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**Brothers in arms:
The value of
coalitions in
sanctions regimes**



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ABSTRACT

BROTHERS IN ARMS: THE VALUE OF COALITIONS IN SANCTIONS REGIMES*

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This paper examines the impact of coalitions on the economic costs of the 2012 Iran and 2014 Russia sanctions. By estimating and simulating a quantitative general equilibrium trade model under different coalition set-ups, we (i) dissect welfare losses for sanction-senders and target; (ii) compare prospective coalition partners and; (iii) provide bounds for the sanctions potential — the maximum welfare change attainable — when sanctions are scaled vertically, i.e. across sectors up to an embargo, or horizontally, i.e. across countries up to a global regime. To gauge the significance of simulation outcomes, we implement a Bayesian bootstrap procedure that generates confidence bands. We find that the implemented measures against Iran and Russia inflicted considerable economic harm, yielding 32 – 37% of the vertical sanctions potential. Our key finding is that coalitions lower the average welfare loss incurred from sanctions relative to unilateral implementation. They also increase the welfare loss imposed on Iran and Russia. Adding China to the coalition further amplifies the welfare loss by 79% for Iran and 22% for Russia. Finally, we quantify transfers that would equalize losses across coalition members. These hypothetical transfers can be seen as a sanctions-equivalent of NATO spending goals and provide a measure of the relative burden borne by coalition countries.

Keywords: Sanctions, Embargoes, Alliances, Sectoral linkages

JEL classification: F10, F13, F14, F51

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1 Introduction

The use of sanctions for the pursuit of geopolitical objectives has been rapidly rising since the 1970s, but most strikingly in the last decade. This unique form of economic statecraft is often considered to be a strategic substitute for military intervention and thereby a form of engaging in ‘war by other means’ (Blackwill and Harris, 2016). The economic cost and coercive force of this instrument however relies upon countries’ positions in global trade networks (Farrell and Newman, 2019). In this paper, we quantify such costs and the deterrent potential of sanctions, and provide novel quantitative evidence on how they are affected by coalitions, i.e. alliances of countries that jointly implement sanctions.

Substantial diplomatic capital is spent toward enlarging or preserving these coalitions as they increase the “moral suasion” of sanctions regimes (Hufbauer et al., 1990). However, coalitions may also shift the magnitude and distribution of economic costs from sanctions, for instance, by reducing opportunities for circumventing restrictions. Here, we investigate the extent to which these cost changes occur by simulating sanctions under different hypothetical coalition set-ups using a quantitative general equilibrium trade model. While the model features many outcomes of potential interest such as prices and wages, we centre our analysis on changes in aggregate welfare that are interpreted as the economic cost of sanctions. Furthermore, we focus on the wave of sanctions enacted against Iran in 2012 and Russia in 2014 as both episodes involved multiple sanction-sending countries that adopted restrictive measures which were unprecedented in terms of their depth at the time.¹

In analysing these sanctions regimes, the paper makes several contributions to the literature. First, our simulations provide different benchmarks against which the punitive force of current and hypothetical sanctions coalitions can be understood. These benchmarks correspond to scenarios wherein sanctions escalate either horizontally through inclusion of all countries (i.e. a global coalition) or vertically through a deepening of measures (i.e. a complete embargo). Here, we find that the current coalition against Iran (Russia) enforces 63.8% (57.9%) of the welfare loss which can be realized by a horizontal expansion of sanctions and 37.4% (32.5%) of the welfare loss under a vertical expansion. Moreover, the fulfilment of these sanctions potentials are greatly increased if China were to join the existing sanctions coalition against Iran and Russia.

Second, we provide a detailed assessment of contributions that member countries make to the sanctions coalition in terms of welfare loss incurred and imposed on Iran and Russia. The ‘value’ of coalitions then emerges from comparisons of these contributions between two scenarios where sanctions are implemented either unilaterally or multilaterally. We find that multilateral enforcement reduces the average domestic welfare loss borne by

¹For further details on the history of these sanctions, see Appendix A.

coalition members up to 8.3% for Iran sanctions and 9.6% for Russia sanctions, relative to the unilateral scenario. Moreover, coalitions amplify the deterrent force of sanctions as welfare loss increases by 4.5% for Iran and 9.3% for Russia. This pattern of declining domestic costs and rising punitive impact of sanctions is observed for most coalition members, indicating that such alliances make countries more effective sanction-senders.

Expanding on methodology, our simulations rely upon a quantitative trade model featuring sector-level trade flows and input-output linkages, specifically a Caliendo and Parro (2015)-type model of the world economy. The framework by Caliendo and Parro (2015) belongs to the class of so-called structural gravity models (see e.g. Head and Mayer, 2014) and we exploit gravity's "dual use" potential that allows (i) a theory-consistent estimation of trade cost effects of observed sanctions and; (ii) a general equilibrium simulation of the changes in trade *flows* and welfare in sanctioned and sanctioning states as well as third-parties under different actual and hypothetical set-ups of sanctions coalitions.

Here, the paper makes two additional contributions. First, we extend the Caliendo and Parro (2015) model by incorporating a transfers mechanism that equalizes aggregate welfare losses from sanctions across coalition members. This extension allows for comparisons of welfare losses across countries (in terms of transfers sent or received) and for calculating the size of a sanctions adjustment fund that would eliminate disparities in welfare losses within the coalition. Our results show that USD 591 million and USD 4.8 billion would need to be mobilized for members to equalize their welfare loss from the Iran and Russia sanctions, respectively. The top contributor to these adjustment funds is the United States whose combined transfers for both sanctions regimes would amount to approximately USD 3.13 billion.

Our second methodological contribution is to introduce a Bayesian bootstrap procedure to provide confidence intervals for both the gravity estimations and the general equilibrium simulation results. In doing so, we capture the uncertainty in the impact of sanctions on trade costs and aggregate welfare. Our choice of the Bayesian bootstrap is motivated by the fact that it retains the same trade network across all model runs, unlike the traditional bootstrap procedure. To our knowledge, this is the first paper that exploits the Bayesian bootstrap in the context of structural gravity models.

The remainder of the paper is structured as follows: In Section 2, we provide an overview of the growing literature on the economic impact of sanctions. We extend the model by Caliendo and Parro (2015)-with a transfers channel to evaluate the effect of coalitions in sanctions regimes in Section 3. Section 4 describes in turn the econometrics and the various data sources used for estimating the gravity model and counterfactual scenarios. In Section 5, we discuss the impact of sanctions on sectoral trade costs. Counterfactual scenarios and the simulation results are described in Section 6. Finally, Section 7 concludes with policy recommendations.

2 Related literature

Politically, sanctions can affect the stability of governing regimes and lead to power shifts within countries (Escribà-Folch et al., 2015). However, the capacity of sanctions to achieve such political goals is contested (Pape, 1997, 1998; Hufbauer et al., 2007; Grauvogel and Von Soest, 2014). Sanction effectiveness therefore crucially hinges upon two factors. First, sanctions have to be threatened with credibility and second, the sanctioning coalition has to be broad enough to display this credibility and to exert economic pressure. This paper contributes to the above literature on sanction effectiveness by emphasising the role played by coalitions. It does so by explicitly quantifying and comparing the punitive force of sanctions under different hypothetical coalition setups.

By focusing on sanctions coalitions, we broadly contribute to prior research on the relationship between trade flows and strategic alliances as well. Papers in this literature find that intensively trading country-pairs are less likely to be involved in military disputes (Polachek, 1980; Pollins, 1989), that military alliances exert a large positive effect on bilateral trade flows (Gowa and Mansfield, 1993) and that alliances which include a major power trade more than those without major power participation (Mansfield and Bronson, 1997). Here, we examine how alliances can be expanded in order to magnify the deterrent force of sanctions on target regimes.

Moreover, sanctions impact trade flows not only between senders and targets (Hinz and Monastyrenko, 2022; Crozet and Hinz, 2020; Neuenkirch and Neumeier, 2016; Heilmann, 2016; Etkes and Zimring, 2015), but also trade with third party countries. These third parties also determine the efficacy of sanctions regimes. For instance, Early (2012) analyses 96 episodes of US sanctions to show that third parties cooperate (sanction-bust) when the costs from sanctions are low (high). Peksen and Peterson (2016) find that sanction senders are more likely to threaten or impose sanctions when the target has limited opportunities to redirect lost trade to third parties. Accounting for trade flows with third parties is therefore important for measuring the overall welfare loss from sanctions. In this paper, we incorporate these wide-ranging third party effects by conducting simulations with a multi-country multi-sector trade model that features rich inter-sectoral linkages. This constitutes an important departure from related political science literature on sanctions that relies on stylized two-country models with limited explanatory power.

