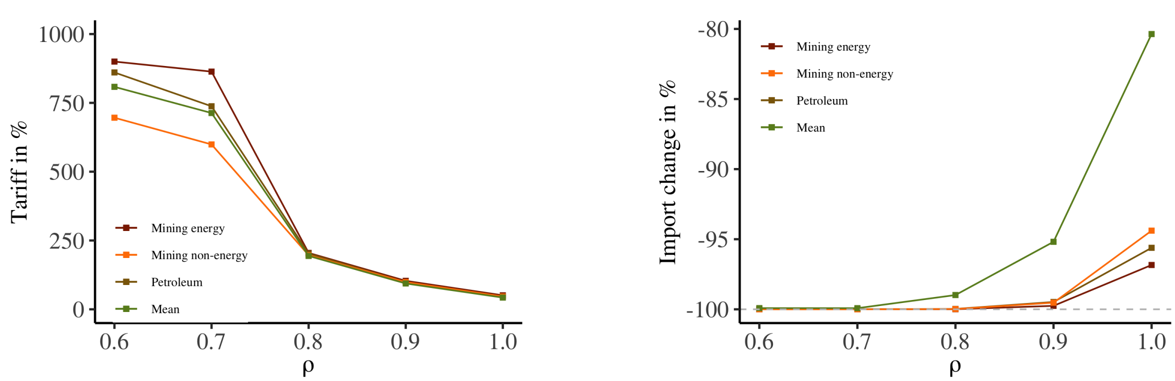
What would happen to the cost-efficient sanctions if a larger coalition of countries joined the current group of sanctioning countries? To answer this question, in this section, we calculate the cost-efficient sanctions when the ROW joins the sanctioning allies. Our findings reveal that if the ROW were to join the sanctions, the EU and other sanctioning allies could impose an embargo on Russia even with low willingness to pay for sanctions. Additionally, the welfare effects of these sanctions on Russia would increase significantly.

If the ROW joined the sanctioning allies, the EU could impose even higher tariffs on

Russia for any willingness to pay for sanctions, as shown in Figure C.8. When Russia still has the ROW to trade with, the impact of each individual sanctioning country on Russia's welfare is limited because Russia can redirect its trade to other countries that have not imposed sanctions. This reduces the benefits of imposing higher sanctions on Russia. However, if other countries are already imposing high tariffs on Russia, each individual country that joins the sanctions will have a significant impact on Russia's remaining trade. This increases the potential benefits of imposing sanctions on Russia and leads to an overall increase in the level of sanctions.

Figure C.8: **Cost-Efficient Sanctions if the ROW Joins the Sanctioning Allies for Different Levels of Willingness to Pay in the EU,** $\rho \in [0.6, 1.0]$

(a) Tariff (b) Change in Imports

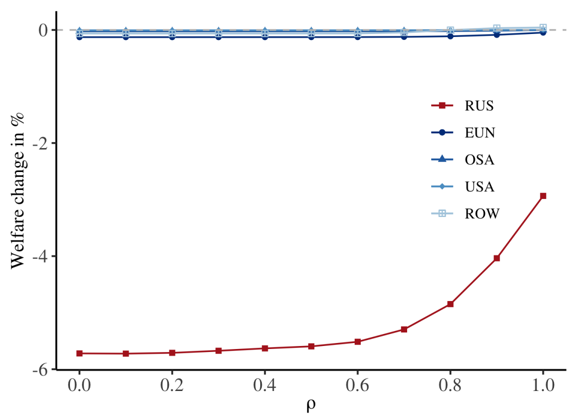


Description: This figure shows the statistics for the EU under cost-efficient sanctions against Russia that vary by the level of willingness to pay for sanctions. We assume that all countries join the sanctions against Russia and that Russia retaliates according to the same willingness to pay for sanctions. ρ ranges from 0.6 to 1.0. Figure C.8a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors by different levels of willingness to pay for sanctions, ρ. Figure C.8b plots the percentage change in imports in the EU for different sectors by different levels of willingness to pay for sanctions.

According to Figure C.9, sanctions would have a much greater impact on the Russian economy if the ROW joined the sanctioning allies. The welfare cost of sanctions for Russia would go from 2% up to 6%, depending on the willingness to pay for sanctions. Two forces cause the increase in the welfare effect of sanctions. First, when all countries impose sanctions against Russia, all of Russia's exports are disrupted. Second, because Russia also retaliates against all countries in the world, Russian imports are also substantially more affected. Together, these two forces dramatically amplify the impact of sanctions against Russia.

Figure C.9 also shows that if countries were allowed to set their tariffs on Russia to maximize their own welfare, Russian welfare would decrease by 2.5%. This is because countries would manipulate the terms of trade jointly, leading to a significant drop in the price of Russia's exported goods. This demonstrates that, to some extent, countries can increase their own welfare while reducing Russia's welfare. Therefore, policies that permit countries to impose arbitrary tariffs on Russia, such as revoking Russia's MFN status, can have significant welfare implications for Russia.

Figure C.9: **Welfare Changes if the ROW Joins the Sanctioning Allies with Russian Retaliation**



Description: This figure shows the welfare change in different countries for different levels of willingness to pay for sanctions, ρ. In this specification, the ROW joins the sanctioning countries in imposing sanctions against Russia, and Russia, the sanctioning countries, and the ROW have the same willingness to pay for sanctions. Welfare refers to the equilibrium real income. Changes are calculated comparing the equilibrium to current tariffs.

C.4.3. Political Weights

In this section, we calculate cost-efficient sanctions if the sanctioning countries target politically relevant sectors instead of the Russian economy as a whole. We show that an embargo on the Russian mining and energy sectors is optimal, even when there is a low willingness to pay for sanctions.

Government's Problem. We assume now that the sanctioning countries want to target particular sectors in Russia according to their political relevance. Let $G_R^{pol}(\tau)$ be the politically weighted welfare in Russia and τ the vector of tariffs imposed by all countries. Formally, the politically weighted welfare is given by

$$G_R^{pol}(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}) = \sum_{j=1}^{J} \lambda_R^j \frac{I_R^j(\tau_{\mathbf{nR}}, \tau_{-\mathbf{nR}})}{P_R^C(\tau_{\mathbf{nR}}, \tau_{-\mathbf{nR}})}, \tag{C.3}$$

where λ_R^j is the political weight of sector j in Russia and $\frac{I_R^j(\tau_{\mathbf{nR}},\tau_{-\mathbf{nR}})}{P_R^C(\tau_{\mathbf{nR}},\tau_{-\mathbf{nR}})}$ is real income in sector j.[41]

The best response of sanctioning country n can now be formulated as the following:

$$g_n^{pol}(\boldsymbol{\tau_{-nR}}) \in argmax_{\{\boldsymbol{\tau_{nR}}\}} \rho G_n(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}) - (1-\rho) G_R^{pol}(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}), \tag{C.4}$$
$$\text{s.t. Equilibrium Conditions B.1-B.8,}$$

where ρ is the willingness to pay for sanctions targeting politically relevant sectors.

Calibration. We calibrate political weights to reflect the revenue share of companies owned by individuals sanctioned by the EU, UK, or US. First, we collect the names of the Russian individuals who had been sanctioned by the EU, UK, and US by March 10, 2022.[42]. Those are part of the Russian political elites, called oligarchs, which are believed to support the current regime. From the same source, we also acquire the names of the companies that they own. Second, we collect the names, sales, and industries of the top 100 Russian companies by revenue from RBC 500, a website that publishes ratings for Russian companies, and match them to the list of sanctioned people.[43] Third, we connect the industry names used in RBC

[41] Real income in sector j is measured with $\frac{L_R^j(\boldsymbol{\tau_{nR}},\boldsymbol{\tau_{-nR}})}{L_R}\frac{I_R(\tau_{\mathbf{nR}},\tau_{-\mathbf{nR}})}{P_R^C(\tau_{\mathbf{nR}},\tau_{-\mathbf{nR}})}$, where $\frac{L_R^j(\boldsymbol{\tau_{nR}},\boldsymbol{\tau_{-nR}})}{L_R}$ is Russia's employment share in sector j, and $\frac{I_R(\tau_{\mathbf{nR}},\tau_{-\mathbf{nR}})}{P_R^C(\tau_{\mathbf{nR}},\tau_{-\mathbf{nR}})}$ is real income. In this model, sector j's employment share is also the sector's share in Russian GDP. In Section C.4.4, we rewrite this optimal sanction problem in changes.

[42] The source is an article by the Guardian: `https://www.theguardian.com/world/2022/mar/04/russia-oligarchs-business-figures-west-sanction-lists-us-eu-uk-ukraine`

[43] The RBC 500 rating has been published since 2015. The rating identifies the largest Russian companies in terms of net revenue. The rating involves companies owned by Russian individuals and legal entities, regardless of their registration in Russia or abroad. The main source of the financial indicator comes from consolidated financial statements. In the case of no available consolidated financial statements, indicators are estimated.

500 to OECD ICIO sectors. In the last step, we calculate, for each OECD ICIO sector, the share of sales by major Russian companies owned by oligarchs in the sector's total sales (output). We use these shares as our political weights, λ_R^j.

