The Cost of Sanctions: Estimating Lost Trade with Gravity *

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Abstract

Economic sanctions are a frequently used tool of foreign policy. Constraining trade flows towards or from the target country is supposed to coerce its government into changing certain policies. However, sanctions constitute an obstacle to trade, thereby affecting flows of all countries, including those of sanctioning countries themselves. I gauge the global impact of three recent sanctions regimes using a structural gravity framework and quantify the "lost trade" in a general equilibrium counterfactual exercise. Each of the episodes, sanctions against Iran, Russia and Myanmar, are instructive in their own way, due to the different nature of bilateral trade and severity of measures applied.

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1 Introduction

Economic sanctions are a frequently used tool of foreign policy. Aimed at targeting the sanctioned country's economy through restrictions or bans on the trade of certain goods and services, severance of financial ties, or an all-out embargo, the measures are used when diplomacy fails, while military options appear too drastic. However, sanctions also affect the countries that are not directly targeted, including the *sanctioning* country itself. Erecting new trade barriers makes the cross-border transfers of goods and money more costly for all exporters and importers—directly or indirectly.

The aim of this chapter is to study the consequence of three recent sanctions cases on international trade. The three case studies are instructive in their own respects:

1. The international sanctions against Iran in response to its nuclear program, in particular those by Western countries, are virtually unprecedented in their severity. The introduced financial sanctions effectively cut off the country from the international financial system and restricted trade seriously, while the ban on imports of crude and refined oil added to Iran's dire economic situation.

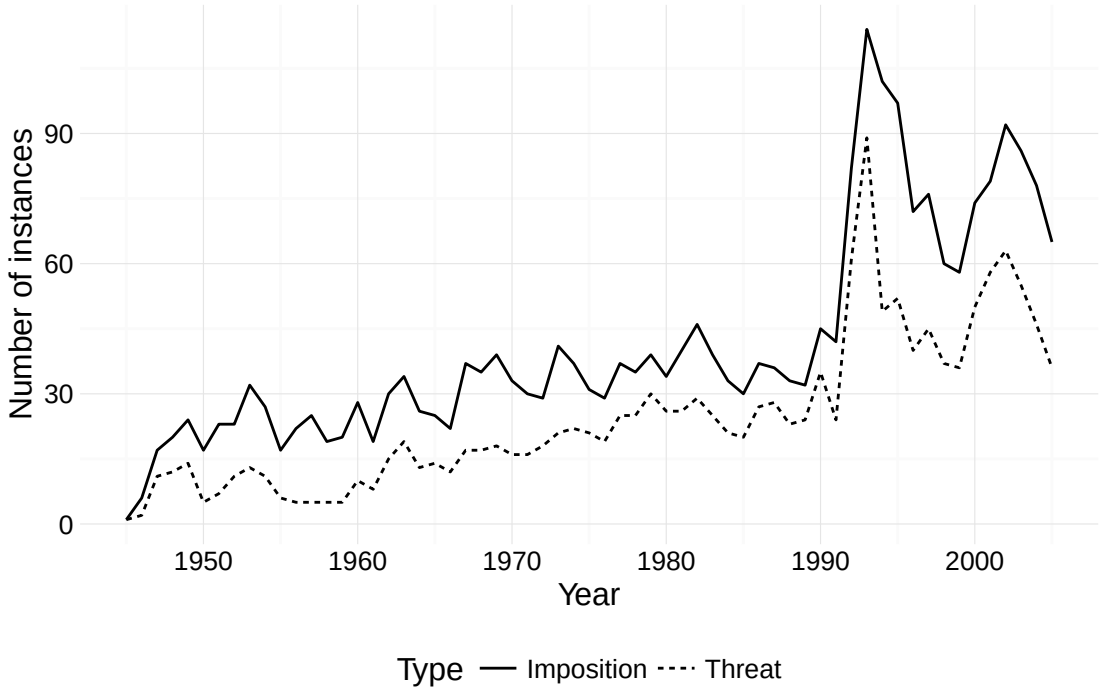
2. Sanctions against the Russian Federation in response to the involvement in the political and military crisis in Ukraine and the annexation of Crimea after the "Maidan Revolution" were less severe compared to the Iran sanction (albeit intensified over time), but hit a country with strong economic ties in the period preceding the events.

3. The sanctions against Myanmar, finally, are instructive in that they represent a case of lifted sanctions. While pre-sanction trade ties against the country were less important and the overall severity of the measures less harsh than in the other two cases, the recovery trade flows (or lack thereof) can be instructive for other cases.