Finally, this paper adds to the latest research concerning the economic cost of Russia sanctions. By evaluating a wide range of coalition scenarios for both Iran and Russia sanctions, this paper extends findings from Langot et al. (2022) who report higher economic costs for Russia if the EU coordinates its sanctions with other nations unfriendly to Russia. Our findings on China's potential cooperation in the sanctions regime also diverge from Mahlstein et al. (2022). With GTAP simulations, they report the additional economic

harm from China's involvement to be marginal for Russia and significantly higher for both China and Allied states. In contrast, this paper uses a modified Caliendo and Parro (2015) model and finds that China's membership substantially increases welfare loss for Russia whilst imposing minimal additional welfare cost on China and the remaining coalition. Our findings on burden-sharing between coalition members also add to recent work by Schropp and Tsigas (2022) who allow for redistribution of additional tariff rents between countries sanctioning Russia. While Schropp and Tsigas (2022) focus solely on the impact of such transfers on welfare losses for Russia, we concentrate on the heterogeneity and uncertainty in the magnitudes of these transfers across coalition members.

3 Model

We now construct a model of the world economy in the spirit of Caliendo and Parro (2015) that allows us to evaluate the effect of sanctions coalitions and that includes a novel channel allowing for transfers between countries for burden sharing.

The setup and notation is similar to that in Hinz and Monastyrenko (2022). There are N countries, indexed o and d , and J sectors, indexed j and k . Production uses labor as the sole factor, which is mobile across sectors but not across countries. All markets are perfectly competitive.

There are L_d representative households in each country that maximize their utility by consuming final goods C_d^j in the familiar Cobb-Douglas form

$$u(C_d) = \prod_{j=1}^J C_d^{\alpha_d^j} \quad \text{with} \quad \sum_{j=1}^J \alpha_d^j = 1.$$

where α_d^j is the constant consumption share on industries j 's goods. Household income I_d is derived from the supply of labor L_d at wage w_d and a lump-sum transfers of tariff revenues. Intermediate goods $\omega^j \in [0, 1]$ are produced in each sector j using labor and composite intermediate goods from all sectors. Let $\beta_d^j \in [0, 1]$ denote the cost share of labor and $\gamma_d^{k,j} \in [0, 1]$ with $\sum_k \gamma_d^{k,j} = 1$ the share of sector k in sector j 's intermediate, such that

$$q_d^j(\omega^j) = z_d^j(\omega^j) \left[l_d^j(\omega^j) \right]^{\beta_d^j} \left[\prod_{k=1}^J m_d^{k,j}(\omega^j) \gamma_d^{k,j} \right]^{1-\beta_d^j}$$

where $z_d^j(\omega^j)$ is the overall efficiency of a producer, $l_d^j(\omega^j)$ is labor input, and $m_d^{k,j}(\omega^j)$ represent the composite intermediate goods from sector k used to produce ω^j . With

constant returns to scale and perfectly competitive markets, unit cost are

$$c_d^j = \frac{\Upsilon_d^j w_d^{\beta_d^j}}{z_d^j(\omega^j)} \left[\prod_{k=1}^J (P_d^k)^{\gamma_d^{k,j}} \right]^{1-\beta_d^j}$$

where P_d^k is the price of a composite intermediate good from sector k , and the constant $\Upsilon_d^j = \prod_{k=1}^J (\gamma_d^{k,j} - \beta_d^j \gamma_d^{k,j})^{-\gamma_d^{k,j} + \beta_d^j \gamma_d^{k,j}} (\beta_d^j \gamma_d^j)^{-\beta_d^j \gamma_d^j}$. Hence, the cost of the input bundle depends on wages and the prices of *all* composite intermediate goods in the economy. Producers of composite intermediate goods supply Q_d^j at minimum costs by purchasing intermediate goods ω^j from the lowest cost supplier across countries, so that

$$Q_d^j = \left[\int r_d^j(\omega^j)^{1-1/\sigma^j} d\omega^j \right]^{\sigma^j/(\sigma^j-1)}.$$

$\sigma^j > 0$ is the elasticity of substitution across intermediate goods within sector j , and $r_d^j(\omega^j)$ the demand for intermediate goods ω^j from the lowest cost supplier such that

$$r_d^j(\omega^j) = \left(\frac{p_d^j(\omega^j)}{P_d^j} \right)^{-\sigma^j} Q_d^j$$

where P_d^j is the unit price of the composite intermediate good

$$P_d^j = \left[\int p_d^j(\omega^j)^{1-\sigma^j} d\omega^j \right]^{1/(1-\sigma^j)}$$

and $p_d^j(\omega^j)$ denotes the lowest price of intermediate good ω^j in d across all possible origin locations. Composite intermediate goods are used in the production of intermediate goods ω^j and as the final good in consumption as C_d^j , so that the market clearing condition is written as

$$Q_d^j = C_d^j + \sum_{k=1}^J \int m_d^{j,k}(\omega^j) d\omega^j$$

Trade in goods is costly, such that the offered price of ω^j from o in d is given by

$$p_{od}^j = \phi_{od}^j \cdot \frac{c_o^j}{z_o^j(\omega^j)}$$

where $\phi_{od}^j = \tau_{od}^j$ denote bilateral sector-specific trade frictions, combining sector-specific ad-valorem tariffs $\tau_{od}^j \geq 1$ and iceberg trade costs $\kappa_{od}^j \geq 1$. Tariff revenue $(\tau_{od}^j - 1)$ is collected by the importing country and transferred lump-sum to its households.

Ricardian comparative advantage is induced à la Eaton and Kortum (2002) through a

country-specific idiosyncratic productivity draw z^j from a Fréchet distribution.²

The price of the composite good is then given as

$$P_d^j = A^j \left[\sum_{o=1}^N \lambda_o^j (c_o^j \phi_{od}^j)^{-\theta^j} \right]^{-1/\theta^j},$$

where $A^j = \Gamma(\xi^j)^{1/(1-\sigma^j)}$ with $\Gamma(\xi^j)$ being a Gamma function evaluated at $\xi^j = 1 + (1 - \sigma^j)/\theta^j$. Total expenditures on goods from sector j in country d are given by $X_d^j = P_d^j Q_d^j$. The expenditure on those goods originating from country o is called X_{od}^j , such that the share of j from o in d is $\pi_{od}^j = X_{od}^j / X_d^j$. This share can also be expressed as

$$\pi_{od}^j = \frac{\lambda_o^j (c_o^j \phi_{od}^j)^{-\theta^j}}{\sum_{h=1}^N \lambda_h^j (c_h^j \phi_{hd}^j)^{-\theta^j}}. \quad (1)$$

Up until here the model is effectively identical to Caliendo and Parro (2015). In order to reflect potential policies for so-called burden sharing of the cost of sanctions, we include a simple transfers mechanisms. Specifically, let $T_d \lesseqgtr 0$ describe the net transfer received by d out of a pool of countries S who form a sanctions coalition.³ Across the group, the transfers are balanced, hence

$$\sum_{d \in S} T_d = 0.$$

The magnitude of the transfer may be determined by any given metric. In our case, we assume countries in the sanctions coalition agree to face the same aggregate welfare cost, such that

$$\frac{\hat{I}_d}{\hat{P}_d} = \frac{\hat{I}_{d'}}{\hat{P}_{d'}} = \bar{c} \quad \forall d, d' \in S$$

Together, these two conditions on the transfers pin down $\bar{c} = \sum_{d \in S} (\hat{w}_d w_d L_d + R'_d + B'_d) / \sum_{d \in S} I_d \hat{P}_d$ and $T'_d = \bar{c}(I_d \hat{P}_d) - (\hat{w}_d w_d L_d + R'_d + B'_d)$. Total expenditures on goods from sector j are the sum of the firms' and households' expenditures on the composite intermediate good, either as input to production or for final consumption

$$X_d^j = \sum_{k=1}^J (1 - \beta_d^k) \gamma_d^{j,k} \sum_{o=1}^N X_o^k \frac{\pi_{od}^k}{\tau_{od}^k c_{od}^k} + \alpha_d^j I_d$$

with $I_d = w_d L_d + R_d + T_d + B_d$, i.e., labor income, tariff revenue, the transfer received

²The productivity distribution is characterized by a location parameter λ_o^j that varies by country and sector inducing *absolute* advantage, and a shape parameter θ^j that varies by sector determining *comparative* advantage.

³This transfers mechanism is implemented only in scenarios where we examine burden sharing.

from or paid to the group of sanctioning countries, as well as an additional exogenous component of aggregate trade balance. Trade is balanced up to the endogenous coalition transfer and the exogenous trade imbalance:

$$\sum_{j=1}^J \sum_{o=1}^N X_d^j \frac{\pi_{od}^j}{\tau_{od}^j \zeta_{od}^j} - B_d - T_d = \sum_{j=1}^J \sum_{o=1}^N X_o^j \frac{\pi_{do}^j}{\tau_{do}^j \zeta_{do}^j}.$$

A counterfactual general equilibrium for alternative trade costs in the form of $\hat{\phi}_{od}^j = \phi_{od}^{j'}/\phi_{od}^j$ (\hat{x} denoting the relative change from a previous value x to a new one x') can be solved for in changes following Dekle et al. (2008).