Table C.6: **Summary Statistics for Political Weights**

Sector	**# Firms owned by Oligarchs**	**Oligarch Share (λ_R^j)**
Agriculture	2	4.89%
Mining energy	11	47.56%
Mining non-energy	6	57.57%
Petroleum	7	57.84%
Chemical	5	41.47%
Basic metals	7	12.79%
Machinery n.e.c.	1	14.31%
Manufacturing n.e.c.	1	9.75%
Service	32	8.82%

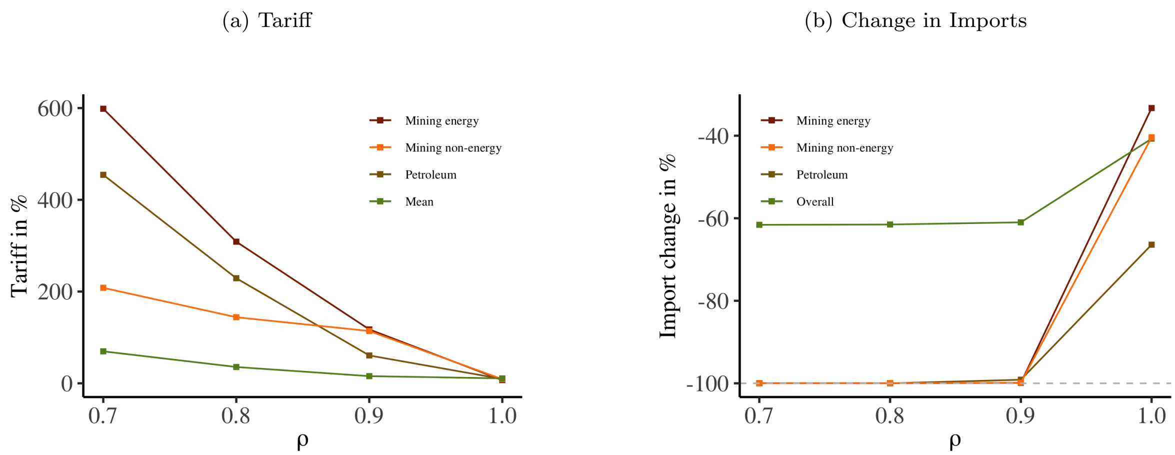
Description: This table presents the summary statistics for the political weights. The table shows, in each sector, the number of top 500 Russian firms owned by Russian oligarchs and the revenue share generated by these firms. We omit the sectors without major oligarch-owned firms.

Table C.6 shows the summary statistics of political weights computed using the Russian oligarchs' share of revenue in each sector. Nine out of 23 sectors have oligarch-owned firms, of which the petroleum sector has the highest political weight at 57.84%, indicating that over half of the revenue in this sector is generated by firms associated with oligarchs.

Results. The results presented in Figure C.10 indicate that targeting politically connected sectors, such as the Russian mining and energy industries, with an embargo is the most cost-efficient sanction strategy, even for countries exhibiting a low willingness to pay for sanctions. If the EU is willing to pay at least US$0.10 for each US$1 drop in Russian income, i.e., $\rho = 0.9$, tariffs should be concentrated in the mining and energy sectors. This is because these are the sectors with the highest shares of firms associated with Russian oligarchs. Moreover, such tariffs would be high enough to decrease imports of mining and energy products from Russia by almost 100%.

Figures C.33 and C.34 show the optimal sanction tariffs and resulting import changes by the US and OSA. Similar to the EU, for a low willingness to pay for sanctions, i.e.,

Figure C.10: **Cost-Efficient Sanctions with Political Weights for Different Levels of Willingness to Pay in the EU,** $\rho \in [0.7, 1.0]$



Description: This figure shows the statistics for the EU under cost-efficient sanctions with different levels of willingness to pay when the EU uses the political weights described in Table C.6. Figure 3a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure 3b plots the percentage change in imports in the EU for the different sectors.

US\$0.10 to reduce Russian real income by US\$1, an embargo on mining and energy sector imports from Russia would be optimal. This suggests that if sanctioning countries would like to target Russian oligarchs, a global embargo on Russia's mining and energy products is optimal.[44]

C.4.4. Equilibrium in Changes with Political Weights

Here, we rewrite the sanctioning countries' problem in changes if they target the politically relevant sectors in Russia. The change in Russia's politically weighted welfare is equal to the following:

$$\hat{G}_R^{pol}(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}) = \sum_{j=1}^{J} \frac{\lambda_R^j L_R^j}{\sum_{s=1}^{S} \lambda_R^s L_R^s} \hat{L}_R^s(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}) \frac{\hat{I}_R(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})}{\hat{P}_R^C(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})}, \tag{C.5}$$

[44]Interestingly, Figures C.33 and C.34 also show that if the US and OSA only target politically relevant sectors in Russia, total imports will increase. The reason is that they have incentives to lower tariffs on the products from Russia that are not politically relevant, such that Russian employment and output can be reallocated from the politically relevant sectors to these other sectors. As the mining and energy sectors do not account for a major share of these countries' imports from Russia, a combination of high tariffs on mining and energy sectors and low tariffs on other sectors can lead to an increase in total imports.

where $\frac{\lambda_R^j L_R^j}{\sum_{s=1}^S \lambda_R^s L_R^s}$ denotes the politically weighted initial employment share of sector j in Russia. The politically weighted welfare increases if the whole economy's real income, $\frac{\hat{I}_R(\hat{\mathbf{t}}_{\mathbf{nR}},\hat{\mathbf{t}}_{-\mathbf{nR}})}{\hat{P}_R^C(\hat{\mathbf{t}}_{\mathbf{nR}},\hat{\mathbf{t}}_{-\mathbf{nR}})}$, increases and if employment/value added increases more in the sectors that have higher political weights. As a result, if other countries would like to target the politically related sectors, on top of reducing the whole economy's real income, they can also set tariffs to reduce employment/value added in the politically related sectors.

Similar to Problem B.16, the objective of sanctioning country n is to both maximize its own welfare and minimize Russia's real income in the politically connected sectors:

$$g_n^{pol}(\hat{\mathbf{t}}_{-\mathbf{nR}}) \in argmax_{\{\hat{\mathbf{t}}_{\mathbf{nR}}\}} \rho G_n \hat{G}_n(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}) - (1-\rho) G_R^{pol} \hat{G}_R^{pol}(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}), \tag{C.6}$$
$$\text{s.t. Equilibrium Conditions B.9-B.14,}$$

where $G_R^{pol} = \sum_{j=1}^J \lambda^j \frac{L_R^j}{L_R} G_R$ represents Russia's politically weighted real income in the initial equilibrium. We calibrate λ^j to Russia's political weights, $\frac{L_R^j}{L_R}$ to Russia's sectoral employment shares, and G_R to Russia's GNI.

Just as for Problem B.17, we assume that Russia retaliates by maximizing the weighted average of its own welfare and negative impact on the sanctioning countries' welfare.

C.5. Robustness

C.5.1. Short- and Long-Run Trade Elasticity

In this section, we show that our results are robust to calibrating the model to the long-run trade elasticities.

Calibration. We modify Equation C.1 to allow for different trade elasticities in the short and long run and by sector. Specifically, we estimate the equation:

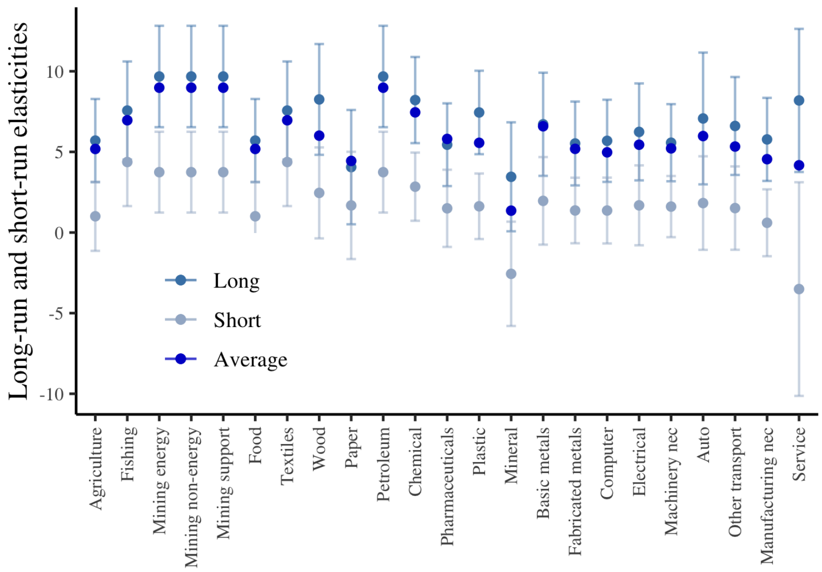
$$\begin{aligned}\log(y_{p,d,o,t}) = \sum_{j=1}^{J} \big[&\theta^j_{\text{Before}} \mathbf{1}(p \in j) \tau_{p,d,o} \mathbb{I}_{p,d,o,t} \{u \text{ Yrs. to AD}, u < 0\} \\ &+ \theta^j_{\text{Short Run}} \mathbf{1}(p \in j) \tau_{p,d,o} \mathbb{I}_{p,d,o,t} \{u \text{ Yrs. to AD}, 0 \leq u \leq 2\} \\ &+ \theta^j_{\text{Long Run}} \mathbf{1}(p \in j) \tau_{p,d,o} \mathbb{I}_{p,d,o,t} \{u \text{ Yrs. to AD}, u > 2\}\big] \\ &+ \gamma \mathbb{N}_{p,d,o,t} \{\text{Committee}\} + \eta_{p,t} + \eta_{p,d} + \eta_{p,o} + \eta_{d,t} + \eta_{o,t} + \epsilon_{p,d,o,t}.\end{aligned}$$

As in Equation (C.1), we utilize within-sector, cross product–country–pair–time tariff variations to identify sectoral trade elasticities in the short and long run (by comparing affirmative and negative investigations). p denotes an investigated product, d denotes a destination, o denotes an origin, and t denotes a year. $y_{p,d,o,t}$ denotes the imports of product p from country o to country d in year t. $\tau_{p,d,o}$ denotes the first AD tariff that d imposes on product p from country o. On the right hand side, j represents a sector, and $\mathbf{1}(p \in j)$ is activated if product p belongs to sector j. $\mathbb{N}_{p,d,o,t} \{\text{Committee}\}$ controls for the number of investigation committees formed at the same product–country–bilateral–year level. $\eta_{p,t}$, $\eta_{p,d}$, $\eta_{p,o}$, $\eta_{d,t}$, and $\eta_{o,t}$ denote product–year, product–destination, product–origin, destination–year, and origin–year fixed effects, respectively.

