(Trade) War and Peace:

How to Impose International Trade Sanctions

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

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Abstract

Trade sanctions are a common instrument of diplomatic retaliation. To guide current and future policy, we ask: What is the most cost-efficient way to impose trade sanctions against Russia? To answer this question, we build a quantitative model of international trade with input-output connections. Sanctioning countries simultaneously choose import tariffs to maximize their income and to minimize Russia's income, with different weights placed on these objectives. We find, first, that for countries with a small willingness to pay for sanctions against Russia, the most cost-efficient sanction is a uniform, about 20% tariff against all Russian products. Second, if countries are willing to pay at least US$0.7 for each US$1 drop in Russian welfare, an embargo on Russia's mining and energy products - with tariffs above 50% on other products - is the most cost-efficient policy. Finally, if countries target politically relevant sectors, an embargo against Russia's mining and energy sector is the cost-efficient policy even when there is a small willingness to pay for sanctions.

Keywords: trade sanctions, tariff, tariff competition

JEL Codes: F13, O24

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1 Introduction

Trade sanctions are a common instrument of diplomacy. In 2016, more than 100 trade sanctions were active.[1] Following the sanctions imposed against Russia, trade sanctions have once again gained the spotlight in public debate.[2] Ultimately, these sanctions are meant to reduce Russia's ability to wage war. However, if they severely restrict trade, they also hurt the sanctioning country. 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?

To answer these questions, we build a model of tariff competition with international trade and input-output connections.[3] 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 with different weights. On the one hand, they want to maximize domestic real income, which is also a measure of households' welfare. On the other hand, they want to minimize Russian welfare. If the government has a high willingness to pay for sanctions, it puts higher weights 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.

To make reliable counterfactuals, we estimate the model to reproduce the effect of tariffs on the international trade of Russia. Using the difference-in-differences estimation strategy introduced in de Souza and Li (2021), we found that a 10% ad-valorem tariff against Russia decreases imports of Russian products by 43% and total imports of the taxed good by 19%, showing that both Russia and the sanctioning country are negatively affected by tariffs. Using the method of de Souza and Li (2021) and tariff variation from all countries, we estimate sectoral trade elasticities to be equal to 6 on average, and they correlate with estimates by Caliendo and Parro (2015) and those that we recover with the Feenstra (1994)

[1]See Kirilakha et al. (2021).

[2]On March 11 2022, US President Biden announced that the United States (US), the European Union (EU), Group of Seven (G7), and North Atlantic Treaty Organization (NATO) countries were to jointly remove Russia's "Most Favored Nation" (MFN) status. The removal of MFN status allowed the allies to arbitrarily raise tariffs, impose more sanctions, or even bans on Russian imports without explicitly violating the WTO rules. Since then, a number of countries have announced trade sanctions against Russia.

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

method.

We highlight five main findings. First, we show that for countries with a small willingness to pay for sanctions, the best policy is to impose a small tariff on all products. For instance, if the sanctioning countries are willing to pay US$0.1 for every dollar of economic damage in Russia, import tariffs should average 20%.[4]

Second, if the European Union (EU) is willing to pay above 0.7 dollars for each 1 dollar of real income loss in Russia, an EU embargo on the mining and energy sectors with 50% tariff on other sectors is cost-efficient.[5] For countries with a large willingness to pay for sanctions, the main driver of cost-efficient tariffs is the import share – to cause more harm in 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. Russia exports more to the EU than to the US or other sanctioning allies.[6] Because of that, tariffs imposed by the US or other sanctioning countries can, at most, reduce Russian real income by only 0.07% or 0.22%, respectively. In contrast, the EU 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 tariffs to punish the sanctioning countries, the economic consequence of tariff sanctions on Russia would more than double. Because the EU is an important importing origin for Russia but Russia is not an important exporting destination for the EU, Russia imposing high tariffs on EU cannot decrease EU welfare much but it causes a large decline in its own welfare.

Finally, we show that if sanctions target sectors with larger political relevance in Russia, an embargo on Russian mining and energy sectors is cost-efficient even for countries with a

[4]For nations with a small willingness to pay for sanctions, there are two forces affecting the choice of tariffs. On the one hand, the government wants to impose high tariffs on sectors with low trade elasticity, i.e., on products in which trade flows are less affected by tariffs. Yet, on the other hand, the government also wants to impose high tariffs on products whose lower import shares from Russia so it does not affect the local economy very much.

[5]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).

[6]More specifically, Russia's exports to the EU are 4.85% of country's total production; its exports to the US, 0.55%; and its exports to other sanctioning allies, 1.63%.

low willingness to pay for sanctions. To calculate political relevance, we link each Russian individual sanctioned by the US, UK, or EU, whom we call an oligarch, to the companies associated with that individual in Russia. Using the company's revenue, we calculate the revenue share of oligarch-owned companies by sector. If the sanctioning countries are willing to pay $0.1 for each $1 of consumption drop in Russia's oligarch income, tariffs on Russian mining and energy sectors should be above 80%, which would cause imports of mining and energy products to drop by almost 100%. Therefore, if the goal of an embargo is to target politically influential sectors, it is the optimal policy even for nations with a low willingness to pay for sanctions.

This paper contributes to the literature on tariff competition. One strand of this literature investigates the welfare consequences of trade policies that countries implement in cooperative and non-cooperative games. These settings include tariff cooperation (Ossa 2014), competition on non-tariff trade barriers (Mei 2021), "Most Favored Nation" (MFN) rules (Bagwell et al. 2021), export subsidies (Beshkar and Lashkaripour 2020), market access concessions (Beshkar et al. 2022), deep trade agreements (Lashkaripour and Lugovskyy 2021), and industrial policies (Bartelme et al. 2021). They find that tariffs should be larger on sectors with larger trade elasticity and that there are welfare gains from cooperation. Another strand of this literature develops theories for punitive tariffs. Punitive tariffs can sustain a cooperative equilibrium (Dixit and Bewley 1987) and thus lead to welfare gains (Mei 2020), should be higher when trade volume surges (Bagwell and Staiger 1990) and in small countries (Park 2000), can be more effective when implemented in a multilateral framework (Maggi 1999, Klimenko et al. 2008) and are easier to enforce than monetary fines (Limao and Saggi 2008).

We contribute to this literature by studying the problem of countries trading-off sanctions and welfare-maximizing trade policy. In our model, countries simultaneously choose import tariffs not only to maximize their income, as in Ossa (2014), Mei (2020), Mei (2021), Bagwell et al. (2021), Beshkar et al. (2022) and many others, but also to minimize Russia's income, with different weights placed on these objectives. As countries put more weight into hurting the Russian economy, optimal tariffs rise more in the sectors that have larger trade flows and higher trade elasticities. If the willingness to pay is above US$0.7 for each US$1 drop in Russian welfare, tariffs should target the main sectors of Russian exports regardless of its trade elasticity.

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, Whang et al. 2013) and should optimally trade off between the punishment on the target's leader and the general public (Baliga and Sjöström 2022). Empirical works show 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, they also negatively impact firm business (Felbermayr et al. 2020b, Gullstrand 2020, Besedeš et al. 2021). Sanctions disrupt international trade (Crozet and Hinz 2020, Miromanova 2021a,b, Kwon et al. 2022).

A few works study the impact of sanctions on Russia in response to its recent aggressions in Ukraine, including how they affect the Ruble exchange rate (Lorenzoni and Werning 2022, Itskhoki and Mukhin 2022), the welfare implications of western countries increasing tariffs and non-tariff trade barriers on Russia (Evenett and Muendler 2022a,b), the consequences of banning Russian oil imports (Bachmann et al. 2022), and how Russian retaliation by restricting imports affects Russia's consumer prices (Hinz and Monastyrenko 2022).

In this paper, we estimate cost-efficient trade sanctions and their economic impacts. Ours is the first paper to study optimal economic sanctions in a quantitative trade framework. Different from Eaton and Engers (1992), Lacy and Niou (2004), Whang et al. (2013) and Baliga and Sjöström (2022), we take the motivation for sanctions as given, and we compute the set of tariffs that hurt the targeted country the most while costing the least to the sanctioning countries. Inspired by Baliga and Sjöström (2022), we also calculate cost-efficient sanctions when the sanctioning countries target the politically-relevant sectors.

We also contribute to the literature that develops new methods to estimate trade elasticities. Previous estimates rely on orthogonality or structural assumptions for identification of the trade elasticity. Feenstra (1994), Broda and Weinstein (2006) and Soderbery (2015) assume that shocks to export supply and import demand are orthogonal. Head and Ries (2001), Anderson and Van Wincoop (2004), Romalis (2007), Boehm et al. (2020) and Fontagné et al. (2022) assume that, conditional on non-tariff trade barriers, shocks to trade flows are uncorrelated with tariffs. Eaton and Kortum (2002), Simonovska and Waugh (2014), Bergstrand et al. (2013), Head et al. (2010) and Caliendo and Parro (2015) impose structural assumptions on non-tariff trade costs.

Different from the previous works, we estimate trade elasticities using difference-in-differences with anti-dumping tariffs. We show that the products that face anti-dumping investigations that lead to tariff increases have similar trends prior to the tariffs as those that face anti-dumping investigations that conclude with no tariffs. We extend the framework, which was used in the context of Brazil, to all countries and their trade partners, which gives us sufficient variations to estimate the trade elasticities at the sector level. Our estimates of trade elasticity average 6 and correlate with previous estimates in the literature.

The rest of the paper proceeds as follows. In Section 2, we present empirical evidence for how a large increase in tariffs can disrupt international trade with Russia. In Section 3, we present the model and the governments' problems. In Section 4, we calibrate the model. In particular, we take the sectoral trade elasticities to our empirical estimates. In Section 5, we show our findings based on model simulations. In Section 6, we conclude.

2 Empirics

We take advantage of the difference-in-differences strategy introduced by de Souza and Li (2021) to investigate how increase in tariffs disrupts trade, in particular the trade with Russia. We learn lessons from global anti-dumping (AD) investigations. The empirical analysis serves two purposes. First, many AD investigations were deployed against Russia and they often resulted in large tariff increases on Russia. Therefore, using their variations, these AD policies can help us understand how recent and upcoming import sanctions on Russia can disrupt trade. Second, using AD investigations that all countries impose on all trade partners, we can estimate the trade elasticity by sector. We defer the second point to Section 4, where we calibrate the model to these sectoral estimates.

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.[7] The World Trade Organization (WTO) allows the destination government to impose anti-dumping tariffs to correct for such price differences, but requires that they must follow certain procedures.[8] First, a sufficient number of firms in a domestic industry should submit a written request to the government. The request should provide evidence that import competition imposed harm on the domestic industry. It should also show that the foreign exporters engaged in dumping. Second, upon receiving the request, the government should establish a committee that investigates the case. Third, using the evidence collected in 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 charges 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 that equals the price difference.[9] If the committee finds otherwise, no AD tariff will be introduced. Anti-dumping duties should terminate no later than five years after first being imposed.

2.1.1 Data

Our data source for AD investigation is the Global Anti Dumping Database (Bown 2005). It contains all AD investigations that 31 major economies conducted 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 conclusion 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 data sets on the country-bilateral and HS 6-digit level.

[7] Adjusted for allowances, trade costs, and currencies in different markets. See Section "Fair comparison of normal value and export price" of WTO's technical note on anti-dumping (`https://www.wto.org/english/tratop_e/adp_e/adp_info_e.htm`).

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

[9] Some investigations ended with the foreign exporter raising their price to avoid an AD tariff. See WTO Agreements on Anti-dumping, 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.

In the Appendix, Table A.1 shows the summary statistics of AD investigations that targeted Russia.[10] During the sample period (1995-2020), Russia faced 393 AD investigations, among which 298 (75%) were ruled positive. Figure A.1a shows the number of AD investigations and affirmative investigations by year. Figure A.1b shows the average tariff rate by sector conditional on an affirmative ruling. Table A.3 shows the summary statistics, by country, of the AD investigations that targeted Russia. The US conducted the most AD investigations on Russia.

Table A.2 shows the summary statistics of AD investigations that all countries imposed on their trade partners. During the sample period, there were a total of 15,131 AD investigations, among which 10370 (68%) ruled positive. Figure A.2a shows the number of global AD investigations and affirmative investigations by year. Figure A.2b shows, at the world level, the average tariff rate by sector conditional on an affirmative ruling. Table A.4 and A.5 shows the summary statistics of global AD investigations by the investigating country and the exporting country.

2.1.2 Discussion

Based on the WTO anti-dumping 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 receive an AD tariff to those that do not. To initiate an AD tariff, an investigation committee has to be formed first. As Staiger and Wolak (1994), Prusa (2001), Lu et al. (2013), and Besedeš and Prusa (2017), among others, show, these investigations can create trade policy uncertainty and disrupt trade even if they do not conclude with tariff changes. Furthermore, as de Souza and Li (2021) show, the investigated products have a lower price, a higher trade volume, a decreasing price price trend, and an increasing trade volume trend, compared with the products that are not investigated. Both the trade policy uncertainty and different trends can be a confounding factor when one compares the tariffed products versus the non-tariffed products without controlling for AD investigations. Therefore, we limit our sample to only the investigated products.

Second, conditional on an AD investigation, the WTO rules require that whether a tariff

[10]We discuss these summary statistics more in Appendix Section A.1.

should be imposed and, if so, the size of the tariff should depend on the price difference that the foreign exporter set in the origin and destination countries in the pre-investigation period. We can use the product-country fixed effect to control such a difference, and once we do so, the AD tariff should be exogenous to the potential trends of the treatment and control groups. To test that countries indeed follow the WTO rules, we confirm in this paper such compliance with an event study design that shows parallel trends between the two groups before the treatment. In de Souza and Li (2021), we supplement it with additional evidence: (1) The AD tariff can be predicted by the exporting country's price that it charges and the AD tariff that it faces on the same product in a third country with a high R-squared. (2) The AD policy applied for a sector is not correlated with the sector's other benefits from the government, including political connections, public procurement, subsidies, and tax breaks. (3) Placebo tests shows that if we replace the real treatment group with one that has similar trends or if we move the treatment time five years earlier, we do not identify any effect of AD tariffs.

2.2 Empirical Strategy

2.2.1 Impact of Import Restrictions on Russian Trade

Following de Souza and Li (2021), we use study the impact of AD tariffs on Russian trade using:

$$y_{p,c,t} = \theta\tau_{p,c,t} + \beta\mathbb{I}_{p,c,t}\{\text{After AD}\} + X'_{p,c,t}\beta + \epsilon_{p,c,t}, \tag{1}$$

where $y_{p,c,t}$ is imports of product p by country c from Russia in year t;[11] $\tau_{p,c,t}$ denotes the AD tariff that country c imposes on product p from Russia in year t; $\mathbb{I}_{p,c,t}\{\text{After AD}\}$ is a dummy after the beginning of the first AD investigation (it captures common trends between treatment and control leading to the investigation); and $X'_{p,c,t}$ is a set of controls.[12]

Our variable of interest is θ, which captures the average effect of AD tariffs on trade.

[11] A product is a Harmonized System (HS) 6-digit code.

[12] The controls are a product-country fixed effect, product-year fixed effect, and dummies for the number of AD investigations.

As it is common in differences-in-difference, 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 (prior to the beginning of the investigation) using:

$$y_{p,c,t} = \sum_j \theta_j \tau_{p,c,\text{first}} \mathbb{I}_{p,c,t} \{j \text{ Yrs. to AD}\} + \sum_j \beta_j \mathbb{I}_{p,c,t} \{j \text{ Yrs. to AD}\} + \eta_{p,c} + \eta_{c,t} + \epsilon_{p,c,t}, \tag{2}$$

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 (this variable equals zero for the control group).[13] Moreover, in this equation, the dummy variable $\mathbb{I}_{p,c,t} \{j \text{ Yrs. to AD}\}$ takes one if year t is j years to the beginning of the first AD investigation; and $\eta_{p,c}$ and $\eta_{c,y}$ are the country-product fixed effect and country-year fixed effect, respectively. We are interested in the coefficient θ_j, which captures the dynamic effect of AD tariffs in the jth year. Having no pre-trend is equivalent to $\theta_j = 0, \forall j < 0$. We limit the sample to product-country pairs that have at least one AD investigation.