I analyze the impact of these three sanction regimes on bilateral trade between sanctioned, sanctioning and non-implicated countries using a structural gravity setup that allows me to perform a general equilibrium counterfactual exercise. Using quarterly trade data from 48 countries from the beginning of 2010 until the end of 2015, the analysis provides an estimate of the "cost of sanctions". The results highlight the heterogeneous impact of the three sanction regimes, by different sanctioned and sanctioning countries involved.

The use of sanctions as a tool of foreign policy has seen a sustained increase over time, in particular since the end of the Cold War. Figure 1 shows the number of sanctions cases active in a given year since 1945. Naturally, the use and effect of sanctions as a foreign policy tool has attracted a substantial literature in both political science and economics. The bulk of the existing work has shed light on the determinants of the success or failure of such policies and the effect of sanctions on the *target* economy through which the

Figure 1: Number of sanctions active in a given year (Data source: Morgan et al. (2009))



intended outcome—change of certain policies—is supposed to work. Drezner (1999), van Bergeijk (2009) and Hufbauer et al. (2009) provide instructive overviews over the state of research in this respect. Rosenberg et al. (2016) and Drezner (2011) provide analyses into the currently fashioned "smart sanctions"', the use of targeted travel bans and asset freezes against implicated individuals. For empirical analyses, Hufbauer et al. (2009) also provide a thorough record of sanctions cases, with an emphasis on American- and European-imposed sanctions. The TIES database by Morgan et al. (2009) provides a second and very detailed source for sanctions encompassing more sender and target countries. Both datasets provide quantitative measures on the scope and intensity of applied measures, and attempt to judge their success or failure with respect to their political aims. Caruso (2003) estimates the average effects of sanctions in the second half of the 20th century in a simple *naive* gravity setup on aggregate trade flows.

A number of papers have looked at the economic impact of sanctions in *sender* countries. The case of the Embargo Act of 1807 is particularly well studied, as it provided the first use of sanctions and embargoes in the modern era. Frankel (1982), Irwin (2005), and O'Rourke (2007) find effects in the range of 4%–8% of U.S. GDP by looking at trade losses and commodity price changes. Hufbauer and Oegg (2003) look at macroeconomic effects of sanctions in place in the 1990s and find the total effect on U.S. GDP to hover around a

much lower 0.4%. Crozet and Hinz (2016) is most closely related to this present chapter. Crozet and Hinz study in depth the case of the Russia sanctions along two dimension, at the country- and firm-level. They distinguish between those goods that were directly affected by the Russian embargo and those that were not, finding substantial "collateral damage". The general equilibrium framework in this chapter borrows their methodology in estimating "lost trade" due to the sanctions in place.

Other studies look at the economic impact on the *target* economy. Dreger et al. (2015) evaluate the economic impact of the sanction regime between Western countries and the Russian Federation, estimating the consequences of the sanctions on the Russian macroeconomic performances. Dizaji and van Bergeijk (2013) study the macroeconomic and political impacts on Iran while aiming to quantify the effectiveness of the sanctions' regime. Also looking at the case of the Western-imposed sanctions on Iran, Haidar (2014) studies the impact of sanctions using firm-level data.

This current chapter is also related to the literature studying the link between conflict and trade. Martin et al. (2008a) and Martin et al. (2008b) analyze the prevalence and severity of interstate and civil wars through the lens of trade economists. They show that multilateral trade openness increases the probability of escalation with another country, while direct bilateral trade deters it. Similarly, small-scale civil wars are shown to be fueled by trade openness while it decreases the probability of large-scale strife. Glick and Taylor (2010) show the disruptive effects of war on international trade and economic activity in general. Their approach relies on a gravity setup and they quantify the losses by accounting for changes in bilateral and multilateral resistances.[1]

Another strand of the literature analyzes changes in the consumer preferences following political shocks. Fuchs and Klann (2013) show that high-level meetings with the Dalai Lama are costly for the hosting country, in the sense that bilateral trade with China is significantly reduced in the following year. Michaels and Zhi (2010) show that the diplomatic clash between France and the United States over the Iraq War in 2003 reduced significantly the trade between the two countries during a short period of time. Pandya and Venkatesan (2016) exploit scanner data to reveal that sales in the U.S. market of brands marketed to appear French, while not necessarily imported from France, were affected by this conflict. Heilmann (2016) studies the impact of various boycott campaigns, among others the boycott Danish products in some Muslim-majority countries in 2006 by using a synthetic control group methodology.