We interact the AD tariffs with time dummies indicating whether year t is before, in the short run after, or in the long run after the AD investigation. $\mathbb{I}_{p,d,o,t} \{u \text{ Yrs. to AD}, u < 0\}$ is a dummy variable that is turned on if time t is before the first AD investigation on product p from country o by country d. $\mathbb{I}_{p,d,o,t} \{u \text{ Yrs. to AD}, 0 \leq u \leq 2\}$ takes the value of 1 up to 2 years after the first AD investigation on product p from country o by country d. $\mathbb{I}_{p,d,o,t} \{u \text{ Yrs. to AD}, u > 2\}$ takes the value of 1 three years after the AD tariff is imposed. The parameters of interest are $\theta^j_{\text{Short Run}}$, which captures the short-term effect of tariffs after they are imposed, and $\theta^j_{\text{Long Run}}$, which captures the long-term effect of tariffs.

Figure C.11 shows the estimates of the short- and long-run trade elasticities, along with the sectoral trade elasticities in an average year after imposition that we estimated in Section C.1. As anticipated, the short-run trade elasticity is smaller than the long-run trade elasticity. In general, the average trade elasticity we estimated in Section C.1 is close to the long-run trade elasticity.

Figure C.11: **Estimates of the Long- and Short-Run Trade Elasticities**



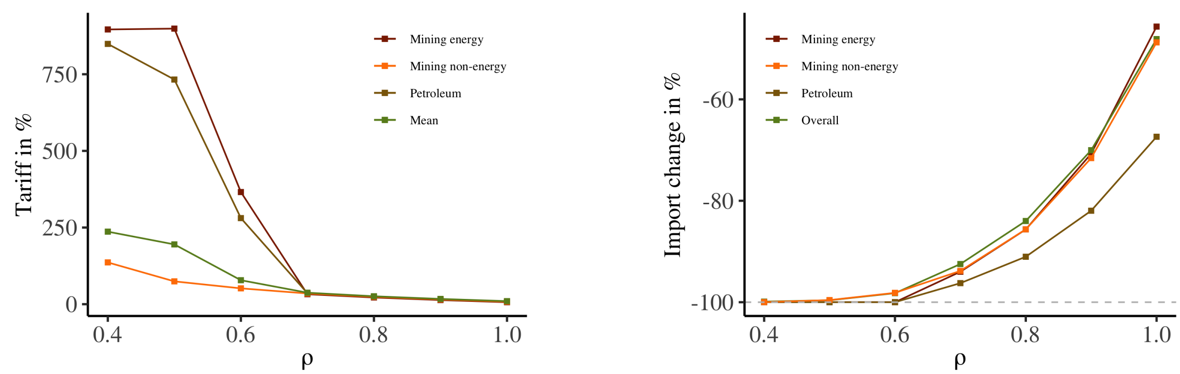
Description: This figure shows sectoral trade elasticities in the short run (from year 0 to year 2), in the long run (from year 3 to year 5), and the average.

Results. Using long-run trade elasticities, an embargo on the Russian mining and energy sectors is still the cost-efficient policy when there is high enough willingness to pay for sanctions, according to the results shown in Figure C.12. Overall, the cost-efficient sanctions are similar to the baseline results.[45]

[45]Figure C.37 displays the cost-efficient tariffs using short-run trade elasticities.

Figure C.12: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the EU, $\rho \in [0.4, 1.0]$ and Long-Run Elasticities**

(a) Tariff (b) Change in Imports



Description: This figure shows the statistics for the EU under cost-efficient sanctions with different levels of willingness to pay with long-run elasticities, as described in Section C.11. Figure C.12a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.12b plots the percentage change in imports in the EU for different sectors.

C.5.2. Caliendo and Parro (2015) Trade Elasticities

We show that the cost-efficient sanctions are robust if we replace the sectoral trade elasticities that we estimated using the difference-in-differences strategy with the estimates of Caliendo and Parro (2015). This is because, as we show in Figure C.3a, these two sets of elasticities are positively correlated.[46]

Figures C.13 to C.14 show the sanctioning countries' optimal strategies under these elasticities. If they would like to pay US$0.10 for a US$1 decline in Russia's welfare, the optimal tariffs should equal, on average, about 15%. Compared to the our estimated trade elasticities, lower willingness to pay for sanctions can justify a mining and energy sector embargo under Caliendo and Parro (2015) trade elasticities. A petroleum sector embargo by the EU is optimal if the willingness to pay is as low as US$0.10 to reduce Russian real income by US$1. If the EU's willingness to pay rises to US$0.70, an embargo on all mining and energy sectors is optimal. As Figure C.3a shows, Caliendo and Parro (2015) trade elasticities are higher than ours on average, and especially so for the energy sectors. Given the willingness

[46] The correlation is 0.57.

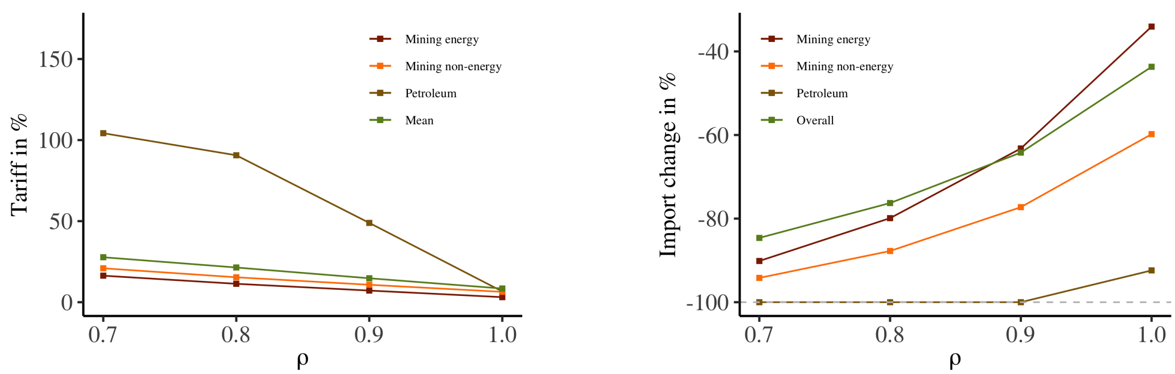
to pay for sanctions, higher trade elasticities provide the sanctioning countries with incentive to impose higher tariffs because they can divert more exports away from Russia and harm its income more.

Similar to Figure 3, if the sanctioning countries are willing to pay US$1.50 for a US$1 reduction in Russia's welfare, an embargo on Russian imports in all sectors is optimal.

Figure C.13: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the EU, $\rho \in [0.7, 1]$ and Caliendo and Parro (2015) Trade Elasticities**

(a) Tariff

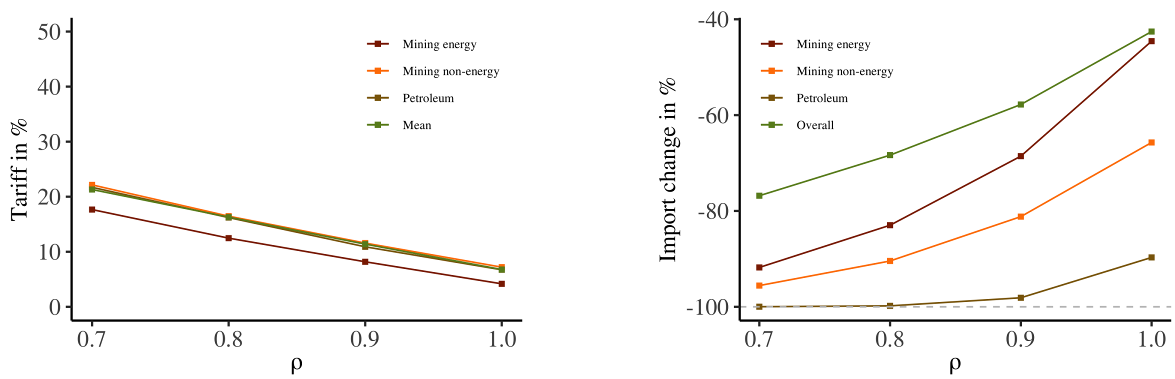
(b) Change in Imports



Description: This figure shows the statistics for the EU under cost-efficient sanctions with different levels of willingness to pay. Figure C.13a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.13b plots the percentage change in imports in the EU for different sectors.

Figure C.14: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the US, $\rho \in [0.7, 1]$ and Caliendo and Parro (2015) Trade Elasticities**

(a) Tariff (b) Change in Imports



Description: This figure shows the statistics for the US under cost-efficient sanctions with different levels of willingness to pay. Figure C.14a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.14b plots the percentage change in imports in the US for different sectors.