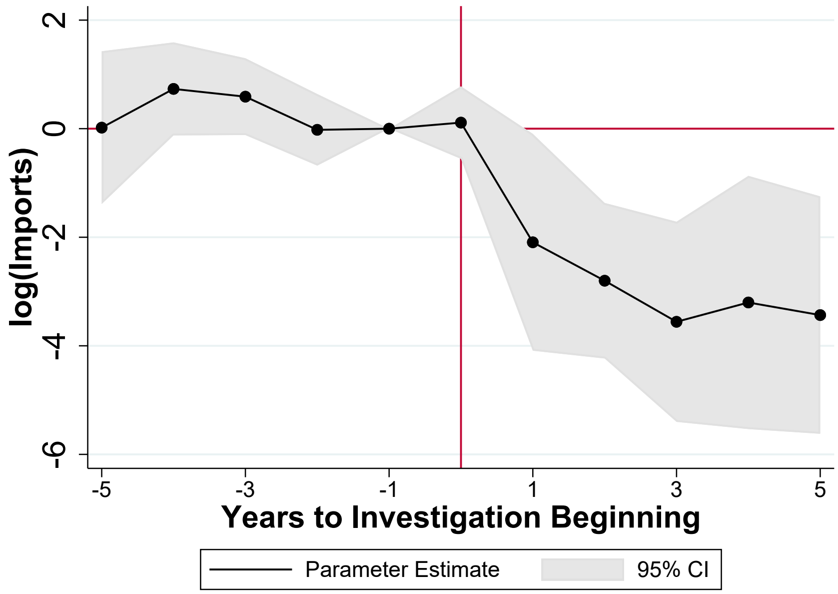
2.3 Results

Figure 1 shows how AD tariffs against Russia affect a country's imports from Russia. AD tariffs cause a significant and large drop in imports – a 10% increase in AD tariffs is associated with a nearly 40% decline in imports of the targeted products. The figure also confirms the nonexistence of a pre-trend; that is, before the increase in tariffs, the treatment and control groups display similar import trends.

In the Appendix, Figure A.3 shows the impact of AD tariffs on the quantity and price of the targeted product imported from Russia. Similar to the value of imports, AD tariffs significantly reduce the quantity of imports from Russia. Figure A.3a shows that, five years from the beginning of an AD investigation, a 10% increase in AD tariffs leads to about 30% drop in the quantity of imports from Russia. Figure A.3b shows that it takes longer for the

[13] In the difference-in-differences analysis, we limit our sample to the first AD investigation for a product that a country conducts on Russia. In this way we ensure that there is no other investigation in the pre-period.

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



Description: This figure shows the dynamic impact of AD tariffs on imports using Model 2. 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 Harmonized System (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.

import price to respond to AD tariffs. A 10% increase in AD tariffs leads to about a 5% drop in import prices. This suggests Russian exporters have to lower prices to remain competitive, and there is incomplete pass-through of AD tariffs to consumers in the destination country.

AD tariffs significantly reduce total exports (to all destinations) of the targeted Russian product, according to Figure 2. A 10% increase in tariffs leads to about a 15% decline in the total exports five years after the AD investigation. This indicates that the decline in the Russian exports of a product to the destination that imposes import restrictions dominates the potential increase in Russian exports of the same product to other destinations. Indeed, Column 1 of Table A.10 shows that Russia can only weakly divert exports to other destinations.[14] These findings suggest that import sanctions by other countries on Russia will likely reduce Russian output and income, a hypothesis we build on in Section 3.

Similarly, Figure 2b shows that AD tariffs significantly reduce total imports (from all

[14]This result is consistent with de Souza and Li (2021), who also find an insignificant trade diversion effect of the AD tariffs that the Brazilian government impose on other countries.

origins) of the targeted product to the country that imposes the import restriction: 10% increase in tariffs leads to about a 20% decline in that country's total imports in the fifth year from the beginning of the AD investigation. This demonstrates that the decline in imports of the targeted product from Russia dominates the potential increase in imports of the same product from other origins. This is further confirmed by Column 2 of Table A.10, whose results show that AD tariffs also only weakly divert the sanctioning country's imports to other origins. These findings suggest that import sanctions by other countries on Russia will likely also reduce the sanctioning country's consumption and income, a hypothesis we will evaluate in Section 3.

Using variation from all AD tariffs imposed against Russia, we show in Table 1 that tariffs against Russia decrease imports, prices, and total exports of Russian products. A 10% increase in tariffs causes a 43% drop in imports of the targeted product from Russia (Column 1), with a 37% drop in quantity imported (Column 2) and a 6% drop in the price of imports (Column 3). Columns 4 and 5 show that a 10% increase in tariffs reduces total Russian exports of the targeted product by 16% and total imports of the targeted product by the tariffing country by 19%, respectively.

Table A.7, A.8 and A.9 show that the impacts of tariffs on imports from Russia, total exports, and total imports are robust to different combinations of fixed effect controls. Column 1 of these figures show the baseline estimates. Column 2 clusters standard errors at the 4-digit product and importer level. Column 3 uses a dummy that denotes whether an investigation committee is formed (instead of the number of committees) to control for the impact of AD investigations. Column 4 controls product, importer, and year fixed effects separately.

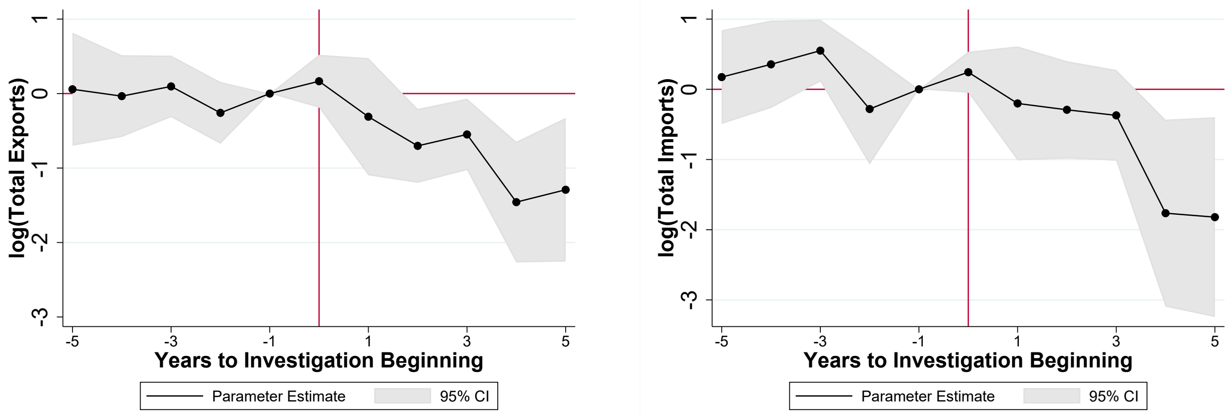
2.4 Discussion of Empirical Results

Tariffs against Russia decrease total imports of the taxed good and exports by Russia. This result has two implications for sanctions against Russia – one on local welfare and another on Russian welfare.

First, the empirical results suggests that trade sanctions decrease local welfare. Because Russian products cannot be easily replaced, the local economy has to pay higher prices to

Figure 2: **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 2. 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 refer to the total exports of the Harmonized System (HS) 6-digit level product by Russia to all destinations; these exports are of the same the same 6-digit product for which other countries initiated an AD investigation on Russia. Total imports refer to the 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 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.

either produce it locally or import it from other countries. Therefore, due to higher prices, local real income goes down.

Second, the empirical results also suggest that trade sanctions can decrease Russian welfare. Because Russia decreases its total exports of the tariffed good, it must be the case that it cannot easily supply it to other countries. The decrease in total Russian demand leads to a drop in income, output, and prices in Russia.

Therefore, the empirical results indicate that if countries want to sanction Russia, they have to incur economic loss. Given certain wiliness to pay for sanctions, how should countries impose tariffs to maximize their own and punish Russia? To answer this question, we build a model of international sanctions with input-output connection to understand the cost-efficient sanctions.

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

VARIABLES	(1) Log Value	(2) Log Quantity	(3) Log Price	(4) Log Total Exports	(5) Log Total Imports
Anti-dumping Tariff	-4.295**	-3.695*	-0.552**	-1.577**	-1.867**
	(1.890)	(1.951)	(0.217)	(0.726)	(0.743)
Observations	1,534	1,524	1,524	1,534	1,534
R-squared	0.807	0.811	0.872	0.804	0.839
Fixed Effects	Product X Importer, Importer X Year, Number of AD committee, After AD investigation				
Cluster	Product X Importer				

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Description: This table presents the impact of anti-dumping tariffs that other countries imposed on Russia on Russian trade, estimated with Model 1. *Log Value* denotes the log of Harmonized System (HS) 6-digit level free on board (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* denotes the log of import price (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 exports value by Russia to all destinations in the same HS 6-digit product that other countries initiated an AD investigation on 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 on Russia in the same 6-digit product that the AD tariff is imposed. The import data is from the United Nations Comtrade Database acquired through the BACI Database of CEPII (Gaulier and Zignago 2010). The AD data is from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020.

3 Model

In this section, 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, we present how governments choose tariffs.

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 households is a Cobb-Douglas function of sector-level consumption goods, C_n^j. Households supply labor inelastically.

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

$$P_n^C = \prod_{j=1}^{J} \left(P_n^j\right)^{\alpha_n^j}. \tag{3}$$

3.2 Intermediate Goods Producer

We assume that all markets competitive, just as Caliendo and Parro (2015). Labor is freely mobile across sectors within a country but is 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:

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

where A_n^j denotes the TFP, L_n^j denotes sectoral employment, and $M_n^{j,k}$ denotes the quantity of sector k composite goods that are 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:

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

where w_n denotes the wage of country n.

3.3 Composite Goods

A country's consumers and firms source their composite goods 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^j_{ni} 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:

$$Q^j_n = C^j_n + \sum_{k=1}^{J} M^{j,k}_n \tag{5}$$

3.4 Expenditure Share

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

$$p^j_{ni} = t^j_{ni} k^j_{ni} p^j_n,$$

where $t^j_{ni} = 1 + \tau^j_{ni}$ is one plus the ad-valorem tariff that country n imposes on country i and where k^j_{ni} 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^j_n, country n's expenditure share on sector j's output from country i equals:

$$\pi^j_{ni} = \frac{(t^j_{ni} k^j_{ni} p^j_i)^{1-\sigma^j}}{\sum_{h=1}^{N} (t^j_{nh} k^j_{nh} p^j_h)^{1-\sigma^j}} \tag{6}$$

The composite goods price is thus given by:

$$P^j_n = \left[\sum_{i=1}^{N} (t^j_{ni} k^j_{ni} p^j_i)^{1-\sigma^j} \right]^{1/(1-\sigma^j)}. \tag{7}$$

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

3.5 Market Clearing

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:

$$X_n^j = \sum_{k=1}^{J} \gamma_n^{k,j} \sum_{i=1}^{N} \frac{X_i^k \pi_{in}^k}{t_{in}^k} + \alpha_n^j I_n, \tag{8}$$

where the first term is country n's demand for inputs 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:

$$I_n = w_n L_n + R_n + D_n \tag{9}$$

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

$$R_n = \tau_{ni}^j \sum_{i=1}^{N} \frac{X_i^k \pi_{in}^k}{t_{in}^k}. \tag{10}$$

Using Equation 8 and the definition of the trade deficit, we can write the labor market clearing condition:

$$w_n L_n = \sum_{j=1}^{J} \gamma_n^j \sum_{i=1}^{N} \frac{X_i^j \pi_{in}^j}{t_{in}^j}. \tag{11}$$

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

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

1. *firms maximize profit (Equation 4);*
2. *the price index satisfies Equations 6 and 7;*
3. *the goods markets clear, satisfying Equations 8 and 9;*

4. the labor market clears, satisfying Equation 11;

5. the government budget constraint (Equation 10) holds.

3.6 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), 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 domestic households' welfare. On the other, they want to minimize Russian welfare. Russia also chooses tariffs to maximize its own welfare and to reduce the sanctioning countries' welfare. We assume that the neutral countries do not change tariffs.[15]

Before we define formally 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 $(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}})$:

$$G_n(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}) = \frac{I_n(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}})}{P_n^C(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}})}, \tag{12}$$

where $I_n(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}})$ denotes household income (Equation 9) and $P_n^C(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}})$ denotes the consumer price index (Equation 3).

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

$$g_n(\boldsymbol{\tau_{-nR}}) \in argmax_{\{\boldsymbol{\tau_{nR}}\}} \rho G_n(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}) - (1-\rho) G_R(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}), \tag{13}$$
$$\text{s.t. Equilibrium Conditions 4-11,}$$

where ρ is the willingness to pay for sanctions against Russia. In other words, the local government is willing to pay $\$\frac{1-\rho}{\rho}$ for every \$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 of its own

[15]We also consider the case in which Russia keep its tariffs constant.

welfare.[16]

Russia, the sanctioned country, trades off maximizing its own welfare and retaliating against the countries that impose the sanctions. Use $\boldsymbol{S}$ to denote the set of sanctioning countries. Russia's problem is the following:

$$g_R(\boldsymbol{\tau_{-RS}}) \in argmax_{\{\boldsymbol{\tau_{RS}}\}} \rho G_R(\boldsymbol{\tau_{-RS}}, \boldsymbol{\tau_{-RS}}) - (1-\rho) \sum_{n \in S} \frac{G_n(\boldsymbol{\tau_{-RS}}, \boldsymbol{\tau_{-RS}})}{N_S} \tag{14}$$

s.t. Equilibrium Conditions 4-11,

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. As with sanctioning countries, ρ captures the willingness to pay for tariff retaliation against sanctioning countries.[17]

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

1. *given tariffs $\{\tau_{ni}^j\}_{j,n,i}$, $\{\{P_n^j\}_{n,j}, \{w_n\}_n\}$ 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 eliminate the fundamentals that are invariant to tariff changes and are difficult to calibrate

[16]In Section C.4, we consider an alternative cost-efficient sanction problem where the sanctioning countries minimize Russia's welfare but require that their own welfare does not decrease.

[17]In the baseline scenario in Section 5, we assume that Russia has the same ρ as the sanctioning countries. In Section 5.4.2, 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.

(for example, non-tariff trade barriers $\{k^j_{ni}\}_{j,n,i}$). We present the sanction equilibrium in changes in Appendix Section B.1.

4 Calibration

To calibrate our model, we rely on two main data sources: 1) the OECD Inter-Country Input-Output (OECD ICIO) Database and 2) estimates of the trade elasticity. We calibrate the baseline global economy to their 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.[18] Countries $i, n \in$ {EUN,OSA,ROW,RUS,USA} denote the European Union, other sanctioning countries, rest of the world, Russia, and United States.[19] European Union and United States are the two largest economies that sanction Russia. Other sanctioning countries comprise Australia, Canada, Israel, Japan, South Korea, New Zealand, Norway, Singapore, Switzerland, Taiwan, and United Kingdom, which are the economies that have joined sanctions on Russia by March 31, 2022.[20] 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. Rest of the world 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.[21]

We calibrate country-bilateral and sector level expenditure shares, π^j_{ni}, country-level input-output coefficients, $\gamma^{k,j}_n$, country-level value added, $w_n L_n$, and country-level trade deficit, D_n, directly to their data counterparts in OECD ICIO.

[18]See Appendix Table A.11 for the list of OECD ICIO sectors and their correspondence with the International Standard Industrial Classification (ISIC) Rev. 4 sectors. As there is no import tariff variation on the service sectors, we merge all service sectors into one single sector.

[19]The European Union 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.

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

[21]Section C.1 in the appendix discusses statistics of Russian trade.

4.1 Estimation of Sector-level Trade Elasticity

We estimate the sector-level trade elasticity, θ^j, which is arguably the most important parameter for tariff analysis (Hillberry and Hummels 2013).[22] We use a similar empirical strategy as in Section 2. We take advantage of the AD investigations and tariffs that all countries impose on all their trade partners to identify the elasticity of imports to tariffs, i.e., the trade elasticity, on the sector level. We estimate it for each goods sector listed in the 2018 OECD Inter-country Input-output Database (OECD ICIO 2018).[23] To this end we use a specification similar to Equation 1:

$$y_{p,d,o,t} = \theta^{j(p)} \tau_{p,d,o,t} + \beta \mathbb{I}_{p,d,o,t} \{\text{After AD}\} + \gamma \mathbb{N}_{p,d,o,t} \{\text{Committee}\} \tag{15}$$

$$+ \eta_{p,t} + \eta_{p,d} + \eta_{p,o} + \eta_{d,t} + \eta_{o,t} + \epsilon_{p,d,o,t}, \tag{16}$$

where p denotes the product, d denotes the destination, o denotes the origin of the trade flow, t denotes the year, and j denotes the sector that product p belongs to. Moreover, $y_{p,d,o,t}$ denotes the trade values of product p from country o to country d in year t. $\tau_{p,d,o,t}$ denotes the AD tariff that country d imposes on country o in year t on the same product p. $\mathbb{I}_{p,d,o,t} \{\text{After AD}\}$ takes one if year t is after the first AD investigation that country d conducts on product p from country o. $\mathbb{N}_{p,d,o,t} \{\text{Committee}\}$ controls the number of investigation committees formed on 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. Table A.6 shows the summary statistics of the variables included in this regression.

Table 2 shows our estimated trade elasticity, θ^j, 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 equals 6.09. Consistent

[22] Remember that $\theta^j = \sigma^j - 1$ where σ^j denotes the elasticity of substitution across countries (see Section 3.3).