[1] Head and Mayer (2014) remark that this does not in fact constitute the general equilibrium impact, as it does not account for changes to production and expenditure. Head and Mayer and Anderson and Yotov (2010) coin this the *modular trade impact* or *conditional* general equilibrium effect. In the analysis below I explicitly do account for changes in production and expenditure figures, following and extending approaches by Dekle et al. (2007, 2008) and Anderson et al. (2016).

The contribution of this chapter is to assess the effect of recent sanctions regimes using quarterly aggregate export data from ITC Trade Map in a structural gravity framework. I find the overall lost trade due to the use of this tool of foreign policy to total more than US$50 billion in 2014, about 0.4 % of world trade. The bulk of this lost trade is carried by a few countries, with the sanctioned countries Russia and Iran unsurprisingly being hit hardest (in 2014: US$ 8.2 billion and US$ 12.2 billion respectively). At the same time, major exporting economies like Germany, France and Italy are bearing a large share as well (in 2014: US$ 12.2 billion, US$ 3.3 billion and US$ 2.8 billion respectively).

The chapter is structured as follows: section 2 provides a brief overview of the three major sanctions regimes that affected global trade flows in recent years. In section 3, I introduce describe the methodology for the structural gravity estimation and subsequent general equilibrium exercise. I present the results in section 4. Finally, section 5 concludes.

2 Recent Sanctions Episodes

I analyze the cost of sanctions for three recent cases of sanctions that are particularly instructive: Iran, Russia and Myanmar. Each of the sanction episodes is insightful in their own way. The sanctions levied on Iran can be considered to be the most severe, as they essentially entailed the cutting of from international financial infrastructure. The case of Russia is particular due to strong existing pre-sanction ties between the sanctioning and sanctioned countries. The case of Myanmar, finally, is instructive as sanctions were first suspended in 2012 and then lifted in 2013, after having been in place for almost half a decade. In the following, I provide a brief overview over the three cases to provide some background information. For the remainder of this study, I denote a "sanctioning" and "sender" country those countries that enacted economic sanctions against the respective "sanctioned" or "target" country, i.e. the Russian Federation, the Islamic Republic of Iran and Myanmar.

Case 1: Iran

Most Western sanctions against the Islamic Republic of Iran have been in response to its nuclear program as well as human rights abuses. The United States has had various forms of sanctions in place since the Iranian revolution in 1979 and the subsequent hostage crisis.[2] The United Nations first placed sanctions on Iran in response to non-cooperation with regard to UN Security Council Resolution 1696 from July 2006, in which it demanded Iran to halt its uranium enrichment programme. After Iran's failure to address the concerns, Resolution 1737 was passed that introduced measures that restricted exports of possible

[2] See Hufbauer et al. (2009) for reference.

nuclear-related technology and material to Iran, as well as levying asset freezes on certain individuals and companies.[3] Subsequent resolutions further toughened these measures, most notably Resolutions 1747 that imposed an arms embargo and expanded the freeze on Iranian assets, Resolution 1803 that called upon states to monitor the activities of Iranian banks, inspect Iranian ships and aircraft, and to monitor the movement of individuals involved with the program through their territory, as well as Resolution 1929 in June 2010 that banned the trade in further military and dual use goods, introduced travel bans and mandated UN member states to actively inspect Iranian vessels and aircraft.[4]

In response to insufficient cooperation by the Iranian authorities, in January 2012 the European Union moved to introduce separate, more severe sanctions on the Islamic Republic.[5] The measures includes further asset freezes and travel bans, most importantly, however, an import embargo on Iranian oil was declared.[6] The next and ultimate escalation of the sanctions regime was then put forward in March 2012, where banks identified to be in violation of previous sanctions regarding trade restriction were disconnected from SWIFT, the global hub of electronic financial transactions, effectively cutting of Iran from the global financial system.[7] After a period of rapprochement between Iran and Western countries, sanctions were lifted as part of the "Joint Comprehensive Plan of Action" that was agreed on in July 2015, adopted in November of the same year and implemented after being greenlighted by the International Atomic Energy Agency in January 2016.[8] In the empirical analysis below, I estimate the effect of the financial and trade sanctions by the European Union and allied countries (next to those by the United Nations on military and dual-use material) that were initially put in place in the first quarter of 2012.