C.5.3. Russian Retaliation Strategies

The cost-efficient sanctions are also robust to Russian retaliation strategies. The reason is that, as Russia is a relatively small export destination for the sanctioning countries (see Figure C.4c), Russia's retaliation on the sanctioning countries' exports should not strongly affect the latter group's output, income, or incentive to impose sanctions.[47] In this section, we consider two alternative strategies of Russian retaliation: in solving Problem 7, Russia always sets its retaliation tariff to maximize its own real income ($\rho_{RUS} \equiv 1$) and to minimize the sanctioning countries' real income ($\rho_{RUS} \equiv 0$).

Figures C.15 to C.20 show the sanctioning countries' optimal tariffs and the associated import changes, with $\rho_{RUS} \equiv 1$. Figures C.21 to C.26 show the same set of variables for $\rho_{RUS} \equiv 0$. Similar to Section 5 where ρ_{RUS} is equal to that of the sanctioning countries, for low willingness to pay to sanction Russia (US\$0.10 for a US\$1 real income drop in Russia), the sanctioning countries should optimally impose tariffs of about 20% on all sectors. If the

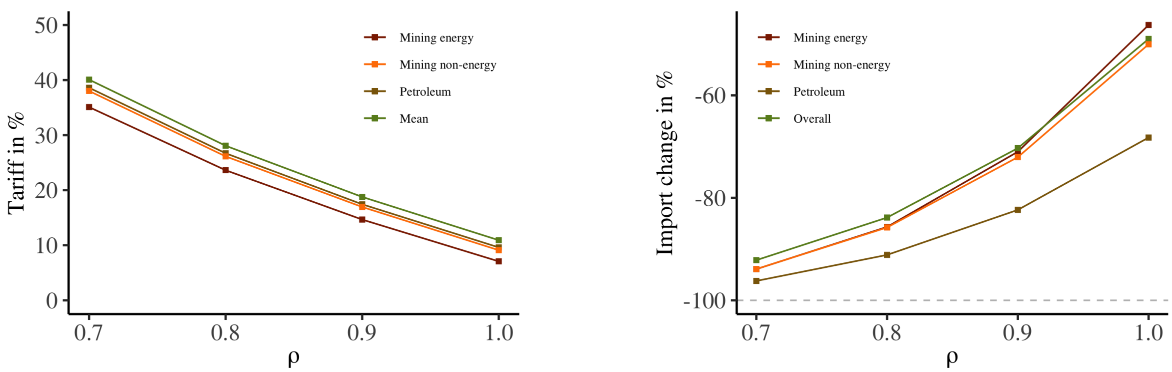
[47]This is also corroborated by Figure 5, which shows that the sanctioning countries' real income is not significantly affected by ρ – the willingness to pay to minimize the opponent's real income in both the the sanctioning countries and Russia.

sanctioning countries would like to pay US$0.7 of their real income to reduce Russian real income by US$1, an embargo on mining and energy sectors would be optimal for the EU. If their willingness to pay is higher than US$1.50, a embargo on all Russian products by all sanctioning countries would be optimal.

Figure C.15: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the EU,** $\rho_{\textbf{Sanction}} \in [0.7, 1]$ **and** $\rho_{RUS} \equiv 1$

(a) Tariff

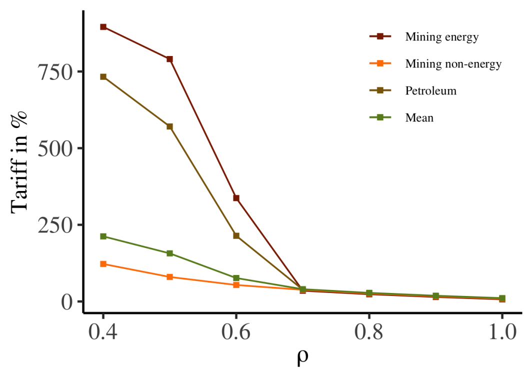
(b) Change in Imports



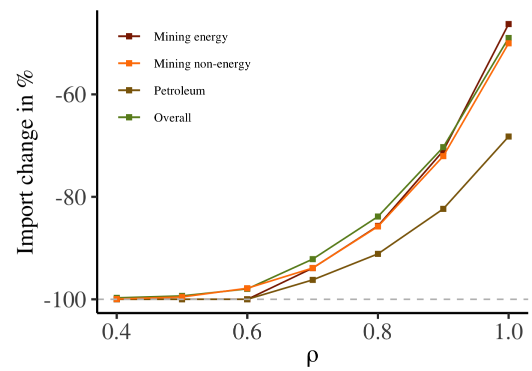
Description: This figure shows the statistics for the EU under cost-efficient sanctions with different levels of willingness to pay. Figure C.15a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.15b plots the percentage change in imports in the EU for different sectors.

Figure C.16: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the EU, $\rho_{\textbf{Sanction}} \in [0.4, 1]$ and $\rho_{RUS} \equiv 1$**

(a) Tariff



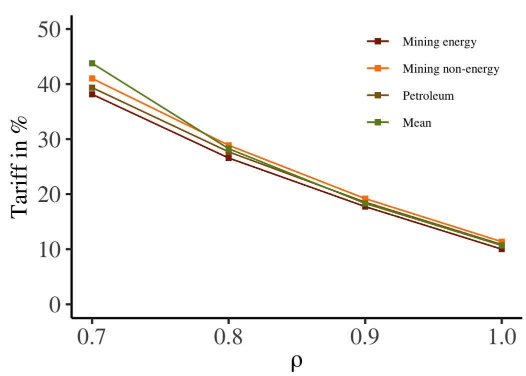
(b) Change in Imports



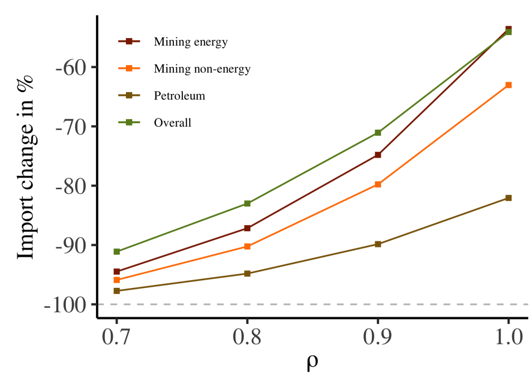
Description: This figure shows the statistics for the EU under cost-efficient sanctions with different levels of willingness to pay. Figure C.16a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.16b plots the percentage change in imports in the EU for different sectors.

Figure C.17: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the US, $\rho_{\textbf{Sanction}} \in [0.7, 1]$ and $\rho_{RUS} \equiv 1$**

(a) Tariff



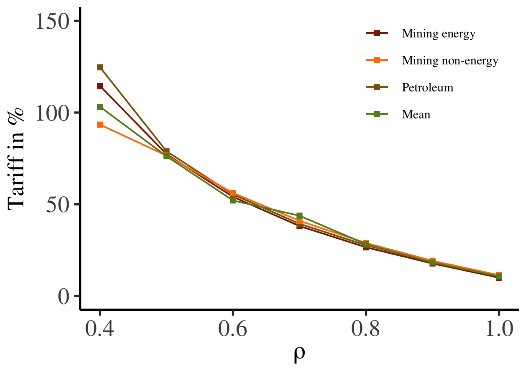
(b) Change in Imports



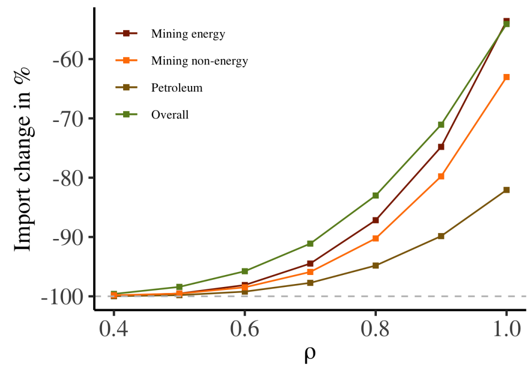
Description: This figure shows the statistics for the US under cost-efficient sanctions with different levels of willingness to pay. Figure C.17a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.17b plots the percentage change in imports in the US for different sectors.

Figure C.18: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the US, $\rho_{\textbf{Sanction}} \in [0.4, 1]$ and $\rho_{RUS} \equiv 1$**

(a) Tariff



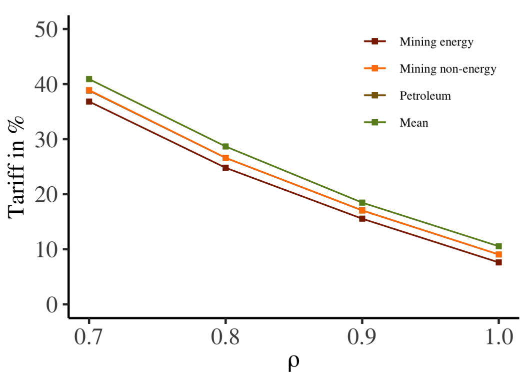
(b) Change in Imports



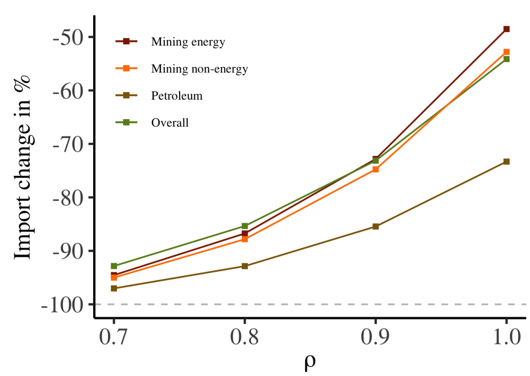
Description: This figure shows the statistics of the US under cost-efficient sanctions with different levels of willingness to pay. Figure C.18a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.18b plots the percentage change in imports in the US for different sectors.