[23] To ensure that there is sufficient cross-product variation that helps us identify the trade elasticities by sector, we estimate the elasticity by pooling together the agriculture sector (D01-D02 of ISIC Rev. 4) and food sector (D10-D12 of ISIC Rev. 4), and pooling together all mining and energy sectors (D05-D09 and D19 of ISIC Rev. 4). We control for product-year, product-destination, product-origin, destination-year, and origin-year fixed effects separately to allow for sufficient variation to identify the elasticities by sector.

with our intuition, sectors that are perceived less substitutable across countries, for example, minerals and manufactured products, have lower trade elasticities than those that are perceived more substitutable across countries, for example, energy and chemical products.

Figure A.5 shows that our estimated elasticities are positively correlated with the estimates acquired by Caliendo and Parro (2015) and the values that we estimate with using the Feenstra (1994) method.[24] On average, our estimates are lower than those found in Caliendo and Parro (2015) (in Figure A.5a more than half of the sectors are below the 45-degree line, and their average estimate across all sectors equals 9.1).[25] Our estimates are higher than those that we estimate with the Feenstra (1994) method (in Figure A.5b, most sectors are above the 45-degree line).[26]

Table 2: **Estimated Sectoral Trade Elasticity, 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				

Description: This table presents the sector-level trade elasticities that we estimate 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.

5 Results

[24]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.

[25]The reason why our estimates are lower than those recovered in Caliendo and Parro (2015) is likely the role of trade policy. de Souza and Li (2021) shows that our treatment and control groups face similar trade policy uncertainty before a tariff was imposed. However, Caliendo and Parro (2015) do not control 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.

[26]Using the Feenstra (1994) method, the average elasticity across all sectors equals 2.6.

5.1 Cost-Efficient Sanctions

In this section we discuss the cost-efficient sanctions imposed by the EU. Figure 3 shows statistics of the optimal sanctions imposed by the EU according to the different levels of willingness to pay for sanctions, ρ. The first panel plots the cost-efficient sanctions for selected sectors. The second panel plots change in imports in the EU implied by different sanctioning schemes.

Cost-efficient sanctions are small and uniform across sectors for a small willingness to pay for sanctions, according to Figure 3. If the EU is willing to pay \$0.1 for each \$1 of income drop in Russia, i.e., $\rho = 0.9$, tariffs should average about 20% for all sectors. They increase with a higher willingness to pay but the dispersion across sectors is small.[27]

Even for a small willingness to pay for sanctions, imports from Russia should drop by more than 80%. If the EU chooses tariffs to maximize its own welfare, i.e., $\rho = 1$, trade with Russia would drop by 60%. Higher tariffs against Russia increase the EU's real income by reducing the price of imported goods relative to exported ones.[28] If the EU has positive willingness to pay for sanctions, it wants to decreases trade with Russia even further. For a willingness to pay of only \$0.4 per dollar for \$1 income dropped in Russia, i.e., $\rho = 0.7$, the EU impose tariffs that decrease Russian imports by 95%.

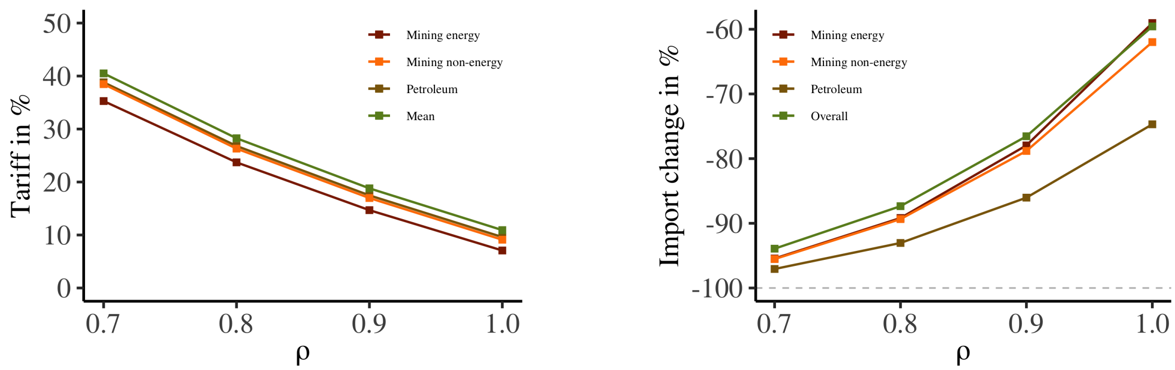
If the EU is willing to pay above \$0.7 dollars for each \$1 dollar of income loss in Russia, i.e., ρ is below 0.6, high taxes on mining and energy products are optimal. Figure 4 extends the horizontal axis of Figure 3 to $\rho = 0.4$, under which the EU is willing to pay \$1.5 for each \$1 of income drop in Russia, and shows optimal tariffs and trade flows changes accordingly. If the EU would like to pay \$0.7 dollars to reduce Russian real income by \$1, tariffs on mining and energy products are specially high, according to Figure 5. A tariff on energy extraction sector products, which includes crude oil and natural gas, is above 300%, and a 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 \$1.5, tariffs on all sectors are above 80% and an embargo on all sectors is optimal.

[27]In Section C.4, we solve the alternative cost-efficient sanction problem where the sanctioning countries minimize Russia's welfare with their own welfare non-decreasing. We find that those cost efficient sanction tariffs resemble the optimal tariffs under low willingness to pay for sanctions.

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

Figure 3: **Cost-Efficient Tariffs in the EU for Different ρ's,** $\rho \in [0.7, 1.0]$

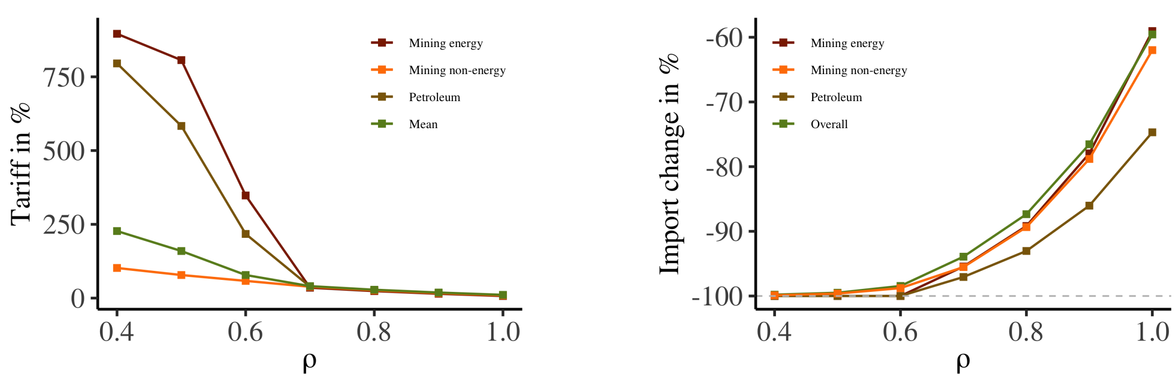
(a) Tariff (b) Change in Imports



Description: This figure shows statistics of 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 3a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted 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.

Figure 4: **Cost-Efficient Tariffs in the EU for Different ρ's,** $\rho \in [0.4, 1.0]$

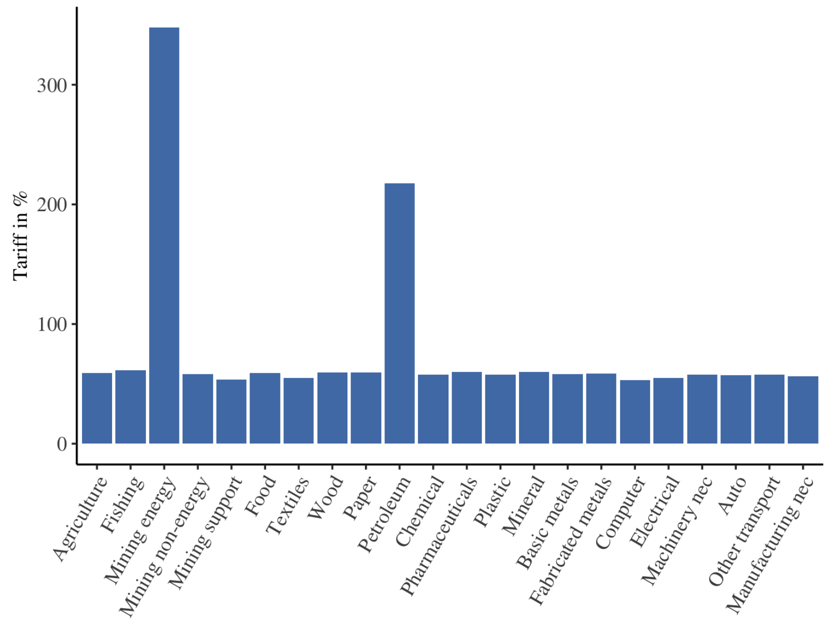
(a) Tariff (b) Change in Imports



Description: This figure shows statistics of 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 tariff on mining energy, mining non-energy, petroleum, and the average unweighted 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.

Conditional on the willingness to pay for sanctions, trade elasticities and initial import share are important determinants of tariffs. For a low willingness to pay, tariffs 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 (see, for example, Bagwell and Staiger 1990). The products in which

Figure 5: **Cost-Efficient Tariffs 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 0.7 dollars for one dollar real income loss in Russia.

the terms of trade are more affected by tariffs are the ones with lower demand elasticity and lower import share.[29]

When there is a large enough willingness to pay for sanctions, tariffs are targeted at 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 more, and cause more harm in Russia. Appendix C.2 discusses these intuitions in detail.

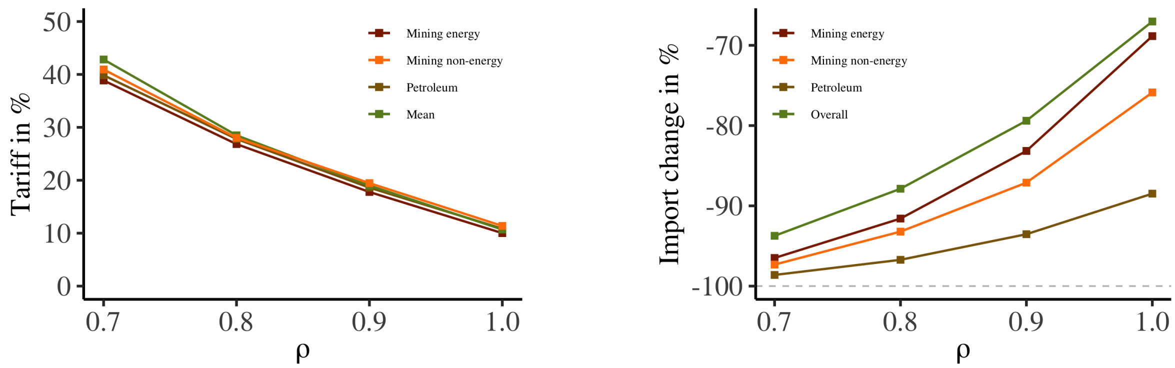
The USA and Other Sanctioning Allied Countries (OSA) follow the same pattern of cost-efficient tariffs, according to Figures 6 and 7. In both cases, cost-efficient sanctions are small and uniform across sectors for small willingness to pay for sanctions but they still cause a large drop in trade with Russia. Figures C.3 shows that as the willingness to pay increases, US optimal tariffs increase uniformly across sectors. The reason is that, as Figure A.4a shows, US expenditure share on Russia is small and similar across sectors. Figure C.4 shows that for other sanctioning countries, embargo on mining and energy sectors is optimal if they

[29]For a formal proof, see Gros (1987), Broda et al. (2008), Opp (2010), Costinot et al. (2015), and Lashkaripour and Lugovskyy (2021), who derive theories that link optimal tariffs to market shares and trade elasticities.

would like to pay \$1 to reduce Russia's income by \$1. If the willingness to pay rises to \$1.5, an embargo by all sanctioning countries on all Russian products is optimal.

Figure 6: **Cost-Efficient Tariffs in the USA for Different ρ's,** $\rho \in [0.7, 1.0]$

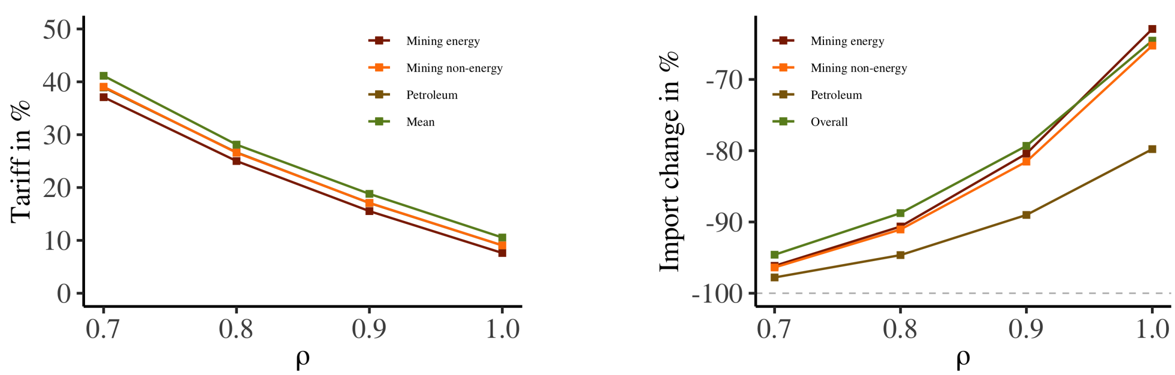
(a) Tariff (b) Change in Imports



Description: This figure shows statistics of the USA under cost-efficient sanctions with different willingness to pay. Figure 6a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure 6b plots the percentage change in imports in the USA at different sectors.

Figure 7: **Cost-Efficient Tariffs in the OSA for Different ρ's,** $\rho \in [0.7, 1.0]$

(a) Tariff (b) Change in Imports



Description: This figure shows statistics of the other sanctioning allies (OSA) under cost-efficient sanctions with different willingness to pay. Figure 7a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure 7b plots the percentage change in imports in the other sanctioning allies (OSA) at different sectors.

5.2 The Welfare Cost of Sanctions

5.2.1 The Welfare Cost of Sanctions on Russia

How much welfare loss can sanctions cause in Russia? To answer this question, Figure 8 shows the welfare changes of 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 14. In the case without Russian retaliation (8b), Russian tariffs are constant at the calibrated value.

According to Figure 8, sanctions can decrease Russian welfare between 0.5% and 3%.[30] 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%. The reason is 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.[31] Because of this, restricting imports from the sanctioning countries cannot reduce the sanctioning countries' income much, but it induces large price increase and real income loss in Russia.[32]

5.2.2 The Welfare Cost of Sanctions on Sanctioning Countries

How much do sanctions cost the sanctioning countries? According to Figure 8, the welfare cost of sanctions is small. The sanctioning countries face a welfare loss of between 0.1% and 0.2%, depending on if Russia retaliates or not. Despite the fact that Russian imports are a large share in some sectors of the sanctioning countries, on average the share corresponds to only 6%, 1%, and 2%, in the EU, USA, and OSA, respectively. Therefore, the losses that the allies can incur are limited.

[30] Under $\rho = 1$ where the sanctioning countries optimally choose tariffs to maximize their own welfare, these tariffs also reduce Russia's welfare (see Figure 8). This is the classical "beggar thy neighbor" effect considered in, for example, Maggi and Rodriguez-Clare (1998).

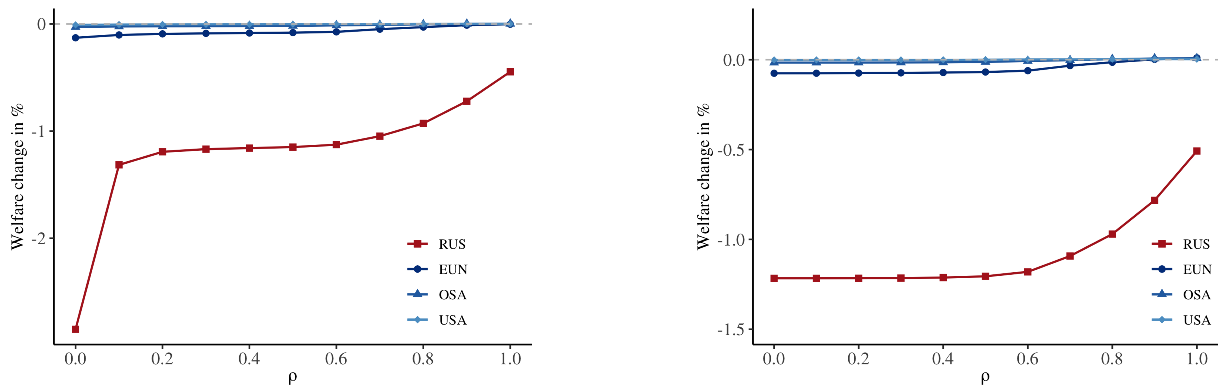
[31] Russia spends 5.2% of their total expenditures on the sanctioning countries. The sanctioning countries sell 0.2% of their output to Russia. See Figures A.4c and A.4d.

[32] This finding also indicates that, as long as Russia cares about domestic welfare ($\rho_{RUS} \geq 0.1$), Russia should not impose high retaliatory tariffs on the sanctioning countries, and the consequences of sanctions are similar with and without Russian retaliation. In Section 5.4.2 we elaborate this point further. We show that the sanctioning countries' optimal tariffs are not significantly affected by Russia's retaliation strategies.