4 Estimation

4.1 Gravity model

Conveniently, the model sketched above yields a sectoral gravity equation that — including a time dimension — can be estimated as follows:

$$X_{odt}^j = \exp \left(\beta^j z_{odt}^j + \Gamma_{ot}^j + \Gamma_{dt}^j + \Gamma_{od}^j \right) \quad (2)$$

The dependent variable is the value of trade flows from origin (o) to destination (d) in sector (j) in a given year (t). Equation (2) includes fixed effects Γ_{ot}^j , Γ_{dt}^j , and Γ_{od}^j to purge all origin \times sector \times time and destination \times sector \times time specific factors, as well as unobserved time-invariant and sector-specific bilateral characteristics. The first two sets of fixed effects are required from a theoretical point of view as they capture unobserved components.⁴ Specifically, they account for country-sector-level technology, costs of production inputs, as well as countries' embeddedness into the global trade network — a feature one could think of as a country's general “remoteness” that has been formalized as “multilateral resistance” by Anderson and van Wincoop (2003). The third set of fixed effects is not dictated by economic theory, but motivated by econometric endogeneity concerns about unobservable trade cost determinants being correlated with trade policy variables of interest. For aggregate bilateral trade flows, Baier and Bergstrand (2007) suggest to tackle this endogeneity using country-pair fixed effects and we follow this by now standard approach, additionally allowing country-pair unobservables to be sector-specific in our more disaggregated consideration of bilateral trade.

The specification features z_{odt}^j , which is a vector of time-varying bilateral trade frictions. These include the incidence of sanctions, as well as customary important policy variables like joint membership in the WTO, a FTA or a currency union. Correspondingly, β is the

⁴See the corresponding trade share equation (1) in the previous section.

vector of the respective sector-specific coefficients. To account for heteroskedasticity and zero trade flows, the equation is estimated with a Poisson pseudo-maximum likelihood (PPML) procedure as suggested by Santos Silva and Tenreyro (2006).

4.2 Bayesian bootstrap

To obtain confidence intervals for both our econometric point estimates and our general equilibrium simulation results, we rely on a bootstrap procedure.⁵ Specifically, we introduce the Bayesian bootstrap by Rubin (1981) to the gravity context, which — akin to the traditional bootstrap — re-samples a number of times and performs the same estimation and hence yields a distribution of estimates rather than just a point estimate, but does so — different from the traditional bootstrap — by assigning non-zero non-integer weights to all observations, hence leaving the overall structure of the sample and all corresponding sets of fixed effects unaffected.⁶

For the econometric point estimates, the need to deviate from standard robust inference results from an incidental parameter problem for the PPML standard errors in the presence of fixed effects. Pfaffermayr (2019) and Pfaffermayr (2021) describe the problem in a cross-sectional gravity setting for heteroskedasticity-robust standard errors and propose jackknife and bootstrap solutions, respectively. Weidner and Zylkin (2021) show that standard errors clustered at the country pair level in a panel gravity setting are downward biased and propose an analytical bias correction. Our bootstrapping procedure is an alternative solution to the downward bias of the standard errors. As Weidner and Zylkin (2021), we allow errors to be serially correlated by drawing the sampling weights not for each observations separately, but by cluster, i.e. by country pair.

For the general equilibrium simulation results of structural gravity models, typically only a single set of results is shown. Three exceptions are Anderson and Yotov (2010), who bootstrap PPML estimates and separately calculate multilateral resistance indices for each draw, Larch and Wanner (2017), who do standard inference for their point estimates, but bootstrap from the distribution of gravity coefficients to account for trade cost uncertainty in their simulations, and Felbermayr et al. (2022), who bootstrap in the estimation and use the resulting distribution of trade cost shocks and trade elasticities rather than a single set of values as inputs to their counterfactual analysis. In considering a range of potential trade cost shocks based on bootstrapped estimates as inputs to our GE analysis, our approach to obtain confidence intervals for the simulations is similar to the one by Felbermayr et al. (2022), but based on a Bayesian rather than a traditional bootstrap in the estimation stage.

⁵In terms of notation in the text, we provide standard errors (SE) in brackets where useful.

⁶We keep the description of our Bayesian bootstrap procedure verbal here and focus on the intuition. See Appendix B for a technical description.

In each iteration of the bootstrap, we use the same weights across the different sector-wise estimations, hence allowing error terms to be correlated not only for a given country pair-sector combination over time, but also for trade flows of the same country pair across all sectors. As the estimation of the sectoral coefficients is perfectly separable given our very strict set of fixed effects, this does not affect individual standard errors obtained with the bootstrap in the estimation stage. It does, however, allow for correlation of the estimates for different sectors across the bootstrap iterations and therefore leads to more to more conservative inference in the general equilibrium stage.

4.3 Data

For estimating the gravity model, data on trade flows is taken from BACI (Gaulier and Zignago, 2010). The CEPII Gravity dataset (Head and Mayer, 2014) is used for information pertaining to variables such as joint membership of countries in the WTO, free trade area or currency union. The model is calibrated using standard data sources. The main input for simulations for the model are derived from the GTAP 10 database (Aguiar et al., 2019). This data supplies the model with information on consumption shares, input coefficients, bilateral trade shares, trade balances and bilateral tariffs. The data is concorded to 65 GTAP sectors and 141 countries or regions.

For both sanctions episodes, general equilibrium simulations are performed from a base period one year before the introduction of the sanctions. In the Iranian case, this implies that we can directly use the 2011 base year data of the GTAP 10 data base. For consistency, we take sectoral bilateral trade shares from the BACI dataset also used in the estimation stage. For Russia, we use the same 2011 data, but additionally project value added for all countries to the 2013 values using observed GDP growth rates taken from the World Bank and adjust sectoral bilateral trade shares to the 2013 values from the BACI data. Trade elasticities are taken from Fontagné et al. (2022) for traded good sectors and from GTAP 10 otherwise.

5 Impact of the 2012 Iran and 2014 Russia sanctions

Impact on aggregate trade flows

Before estimating the disaggregated sectoral gravity model as described by equation (2), we first examine the partial equilibrium impact of the Iran and Russia sanctions on aggregate trade flows. Results from this exercise are reported in Table 1. In the case of Iran, we find that sanctions reduced overall exports flows by $(\exp(-0.3401) - 1) \times 100 = -40.51\%$. The effect on imports is even stronger, with trade flows dropping by 82.72%. In the case of Russian sanctions, exports decline by 35.61% whereas imports are reduced by 31.32%. Together, these coefficients indicate the severe impact of sanctions imposed on Iran and Russia on aggregate trade.

Table 1: Impact of the Iran and Russia sanctions on aggregate international trade

Dependent Variable:	Trade value
Sanctions on flows to Iran	-0.3401** (0.1796)
Sanctions on flows from Iran	-0.6028*** (0.1879)
Sanctions on flows to Russia	-0.3046*** (0.0656)
Sanctions on flows from Russia	-0.2725*** (0.0946)
WTO	0.2028*** (0.0548)
Common currency	0.1166** (0.0341)
FTA	0.0626*** (0.0205)
<i>Fixed-effects</i>	
origin × year	Yes
destination × year	Yes
origin × destination	Yes
<i>Fit statistics</i>	
Observations	347,407
Pseudo R ²	0.9916

Note: Clustered (origin & destination) bootstrapped standard-errors based on 1000 replications in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

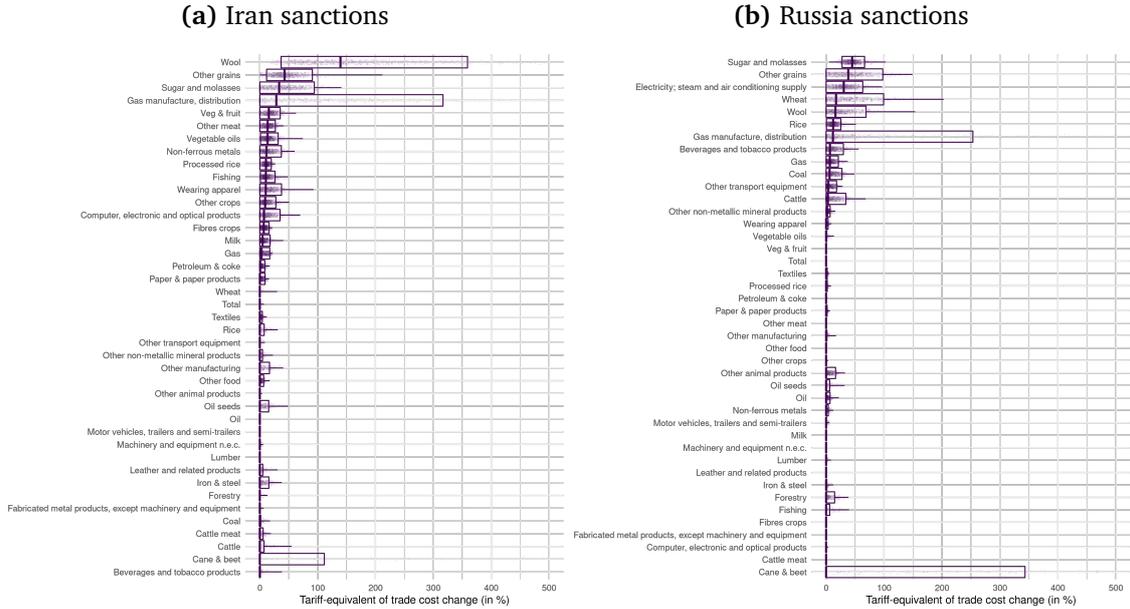
Impact by sector

Having analysed the impact of the Iran and Russia sanctions on aggregate trade flows, we next turn to estimating equation (2) at the sectoral level. We use the implied estimated relative changes in trade costs due to the sanctions by sector to inform our simulations in Section 6.⁷ The estimated sectoral coefficients are then translated into tariff and export tax equivalents as $\exp(\hat{\beta}^j / (\theta^j + 1)) \times 100\%$ and reported in Figures 1 and 2.