Case 2: Russia

The Western sanctions against the Russian Federation and their counter-sanctions are rooted in the simmering conflict in the eastern Ukraine and the Crimea. Following the Russian annexation of Crimea and its support of separatists in the eastern part of Ukraine, the European Union and allied Western countries, most prominently the United States, imposed the first sanctions against the Russian Federation in mid-March 2014. This initial first wave of sanctions from Western countries, dubbed smart sanctions, focused on implicated political and military personnel as well as select Russian financial institutions (Ashford, 2016). A second wave in the weeks to follow expanded the list of sanctioned

[3] See e.g. http://news.bbc.co.uk/2/hi/middle_east/6205295.stm.

[4] See e.g. http://www.bbc.com/news/10276276 and https://www.whitehouse.gov/the-press-office/fact-sheet-new-un-security-council-sanctions-iran.

[5] See http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/EN/foraff/127446.pdf.

[6] See http://www.bbc.com/news/world-europe-16674660. Existing oil contracts were allowed to be honored until July 2012.

[7] See Bashir and Lorber (2016) and http://www.bbc.com/news/business-17390456.

[8] See e.g. http://www.bbc.co.uk/news/world-middle-east-35335078.

individuals and entities.[9]

The first and second wave of EU sanctions consisted of travel bans and asset freezes on several officials and institutions from Russia and Ukraine, which were implemented through *Council Decision 2014/145/CFSP* and *Council Regulation (EU) No 269/2014* in March 2014 and amounted to an "EU-wide asset freeze and travel ban on those undermining the territorial sovereignty or security of Ukraine and those supporting or doing business with them." The list of targeted individuals and entities was further amended with over the course of the spring of 2014. The measures imposed by the United States, implemented by *Executive Orders 13660*, *13661* and *13662*, also consisted of asset freezes and travel bans. It was also progressively extended over the course of 2014 to a growing list of persons and entities, including major Russian financial institutions with close links to the Kremlin (Baker and McKenzie, 2014). Other countries allied with the European Union and the United States followed a similar path and introduced comparable measures at around the same time.[10] These lists of individuals and entities were successively appended over the spring and summer of 2014.[11] The Russian Federation condemned the measures and reciprocated by issuing travel bans on influential Western politicians and officials.[12]

After the crash of a civilian airplane (the Malaysian airlines flight MH17), shot down over the separatist region of Donbass with the alleged implication of pro-Russian insurgents, trade sanctions were levied and existing financial restrictions further expanded. This so-called third wave of EU sanctions went beyond previous measures in depth and scope. Not only were Russian individuals and entities targeted, but European entities were restricted from exporting certain goods and buying certain Russian assets (Dreger et al., 2015). These new restrictions were enacted through *Council Decision 2014/512/CFSP* and *Council Regulation (EU) No 833/2014* at the end of July 2014. Exporting firms in Western countries were still mostly indirectly affected, as only a small number of industries' exports were directly targeted: Those firms that export products and technology intended for military and dual use and some equipment for the oil industry.[13] The United States had implemented its own measures in mid-July 2014, stating that the US Treasury Department had "imposed sanctions that prohibit U.S. persons from providing new financing to two major Russian financial institutions [...] and two Russian energy firms [...], limiting their access to U.S. capital markets", as well as "eight Russian arms firms, which are responsible

[9] See also Crozet and Hinz (2016) for detailed timeline and description of sanctions and countersanctions.

[10] See `https://en.wikipedia.org/wiki/List_of_individuals_sanctioned_during_the_Ukrainian_crisis` for a list of sanctioned individuals by the respective countries.

[11] Compare, e.g., Ashford (2016) and Dreger et al. (2015).

[12] See `http://archive.mid.ru//brp_4.nsf/newsline/1D963ACD52CC987944257CA100550142` and `http://archive.mid.ru//brp_4.nsf/newsline/177739554DA10C8B44257CA100551FFE`

[13] Military use products are defined in the so-called *common military list* as adopted through *Council Common Position 2008/944/CFSP* and dual use goods through *Council Regulation (EC) No 428/2009*. See Crozet and Hinz (2016) for a list of the affected HS 8 codes.

for the production of a range of materiel that includes small arms, mortar shells, and tanks."[14] Other Western countries reciprocated the measures taken by the United States and European Union and enacted similar trade sanctions and financial restrictions (Dreger et al., 2015; Dreyer et al., 2015). The Swiss government enacted legislation that was meant to prevent circumvention of existing sanctions, while maintaining not to impose direct sanctions on the Russian Federation and as such was not affected by Russian counter-sanctions (Reuters, 2014).[15]

The Russian side, unsurprisingly, retaliated and enacted sanctions on European and other sanctioning countries. In early August 2014, the Russian Federation imposed a ban on imports of certain raw and processed agricultural products as an "application of certain special economic measures to ensure the security of the Russian Federation."[16] The embargoed products are select agricultural products, raw materials and foodstuffs originating from the European Union, the United States, Canada, Australia and Norway.[17] In the empirical analysis below I assume that trade relations were impacted by the diplomatic tensions and sanctions measures since the first quarter of 2014.