Figure C.19: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in OSA, $\rho_{\textbf{Sanction}} \in [0.7, 1]$ and $\rho_{RUS} \equiv 1$**

(a) Tariff



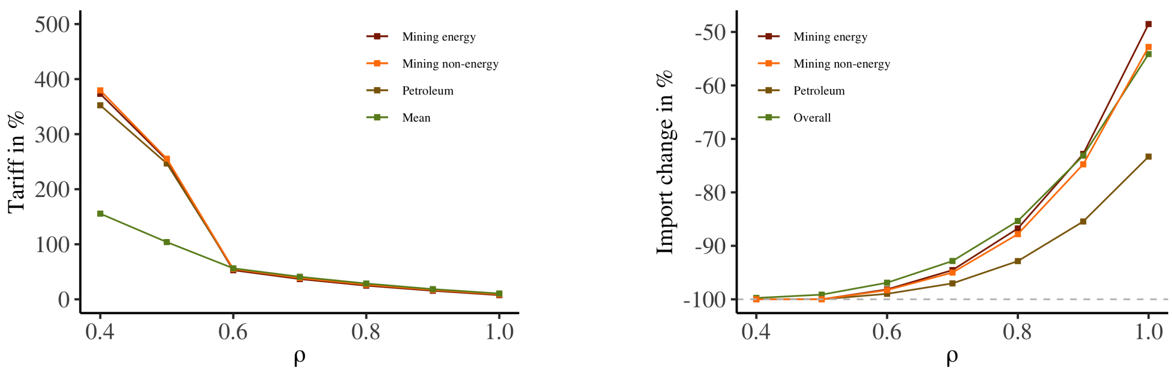
(b) Change in Imports



Description: This figure shows the statistics of OSA under cost-efficient sanctions with different levels of willingness to pay. Figure C.19a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.19b plots the percentage change in imports in OSA for different sectors.

Figure C.20: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in OSA, $\rho_{\textbf{Sanction}} \in [0.4, 1]$ and $\rho_{RUS} \equiv 1$**

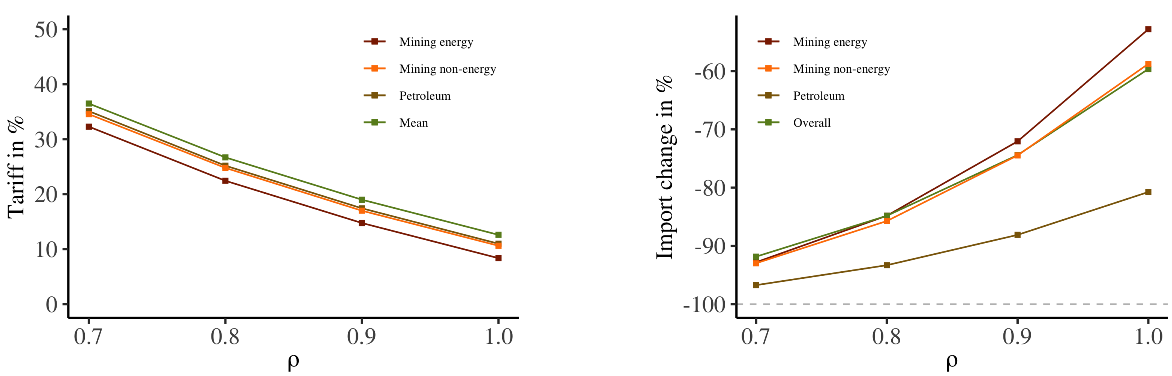
(a) Tariff (b) Change in Imports



Description: This figure shows the statistics for OSA under cost-efficient sanctions with different levels of willingness to pay. Figure C.20a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.20b plots the percentage change in imports in OSA for different sectors.

Figure C.21: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the EU, $\rho_{\textbf{Sanction}} \in [0.7, 1]$ and $\rho_{RUS} \equiv 0$**

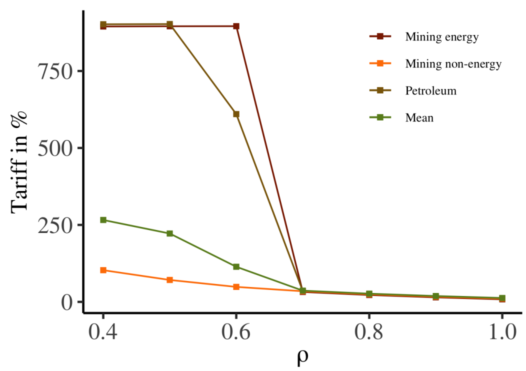
(a) Tariff (b) Change in Imports



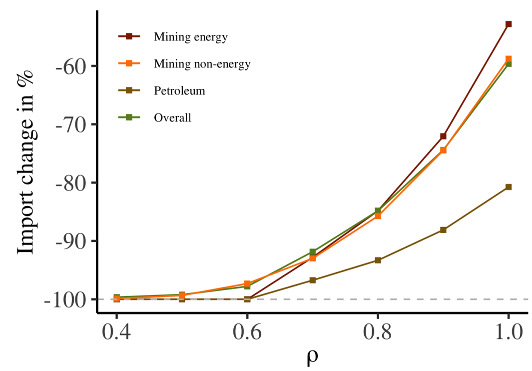
Description: This figure shows the statistics for the EU under cost-efficient sanctions with different levels of willingness to pay. Figure C.21a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.21b plots the percentage change in imports in the EU for different sectors.

Figure C.22: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the EU, $\rho_{\textbf{Sanction}} \in [0.4, 1]$ and $\rho_{RUS} \equiv 0$**

(a) Tariff



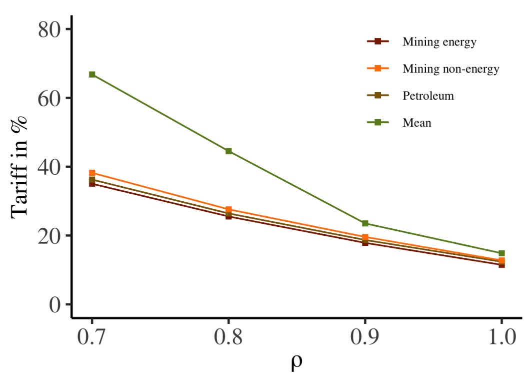
(b) Change in Imports



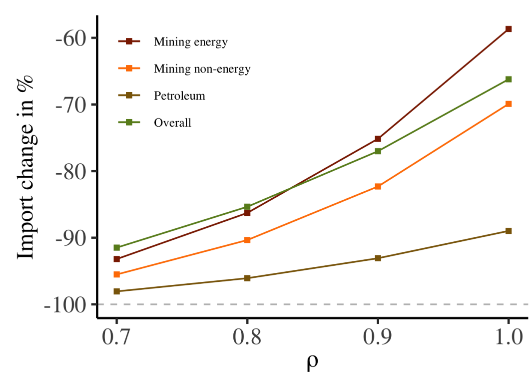
Description: This figure shows the statistics for the EU under cost-efficient sanctions with different levels of willingness to pay. Figure C.22a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.22b plots the percentage change in imports in the EU for different sectors.

Figure C.23: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the US, $\rho_{\textbf{Sanction}} \in [0.7, 1]$ and $\rho_{RUS} \equiv 0$**

(a) Tariff



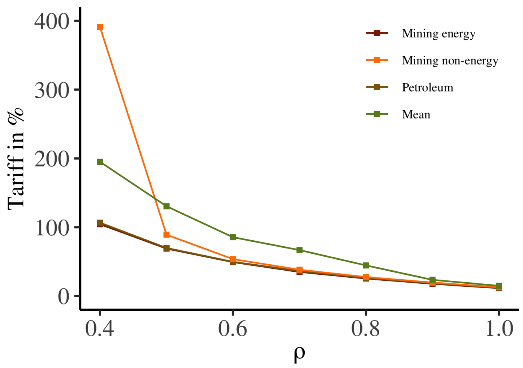
(b) Change in Imports



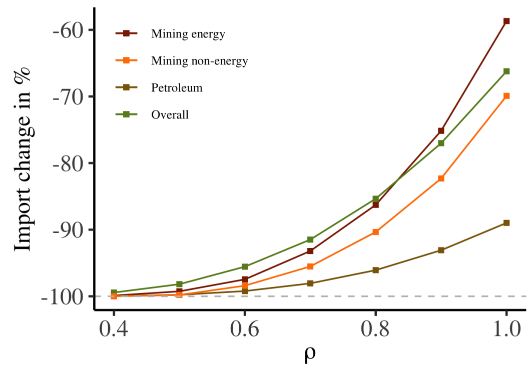
Description: This figure shows the statistics for the US under cost-efficient sanctions with different levels of willingness to pay. Figure C.23a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.23b plots the percentage change in imports in the US for different sectors.