Looking at Figure 1, we note that sanctions increased trade costs for exporting to Iran and Russia across a broad range of sectors. For Iran, trade costs escalate in nearly all primary sectors including wool, other grains, sugar and molasses, vegetables and fruits, other meats and vegetable oils. Besides these industries, gas manufacture and distribution, wearing apparel and computer, electronic and optical products are also hit significantly by sanctions. In the case of Russia, agri-food products are hit hardest with trade costs rising substantially for exports of sugar and molasses (45%, $SE = 12$), wheat (17%, $SE = 35$) and other grains (38%, $SE = 31$). Energy products such as electricity, gas and coal are affected as well.

⁷Note that, as customary in the related literature, we only use those estimated changes where the coefficient indicates an increase in bilateral trade costs.

Figure 1: Sanctions impact on exports to Iran (a) and Russia (b) by sector



Note: The figures above display tariff equivalents implied by the coefficients and their 95% confidence intervals based on 1000 bootstrap replications of estimations of the sectoral gravity model as outlined in equation (2). The estimates capture the impact of sanctions on each sector's exports to Iran and Russia.

In Figure 2, we report changes in trade costs for imports from Russia and Iran. For imports sourced from Iran, the detrimental impact of sanctions is highest for wheat (318%, $SE = 108$) and other grains (203%, $SE = 101$). In the case of Russia, the steepest increase in trade costs is observed for imports of computer, electronic and optical products, forestry, other meat, rice, vegetables and fruits.

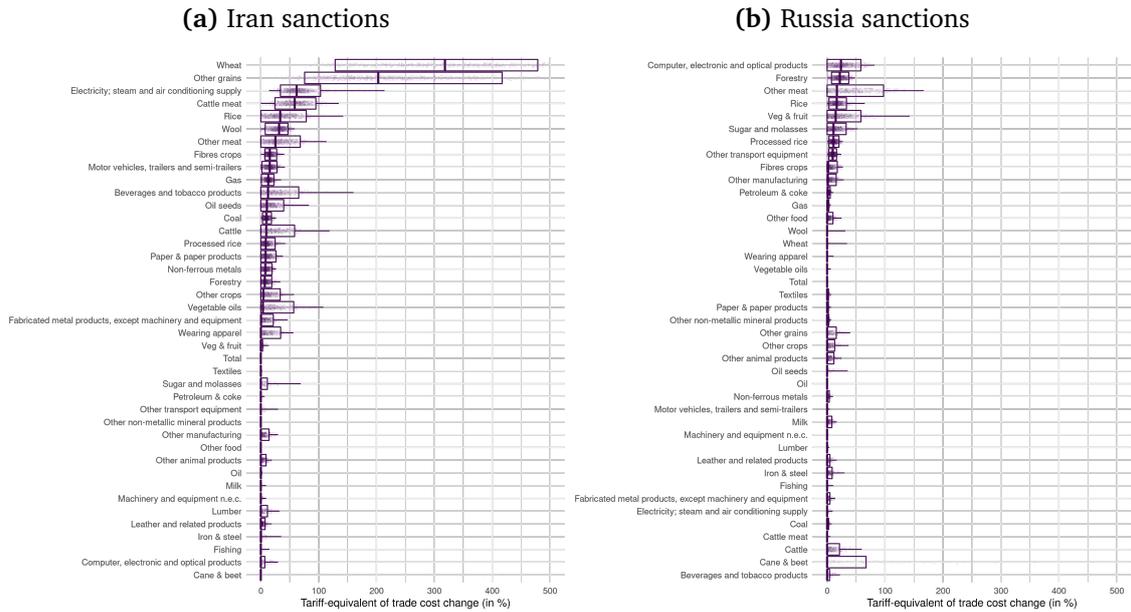
Together these estimations reveal that sanctions against Russia and Iran caused trade costs to surge in multiple industries but to varying degrees. This heterogeneity in sectoral responses to sanctions is masked by gravity estimations at the aggregate level. Therefore, subsequent simulations with the CGE model will draw upon these sectoral elasticities to generate more precise counterfactuals for the role of coalitions in sanctions regimes.

6 General Equilibrium Simulation Results

While gravity estimations in Section 5 revealed the negative impact of sanctions on trade flows at the aggregate or sectoral level, they do not account for the full economic costs associated with sanctions. To do so requires running simulations in a general equilibrium model.

Aside from quantifying the welfare costs from the implemented sanctions policies against Iran and Russia, we use the model to perform a number of counterfactual experiments. What would happen if all countries globally implemented the measures currently enforced

Figure 2: Sanctions impact on imports from Iran (a) and Russia (b) by sector



Note: The figures above display tariff equivalents implied by the coefficients and their 95% confidence intervals based on 1000 bootstrap replications of estimations of the sectoral gravity model as outlined in equation (2). The estimates capture the impact of sanctions on each sector's imports from Iran and Russia.

by the coalition, i.e. a horizontal expansion of sanctions? What would happen if the current coalition were to implement an embargo against Iran or Russia, respectively, i.e. a vertical expansion of sanctions? The model also allows us to explore the individual contributions of all current — and hypothetical third — countries.

Therefore, we now proceed to computing a series of counterfactual scenarios that evaluate different setups of sanctions coalitions and policies with the help of the model sketched in Section 3 and calibrated using the estimates described in Section 5.

6.1 Benchmarks

For our first set of simulations, we examine the welfare loss imposed by the current sanctions coalitions on Iran and Russia. Furthermore, this welfare loss is evaluated against several benchmarks that reflect the coercive 'potential' of sanctions. Such measurement of sanctions potentials is similar to the idea of Heid and Larch (2014), who investigate the economic vulnerability of countries due to their integration into the global economy. In contrast, we compute the potential of sanctions to reduce welfare in target regimes in three distinct ways.

First, we examine the 'vertical' potential of sanctions by computing changes in welfare if the current coalition were to enforce a complete embargo on trade with Iran and Russia. Next, we compute the 'horizontal' sanctions potential by evaluating a scenario wherein these sanctions are implemented by a global coalition that maintains the severity of current

Table 2: Benchmark impact for actual and hypothetical coalitions and measures

(a) Iran sanctions			(b) Russia sanctions		
	Current coalition	Global implementation		Current coalition	Global implementation
Current measures	-1.50 % (0.26)	-2.35 % (0.64)	Current measures	-1.68 % (0.18)	-2.90 % (0.31)
Complete embargo	-4.01 %	-13.34 %	Complete embargo	-5.16 %	-14.57 %

Note: The table above displays welfare losses imposed on Iran and Russia under four different scenarios, namely, (i) the status-quo with current coalition composition and current measures; (ii) a ‘horizontal sanctions potential’ as sanctions are expanded to a global coalition enforcing the current set of measures; (iii) a ‘vertical sanctions potential’ as sanctions are expanded by the current coalition to a complete embargo and; (iv) the autarky scenario where a global coalition places a complete embargo on trade with Iran or Russia. Note that bootstrapped standard errors based on 1000 replications can only be computed for (i) and (ii) as there is no uncertainty in trade costs for (iii) and (iv).

measures i.e. imposes trade costs that match those estimated in Section 5. The final benchmark corresponds to the autarky case which corresponds to the maximum welfare loss that can potentially be imposed on Iran and Russia through the toughest of sanctions.

In summary, the model computes changes in welfare when moving from the baseline case where no country imposes sanctions on Iran or Russia to four counterfactuals that include the current coalitions set-up and the three benchmark scenarios described above. Note that in these scenarios, we assume a baseline of balanced trade, as is common in the literature.⁸

The results are displayed in Tables 2a and 2b. In the case of Iran sanctions, the current coalition imposes a welfare loss of 1.5% ($SE = 0.26$) on Iran with its existing set of measures. If this coalition were to enforce a complete embargo on trade with Iran, welfare loss imposed would rise to 4.01%. Comparing these outcomes, we note that the current coalition set-up thus achieves more than a third of the punitive force that can be realized under an embargo scenario. If however, the current coalition were to expand its membership to include all countries while retaining the stringency of its existing measures, the welfare loss imposed increases to 2.35% ($SE = 0.64$). Therefore, even with a limited set of partners, the current coalition is able to reach nearly two-thirds of the sanctions potential of a hypothetical global coalition.

Our final benchmark relates to the welfare loss that can be imposed on Iran when its placed under autarky by a global coalition implementing a complete embargo. This extreme case enables us to understand the upper bound of sanctions-induced welfare costs. Under this scenario, welfare loss imposed on Iran climbs to 13.34% – approximately 9.3 pp. higher than the loss which is enforced by the current coalition set-up.