Case 3: Myanmar

Some form of economic sanctions against Myanmar have been in place for decades, mostly in response to human rights issues in the (now former) military dictatorship.[18] In the wake of the transition from a military to civil government, coupled with the release of political prisoners, the European Union and United States first suspended in the first half of 2012 and then lifted most sanctions in 2013. The EU suspended sanctions with *Council Regulation (EU) 409/2012* repealing *Council Regulation (EC) 194/2008* that first enacted the measures.[19] The United States followed in May 2012 and the following months by suspending parts of the so-called "Burmese Sanctions Regulations" enforced by the Treasury Department's Office of Foreign Assets Control (OFAC).[20] Further restrictions were lifted in September 2016.[21] While the Southeast Asian nation had not been well integrated into the world economy—likely in large part due to the political and economic

[14] See `https://www.treasury.gov/press-center/press-releases/Pages/jl2572.aspx`. Additionally, existing "smart sanctions" were extended to more individuals and entities, including the two Ukrainian break-away regions "Luhansk People's Republic" and the "Donetsk People's Republic".

[15] See also the Swiss *Verordnung über Massnahmen zur Vermeidung der Umgehung internationaler Sanktionen im Zusammenhang mit der Situation in der Ukraine, AS 2014 877*. As a Schengen member state, all travel bans automatically included travel to Switzerland.

[16] See the *Russian President's Decree No. 560 of August 6, 2014* and the *Resolution of the Government Of the Russian Federation No. 830* of August 20, 2014.

[17] See Crozet and Hinz (2016) for the specific 4 digit HS codes targeted.

[18] See Hufbauer et al. (2009) and `https://piie.com/commentary/speeches-papers/case-88-1`.

[19] See e.g. `http://www.bbc.com/news/world-asia-17813656` and `http://www.bbc.com/news/world-asia-22254493`.

[20] See Strangio (2012) for more detail.

[21] See e.g. `http://www.bbc.com/news/world-africa-37365835`.

reclusiveness pursued by the military junta and externally enforced by the sanctions in place—the case provides insights into the dynamics of trade when lifting sanctions. In the following empirical analysis I mark the second quarter of 2012 as the beginning of sanctions-free trade between previously "treated" country pairs.

3 Computing the Cost of Sanctions with Gravity

I analyze the impact of the sanctions' regimes against Iran, Russia and Myanmar using quarterly trade data and relying on the methodology introduced by Crozet and Hinz (2016). Their methodology complements recent advances in the estimation of general equilibrium gravity models—and their application to counterfactual simulations. Two recent prominent works are Adao et al. (2017), who develop a nonparametric counterfactual methodology, and Anderson et al. (2016), who use of the properties of the PPML estimator following Santos Silva and Tenreyro (2006) and Fally (2015) to "estibrate" theory-consistent counterfactual flows in the spirit of Dekle et al. (2007) and Dekle et al. (2008). Crozet and Hinz's procedure follows closely that of Anderson et al., but does not rely on any data next to observable trade flows by fully relying on estimated fixed effects. This makes the estimations consistent with theory, immune to data collection issues and additionally does not impose an a-priori structure on how sanctions impacted trade flows.

In the current context, the different sets of sanctions imposed by the EU and other countries against Iran, Russia, and Myanmar enter as a *bilateral* trade cost. As such, the approach is similar to Hufbauer et al. (2009), but improves upon the theoretical foundation of the model, as no structure on the effect of the sanctions is imposed.[22] I quantify the "lost trade" due to the sanctions episodes as the difference between observed trade and those flows predicted in the general equilibrium counterfactual framework.

3.1 Theoretical Framework

In order to calculate the lost trade due to the various sanctions measures put in place, I make use of the methodology of Crozet and Hinz (2016), which extends the previous works by Dekle et al. (2007, 2008) and Anderson et al. (2016). The main idea is that using information embedded in observed trade flows, hypothetical trade flows between "treated" countries can be constructed.