Figure 8: **Welfare Changes with and without Russian Retaliation**

(a) With Russian Retaliation

(b) Without Russian Retaliation



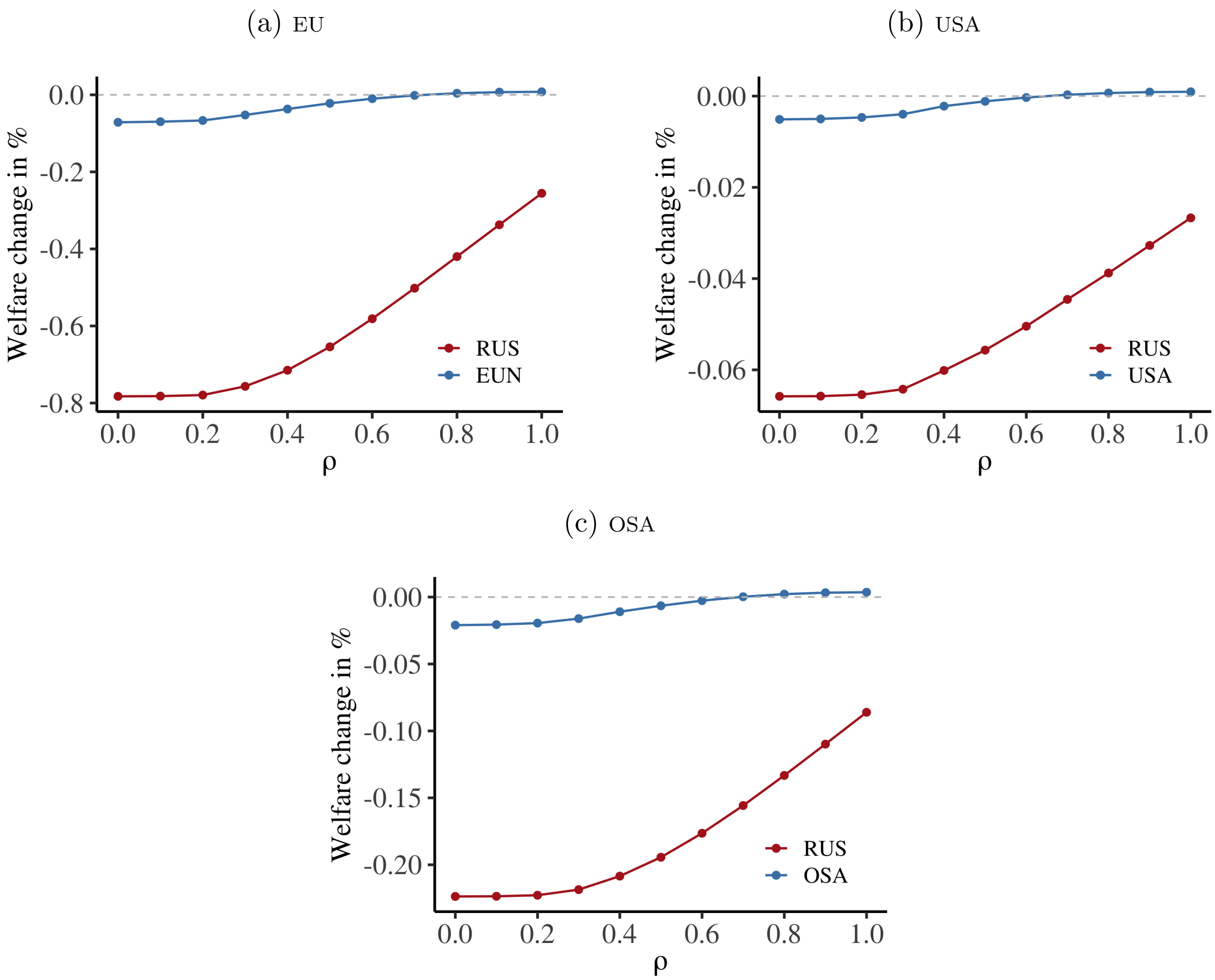
Description: This figure shows the welfare change by the different willingness to pay for sanctions, ρ, under two variations of the model discussed in Section 3. Figure 8a displays the welfare changes in Russia, the European Union nations (EUN), the other sanctioning countries (OSA), and the USA when Russia also changes its tariff to affect the welfare of the sanctioning countries. Figure 8b displays the welfare change in Russia, the European Union nations (EUN), the other sanctioning countries (OSA), and the USA 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.

To understand which of the sanctioning countries can impose a larger cost on Russia, we consider the case where the EU, the USA, and other sanctioning countries individually set tariffs to target Russia's real income. For simplicity, we assume that Russia keeps its tariffs constant. Figure 9 shows the welfare changes of 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 13 while Russia and all the other countries keep their tariff constant.

According to Figure 9, 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%. The US and OSA would have a welfare loss of only 0.01% and 0.02%. The reason is that the EU is the country that trades the most with Russia.

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

Figure 9: 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 9a shows the welfare change if the EU chooses tariffs against Russia to maximize 13 while all the other countries have tariffs constant. Figure 9b shows the welfare change if the US chooses tariffs against Russia to maximize 13 while all the other countries have tariffs constant. Figure 9c shows the welfare change if OSA chooses tariffs against Russia to maximize 3 while all the other countries have tariffs constant. Welfare refers to the equilibrium real income. Changes are calculated comparing to the equilibrium with current tariffs.

5.3 Political Weights

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

$$G_R^{pol}(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}) = \sum_{j=1}^{J} \lambda^j I_R^j(\tau_{\mathbf{nR}}, \tau_{\mathbf{-nR}}), \tag{17}$$

where λ^j is the political weight of sector j and $I_R^j(\tau_{\mathbf{nR}}, \tau_{\mathbf{-nR}})$ is real income in sector j.[33] [34] [35]

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

$$g_n^{pol}(\boldsymbol{\tau_{-nR}}) \in argmax_{\{\boldsymbol{\tau_{nR}}\}} \rho G_n(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}) - (1-\rho) G_R^{pol}(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}), \tag{18}$$
$$\text{s.t. Equilibrium Conditions 4-11,}$$

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

Calibration We calibrate political weights to reflect the revenue share of companies owned by individuals sanctioned by the EU, UK, or the USA. First, we collect the names of the Russian individuals who have been sanctioned by European Union, United Kingdom, and United States by Mar 10, 2022.[36]. Those are part of the Russian political elite, called oligarchs, which are believed to support the current regime. 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.[37] Third, we connect the industry names used in RBC 500 to OECD ICIO sectors. In the last step, we calculate, for

[33]Real income in sector j is given by $\frac{L_R^j(\boldsymbol{\tau_{nR}},\boldsymbol{\tau_{-nR}})}{L_R}\frac{I_R(\tau_{\mathbf{nR}},\tau_{\mathbf{-nR}})}{P_R^C(\tau_{\mathbf{nR}},\tau_{\mathbf{-nR}})}$, 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.

[34]In this model, sector j's employment share is also the sector's share in Russian GDP.

[35]In Appendix Section B.2, we rewrite this optimal sanction problem in changes, where we further elaborate on this point.

[36]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`

[37]The RBC 500 rating has been published since 2015. The rating is to identify 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 would be estimated.

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_{Rj}.

Table 3: **Summary Statistics of Political Weights**

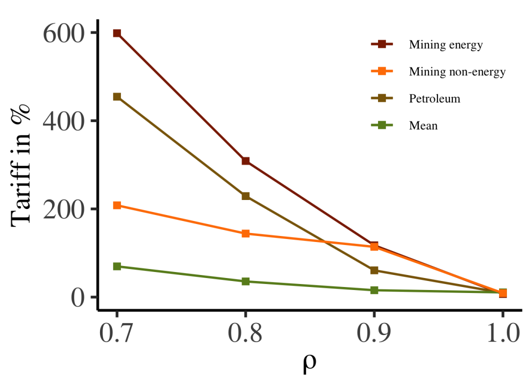
Sector	# Firms owned by Oligarchs	Oligarch Share (λ_{Rj})
Agriculture	2	4.89%
Mining energy	11	47.56%
Mining non-energy	6	57.57%
Petroleum	7	57.84%
Chemical	5	41.47%
Basic metals	7	12.79%
Machinery n.e.c.	1	14.31%
Manufacturing n.e.c.	1	9.75%
Service	32	8.82%

Description: This table presents summary statistics of 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. The data is compiled for this research.

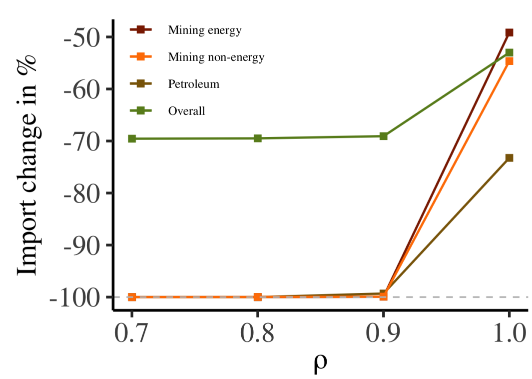
Table 3 shows the summary statistics of political weights computed using Russian oligarchs' share of revenue in each sector. Nine out of 23 sectors have oligarch-owned firms, among which the petroleum sector has the highest political weight, 57.84%, indicating that over half of the revenue in this sector is generated by firms owned by oligarchs.

Figure 10: **Cost-Efficient Tariffs with Political Weights in the EU for Different ρ's, $\rho \in [0.7, 1.0]$**

(a) Tariff



(b) Change in Imports



Description: This figure shows statistics of the EU under cost-efficient sanctions with different willingness to pay when the EU uses political weights described in 3. Figure 4a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure 4b plots the percentage change in imports in the EU at different sectors.

Results Even for countries with a small willingness to pay for sanctions, an embargo against Russian mining and energy sectors are the most cost-efficient sanction, according to result in Figure 10. If the EU is willing to pay \$0.1 for each \$1 of income drop in Russia, i.e., $\rho = 0.9$, tariffs should be concentrated in the mining and energy sector. That happens because those are the sectors with the highest concentration of firms owned by Russian oligarchs. Moreover, tariffs should be high enough to decrease imports of mining and energy products from Russia by almost 100%.

Figures C.5 and C.6 show the optimal sanction tariffs and resulting import changes by the US and other sanctioning countries. Similar to the EU, for small willingness to pay for sanctions, i.e. \$0.1 to reduce Russian real income by \$1, an embargo on mining and energy sector imports from Russia is optimal.[38]

5.4 Robustness

In this section, we show that the cost-efficient sanctions that we derive are robust to two alternative model specifications. First, we replace the trade elasticities that we estimated with those that Caliendo and Parro (2015) acquired. Second, we consider alternative retaliation strategies by Russia.

5.4.1 Caliendo and Parro (2015) Trade Elasticities

We show that the cost-efficient sanctions are robust, if we replace the sectoral trade elasticities that we estimate using the difference-in-differences strategy with the estimates that Caliendo and Parro (2015) acquired. The reason is that, as we show in Figure A.5a, these two sets of elasticities are positively correlated.[39]

Figures C.7 to C.10 show the sanctioning countries' optimal strategies under these elasticities. If they would like to pay \$0.1 for \$1 decline in Russia's welfare, the optimal tariffs

[38]Figures C.5 and C.6 also show that if the US and other sanctioning countries 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 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.

[39]The correlation is 0.57.

should equal, on average, about 15%. Compared to the our estimated trade elasticities, lower willingness to pay for sanction can justify mining and energy sector embargo under Caliendo and Parro (2015) trade elasticities. Petroleum sector embargo by the EU is optimal if the willingness to pay is as low as \$0.1 to reduce Russian real income by \$1. If the EU's willingness to pay rises to \$0.7, an embargo on all mining and energy sectors is optimal. As Figure A.5a shows, Caliendo and Parro (2015) trade elasticities are higher than ours on average, and especially so for the energy sectors. Given the willingness to pay for sanction, higher trade elasticities provide the sanctioning countries incentives to impose higher tariffs because they can divert more exports away from the opponent and harm their income more.

Similar to Figure 4, if the sanctioning countries are willing to pay \$1.5 for \$1 reduction in Russia's welfare, an embargo on Russian imports in all sectors is optimal.

5.4.2 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 A.4c), Russia's retaliation on the sanctioning countries' exports should not strongly affect the latter group's output, income, nor their incentives to impose sanctions.[40] In this section we consider two alternative Russian retaliations: in solving Problem 14, Russia always sets their retaliation tariff to maximize their own real income ($\rho_{RUS} \equiv 1$) and to minimize the sanctioning countries' real income ($\rho_{RUS} \equiv 0$).

Figures C.11 to C.16 show the sanctioning countries' optimal tariffs and the associated import changes, with $\rho_{RUS} \equiv 1$. Figure C.17 to C.22 show the same set of variables for $\rho_{RUS} \equiv 0$. Similar to Section 5 where ρ_{RUS} equals that of the sanctioning countries, for small willingness to pay to sanction Russia (\$0.1 for \$1 real income drop in Russia), the sanctioning countries should optimally impose around 20% tariffs on all sectors. If the sanctioning countries would like to pay \$0.7 of their real income to reduce Russian real income by \$1, an embargo on mining and energy sectors is optimal for the EU. For willingness to pay higher than \$1.5, a embargo on all Russian products by all sanctioning countries is

[40]This is also corroborated by Figure 8 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.

optimal.

6 Conclusion

In this paper we study how countries should optimally impose import sanctions. We investigate how these sanctions depend on countries' willingness to pay for sanctions, trade shares, and trade elasticities. We develop a model of tariff competition which features multiple countries, multiple sectors and input-output linkages. Countries weigh the objectives of maximizing their own income and diminishing their opponent's income, and they respond optimally to other countries' tariff strategies.

Russia's invasion of Ukraine has caused significant causalities, economic damage, and threatened global stability and economic prosperity. We apply the model to study the cost-efficient sanctions on Russia. Basing on the difference-in-differences empirical strategy developed in de Souza and Li (2021) and global anti-dumping investigations and tariffs from the Global Anti-dumping Database (Bown 2005), we first document that tariffs on imports from Russia strongly decrease Russian total exports and the sanctioning country's total imports in the targeted products. Using the same empirical strategy, we estimate the model's trade elasticity for each sector.

We find that if the sanctioning countries would like to pay \$0.1 of real income to diminish Russian real income by \$1, the sanctioning tariffs should be about 20% and similar across sanctioning countries and across sectors. If the sanctioning countries' willingness to pay rises to \$0.7, the EU should impose an embargo on the energy and mining sectors. If the willingness to pay increases to \$1.5, an embargo on all sectors is close to optimal.

We also find that sanctions by the EU can lead to larger real income loss in Russia than the USA and other sanctioning allies. Russian retaliation slightly increases the welfare loss in the sanctioning countries. However, it leads to substantially larger welfare loss in Russia.

Furthermore, if sanctions target the sectors that are politically relevant, a global embargo on Russia's mining and energy sectors is optimal even with low willingness to pay for sanctions.

Many countries have implemented trade sanctions on Russia. With these analyses, we propose a rationale why the observed sanctions differ across countries and sectors. We provide a toolbox that helps policy makers optimally impose sanctions, as they trade off between undermining Russia's capacity to continue its war and the cost on domestic welfare.

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A Empirics

A.1 Summary Statistics

Table A.1 shows the summary statistics of AD investigations that targeted Russia. During the sample period (1995-2020), Russia faced 393 AD investigations, among which 298 (75%) ruled positive. 150 products that Russia exported faced AD investigations, among which 112 had tariff increases.[41] 20 countries imposed AD tariffs on Russia. Conditional on an investigation that leads 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, conditional on an investigation that was ruled positive, the average AD tariff was the highest on metal and machinery sectors.

Table A.3 shows the summary statistics, by country, of the AD investigations that targeted Russia. The United States conducted the most AD investigations, followed by the European Union, Canada and Ukraine. Conditional on an affirmative investigation, the AD tariff rate imposed by the United States was the highest (52.63%).

Table A.2 shows the summary statistics of AD investigations that all countries imposed on their trade partners. There were a total of 15131 AD investigations, among which 10370 (68%) ruled positive. 1585 products faced AD investigations, among which 1298 had tariff increases. Conditional on an investigation that lead 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, on the world level, conditional on an investigation that was ruled positive, the average AD tariff was the highest on mining (non-energy), mining support and automobile sectors. Table A.4 and A.5 shows the summary statistics of global AD investigations by the investigating country and the exporting country.

[41] A product refers to a Harmonized System (HS) 6-digit code.

Table A.1: **Statistics of AD Investigations that Targeted 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 of the anti-dumping investigations that targeted Russia during 1995 and 2020. Each investigation is conducted on a product from Russia. The average and median tariff is the simple average and the median across investigations. The investigation-level tariff is computed in ad-valorem terms.