Figure C.24: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the US, $\rho_{\textbf{Sanction}} \in [0.4, 1]$ and $\rho_{RUS} \equiv 0$**

(a) Tariff



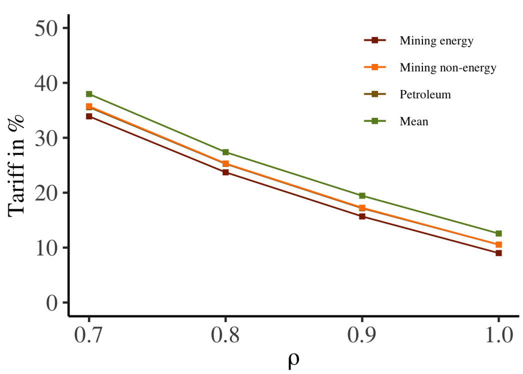
(b) Change in Imports



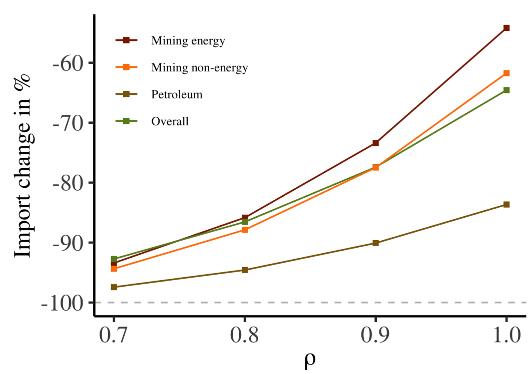
Description: This figure shows the statistics of the US under cost-efficient sanctions with different levels of willingness to pay. Figure C.24a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.24b plots the percentage change in imports in the US for different sectors.

Figure C.25: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in OSA, $\rho_{\textbf{Sanction}} \in [0.7, 1]$ and $\rho_{RUS} \equiv 0$**

(a) Tariff



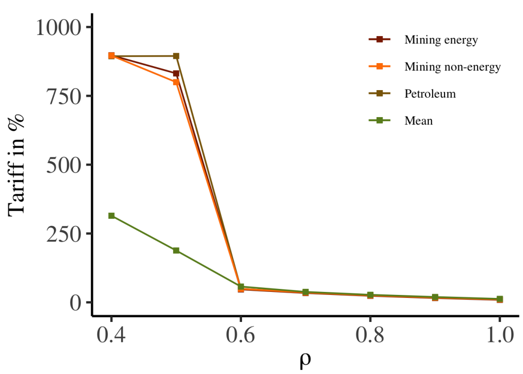
(b) Change in Imports



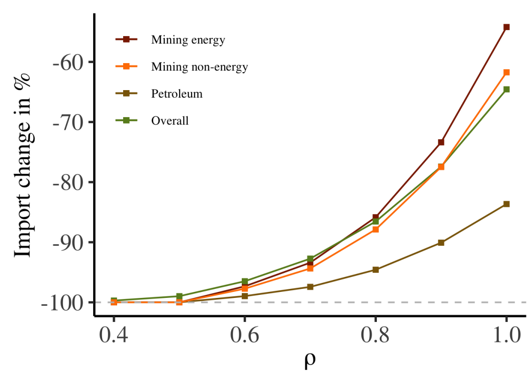
Description: This figure shows the statistics of OSA under cost-efficient sanctions with different levels of willingness to pay. Figure C.25a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.25b plots the percentage change in imports in OSA for different sectors.

Figure C.26: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in OSA, $\rho_{\textbf{Sanction}} \in [0.4, 1]$ and $\rho_{RUS} \equiv 0$**

(a) Tariff



(b) Change in Imports



Description: This figure shows the statistics of OSA under cost-efficient sanctions with different willingness to pay. Figure C.26a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.26b plots the percentage change in imports in OSA for different sectors.

C.5.4. CES Production Function

The elasticity of substitution between inputs plays a crucial role in the impact of sanctions. For example, if petroleum can be readily substituted for other inputs or labor, imposing sanctions on Russia would have a limited impact on domestic production. In this section, we demonstrate that our main findings remain valid for a range of elasticities of substitution across inputs.

For this section, we assume that production is given by

$$Y_n^j = A_n^j \left((e_n^j)^{\frac{1}{\rho}} (L_n^s)^{\frac{\rho-1}{\rho}} + \sum_{k=1}^{J} (f^{j,k})^{\frac{1}{\rho}} (M_n^{j,k})^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}, \tag{C.7}$$

where A_n^j is the TFP of sector j in country n, L_n^s is the labor demand by sector s, and $M_n^{j,k}$ is the quantity of sector k output used by sector j. ρ denotes the elasticity of substitution across inputs. e_n^j and $f^{j,k}$ are labor- and input-augmenting technology parameters.

Figure C.27 shows the results of the model using the production function given by equation C.7 and a calibrated elasticity of substitution of 0.66, as estimated by de Souza and Li (2022).[48] Overall, the patterns of cost-efficient tariffs are still the same. Even for low willingness to pay for sanctions, the EU should reduce trade with Russia through a tariff ranging from 20% to 30%, depending on the willingness to pay for sanctions. If ρ is below 0.6, i.e., the EU is willing to pay US\$0.70 for each US\$1 drop in Russian income, the EU should impose an embargo on the Russian petroleum and mining energy sectors.

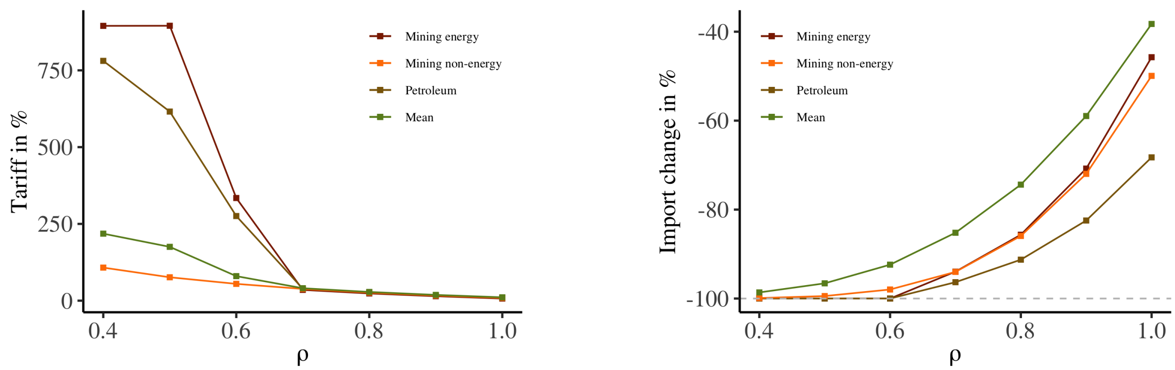
Figure C.28 explores the cost-efficient sanctions with an even lower elasticity of substitution between inputs of 0.1. The qualitative results remain consistent, with an optimal embargo on the Russian petroleum and mining energy sectors for ρ below 0.6. When willingness to pay for sanctions is low, the cost-efficient sanctions are homogeneous across sectors and effectively decrease trade with Russia.

[48] Oberfield and Raval (2021) find a similar elasticity of substitution across inputs.

Figure C.27: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the EU with CES Production Function**

(a) Tariff

(b) Change in Imports

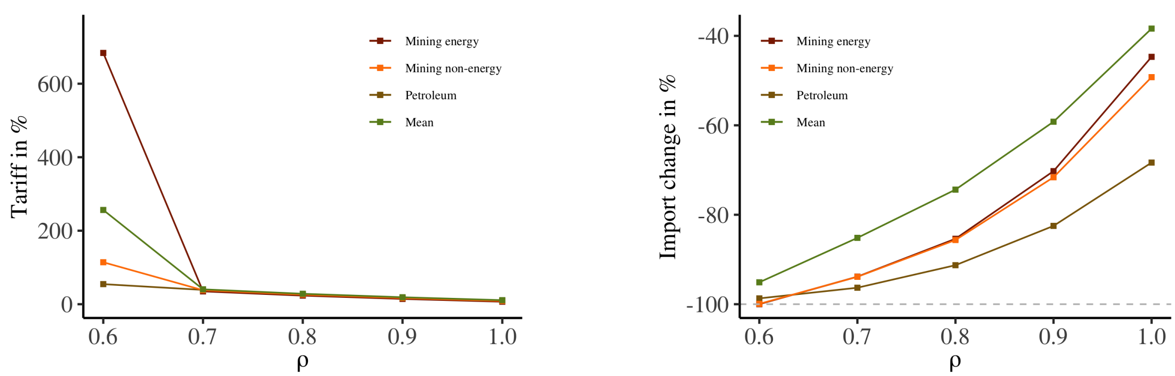


Description: This figure shows the statistics for the EU under cost-efficient sanctions with different levels of willingness to pay for sanctions. The production function is as described in Equation C.7 and the elasticity of substitution between labor and materials is calibrated to 0.66, as in de Souza and Li (2022). Figure C.27a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.27b plots the percentage change in imports in the EU for different sectors.

Figure C.28: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the EU with CES Production Function and Low Elasticity of Substitution**

(a) Tariff

(b) Change in Imports

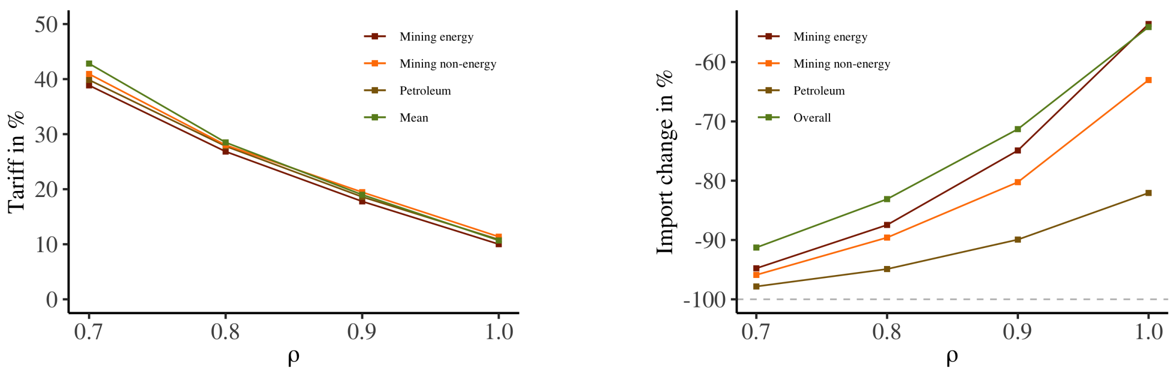


Description: This figure shows the statistics for the EU under cost-efficient sanctions with different levels of willingness to pay for sanctions. The production function is described in Equation C.7 and the elasticity of substitution between labor and materials is calibrated to 0.1. Figure C.28a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.28b plots the percentage change in imports in the EU for different sectors.