Suppose therefore that bilateral trade flows X_{odt} between origin country o and destination

[22] Hufbauer et al. (2009) employ what Head and Mayer (2014) coin a *naive* gravity setup.

country d at time t are described by

$$X_{odt} = \frac{Y_{ot}}{\Omega_{ot}} \cdot \frac{X_{dt}}{\Phi_{dt}} \cdot \tau_{odt} \tag{1}$$

where $Y_{ot} = \sum_d X_{odt}$ is the value of production in origin country o, $X_{dt} = \sum_o X_{odt}$ is the value of expenditure d, and

$$\Omega_{ot} = \sum_d \frac{X_{dt}\tau_{odt}}{\Phi_{dt}} \quad \text{and} \quad \Phi_{dt} = \sum_o \frac{Y_{ot}\tau_{odt}}{\Omega_{ot}}$$

are the respective outward and inward multilateral resistance terms. I assume sanctions to enter as a component of bilateral trade costs, such that sanction S_{odt} affect trade through changes in $\tau_{odt} = \phi_{odq} e^{\delta S_{odt}}$. ϕ_{odq} is an exporter-importer-quarter specific characteristic.

Usually one could now go ahead and estimate the *average partial effect* of sanctions, δ, by specifying S_{odt} as a dummy variable that turns 1 for a "treated" country pair at a time of sanctions. This, however, imposes a certain structural form on how sanctions affect bilateral trade. Instead, following the method by Crozet and Hinz (2016), I proceed differently here in a way that permits us to be agnostic about the impact. Following Santos Silva and Tenreyro (2006), I estimate (1) as

$$X_{odkt} = \exp\left(\Xi_{ot} + \Theta_{dt} + \phi_{odq}\right) + \epsilon_{odt}, \tag{2}$$

using a Poisson estimator and explicitly *excluding* observations that are treated with sanctions. Ξ_{ot}, Θ_{dt} and ϕ_{odq} are fixed effects capturing all exporter $\times$ time, importer $\times$ time, and exporter $\times$ importer $\times$ quarter characteristics. I let the latter vary at quarterly frequency (i.e. "Q1", "Q2", etc.) in order to control for bilateral seasonal variations, very present in quarterly trade data.

The rationale behind excluding treated observations is the following. Having data for all country pairs (including those "treated") before or after the period the sanctions were enforced, all fixed effects can still be estimated. Hence, given a reference exporter $\times$ time fixed effect as well as reference exporter $\times$ importer $\times$ quarter fixed effects,[23] I obtain values for all Ξ_{ot}, Θ_{dt} and ϕ_{odq}.[24]

[23] Which are "dropped", i.e. implicitly set to 0.

[24] In effect, the estimation is equivalent to estimating $X_{odkt} = \log\left(\Xi_{ot} + \Theta_{dt} + \phi_{odq} + \beta_{odt} \cdot S_{odt}\right)$.

3.2 General Equilibrium Counterfactuals

Using the estimated fixed effects from equation (2) allows me to construct counterfactual trade flows $\hat{X}_{odt}$ in the absence of sanctions by computing

$$\hat{X}_{odt}(\hat{\phi}_{odq}) = \frac{\hat{Y}_{ot}(\hat{\phi}_{odq})}{\hat{\Pi}_{ot}(\hat{\phi}_{odq})^{1-\sigma}} \frac{\hat{E}_{dt}(\hat{\phi}_{odq})}{\hat{P}_{dt}(\hat{\phi}_{odq})^{1-\sigma}} (\hat{\phi}_{odq})$$

All terms can be recovered and iteratively computed similar to the procedure described by Anderson et al. (2016). Current pseudo-production and expenditure figures can be retrieved from the estimated fixed effects as

$$\hat{Y}_{ot}^{\text{current}} = \sum_{d} \exp\left(\hat{\Xi}_{ot} + \hat{\Theta}_{dt} + \hat{\phi}_{odq}\right) \quad \text{and analogously}$$
$$\hat{X}_{dt}^{\text{current}} = \sum_{o} \exp\left(\hat{\Xi}_{dt} + \hat{\Theta}_{dt} + \hat{\phi}_{odq}\right)$$

while inward and outward multilateral resistance terms can be constructed for any given global trade cost matrix $\hat{\phi}_q$ via a contraction mapping algorithm, i.e. iteratively solving the following system of matrix equations:

$$\hat{\Pi}_t^{1-\sigma} = \hat{\phi}_t \left(\hat{X}_t \otimes \hat{P}_t^{-\sigma}\right)$$
$$\hat{P}_t^{1-\sigma} = \hat{\phi}_t^{\mathrm{T}} \left(\hat{Y}_t \otimes \hat{\Pi}_t^{-\sigma}\right)$$

where $\hat{\Pi}_t^{1-\sigma}$ and $\hat{P}_t^{1-\sigma}$ are vectors of outward and inward multilateral resistances at time t. $\hat{\Pi}_t^{-\sigma}$ and $\hat{P}_t^{-\sigma}$ are vectors of elementwise inverses of $\hat{\Pi}_t^{1-\sigma}$ and $\hat{P}_t^{1-\sigma}$, and $\otimes$ denotes the elementwise product.[25] Changes in the production and expenditures of exporters and importers due to the new trade costs are computed using first-order price adjustments following Anderson et al. (2016) as

$$\hat{Y}_{ot} = \hat{Y}_{ot}^{\text{current}} \cdot \left(\frac{\hat{\Omega}_{ot}}{\hat{\Omega}_{ot}^{\text{current}}}\right)^{\frac{1}{1-\sigma}} \quad \text{and} \quad \hat{X}_{dt} = \hat{X}_{dt}^{\text{current}} \cdot \left(\frac{\hat{\Omega}_{dt}}{\hat{\Omega}_{dt}^{\text{current}}}\right)^{\frac{1}{1-\sigma}}$$

where σ is the elasticity of substitution, which I set at 5 following Head and Mayer (2014).

The general equilibrium counterfactuals are computed by adjusting production and expenditure figures, as well as the respective inward and outward multilateral resistance terms iteratively until convergence to new equilibrium flows.

[25] Alternatively, Anderson et al. (2016) show that the PPML estimator itself can be used to compute multilateral resistance terms with observed trade flows and counterfactual trade costs.

4 Estimated General Equilibrium Impact

In the following I present the results from estimating equation (2) and performing the general equilibrium exercise using the estimated fixed effects as detailed above. For each case I calculate the general equilibrium counterfactuals and report the lost trade, i.e. the difference between predicted and observed trade flows. For information on observed bilateral trade flows, I rely on quarterly export data from ITC Trade Map (United Nations Statistics Division, 2015) from the beginning of 2010 until the end of 2015 between the Russia, Iran and Myanmar, and the 48 other largest exporters in the world. Export data for Iran and Myanmar is constructed using mirror flows, i.e. *imports* from all other countries. The sample covers 94 % of world trade. I provide the list of countries and descriptive statistics in table 1 in appendix A.

Case 1: Iran

As described above, the European Union and other Western countries introduced *additional* sanctions next to already existing UN restrictions in early 2012. I therefore remove all bilateral observations between sanctioning countries and Iran for the time period since the first quarter of 2012. The bilateral calendar month fixed effects are therefore estimated on trade flows in the years 2010–2011.

Figure 2 shows the predicted and observed flows between sanctioning countries and Iran. Figure 2a shows the total exports to Iran over the period of 2010 to 2015. While the immediate impact of the sanctions in 2012 was muted, the red dotted line, i.e. the predicted total exports to Iran, visibly diverges from the solid line, the observed flows. The total lost trade over the whole time period—the difference between the dotted and solid line—amounts to $US 31.82 billion. Figure 2b shows the same graph for a single exemplary exporter, in this case France. To contrast the results, the blue lines denote predicted and observed exports to India. The drop in exports is visibly significant, already starting in 2012. The lost trade for France amounts to $US 6.35 billion, or, in relative terms, a decrease by 68 % compared to predicted exports to Iran. Figure 2c shows the same plot for *imports* from Iran by sanctioning and non-sanctioning countries. Unsurprisingly, Iranian exports are hit severely with total lost trade totalling $US 45.18 billion over the time period.

The impact of the sanctions is very heterogeneous across countries. Figures 3a and 3b display the absolute and relative difference between predicted and observed flows (in terms of total exports) by country. A visible positive outlier is Turkey that has, apparently, quite significantly increased exports to Iran over the sanctions period, despite officially sanctioning the Islamic republic. While in absolute terms Germany, France and Korea are affected most, in relative terms Sweden is the most severely affected sanctioning country

with a drop in its total exports by 0.39 %. To put this number in perspective, Iran's total exports are 16 % lower than they would be without sanctions. Table 2 shows the aggregate lost trade in absolute and relative terms over the whole time period.