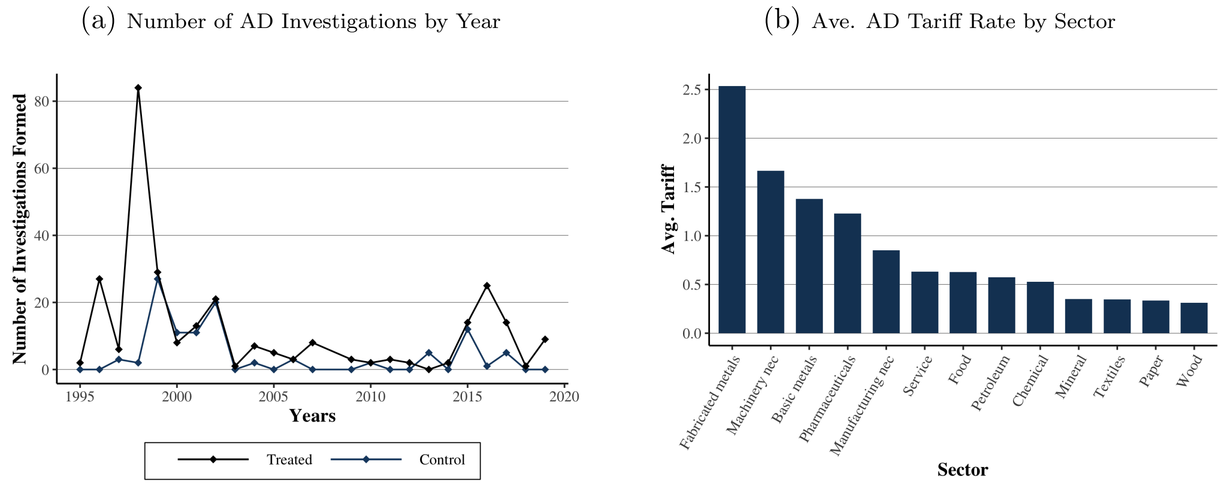
Table A.2: **Statistics of Global AD Investigations**

	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 of the anti-dumping investigations that targeted Russia during 1995 and 2020. Each investigation is conducted on a product from Russia. The average and median tariff is the simple average and the median across investigations. The investigation-level tariff is computed in ad-valorem terms.

A.2 Other Figures and Tables

Figure A.1: **Summary Statistics of AD Investigations on Russia**



Description: This figure shows the summary statistics of the AD investigations and AD tariffs that target Russia. The left panel shows the number of AD investigations that are ruled affirmative and negative 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 the 2018 OECD Inter-country Input-output Database (OECD ICIO 2018). The AD data is from the Global Anti-dumping Database (Bown 2005). The sample runs from 1995 to 2020.

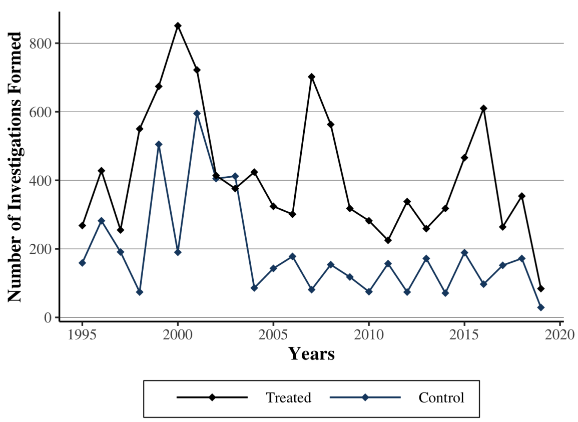
Table A.3: **AD Investigations that Targeted Russia by Country**

	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

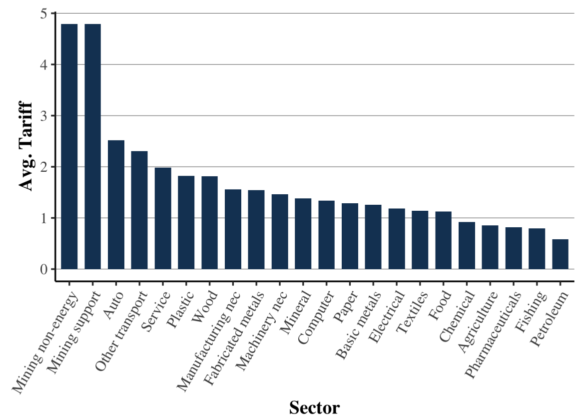
Description: This table presents summary statistics of the AD investigations that targeted Russia by the country that initiated the investigation. The table shows the number of investigations, the fraction of the investigations that lead to a tariff increase, the average tariff rate conditional on an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

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

(a) Number of AD Investigations by Year



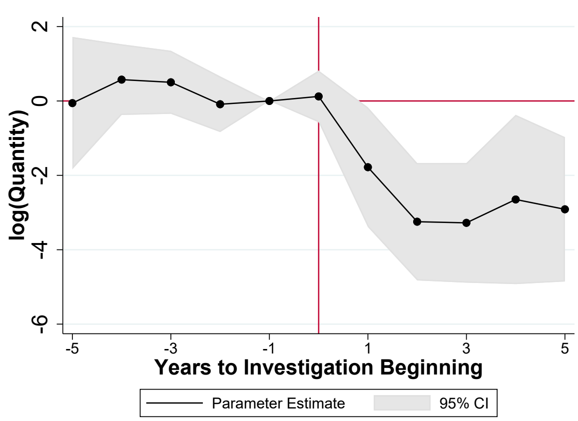
(b) Ave. AD Tariff Rate by Sector



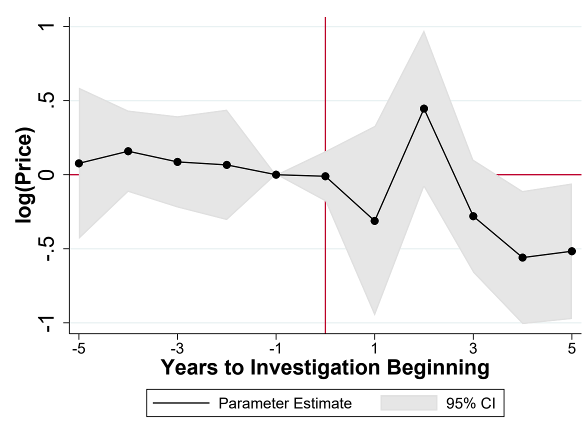
Description: This figure shows the summary statistics of the AD investigations and AD tariffs that all countries imposed on their trade partners. The left panel shows the number of AD investigations that are ruled affirmative and negative by year. The right panel shows, by sector, the average tariff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

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

(a) Quantity



(b) Price



Description: This figure shows the dynamic impact of AD tariffs on the quantity and price of imports using Model 2. 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 Harmonized System (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.

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 of the global AD investigations by the country that initiated the investigation. The table shows the number of investigations, the fraction of the investigations that lead to a tariff increase, the average tariff rate conditional on an affirmative investigation, and the average tariff rate of all investigations. The AD data is 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 of the global AD investigations by the exporting country. The table shows the number of investigations, the fraction of the investigations that lead to a tariff increase, the average tariff rate conditional on an affirmative investigation, and the average tariff rate of all investigations. The AD data is from the Global Anti-dumping Database. The sample runs from 1995 to 2020.

Table A.6: **Summary Statistics of Diff-in-Diff 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

Table A.7: **Effect of AD Tariffs on Imports from Russia**

Dependent Variable	Log Value			
	(1)	(2)	(3)	(4)
Anti-dumping Tariff	-4.295**	-4.295**	-4.468**	-3.966*
	(1.890)	(1.917)	(1.992)	(2.004)
Observations	1,534	1,534	1,534	1,638
R-squared	0.807	0.807	0.804	0.688
Product X Importer	X	X	X	
Importer X Year	X	X	X	
Number of AD committee	X	X		X
After AD investigation	X	X	X	X
Product				X
Importer				X
Year				X
Dummy for AD committee			X	
Cluster	Product X Importer	4-digit X Importer	Product X Importer	Product X Importer

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Description: This table presents the impact of anti-dumping tariffs imposed on Russia by other countries on the log of imports from Russia by the country that initiated the AD investigation. We study Harmonized System (HS) 6-digit level imports. Imports are measured in free on board (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.

Table A.8: **Effect of AD Tariffs on Total Exports**

Dependent variable	Log Total Exports			
	(1)	(2)	(3)	(4)
Anti-dumping Tariff	-1.577**	-1.577*	-1.445*	-1.013
	(0.726)	(0.796)	(0.741)	(0.989)
Observations	1,534	1,534	1,534	1,638
R-squared	0.804	0.804	0.803	0.657
Product X Importer	X	X	X	
Importer X Year	X	X	X	
Number of AD committee	X	X		X
After AD investigation	X	X	X	X
Product				X
Importer				X
Year				X
Dummy for AD committee			X	
Cluster	Product X Importer	4-digit X Importer	Product X Importer	Product X Importer
Robust standard errors in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

Description: This table presents the impact of anti-dumping tariffs imposed on Russia by other countries on the log of Harmonized System (HS) 6-digit level total exports by Russia to all destinations. The coefficients are estimated with Model 1. Total exports refer to total exports of the HS 6-digit level product by Russia to all destinations; these exports of the same 6-digit product 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.

Table A.9: **Effect of AD Tariffs on Total Imports**

Dependent Variable	Log Total Imports			
	(1)	(2)	(3)	(4)
Anti-dumping Tariff	-1.867**	-1.867**	-1.890**	-1.499*
	(0.743)	(0.764)	(0.826)	(0.871)
Observations	1,534	1,534	1,534	1,638
R-squared	0.839	0.839	0.837	0.738
Product X Importer	X	X	X	
Importer X Year	X	X	X	
Number of AD committee	X	X		X
After AD investigation	X	X	X	X
Product				X
Importer				X
Year				X
Dummy for AD committee			X	
Cluster	Product X Importer	4-digit X Importer	Product X Importer	Product X Importer
Robust standard errors in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

Description: This table presents the impact of anti-dumping tariffs imposed on Russia Russia by other countries on the log of Harmonized System (HS) 6-digit level total imports by another country from all origins. The coefficients are estimated with Model 1. Total imports refer 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 product on which the AD tariff has 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.

Table A.10: **Effect of AD Tariffs on Trade Diversion**

VARIABLES	(1) Log Exports to Other Destinations	(2) Log Imports from Other Origins	(3) Log Imports of Other Products
Anti-dumping Tariff	0.202	0.112	-0.214
	(0.525)	(0.372)	(0.344)
Observations	1,063	1,062	1,064
R-squared	0.888	0.908	0.901
Fixed Effects	Product X Importer, Importer X Year, Number of AD committee, After AD investigation		
Cluster	Product X Importer		
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Description: This table presents the impact of anti-dumping 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 Harmonized System (HS) 6-digit level product by Russia to all destinations except the country that imposed the anti-dumping 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 Harmonized System (HS) 6-digit level imports by the country that imposed the anti-dumping 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.

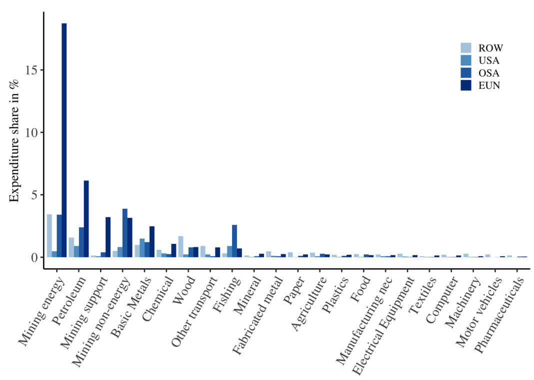
Table A.11: **OECD ICIO Sectors and International Standard Industrial Classification (ISIC) Revision 4 Sectors**

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

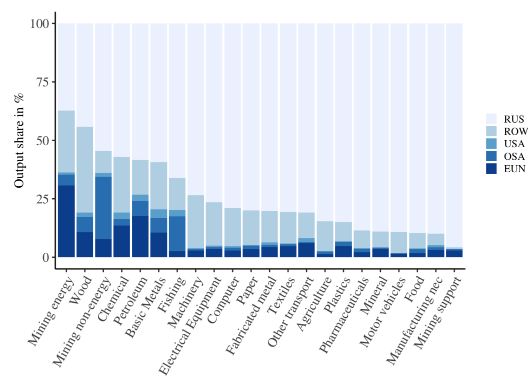
Description: This table shows the relationship between the OECD ICIO sectors that we consider and the International Standard Industrial Classification (ISIC) Rev. 4 sectors.

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

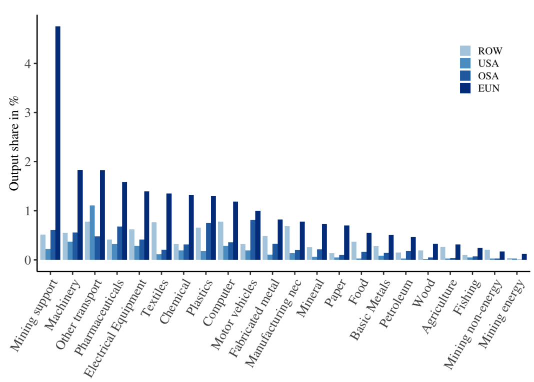
(a) Other Countries' Expenditure Share



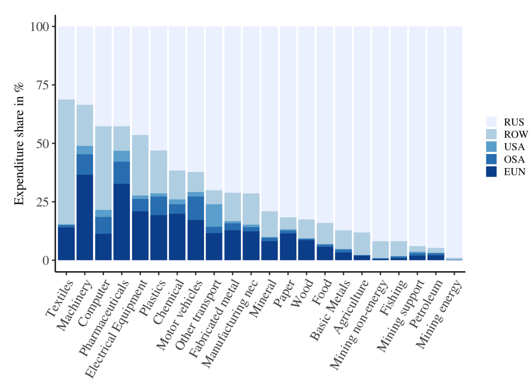
(b) Russia's Share of Output



(c) Other Countries' Share of Output



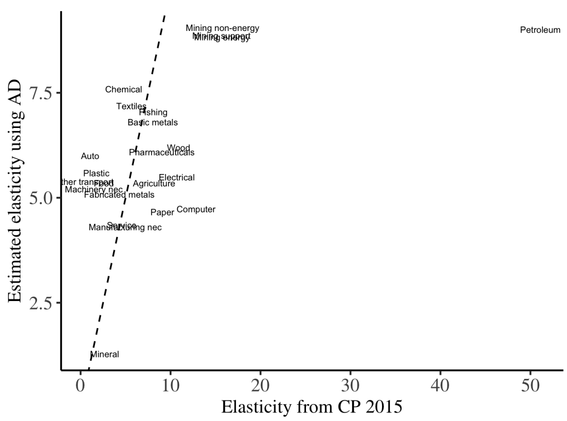
(d) Russia's Expenditure Share



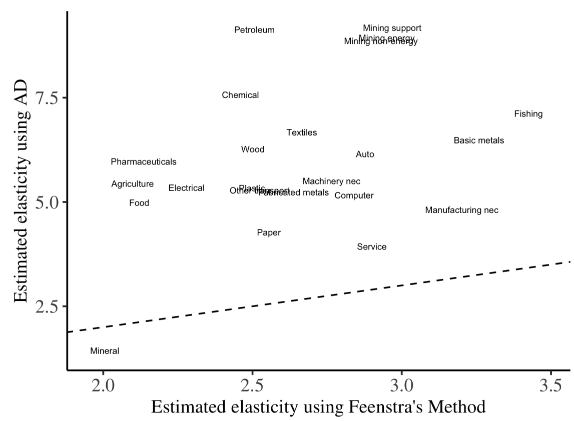
Description: This figure shows, by country and sector, the trade statistics with Russia. Figure A.4a shows the share from Russia in total expenditure on the sector's products. Figure A.4b shows the share of output sold to each country in Russia's sectoral total output. Figure A.4c shows the share of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

Figure A.5: **Correlation between Trade Elasticities Estimated with Diff-in-Diff and the Estimated Values (1) in Caliendo and Parro (2015) and (2) that we estimate with the Feenstra (1994) method**

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



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



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 with those that Caliendo and Parro (2015) find. The right panel shows the correlation between our elasticities with what we estimate with the Feenstra (1994) on the same level of sectors.

B Model

B.1 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 $\{\hat{t}^j_{ni}\}_{j,n,i}$ ($\hat{t}^j_{ni} = (1+\tau^{j'}_{ni})/(1+\tau^j_{ni})$):

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

$$\hat{P}^j_n = \left[\sum_{i=1}^{N} \pi^j_{ni} (\hat{t}^j_{ni} \hat{c}^j_i)^{-\theta^j} \right]^{-1/\theta^j} \tag{B.2}$$

$$\hat{\pi}^j_{ni} = \left(\frac{\hat{c}^j_i \hat{t}^j_{ni}}{\hat{P}^j_n} \right)^{-\theta^j} \tag{B.3}$$

$$X^{j'}_n = \sum_{k=1}^{J} \gamma^{j,k}_n \sum_{i=1}^{N} \frac{\pi^{k'}_{in}}{t^{k'}_{in}} X^{k'}_i + \alpha^j_n I'_n \tag{B.4}$$

$$I'_n = \hat{w}_n w_n L_n + D'_n + \sum_{j=1}^{J} \sum_{i=1}^{N} \tau^{j'}_{ni} \frac{X^{j'}_n \pi^{j'}_{ni}}{t^{j'}_{ni}} \tag{B.5}$$

$$\hat{w}_n = \sum_{j=1}^{J} \gamma^j_n \sum_{i=1}^{N} X^{j'}_i \frac{\pi^{j'}_{in}}{t^{j'}_{in} w_n L_n}, \tag{B.6}$$

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 $\gamma^{k,j}_n$, 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 counter-factual tariffs will treat this purged trade flow data as the factual equilibrium.