⁸Results for simulations with a baseline of unbalanced trade are available in an online appendix here: https://julianhinz.com/research/sanctions_coalitions/online-appendix.pdf.

This pattern is similar for Russia sanctions. In this case, the welfare loss imposed on Russia by the current coalition set-up (-1.68%, $SE = 0.18$) is more than tripled if the coalition moves to an embargo (-5.16%). In comparison, the additional welfare loss on Iran from a global coalition that enforces the current set of sanctions measures is lower ($2.9 - 1.68 = 1.22$ pp.). Interpreted differently, the current coalition set-up attains more than half of the coercive power of a global coalition that employs similar measures. The final benchmark reveals the maximum possible welfare loss that can be imposed on Russia when it is embargoed by a global coalition. Here, welfare loss jumps to 14.57%, more than 2.5 times than what could be achieved by the current coalition imposing an embargo on Russia.

Taken together, these benchmarks suggest that there remains significant ‘water’ in the sanctions policy of the current coalition. However, the extent to which welfare losses against the target regime can be increased is capped by the autarky scenario.

6.2 Individual contributions of countries

In the next set of scenarios, we examine the contributions that coalition members make towards maintaining the sanctions regimes against Iran and Russia. These contributions are assessed by examining (i) the domestic welfare loss experienced from implementing sanctions; and (ii) the welfare loss which is imposed on the target regime from these sanctions.⁹ The value of coordinating sanctions packages through coalitions is ascertained by the comparing these contributions under different scenarios where sanctions are either applied unilaterally or multilaterally.

In the unilateral case, we examine welfare losses when moving from a baseline (with no sanctions) to a series of counterfactuals where each member of the current coalition independently imposes sanctions on Russia or Iran. These scenarios correspond to a complete break-down of coalitions as each sanctioning state acts in isolation. In the multilateral case, we examine changes in welfare for the j -th country when it is the last member to be included in the sanctions coalition. Therefore, the baseline here corresponds to a scenario where all coalition members except j sanction Iran or Russia.

Results from these counterfactuals are reported in Table 3. For both Iran and Russia sanctions, the average domestic welfare loss incurred by coalition members is when sanctions are enacted multilaterally instead of unilaterally. These difference are substantial as domestic welfare loss is nearly 8.3% lower for Iran sanctions and 9.6% for Russia sanctions. This difference primarily stems from the presence of multilateral resistance terms as countries are less remote when they cooperate on sanctions. Overall, the reduction in

⁹Note that the domestic welfare losses arise from the increase in cross-border frictions which raises the operating costs for businesses trading with sanctioned states. The costs are further magnified in the presence of supply chains and for countries dependent upon inputs sourced from the sanctioned state.

Table 3: Average losses incurred and imposed

(a) Iran sanctions			(b) Russia sanctions		
	Loss incurred	Loss imposed		Loss incurred	Loss imposed
unilateral	-0.0072 %	-0.0265 %	unilateral	-0.1351 %	-0.0427 %
multilateral	-0.0066 %	-0.0277 %	multilateral	-0.1220 %	-0.0467 %

Note: The table above displays the collective welfare loss incurred by all members of the current sanctions coalition against Iran or Russia. In the unilateral scenario each country imposes its sanctions in isolation whereas in the multilateral scenario, members jointly implement sanctions measures.

domestic welfare loss under the multilateral relative to the unilateral scenario demonstrates the value of coordinating sanctions across countries.

The value of coalition formation is further evidenced by the difference in welfare losses imposed on the target economy. Table 3 reports that sanctions carry additional punitive force under the multilateral scenario for both sanctions regimes with the welfare losses increasing by 4.5% for Iran and 9.3% for Russia. This higher welfare loss is the result of reduced opportunities for trade diversion as multiple countries enforce sanctions.

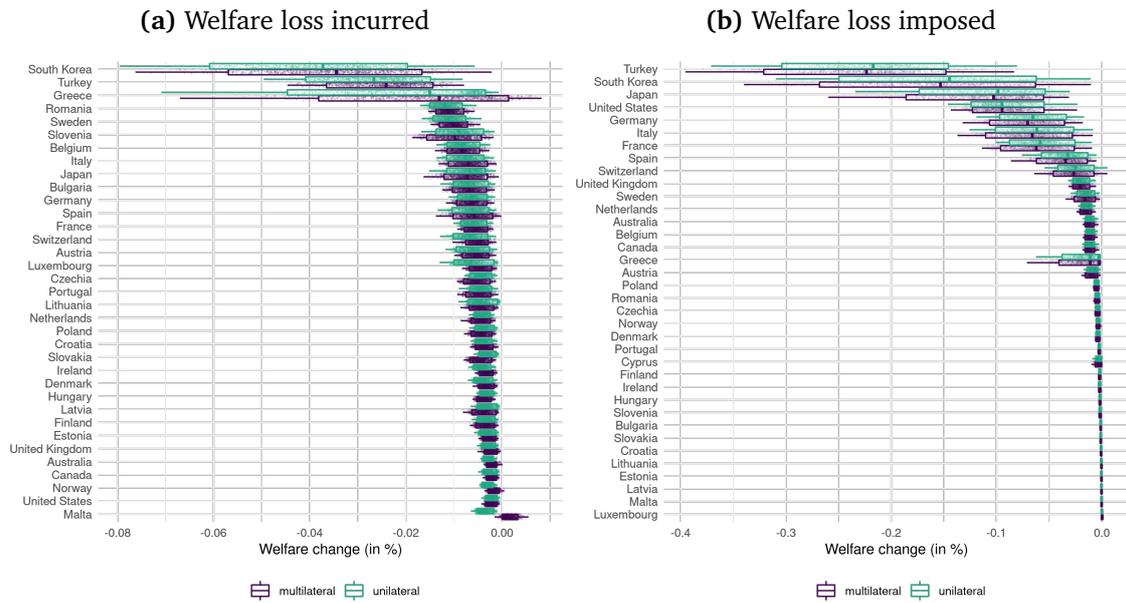
Hence coalitions have the twin advantage of not only lowering the average domestic welfare loss faced by its members but also escalating the imposed welfare loss for sanctioned states. As such, countries are observed to be more ‘effective’ sanction senders under a coalition framework.

How do contributions towards the sanctions regimes vary across members within the coalition? To investigate this issue, we plot welfare changes experienced by sanctioning states domestically and that incurred by the sanctioned state for both the unilateral and multilateral implementation scenarios.

The simulations produce several interesting outcomes. Considering the magnitude of the domestic welfare loss, we observe substantial skewness across countries in their economic expenditure toward the sanctions regime. The top five contributors in this regard to the Iran sanctions are South Korea (-0.037%, $SE = 0.013$), Turkey (-0.024%, $SE = 0.007$), Greece (-0.013%, $SE = 0.013$), Romania (-0.011%, $SE = 0.002$) and Sweden (-0.01%, $SE = 0.002$). In the case of Russia, the leading contributors are Lithuania (-0.734, $SE = 0.055$), Estonia (-0.427, $SE = 0.095$), Ukraine (-0.375, $SE = 0.054$), Latvia (-0.331, $SE = 0.139$) and Slovakia (-0.275, $SE = 0.044$). For these coalition members, sanctions are significantly more costly. Moreover, these domestic welfare losses are amplified when sanctions are implemented unilaterally relative to the multilateral case.

Not only is the burden of sanctions unevenly distributed, but also the capacity to impose welfare loss on the sanctioned state differs across members states. For Iran, the coalition members which exert the highest coercive force (welfare loss on Iran) are Turkey (-0.223%,

Figure 3: Individual contributions — Iran sanctions



Note: Figures above display each country in the current sanctions coalition against Iran and the welfare change it experiences domestically and that which it imposes on the sanctioned state. The 95% confidence intervals on welfare losses are constructed from 1000 bootstrap replications of the simulations.