C.6. Other Figures and Tables

Figure C.29: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the US,** $\rho \in [0.7, 1.0]$

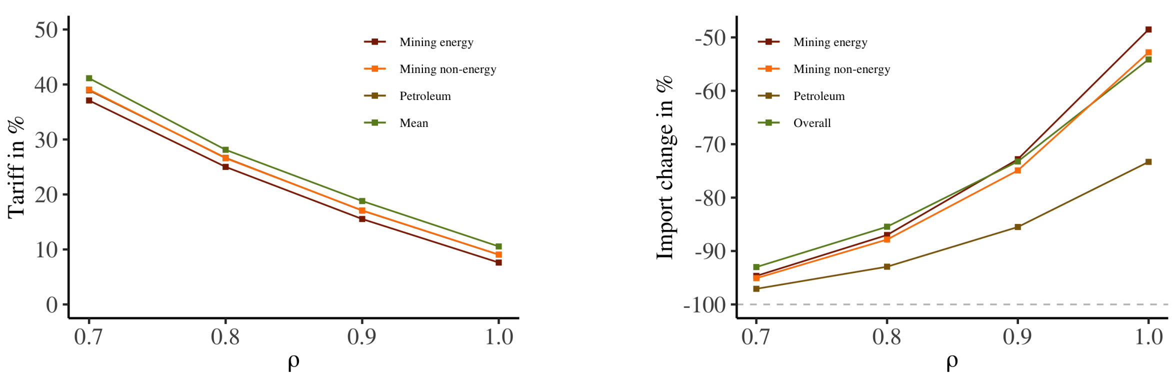
(a) Tariff (b) Change in Imports



Description: This figure shows the statistics of the US under cost-efficient sanctions with different levels of willingness to pay. Figure C.29a plots the cost-efficient sanctions on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.29b plots the percentage change in imports in the US for different sectors.

Figure C.30: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in OSA,** $\rho \in [0.7, 1.0]$

(a) Tariff (b) Change in Imports

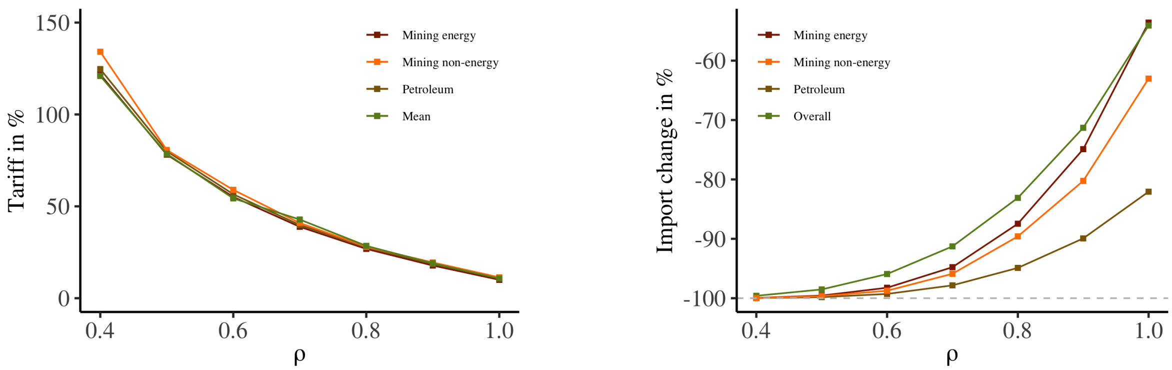


Description: This figure shows the statistics for OSA under cost-efficient sanctions with different levels of willingness to pay. Figure C.30a plots the cost-efficient sanctions on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.30b plots the percentage change in imports in OSA for different sectors.

Figure C.31: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the US,** $\rho \in [0.4, 1]$

(a) Tariff

(b) Change in Imports

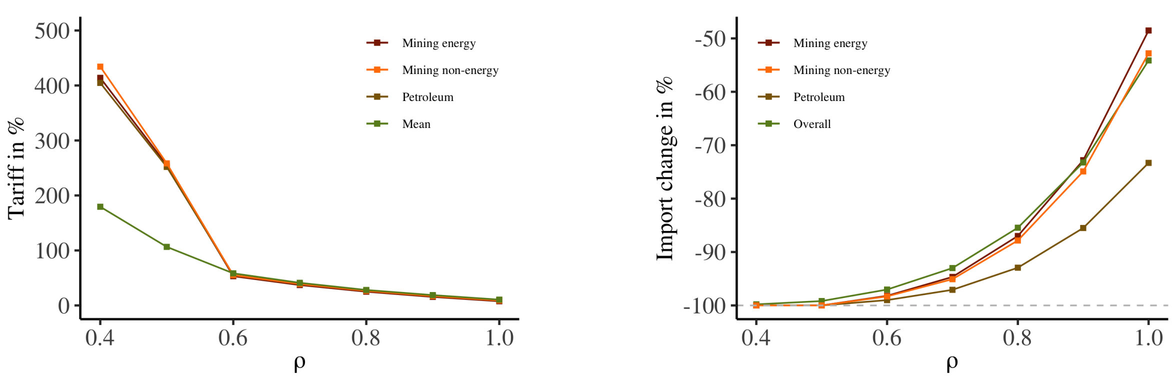


Description: This figure shows the statistics for the US under cost-efficient sanctions with different levels of willingness to pay. Figure C.31a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.31b plots the percentage change in imports in the US at different sectors.

Figure C.32: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in OSA,** $\rho \in [0.4, 1]$

(a) Tariff

(b) Change in Imports

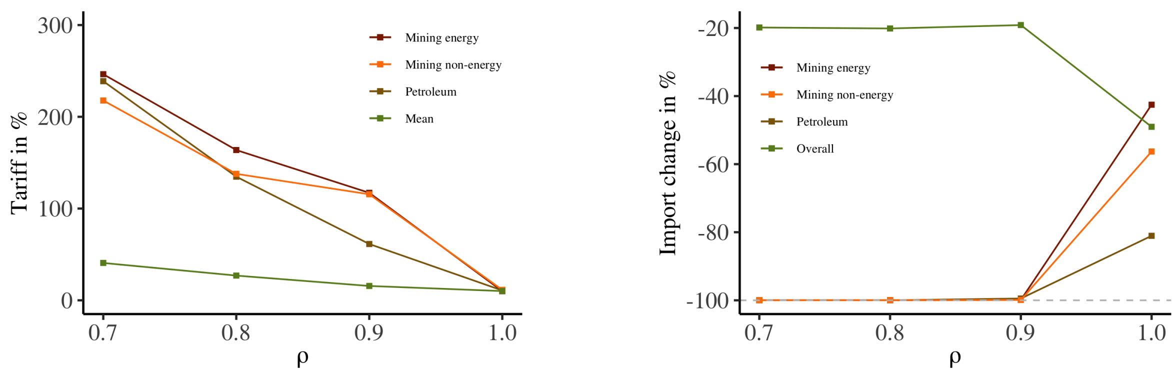


Description: This figure shows the statistics for OSA under cost-efficient sanctions with different levels of willingness to pay. Figure C.32a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariffs across sectors for different willingness to pay for sanctions, ρ. Figure C.32b plots the percentage change in imports in OSA for different sectors.

Figure C.33: **Cost-Efficient Sanctions with Political Weights for Different Levels of Willingness to Pay in the US,** $\rho \in [0.7, 1]$

(a) Tariff

(b) Change in Imports

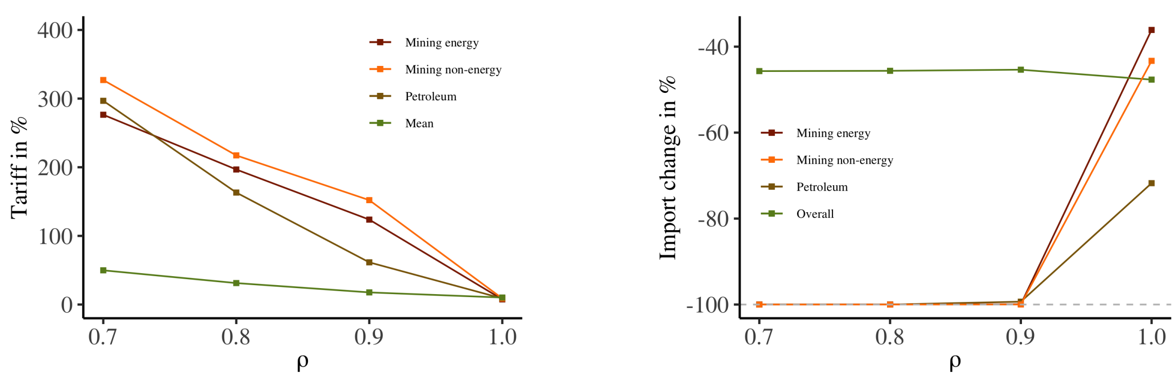


Description: This figure shows the statistics for the US under cost-efficient sanctions with different levels of willingness to pay when the US targets the politically relevant sectors, as described in Table C.6. Figure C.33a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.33b plots the percentage change in imports in the US for different sectors.