Equilibrium in Changes Given Tariff Changes *Given changes in tariffs* $\{\hat{t}^j_{ni}\}_{j,n,i}$*, 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.1);*

2. The price index satisfies Equations B.2 and B.3;

3. The goods markets clear, satisfying Equations B.4 and B.5;

4. The labor market clears, satisfying Equation B.6;

Tariff Competition with Equilibrium in Changes Following the notations in Section 3.6, 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:

$$\hat{G}_n(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}) = \frac{\hat{I}_n(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})}{\hat{P}_n^C(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})}, \tag{B.7}$$

where $\hat{I}_n(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})$ denotes the change in country n 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 their own welfare (real income, or GNI) and minimize Russian welfare in the counterfactual equilibrium:

$$g_n(\hat{\mathbf{t}}_{-\mathbf{nR}}) \in argmax_{\{\hat{\mathbf{t}}_{\mathbf{nR}}\}} \rho G_n \hat{G}_n(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}) - (1-\rho) G_R \hat{G}_R(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}), \tag{B.8}$$
$$\text{s.t. Equilibrium Conditions B.1-B.6,}$$

where G_n and G_R denotes country n 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.[42]

Russia, when it retaliates, it maximizes a weighted average of maximizing its own welfare

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

and minimizing the allies' welfare, both in the counterfactual equilibrium:

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

s.t. Equilibrium Conditions B.1-B.6

Equilibrium in Changes with Sanctions *Given changes in all tariffs except what the sanctioning countries impose on Russia and Russia imposes on sanctioning countries,* $\{\hat{t}^j_{ni}\}_{j,n,i} \setminus \{\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{\mathbf{Rn}}\}_{n\in\mathbf{S}}$*, an equilibrium with optimal sanctions is given by tariffs imposed against Russia by sanctioning countries,* $\{\hat{\mathbf{t}}_{\mathbf{nR}}\}_{n\in\mathbf{S}}$*, tariffs imposed against 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* $\{\hat{t}^j_{ni}\}_{j,n,i}$*,* $\{\{\hat{P}^j_n\}_{n,j}, \{\hat{w}_n\}_n\}$ *is an equilibrium;*

2. *Sanctioning countries and Russia optimally choose changes in their tariffs:*

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

B.2 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 equals the following:

$$\hat{G}^{pol}_R(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}) = \sum_{j=1}^{J} \frac{\lambda^j L^j_R}{\sum_{s=1}^{S} \lambda^s L^s_R} \hat{L}^s_R(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}) \frac{\hat{I}_R(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})}{\hat{P}^C_R(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})}, \tag{B.10}$$

where $\frac{\lambda^j L^j_R}{\sum_{s=1}^{S} \lambda^s L^s_R}$ denotes the politically weighted initial employment share of sector j in Russia. The politically weighted welfare increases if the whole economy's real income, $\frac{\hat{I}_R(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})}{\hat{P}^C_R(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}})}$, increases, and if employment/value added increases more in the sectors that have higher political weights. On the other hand, 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.8, the objective of sanctioning country n is to both maximize their own welfare and minimize Russia's real income in the politically connected sectors:

$$g_n^{pol}(\hat{\mathbf{t}}_{-\mathbf{nR}}) \in argmax_{\{\hat{\mathbf{t}}_{\mathbf{nR}}\}} \rho G_n \hat{G}_n(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}) - (1-\rho) G_R^{pol} \hat{G}_R^{pol}(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{-\mathbf{nR}}), \qquad \text{(B.11)}$$
$$\text{s.t. Equilibrium Conditions B.1-B.6,}$$

where $G_R^{pol} = \sum_{j=1}^{J} \lambda^j \frac{L_R^j}{L_R} G_R$ equals 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.

Same as Problem B.9, we assume that Russia retaliates by maximizing a weighted average of its own welfare and punishment on the sanctioning countries' welfare.

C Quantitative

C.1 Sectoral Trade Statistics with Russia

In Figure A.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 is important for both the EU's consumption and Russia's production. Mining and energy sector products from Russia accounts for about 20% of the EU's total expenditure on these products (Figure A.4a), and exports of these products to the EU accounts for more than a quarter of Russia's total output (Figure A.4b). This suggests that among all sanctioning countries, the EU should carry a heavy load.[43] If the EU sanctions mining and mining products from Russia, this can cause significantly economic losses in Russia, but it may also hurt the EU's welfare.

[43]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).

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

C.2 Cost-Efficient Tariffs and Fundamentals

To study the relationship between sectoral optimal tariffs imposed on Russia and the fundamental differences across sectors, we use the following regression:

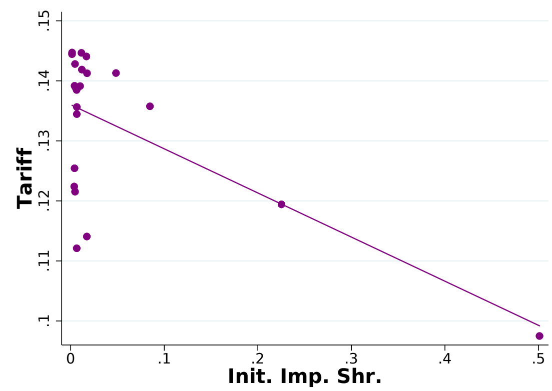
$$\tau_{s,\rho} = \beta_{\sigma,\rho}\sigma_s + \beta_{ups,\rho}upstreamness_s + \beta_{imp,\rho}ImpShr_s + \epsilon_{s,\rho} \tag{C.1}$$

where $\tau_{s,\rho}$ is the optimal tariff imposed by the EU on sector s imports from Russia when EU's willingness to pay is governed by ρ. σ_s is the trade elasticity of sector s. $upstreamness_s$ measures sector s' upstreamness Antràs et al. (2012) – the average number of sectors one dollar of sector s output goes through until it reaches the final consumer. $ImpShr_s$ is the share of imports from Russia in total sector s' imports by the EU in the baseline economy. To make each variable comparable, they are normalized to have mean 0 and variance 1.

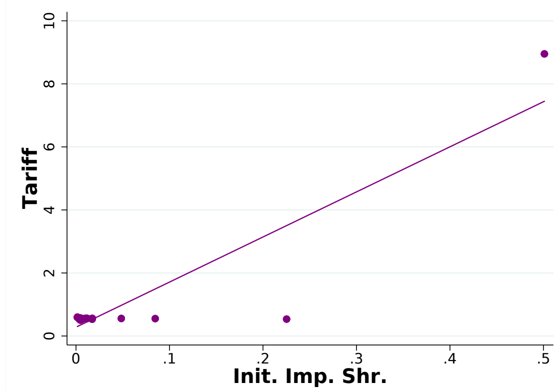
In Figure C.1 we plot the raw correlations between sectoral optimal tariffs by the EU and individual sector characteristics for $\rho = 1$ and $\rho = 0.6$. In Figure C.2, we plot how the partial correlations change with ρ. For low willingness to pay for sanctions, i.e., when ρ is large, higher tariffs should be set on sectors that have small import shares, lower trade elasticities and are more downstream. For example, when $\rho = 1$, a sector whose import share is one standard deviation smaller should be targeted by a tariff that is 0.5 standard deviation higher. Similarly, a sector whose trade elasticity is 1 standard deviation larger should face a tariff that is 0.4 standard deviations lower. These relationships change when

Figure C.1: **Correlations of Sectoral Cost-Efficient Tariffs and Fundamentals**

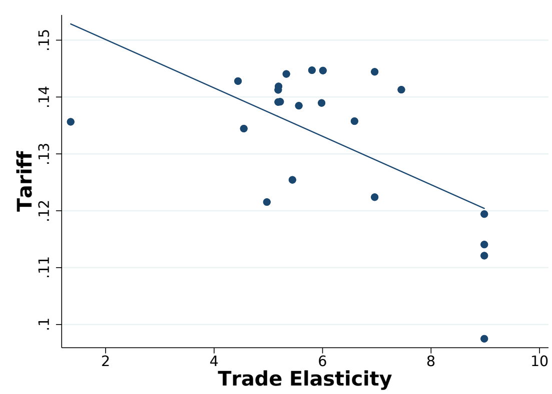
(a) Tariffs and Initial Import Share, $\rho = 1$



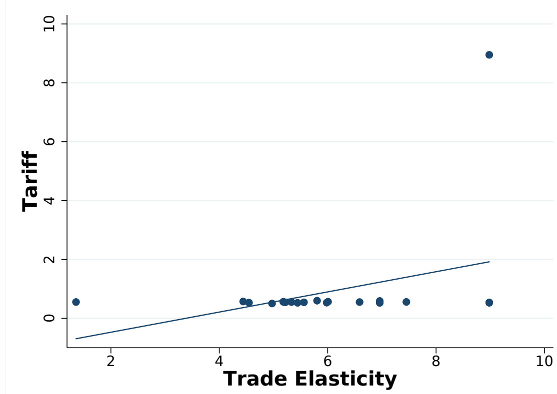
(b) Tariffs and Initial Import Share, $\rho = 0.6$



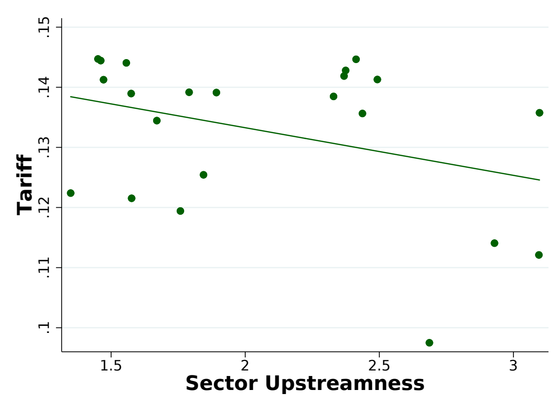
(c) Tariffs and Trade Elasticity, $\rho = 1$



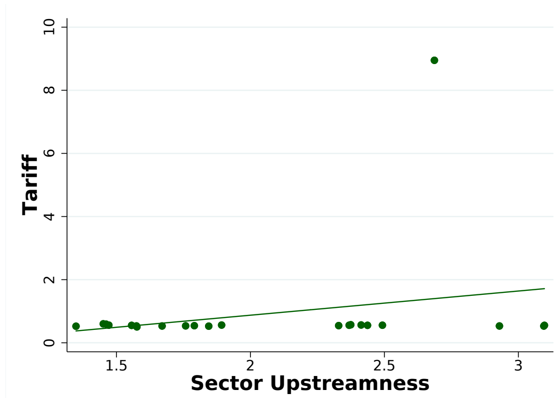
(d) Tariffs and Trade Elasticity, $\rho = 0.6$



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



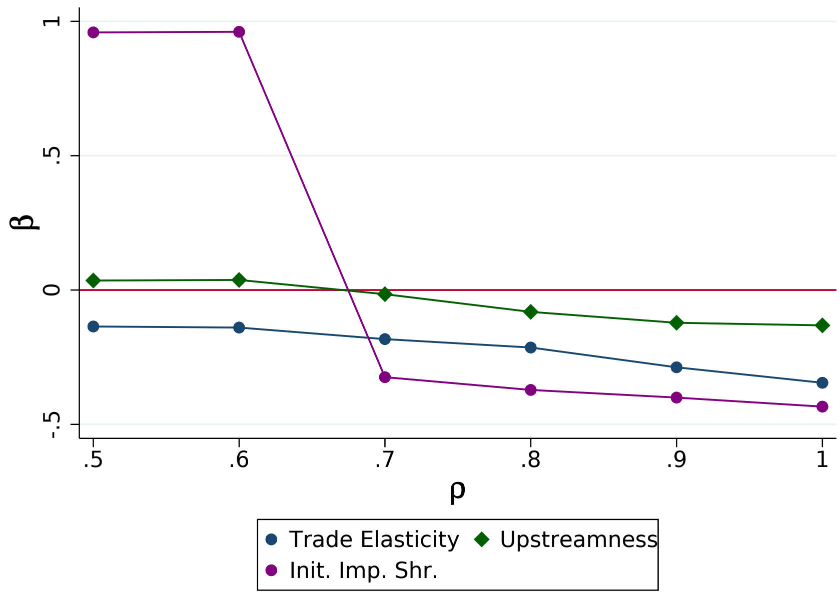
(f) Tariffs and Upstreamness, $\rho = 0.6$



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

ρ falls below 0.7, i.e. when the EU places greater weight in punishing Russia. For these higher willingness to pay, sectors with larger import shares and higher trade elasticities are targeted with higher tariffs.

Figure C.2: **Correlations of Tariffs with Different Fundamentals for Different ρ**

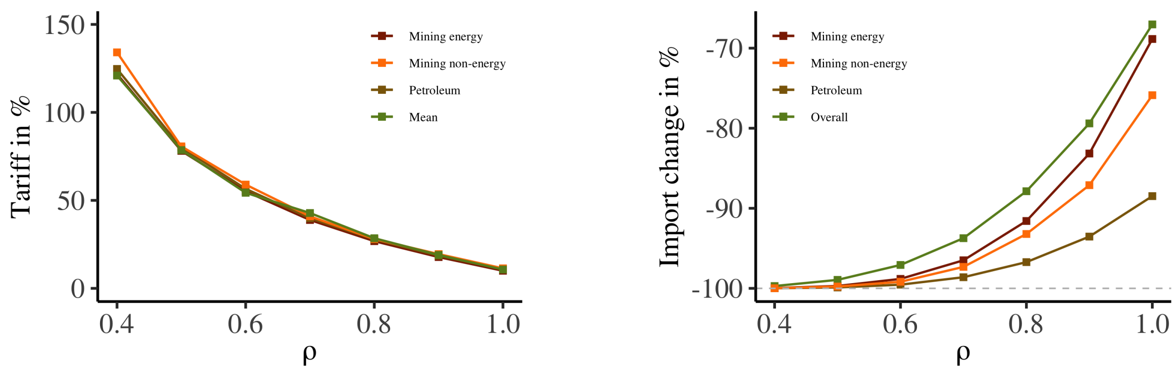


Description: This figure shows the partial correlations between the sectoral optimal tariffs imposed on Russia by the EU and different sector-level fundamentals under different ρ's (estimated with Equation C.1).

C.3 Other Figures and Tables

Figure C.3: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the USA,** $\rho \in [0.4, 1]$

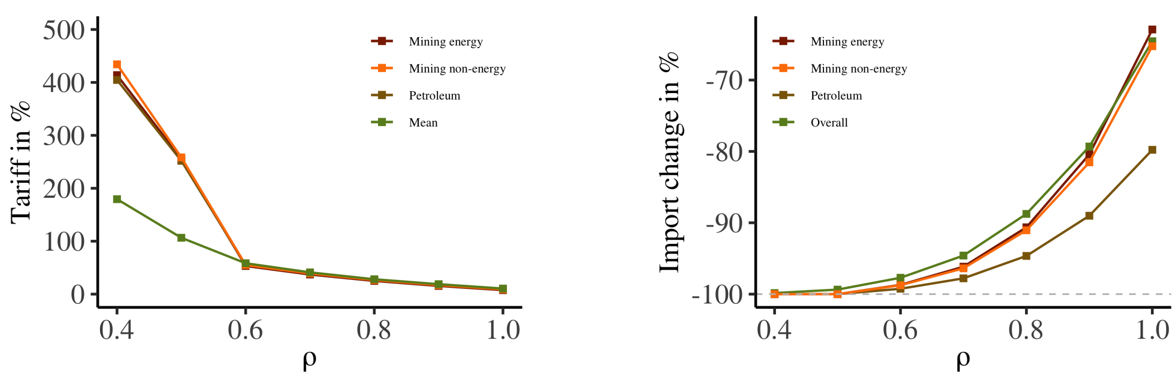
(a) Tariff (b) Change in Imports



Description: This figure shows statistics of the USA under cost-efficient sanctions with different willingness to pay. Figure C.3a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure C.3b plots the percentage change in imports in the USA at different sectors.