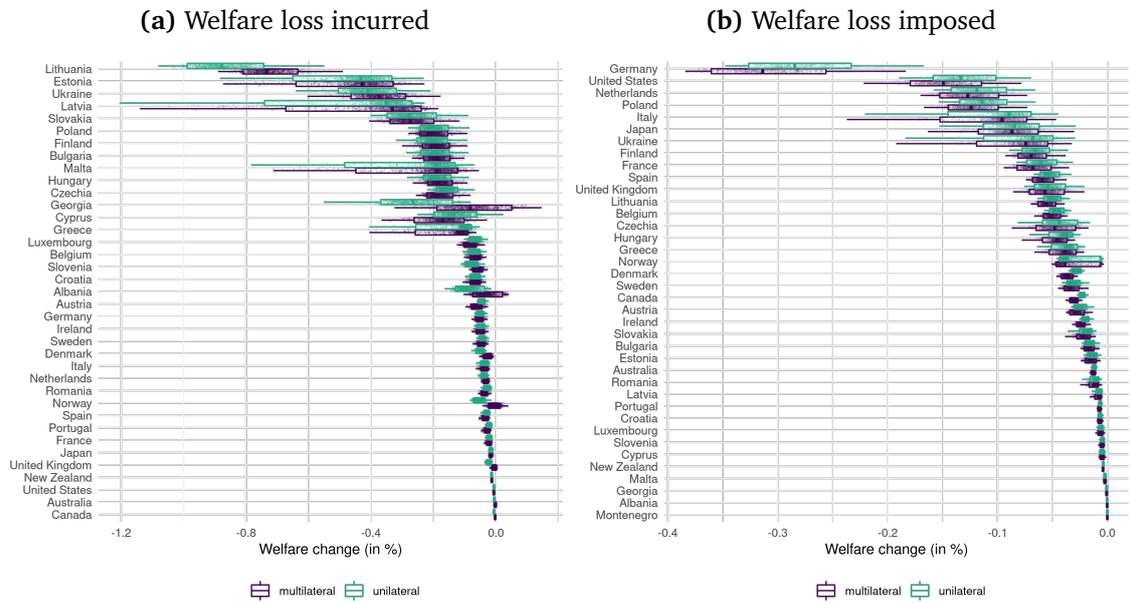
$SE = 0.051$), South Korea (-0.153%, $SE = 0.064$), Japan (-0.103%, $SE = 0.041$), United States (-0.095%, $SE = 0.021$) and Germany (-0.07%, $SE = 0.021$). Looking at Russia, the punitive impact is highest for coalition members such as Germany (-0.314%, $SE = 0.032$), United States (-0.149%, $SE = 0.02$), Netherlands (-0.127%, $SE = 0.016$), Poland (-0.124%, $SE = 0.014$) and Italy (-0.096%, $SE = 0.024$). For the majority of countries, welfare loss imposed is higher under the multilateral than the unilateral case.

Finally, we note that the United States is the most effective in imposing the Iran and Russia sanctions in terms of welfare cost borne at home vis-à-vis welfare loss imposed on the target. Closely following the United States are other large economies such as Japan and Germany. In comparison, smaller nations such as Malta, Estonia, Latvia incur relatively high costs of sanctions that translate only into marginal welfare loss for Russia. They are also ranked low in terms of the welfare loss imposed on Iran. Therefore, coalition members differ substantially not only in their contributions towards the sanctions regime but also in their effectiveness.

6.3 Impact of non-cooperating China

The previous simulations revealed that sanctions coalitions both reduce the average domestic welfare losses borne by coalition members and deepen the welfare losses enforced on Iran and Russia. In this scenario, we examine whether these dual advantages are further magnified when a major trading economy, specifically China, is included in the coalition.

Figure 4: Individual contributions — Russia sanctions



Note: Figures above display each country in the current sanctions coalition against Russia and the welfare change it experiences domestically and that which it imposes on the sanctioned state. The 95% confidence intervals on welfare losses are constructed from 1000 bootstrap replications of the simulations.

China has consistently characterized its position as a neutral party that prefers diplomatic resolutions over sanctioning Iran or Russia. Given this stance, what are the implicit welfare implications of China’s non-alliance?

To examine this issue, we construct a counterfactual that consists of China joining the existing sanctioning coalition and therefore imposing new export and import restrictions against Russia and Iran. Since China has not implemented sanctions, we presume that the increase in trade costs from these hypothetical restrictions are equivalent to those of the existing coalition and their current measures. The resulting shift in welfare costs borne by Russia and Iran as well as the sanctioning states is then considered to be the hidden costs of China’s non-cooperation in the status quo.

Results from these counterfactuals are reported in Table 4a and Table 4b. In each table, we report the welfare change under the existing sanctions coalition and the welfare change from China joining the coalition. These changes are computed from a baseline scenario where no country sanctions Russia or Iran. In both cases, China’s involvement in the sanctions regime greatly deepens the welfare loss incurred by the sanctioned state. Iran’s welfare reduces by an additional 0.76 pp and Russia’s by 0.36 pp.

We can also contrast these welfare changes with the benchmarks described in Section 6.1. We note that an expanded coalition with China would realize nearly 75% of the welfare loss on Iran and approximately 71% of the welfare loss on Russia that a global coalition

Table 4: Impact of non-cooperating China

(a) Iran sanctions with China			(b) Russia sanctions with China		
	Current coalition	incl. China		Current coalition	incl. China
Iran	-0.9730 % (0.2606)	-1.7393 % (0.4114)	Russia	-1.6918 % (0.1822)	-2.0585 % (0.2217)
China	0.0019 % (0.0007)	-0.0127 % (0.0029)	China	0.0045 % (0.0010)	-0.0237 % (0.0031)
Current coalition	-0.0057 %	-0.0055 %	Current coalition	-0.1220 %	-0.1183 %
Rest of the world	0.0021 %	0.0028 %	Rest of the world	0.0184 %	0.0232 %

Note: The tables above display welfare changes from sanctions in the benchmark scenario and a scenario in which China joins the existing sanctions coalitions. Clustered standard errors are based on 1000 bootstrap replications of the simulations.

with the same set of measures would achieve (termed as the ‘horizontal’ sanctions potential in Section 6.1). Thus the addition of China allows for closer fulfilment of the sanctions potential, relative to the current coalition (64% and 58% for Iran and Russia, respectively).

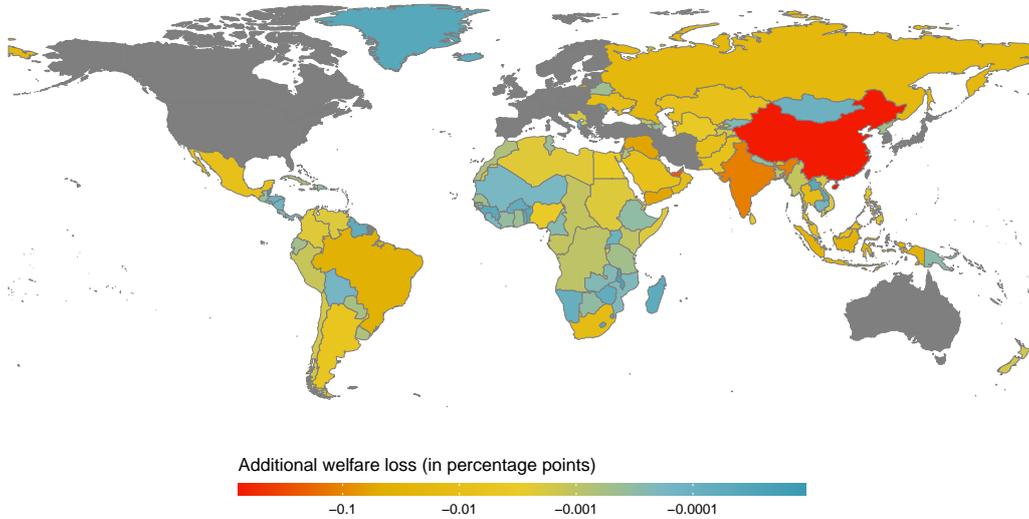
At the same time, China itself incurs minimal welfare loss from joining the Iran (-0.013%) or Russia (-0.024%) sanctions coalitions. Moreover, existing coalition members experience small declines in their welfare losses from the sanctions regimes when China joins the coalition. Taken together, these counterfactuals indicate that China can substantially raise the coercive power of sanctions regimes without facing significant domestic welfare costs or imposing such costs on current coalition members. Interestingly, one dimension of the implicit cost of China’s non-cooperation in the status quo is borne by the rest of the world (RoW). This group could experience a 33.3% increase in their welfare (on average) from China sanctioning Iran and 26.1% increase from China sanctioning Russia in comparison to the status quo. Note that since these increases are computed as unweighted averages, they are driven by small oil-producing nations which benefit from China sanctioning Iran and Russia.

6.4 Ideal coalition partners

In the next set of scenarios, we build on the previous counterfactual and examine the issue of which countries in general (not only China) would need to join the existing sanctions coalitions in order to make sanctions more costly for targeted nations. To do so, we construct a succession of counterfactuals. In each counterfactual, we expand the current sanctioning coalition by including one additional country that does not currently impose sanctions against Russia or Iran. Here, we presume that the addition of new members in the sanctions coalition does not cause other members of the coalition to depart and does not dilute the stringency of measures implemented.

This generates a series of counterfactuals, one for each third-party country in the world. Comparing the welfare loss incurred under these various counterfactuals with the welfare

Figure 5: New coalition partners: Welfare loss imposed on Iran



Note: The map above displays the additional welfare loss incurred by Iran from each new country joining the current sanctions coalition. Countries in grey correspond to those which already sanction Iran.

loss under the status-quo scenario allows us to compute the additional coercive power of each third-party country to the sanctions coalition. Based on this, we create a ranked list of nations that would be ‘ideal’ coalition partners to be approached if the existing coalition decides to strengthen the sanctions regimes against Iran and Russia. The results from these counterfactuals are depicted in Figure 5 and Figure 6. In both maps, we plot the additional welfare loss incurred by the targeted nation from each country joining (one at a time, with replacement) the existing sanctions regime against Iran or Russia.