Figure C.34: **Cost-Efficient Sanctions with Political Weights for Different Levels of Willingness to Pay in OSA,** $\rho \in [0.7, 1]$

(a) Tariff

(b) Change in Imports

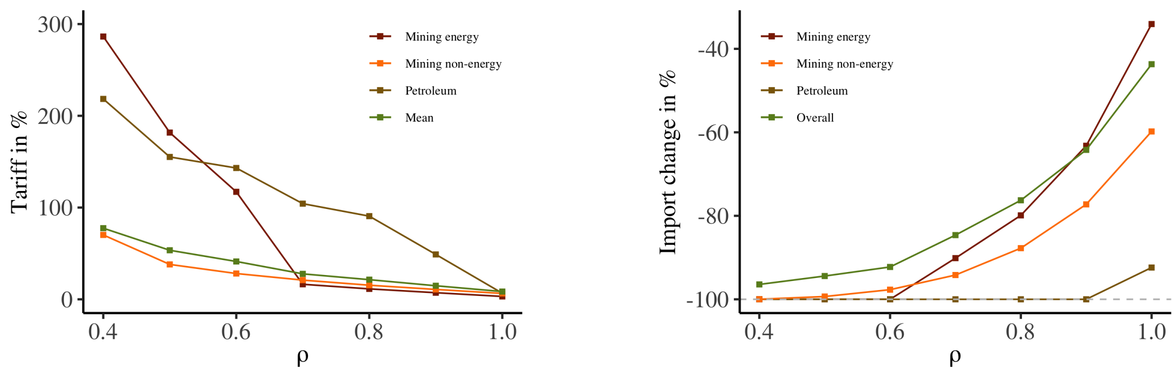


Description: This figure shows statistics for OSA under cost-efficient sanctions with different levels of willingness to pay when OSA targets the politically relevant sectors, as described in Table C.6. Figure C.34a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.34b plots the percentage change in imports in OSA for different sectors.

Figure C.35: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the EU, $\rho \in [0.4, 1]$ and Caliendo and Parro (2015) trade elasticities**

(a) Tariff

(b) Change in Imports

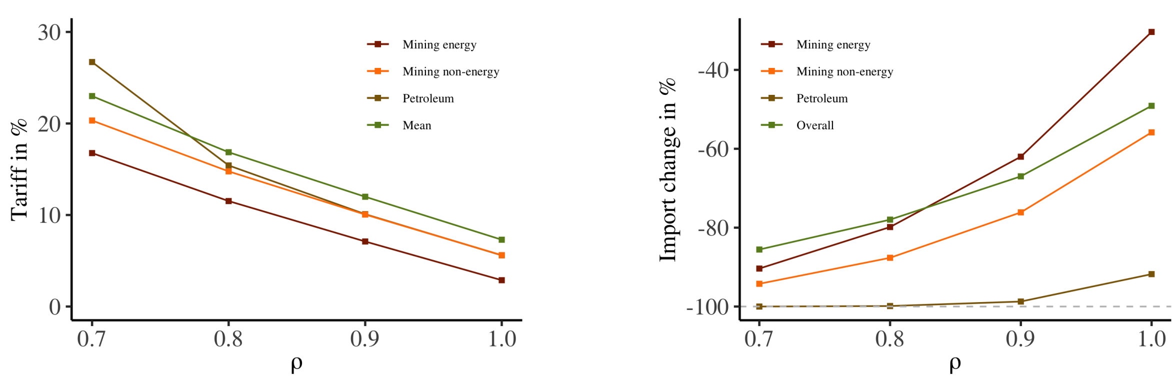


Description: This figure shows the statistics of the EU under cost-efficient sanctions with different levels of willingness to pay. Figure C.35a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.35b plots the percentage change in imports in the EU for different sectors.

Figure C.36: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in OSA, $\rho \in [0.7, 1]$ and Caliendo and Parro (2015) trade elasticities**

(a) Tariff

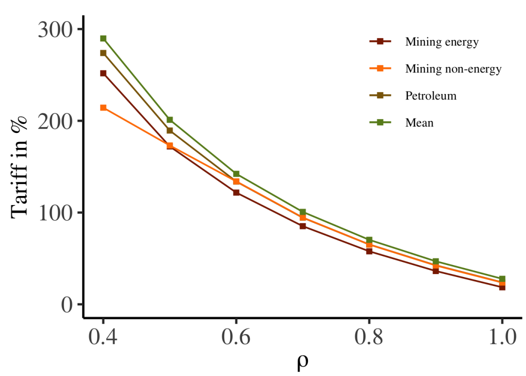
(b) Change in Imports



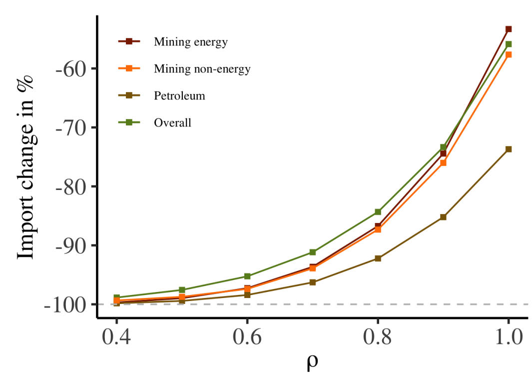
Description: This figure shows the statistics for OSA under cost-efficient sanctions with different levels of willingness to pay. Figure C.36a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.36b plots the percentage change in imports in OSA for different sectors.

Figure C.37: **Cost-Efficient Sanctions for Different Levels of Willingness to Pay in the EU, $\rho \in [0.4, 1.0]$ and Short-Run Elasticities**

(a) Tariff



(b) Change in Imports



Description: This figure shows the statistics for the EU under cost-efficient sanctions with different levels of willingness to pay with short-run elasticities described in Figure C.11. Figure C.37a plots the cost-efficient tariffs on mining energy, mining non-energy, petroleum, and the average tariff across sectors for different levels of willingness to pay for sanctions, ρ. Figure C.37b plots the percentage change in imports in the EU for different sectors.

C.7. Sanctioning Countries' Real Income Does not Decrease

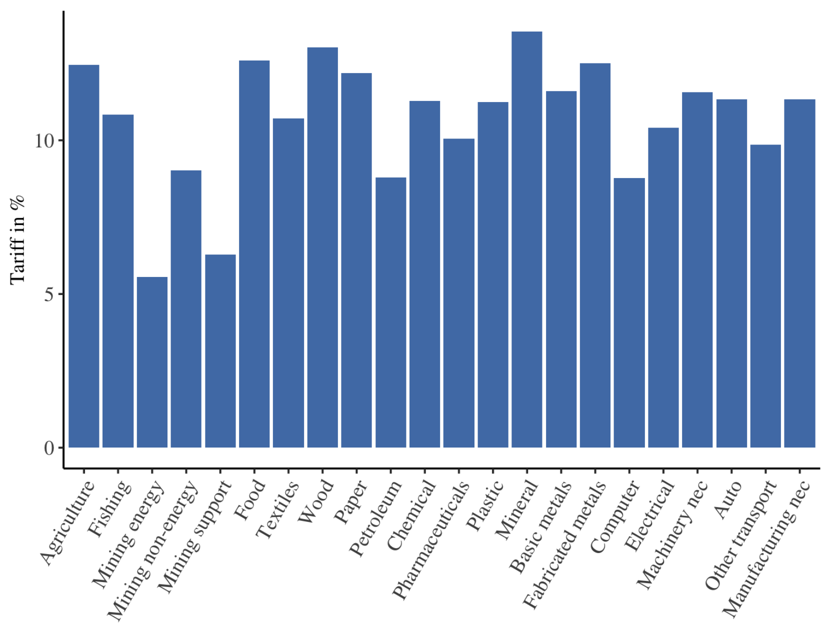
In this section, we study the cost-efficient sanctions that do not decrease the sanctioning countries' real income but minimize the real income in Russia. The sanctioning country n's problem (in changes) is the following. Conditional on all other tariffs except those that country n imposes on Russia, $\hat{\mathbf{t}}_{-\mathbf{nR}}$, country n solves:[49]

$$\begin{aligned} g_n(\hat{\mathbf{t}}_{-\mathbf{nR}}) \in argmin_{\{\boldsymbol{\tau}_{\boldsymbol{n},\boldsymbol{R}}\}} & G_R \hat{G}_R(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}), \\ & \text{s.t. Equilibrium Conditions B.9-B.14}, \\ & \hat{G}_n(\boldsymbol{\tau}_{\boldsymbol{nR}}, \boldsymbol{\tau}_{-\boldsymbol{nR}}) \geq 1. \end{aligned} \tag{C.8}$$

Figure C.38 shows cost-efficient sanctions by the EU that satisfy Problem C.8. These tariffs are similar to those when the sanctioning country has low willingness to pay to sanction Russia. The tariffs are low (about 10%) on average and similar across sectors. As the EU does not want to decrease its own real income, lower tariffs should be imposed on the energy extraction and petroleum sectors.

[49] We assume that Russia's retaliation strategy is to set tariffs on the sanctioning countries to maximize Russia's welfare; it follows Problem 7 where we set $\rho_{RUS} = 1$.

Figure C.38: **Cost-Efficient Sanctions with No Decrease in EU Welfare**



Description: This figure shows the cost-efficient sectoral tariffs that the EU imposes on Russia when the EU solves Problem C.8: the EU minimizes Russian welfare but requires that its own welfare does not decrease.