Figure C.4: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the OSA,** $\rho \in [0.4, 1]$

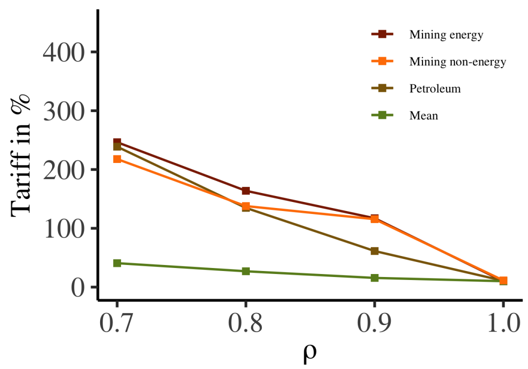
(a) Tariff (b) Change in Imports



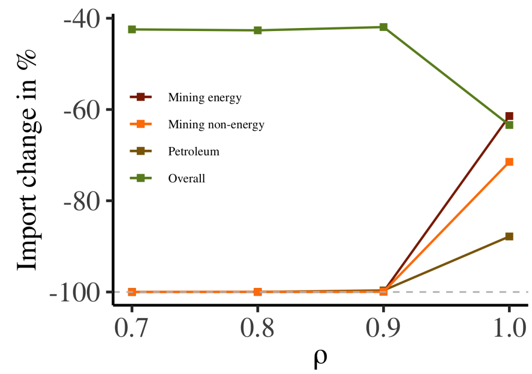
Description: This figure shows statistics of the other sanctioning allies (OSA) under cost-efficient sanctions with different willingness to pay. Figure C.4a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure C.4b plots the percentage change in imports in the other sanctioning allies (OSA) at different sectors.

Figure C.5: **Cost-Efficient Tariffs with Political Weights for Different Levels of Willingness to Pay in the USA,** $\rho \in [0.7, 1]$

(a) Tariff



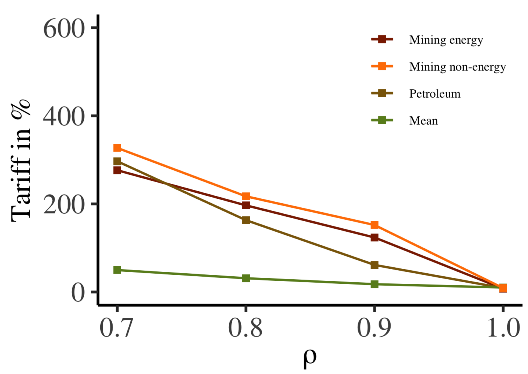
(b) Change in Imports



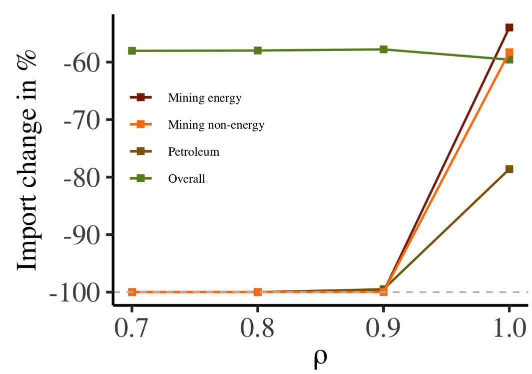
Description: This figure shows statistics of the USA under cost-efficient sanctions with different willingness to pay when the USA uses political weights described in Table 3. Figure C.5a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure C.5b plots the percentage change in imports in the USA at different sectors.

Figure C.6: **Cost-Efficient Tariffs with Political Weights for Different Levels of Willingness to Pay in the OSA,** $\rho \in [0.7, 1]$

(a) Tariff



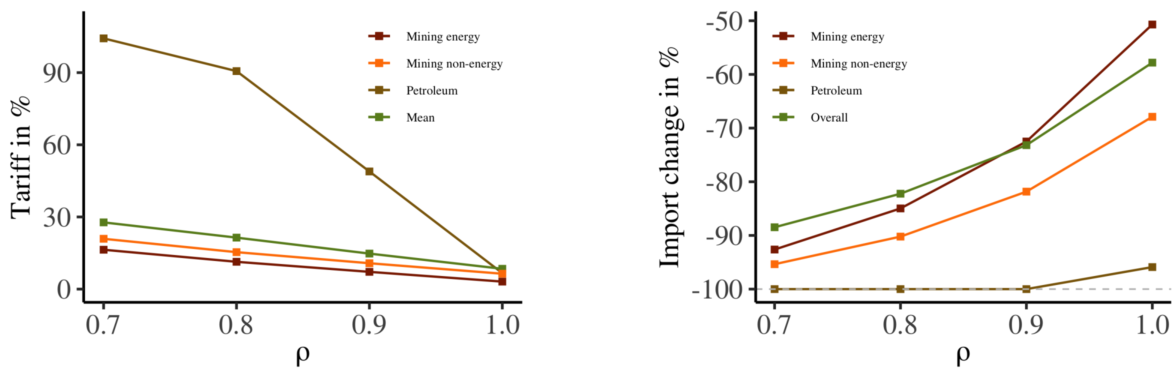
(b) Change in Imports



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

Figure C.7: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the EU, $\rho \in [0.7, 1]$ and Caliendo and Parro (2015) trade elasticities**

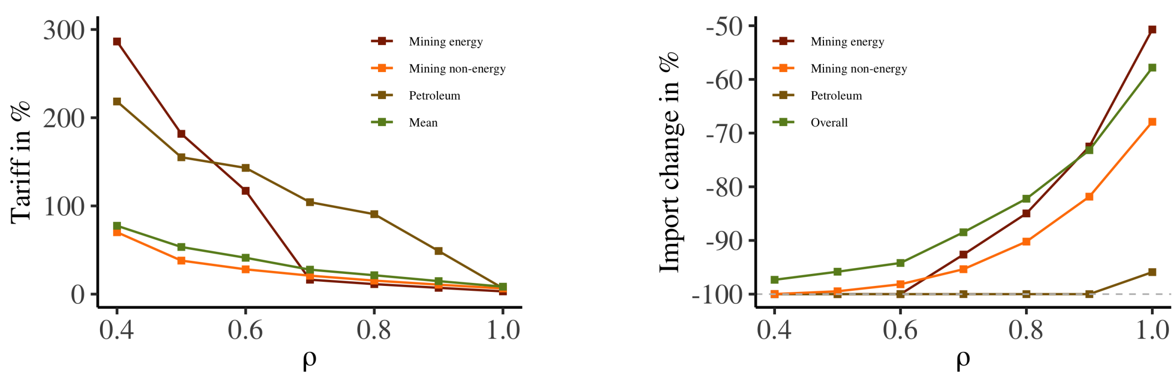
(a) Tariff (b) Change in Imports



Description: This figure shows statistics of the EU under cost-efficient sanctions with different willingness to pay. Figure C.7a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure C.7b plots the percentage change in imports in the EU at different sectors.

Figure C.8: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the EU, $\rho \in [0.4, 1]$ and Caliendo and Parro (2015) trade elasticities**

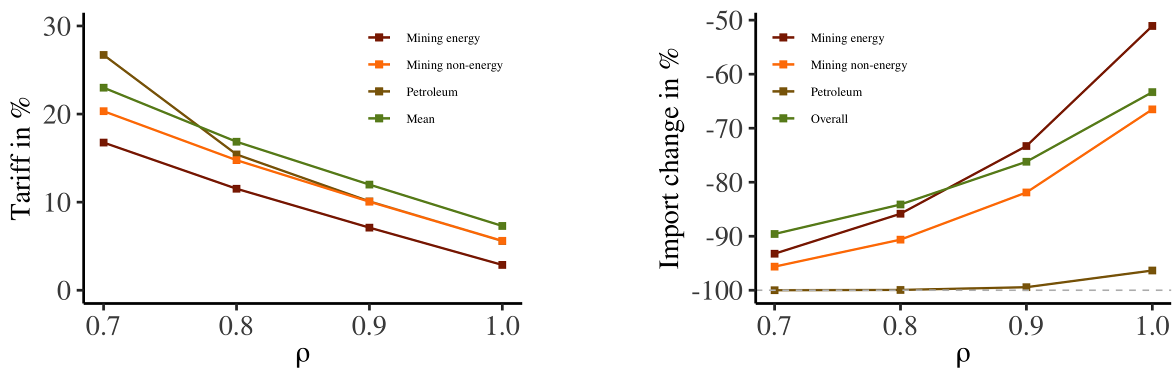
(a) Tariff (b) Change in Imports



Description: This figure shows statistics of the EU under cost-efficient sanctions with different willingness to pay. Figure C.8a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure C.8b plots the percentage change in imports in the EU at different sectors.

Figure C.9: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the OSA, $\rho \in [0.7, 1]$ and Caliendo and Parro (2015) trade elasticities**

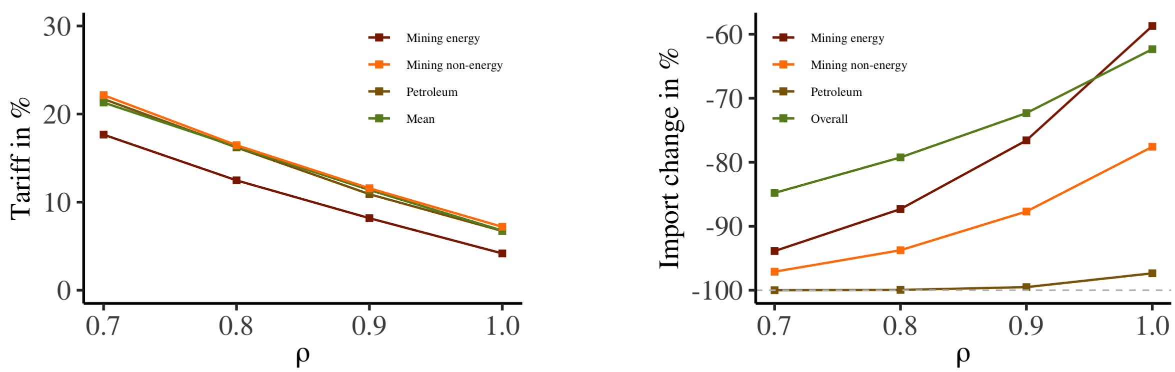
(a) Tariff (b) Change in Imports



Description: This figure shows statistics of the other sanctioning allies (OSA) under cost-efficient sanctions with different willingness to pay. Figure C.9a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure C.9b plots the percentage change in imports in the other sanctioning allies (OSA) at different sectors.

Figure C.10: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the USA, $\rho \in [0.7, 1]$ and Caliendo and Parro (2015) trade elasticities**

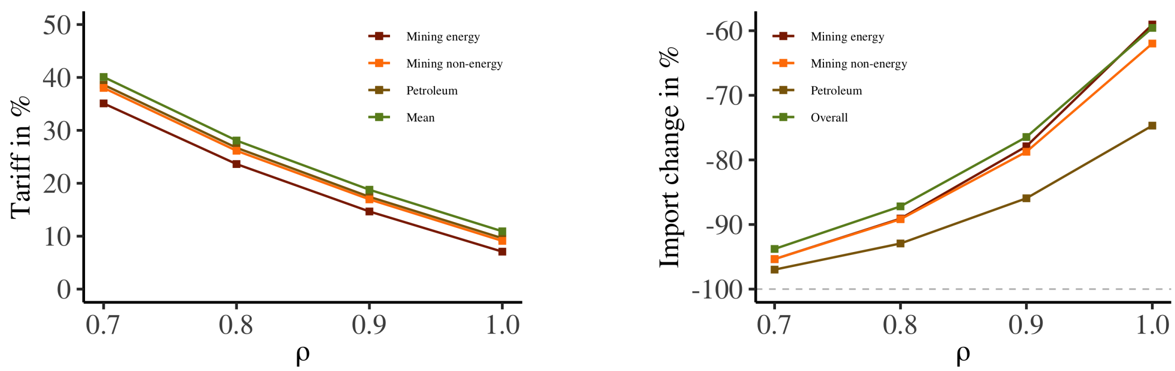
(a) Tariff (b) Change in Imports



Description: This figure shows statistics of the other sanctioning allies (USA) under cost-efficient sanctions with different willingness to pay. Figure C.10a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure C.10b plots the percentage change in imports in the other sanctioning allies (OSA) at different sectors.

Figure C.11: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the EU, $\rho_{\textbf{Sanction}} \in [0.7, 1]$ and $\rho_{RUS} \equiv 1$**

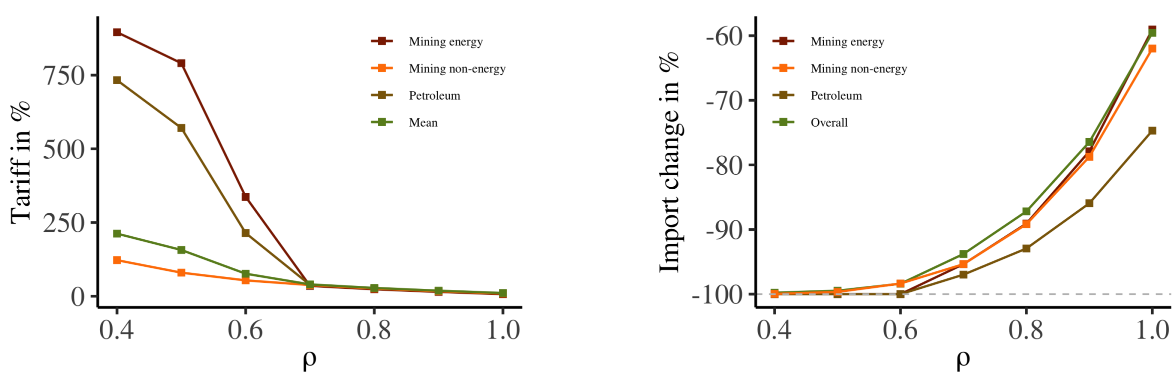
(a) Tariff (b) Change in Imports



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

Figure C.12: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the EU, $\rho_{\textbf{Sanction}} \in [0.4, 1]$ and $\rho_{RUS} \equiv 1$**

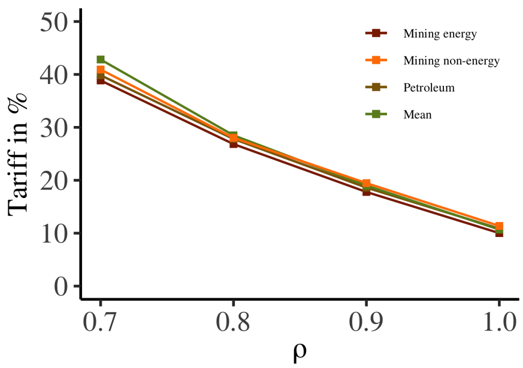
(a) Tariff (b) Change in Imports



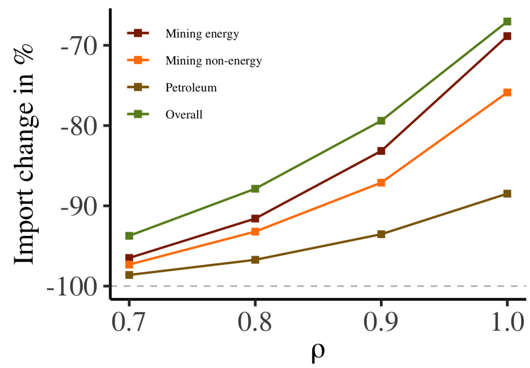
Description: This figure shows statistics of the EU under cost-efficient sanctions with different willingness to pay. Figure C.12a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure C.12b plots the percentage change in imports in the EU at different sectors.