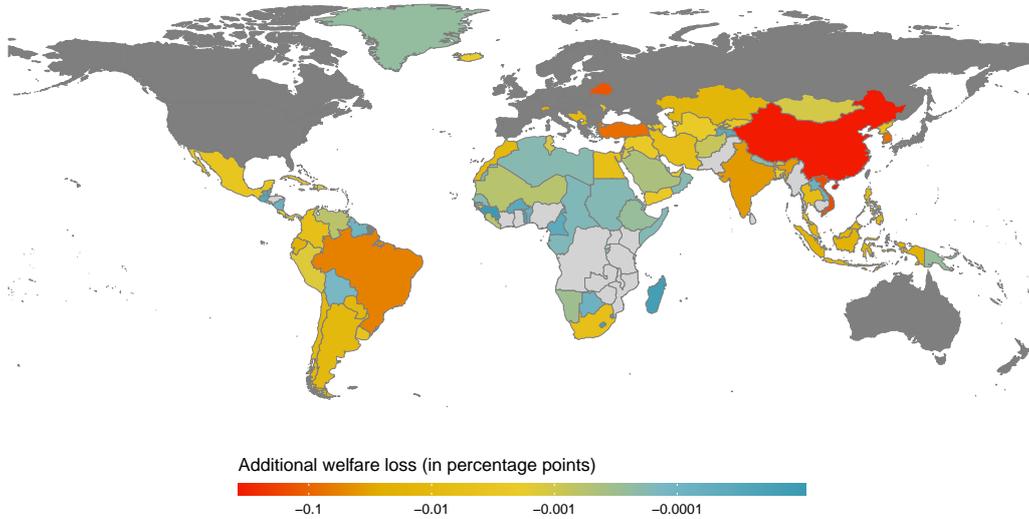
In the case of Iran sanctions, the most important third-party countries which would increase the punitive impact of sanctions are China (-0.77%), as seen in section 6.3, UAE (-0.24%), India (-0.12%), Singapore (-0.04%) and Brazil (-0.04%). For the Russia sanctions, the leading potential coalition partners that would increase the welfare loss for Russia are China (-0.37%), as previously seen, as well as Vietnam (-0.15%), Belarus (-0.13%), Turkey (-0.08%) and South Korea (-0.08%). Coordinating sanctions with these countries would reduce opportunities for sanction-busting by targeted nations and increase the punitive force of sanctions regimes.¹⁰

6.5 Burden sharing

The counterfactual results reported in Section 6.2 show that sanctions impose uneven domestic welfare costs on coalition members. Therefore, in the final set of scenarios, we examine the potential for burden sharing within the coalition. Calls for such burden sharing mechanisms have been raised previously by countries at the UN, given the increasing

¹⁰For ranked lists of the top ten prospective coalition partners, see Tables 5 and 6 in Appendix C.

Figure 6: New coalition partners: Welfare loss imposed on Russia



Note: The map above displays the additional welfare loss incurred by Russia from each new country joining the current sanctions coalition. Countries which already sanction Russia are depicted in dark grey whereas countries in light grey correspond to those, whose membership in the coalition causes Russian welfare loss to marginally reduce.

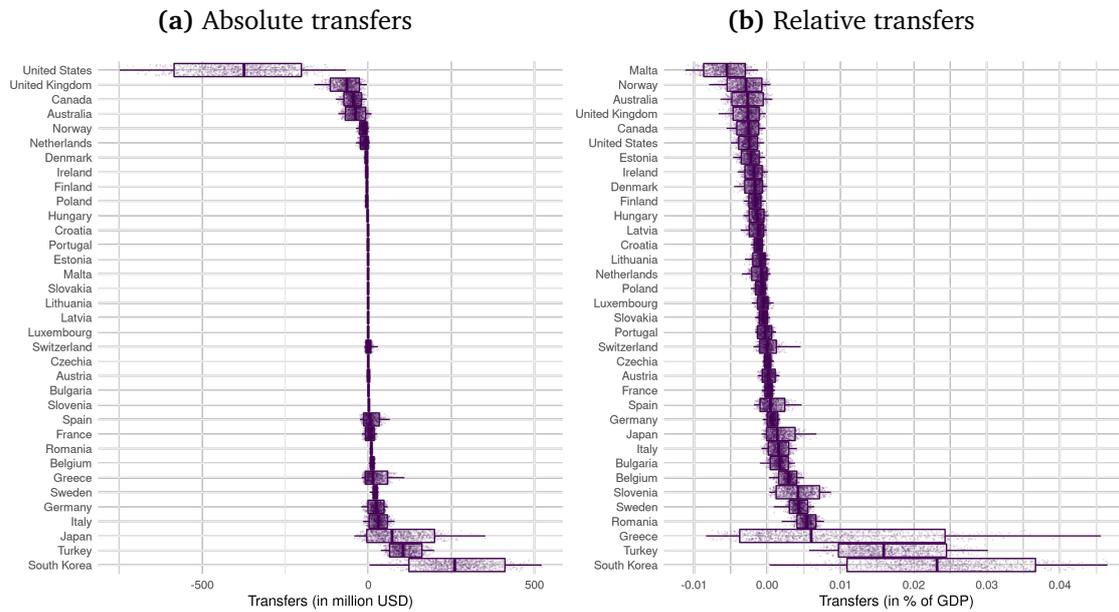
frequency and severity of sanctions.¹¹ In mitigating the adverse impact of sanctions and their asymmetric incidence across countries, burden sharing policies can also stabilize sanctions coalitions and incentivize new countries to join.

Here, we investigate one potential mechanism by which sanctioning states can offset the economic costs incurred from the Iran and Russia sanctions. This mechanism takes the form of an adjustment fund, executed through transfers between coalition members such that all countries experience identical domestic welfare losses from implementing sanctions. We implement these transfers as described in Section 3. Incidentally, these hypothetical transfers also represent a measure of the relative sanctions costs the coalition countries face.

Figures 7 and 8 report the absolute and relative magnitude of these transfers by member country, for the current coalition set-up. Here, negative values correspond to net transfers made while positive values indicate net transfers received. Looking at absolute values, we find that the United States would need to allocate more than USD 374 million ($SE = 117$) for compensating coalition members for the Iran sanctions and USD 2.76 billion ($SE = 401$) for the Russian sanctions regimes. Combining both sanctions regimes, other top transfer-sending states are United Kingdom (USD 586 million), Canada (USD 446 million), Australia (USD 348 million) and Norway (USD 165 million).

¹¹See “Calls for burden-sharing mechanism to ease sanctions effects on third states, as Sixth Committee continues discussion of report of Charter Committee”, United Nations Press Release GA/L/3075, October 1998. Link: <https://bit.ly/3MmqY11>.

Figure 7: Burden sharing through transfers — Iran sanctions

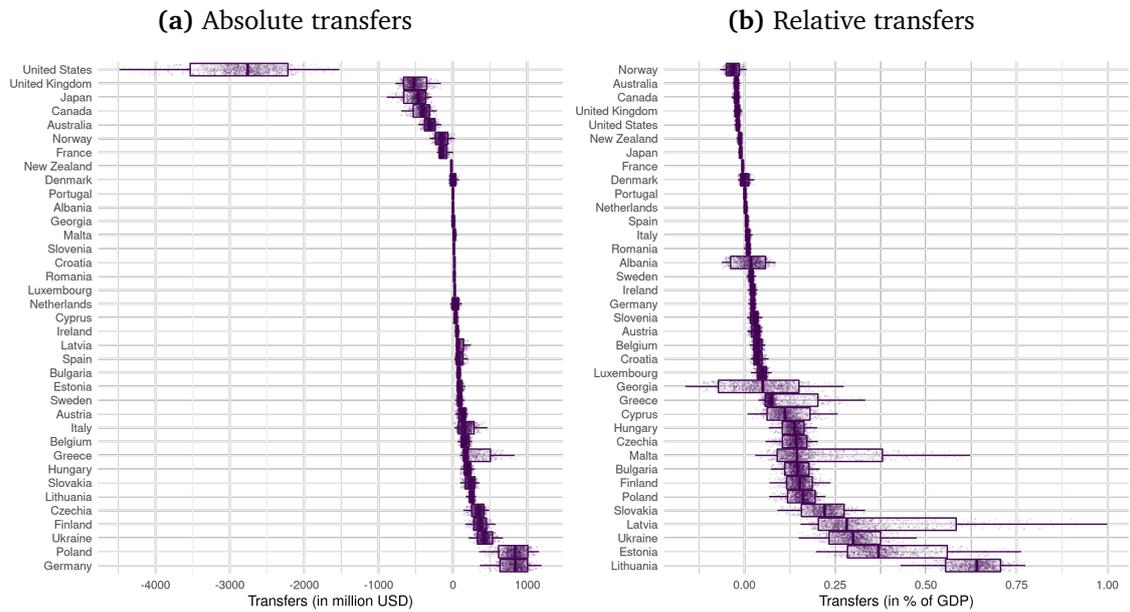


Note: Figures above display each country in the sanctions coalition against Iran in 2012 and the transfers it sends or receives such that welfare losses are equalized across coalition members. The 95% confidence intervals are constructed from 1000 bootstrap replications of the simulations.

Turning to the top transfer recipient countries, these are South Korea (USD 260 million, $SE = 87$), Turkey (USD 105 million, $SE = 30$) and Japan (USD 72 million, $SE = 65$) for Iran sanctions and Germany (USD 840 million, $SE = 120$), Poland (USD 836 million, $SE = 123$) and Ukraine (USD 425 million, $SE = 61$) for the Russian sanctions. Several Baltic states that incur relatively heavy domestic welfare losses from Russia sanctions also receive transfers that are significant in terms of the shares of their GDP, e.g., Lithuania (0.64%, $SE = 0.05$), Estonia (0.37%, $SE = 0.08$), Latvia (0.28%, $SE = 0.12$), but also Ukraine (0.3%, $SE = 0.04$) and Slovakia (0.22%, $SE = 0.04$).

Cumulatively, we find that the current coalition set-up would require an adjustment fund totalling USD 591 million ($SE = 197$) to equalize domestic welfare losses from Iran sanctions and USD 4.8 billion ($SE = 671$) from Russia sanctions. While such direct compensations of sanctions-induced economic costs are likely difficult to be institutionalised, the hypothetical relative transfers can be seen as a sanctions-equivalent of NATO spending goals. An actual implementation would promote the resilience of sanctions coalitions over the long run by reducing disparities in economic burdens between member states.

Figure 8: Burden sharing through transfers — Russia sanctions



Note: Figures above display each country in the sanctions coalition against Russia in 2014 and the transfers it sends or receives such that welfare losses are equalized across coalition members. The 95% confidence intervals are constructed from 1000 bootstrap replications of the simulations.

7 Conclusion

This paper provides novel empirical results concerning the impact of coalitions on the economic cost and deterrent power of sanctions. To do so, we examine various hypothetical geometries of sanctions coalitions against Iran and Russia and compute the resulting changes in welfare loss experienced by sanctioning and sanctioned states. These welfare losses are calculated by running simulations with a modified Caliendo and Parro (2015)-type new quantitative trade model that uses sector-specific trade cost changes due to implemented sanctions measures, drawn from model-implied structural gravity estimations.

The simulations provide strong evidence that coalitions serve two important purposes. First, they magnify the coercive force of sanctions regimes by raising the welfare losses incurred by targeted nations. Second, they reduce the welfare losses borne by individual sanctioning states. These twin objectives of raising the punitive force of sanctions whilst lowering domestic welfare losses is affected by the constellation of nations that belong to the coalition. For instance, large developing economies such as China, India, Brazil and Vietnam are ‘ideal’ prospective allies if the coalition seeks to increase the cost of sanctions for Iran and Russia. The cost of not having these members in the existing sanctions coalition is particularly high in the case of China. Counterfactuals show that China’s cooperation in sanctions against Iran and Russia would raise the deterrence capability

of sanctions, allowing the coalition to reach more than 70% of the horizontal sanctions potential i.e. the prospective welfare loss that a global coalition would impose on the sanctioned state.

Counterfactuals also reveal considerable skewness in how welfare losses from sanctions are distributed across coalition members. These welfare costs tend to be disproportionately borne by small states, for instance by Latvia, Lithuania and Estonia in the case of Russia sanctions. Given this inequity in economic expenditures, we compute the size of transfers that would level welfare losses from sanctions across all coalition members. The scale of such an adjustment fund is USD 591 million for Iran sanctions and USD 4.8 billion for Russia sanctions with United States being the leading transfer-sending member. The hypothetical transfers also provide a measure for the relative burden borne by participating coalition countries.

In conclusion, this paper contributes to the growing literature that analyzes the economic cost of sanctions, focusing on the role of sanctions coalitions. Future research could complement this endeavour by highlighting the importance of the sector, as well as finding “optimal” combinations of sanctioning countries and/or sectors.

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A Brief context for the 2012 Iran sanctions and 2014 Russia sanctions

As mentioned previously, our analysis focuses on the 2012 Iran and 2014 Russia sanctions given their severity. Moreover, these episodes saw several countries adopting restrictive measures against Iran (36) and Russia (38). This joint action on sanctions packages across multiple nations, whether tacit or formalized, allows us to investigate the role of coalitions. In the case of Iran, the 2012 wave of sanctions followed concerns related to the country’s nuclear programme. Amongst these sanctions, the hardest hitting measures included an embargo against Iranian oil and natural gas and the isolation of Iran from the SWIFT system and global financial markets. These sanctions were eased in 2016 as part of the “Joint Comprehensive Plan of Action” (JCPOA) deal. However, the withdrawal of the United States from the JCPOA in 2018 triggered a reinstatement of sanctions against Iran.

The 2014 series of sanctions imposed against Russia in 2014 followed its annexation of Crimea. These sanctions were initially limited to targeted travel bans, visa restrictions and asset freezes on Russian and Crimean officials. However, sanctions were toughened following the shooting down of a civilian airplane in the contested Donbass region in July 2014. After this incident, new trade and financial sanctions were imposed. These measures included restrictions on exports of dual-use and sensitive technologies, restrictions on access to loans and capital markets for major Russian banks, energy companies and defence equipment manufacturers and the addition of more Russian entities on the sanctions list. Together, these policies aimed to severely restrict economic activity in Russia. In August 2014, Russia retaliated by banning imports of agri-food products from sanctioning states. These sanctions regimes have continued and escalated even further in 2022 following Russia’s invasion of Ukraine.

B Bayesian bootstrap procedure

The original bootstrap was introduced by Efron (1979). Inference for parameters is based on the empirical distribution of repeated estimation of the parameters with varying samples that are obtained from the original sample by randomly drawing with replacement. Some observations i happen never to be drawn, while others are drawn a potentially large number of times, the resulting distribution of numbers of occurrences x_i being multinomial with $n = k$ and $p_i = p = 1/n \forall k$ and probability mass function:

$$f(x_1, \dots, x_n) = \frac{\Gamma(\sum_i x_i + 1)}{\prod_i \Gamma(x_i + 1)} \left(\frac{1}{n}\right)^n,$$

where Γ is the gamma function. In any bootstrap iteration, an observation i has a proportion $w_i = x_i/n$ with $E[w_i] = 1/n$. In any combination of x_1, \dots, x_n other than

$x_1 = \dots = x_n = 1$ (which is the original sample) with positive probability mass, some $x_i = 0$ and hence some observations have a zero proportion in the respective bootstrap iteration.

The Bayesian bootstrap proposed by Rubin (1981) similarly assigns different proportions ω_i to the original observations in every bootstrap sample. It deviates from the traditional bootstrap in drawing these proportions from a continuous distribution, specifically from the Dirichlet distribution with $K = n$ and $\alpha_i = \alpha \forall i$ and probability density function:

$$g(\omega_1, \dots, \omega_n) = \frac{\Gamma(n\alpha)}{(\Gamma(\alpha))^n} \prod_i \omega_i^{\alpha-1}.$$

The non-integer “number of times” any observation is drawn for a bootstrap sample is given by $\omega_i n$. Each observation’s proportion is the same in expectation as in the traditional bootstrap, i.e. $E[\omega_i] = E[w_i] = 1/n$, but the continuous reformulation implies that no observations receive a zero weight in any bootstrap iteration. This in turn implies that — different than in the traditional bootstrap — the collinearity structure of the original sample is retained in every iteration, i.e. any parameter that is identified in the original sample is also identified in every bootstrap iteration.

We follow the common choice for the Dirichlet concentration parameters of $\alpha = 1$, in which case the drawing of the Dirichlet weights can be implemented in a very straightforward way by taking $n - 1$ draws from the uniform $(0, 1)$ distribution and using the n resulting gaps on the $[0, 1]$ interval as the n proportions ω_i .

The Bayesian bootstrap can deal with potential correlation in the error terms across observations in the same way as the traditional bootstrap, namely by incorporating the notion of clustering from standard inference into the bootstrapping procedure. Specifically, just as one draws with replacement from the clusters rather than from the individual observations in the clustered traditional bootstrap, a common Dirichlet weight is drawn for every cluster, i.e. in our case for every country pair in order to allow for serial correlation.

C Additional simulation results

Table 5: Iran Sanctions: Top 10 additional coalition partners

Country	Additional welfare change
China	-0.7663 %
United Arab Emirates	-0.2361 %
India	-0.117 %
Singapore	-0.0427 %
Brazil	-0.0365 %
Indonesia	-0.0317 %
Russia	-0.0183 %
South Africa	-0.0135 %
Thailand	-0.0132 %
Oman	-0.0132 %

Note: The table above displays the additional welfare loss that is imposed on Iran when each of the listed countries joins the current coalition. For further description of these scenarios, see Section 6.4.

Table 6: Russia Sanctions: Top 10 additional coalition partners

Country	Additional welfare change
China	-0.3667 %
Vietnam	-0.15 %
Belarus	-0.1283 %
Turkey	-0.082 %
South Korea	-0.0779 %
Brazil	-0.0582 %
India	-0.0372 %
Israel	-0.0283 %
Switzerland	-0.0275 %
Singapore	-0.0228 %

Note: The table above displays the additional welfare loss that is imposed on Russia when each of the listed countries joins the current coalition. For further description of these scenarios, see Section 6.4.