Figure C.13: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the USA, $\rho_{\textbf{Sanction}} \in [0.7, 1]$ and $\rho_{RUS} \equiv 1$**

(a) Tariff



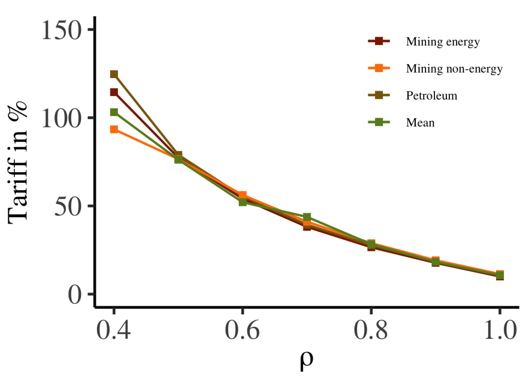
(b) Change in Imports



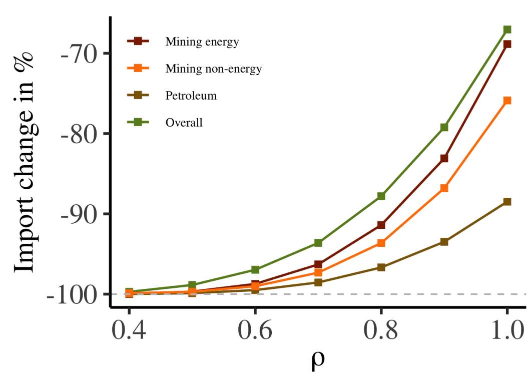
Description: This figure shows statistics of the USA under cost-efficient sanctions with different willingness to pay. Figure C.13a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions,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

Figure C.14: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the USA, $\rho_{\textbf{Sanction}} \in [0.4, 1]$ and $\rho_{RUS} \equiv 1$**

(a) Tariff



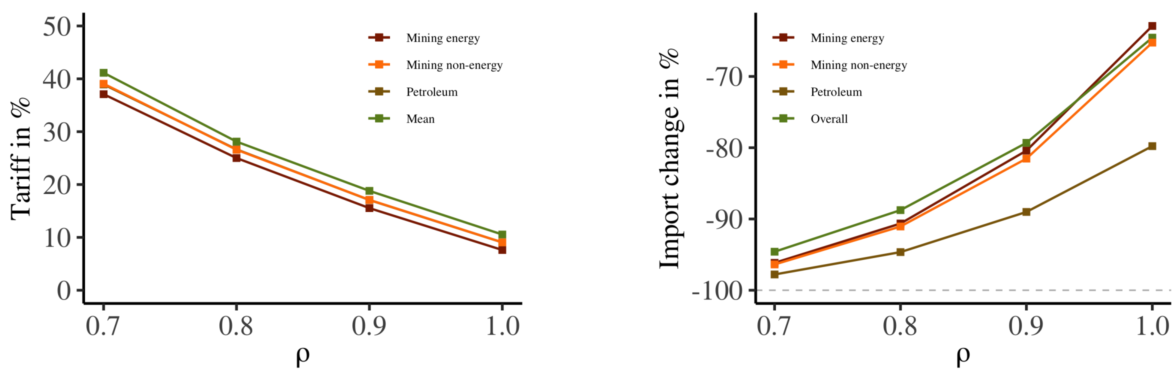
(b) Change in Imports



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

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

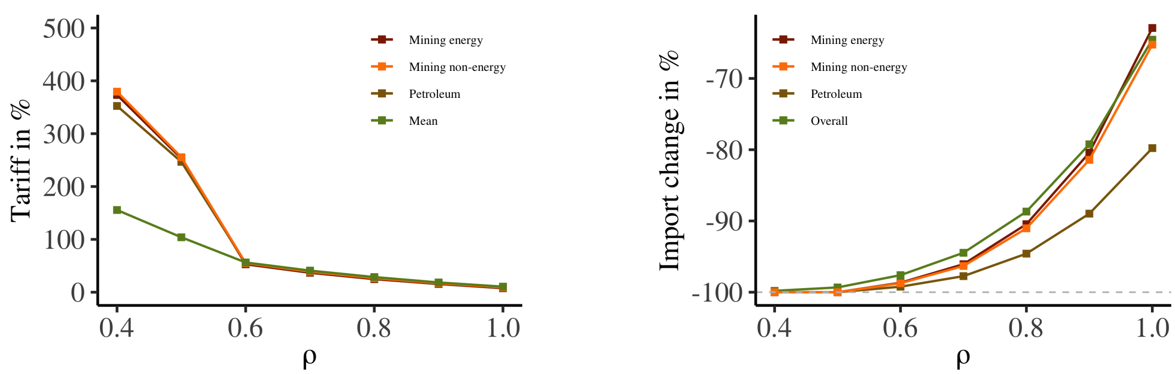
(a) Tariff (b) Change in Imports



Description: This figure shows statistics of the other sanctioning allies (OSA) under cost-efficient sanctions with different willingness to pay. Figure C.15a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure C.15b plots the percentage change in imports in the other sanctioning allies (OSA) at different sectors.

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

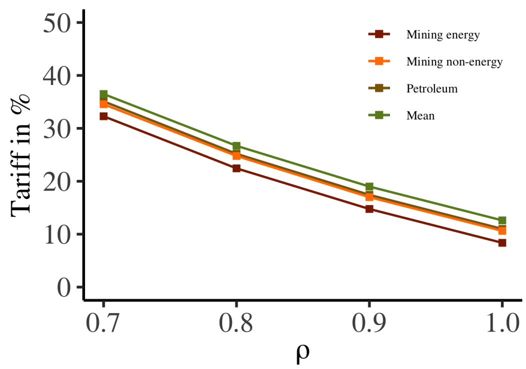
(a) Tariff (b) Change in Imports



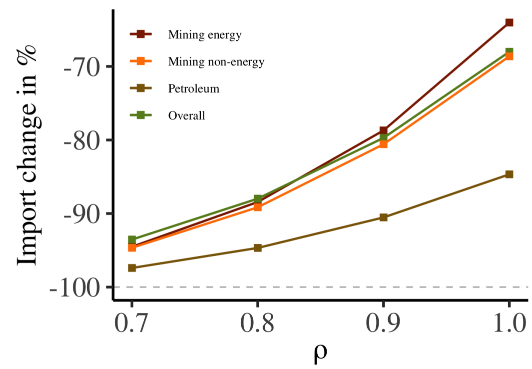
Description: This figure shows statistics of the other sanctioning allies (OSA) under cost-efficient sanctions with different willingness to pay. Figure C.16a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure C.16b plots the percentage change in imports in the other sanctioning allies (OSA) at different sectors.

Figure C.17: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the EU, $\rho_{\textbf{Sanction}} \in [0.7, 1]$ and $\rho_{RUS} \equiv 0$**

(a) Tariff



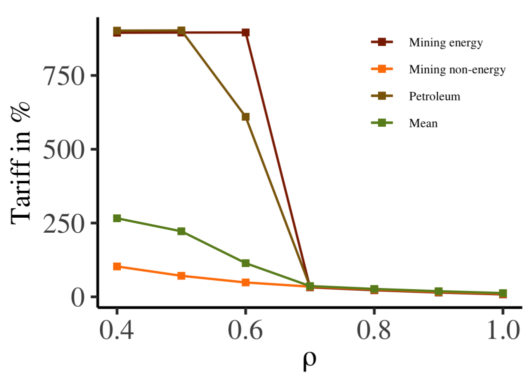
(b) Change in Imports



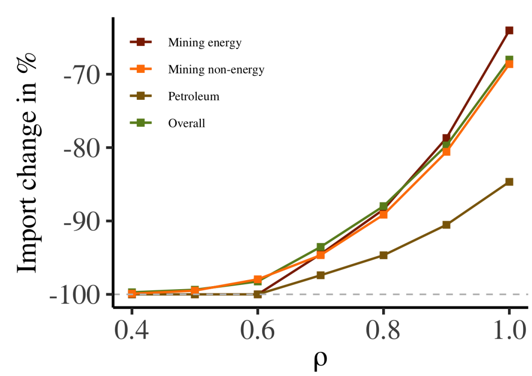
Description: This figure shows statistics of the EU under cost-efficient sanctions with different willingness to pay. Figure 3a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure 3b plots the percentage change in imports in the EU at different sectors.

Figure C.18: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the EU, $\rho_{\textbf{Sanction}} \in [0.4, 1]$ and $\rho_{RUS} \equiv 0$**

(a) Tariff



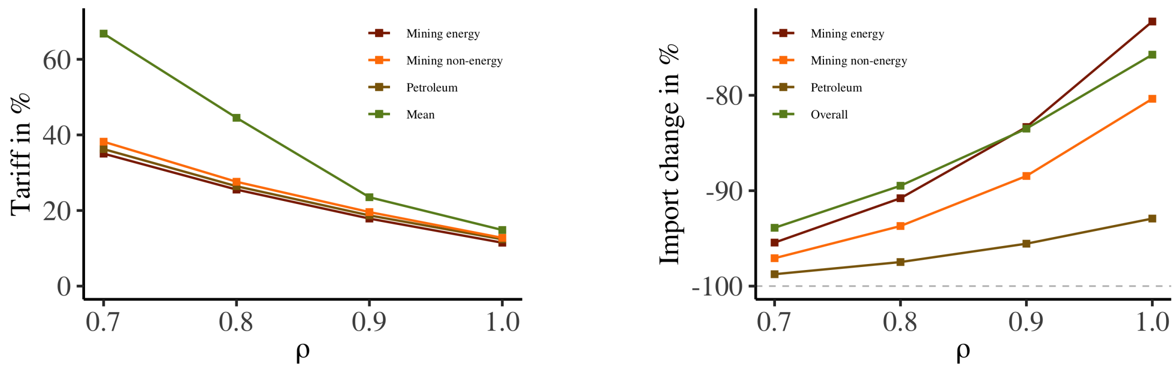
(b) Change in Imports



Description: This figure shows statistics of the EU under cost-efficient sanctions with different willingness to pay. Figure 4a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure 4b plots the percentage change in imports in the EU at different sectors.

Figure C.19: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the USA, $\rho_{\textbf{Sanction}} \in [0.7, 1]$ and $\rho_{RUS} \equiv 0$**

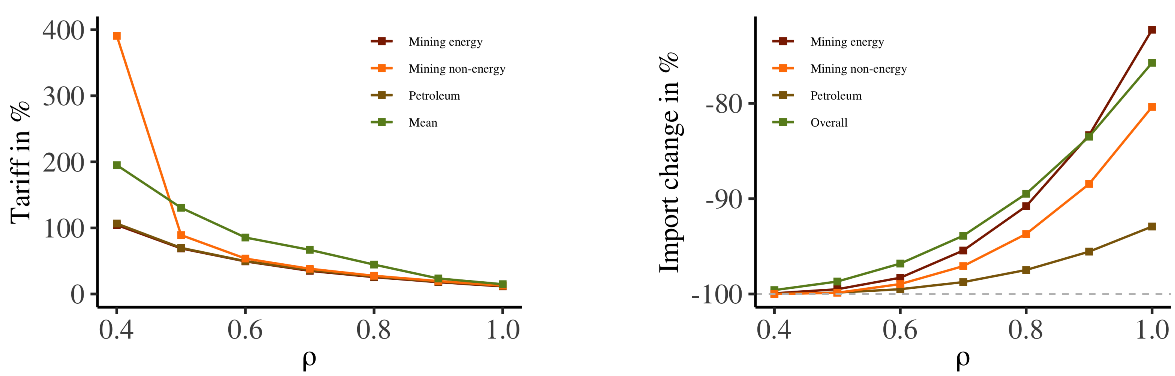
(a) Tariff (b) Change in Imports



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

Figure C.20: **Cost-Efficient Tariffs for Different Levels of Willingness to Pay in the USA, $\rho_{\textbf{Sanction}} \in [0.4, 1]$ and $\rho_{RUS} \equiv 0$**

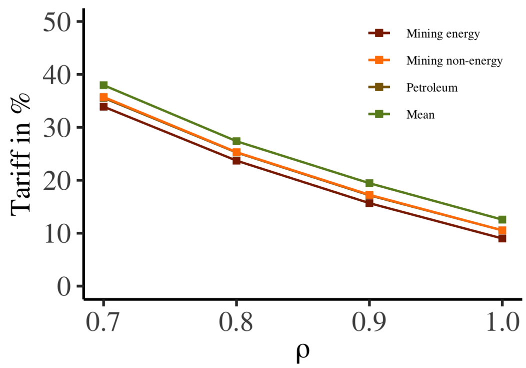
(a) Tariff (b) Change in Imports



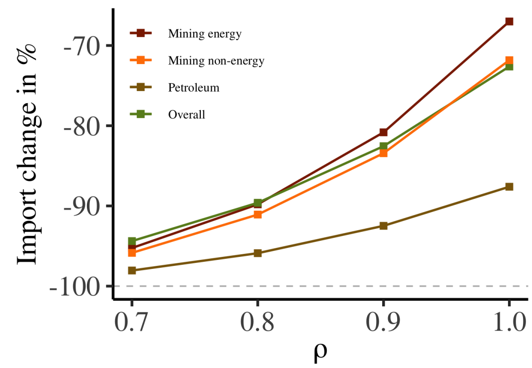
Description: This figure shows statistics of the USA under cost-efficient sanctions with different willingness to pay. Figure C.20a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions,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

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

(a) Tariff



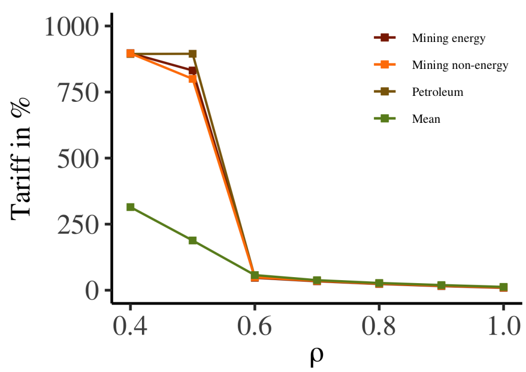
(b) Change in Imports



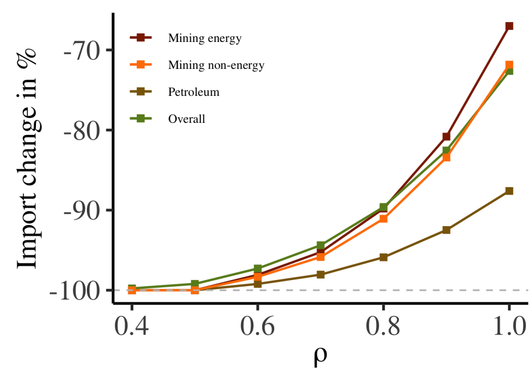
Description: This figure shows statistics of the other sanctioning allies (OSA) under cost-efficient sanctions with different willingness to pay. Figure C.21a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure C.21b plots the percentage change in imports in the other sanctioning allies (OSA) at different sectors.

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

(a) Tariff



(b) Change in Imports



Description: This figure shows statistics of the other sanctioning allies (OSA) under cost-efficient sanctions with different willingness to pay. Figure C.22a plots the cost-efficient tariff on mining energy, mining non-energy, petroleum, and the average unweighted tariff across sectors for different willingness to pay for sanctions, ρ. Figure C.22b plots the percentage change in imports in the other sanctioning allies (OSA) at different sectors.

C.4 Sanctioning Countries' Real Income Does not Decrease

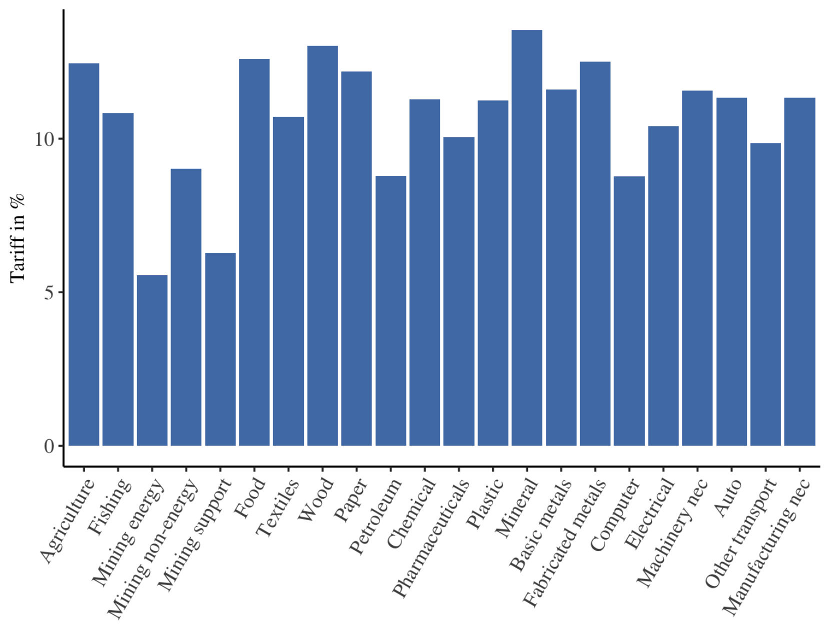
In this section we study the cost-efficient sanctions with which the sanctioning countries' real income does not decrease and they minimize the real income in Russia. The sanctioning country, n's problem (in changes) is the following. Conditional on all other tariffs except those country n imposes on Russia, $\hat{\mathbf{t}}_{\mathbf{-nR}}$, the objective of country n is:[44]

$$
\begin{aligned}
g_n(\hat{\mathbf{t}}_{\mathbf{-nR}}) \in argmin_{\{\boldsymbol{\tau_{n,R}}\}} G_R \hat{G}_R(\hat{\mathbf{t}}_{\mathbf{nR}}, \hat{\mathbf{t}}_{\mathbf{-nR}}), \\
\text{s.t. Equilibrium Conditions B.1-B.6,} \\
\hat{G}_n(\boldsymbol{\tau_{nR}}, \boldsymbol{\tau_{-nR}}) \geq 1
\end{aligned}
\tag{C.2}
$$

Figure C.23 shows cost-efficient sanctions by the EU that satisfy Problem C.2. These tariffs are similar to those if the sanctioning countries have low willingness to pay to sanction Russia. They are low (about 10%) on average and similar across sectors. As the EU does not want to decrease their own real income, lower tariffs should be imposed on energy extraction and petroleum sectors.

[44] We assume Russia's retaliation strategy is to set tariffs on the sanctioning countries to maximize Russia's welfare – it follows Problem 14 where we set $\rho_{RUS} = 1$.

Figure C.23: **Cost-Efficient Tariffs with EU Welfare Non-decreasing**



Description: This figure shows the cost-efficient sectoral tariffs that the EU imposes on Russia when the EU solves Problem C.2 – the EU minimizes Russian welfare but requires that its own welfare does not decrease.