Case 2: Russia

As described above, the sanctions against the Russian Federation are very instructive in that pre-sanction trade ties between sanctioning and sanctioned country were very strong. Figure 4 shows again the predicted and observed flows, here between sanctioning countries and Russia. Figure 4a shows the total exports to Russia over the period of 2010 to 2015. Sanctions were first introduced at the end of the first quarter of 2014. The impact is immediate visible. The red dotted line, i.e. the predicted total exports to Russia, significantly diverges from the solid line, the observed flows, starting in 2014 and all the way through the end of the sample at the end of 2015. The total lost trade over the time period amounts to $US 62.94 billion. Owing to the mentioned pre-sanction strength of ties (and size of the Russian economy), the yearly global lost trade borne by the sanctioning countries is about four times as high as the one in the case of the Iran sanctions.[26] Figure 4b shows the same graph singling out another exemplary exporter, in this case Germany. The country's predicted and observed exports to the Russian Federation are contrasted to those to Turkey. The drop in exports is visibly significant since the very beginning of the sanctions episode in early 2014. The lost trade for Germany due to the Russia sanctions amounts to $US 23.22 billion, a decrease in relative terms by 27 % compared to predicted exports to the Russian Federation. Figure 4c shows the same plot for *imports* from Russia by sanctioning and non-sanctioning countries. Russian exports are hit severely with total lost trade totalling $US 35.83 billion over the time period.

As in the case of the Iran sanctions, the impact of the sanctions is very heterogeneous across countries.[27] Figures 5a and 5b display the absolute in billion USD and relative losses as a share of predicted total exports by country. In absolute terms Germany and France ($US 4.67 billion) are again most affected, with Poland ($US 4.38 billion) following as third. In relative terms Finland is the most severely affected sanctioning country with a drop in its total exports by 2.45 %. This compares to Russia's total exports being 5.32 % lower than they would be without the sanctions in place. Table 3 shows the aggregate lost trade in absolute and relative terms over the whole time period.

[26] Notice also that even for non-sanctioning countries exports decrease in early 2015 due to the tumbling oil price and Ruble (Dreger et al., 2015).

[27] See also Crozet and Hinz (2016) for a further disaggregation into embargoed and non-embargoed goods.

Case 3: Myanmar

The case of Myanmar is different. Although the case is instructive by observing the end of a sanctions regime in place as described above, econometrically the results are not comparable to the ones from the Iran and Russia cases. Contrary to the previous two cases, I delete observations from before the *end* of the sanctions. Hence, I effectively compute the "cost" of prolonging the existing sanctions for another quarter or year. Table 4 shows the aggregate lost trade in absolute and relative terms over the whole time period.

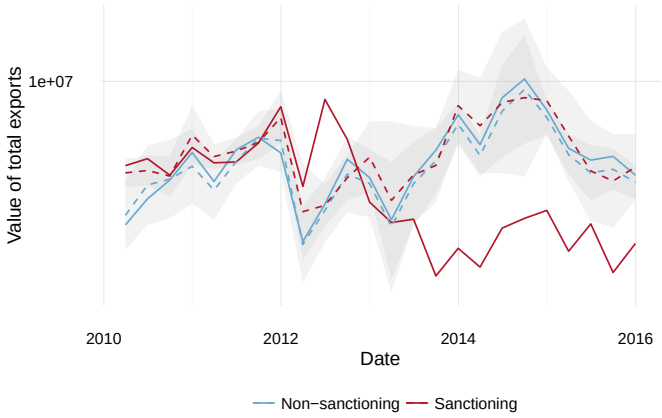
Figure 6a shows again the total exports of sanctioning countries to and imports from the sanctioned country—here Myanmar. The sanctions were lifted in the second quarter of 2012. The difference between the predicted and observed export to Myanmar was relatively constant over time, with $US 198 million in 2010, $US 199 million in 2011 and $US 77 million in the first quarter of 2012. Figure 6b shows the flows going the other direction: Myanmar's lost exports, i.e. sanctioning countries foregone imports, however are not significant. One notable observation can be made: Both exports to, as well as imports from the previously sanctioned country did not recover quickly. Aside from a temporary peak of exports to Myanmar in the last quarter of 2012, growth is essentially flat and outpaced by already much higher trade flows with non-sanctioning countries.

5 Conclusion

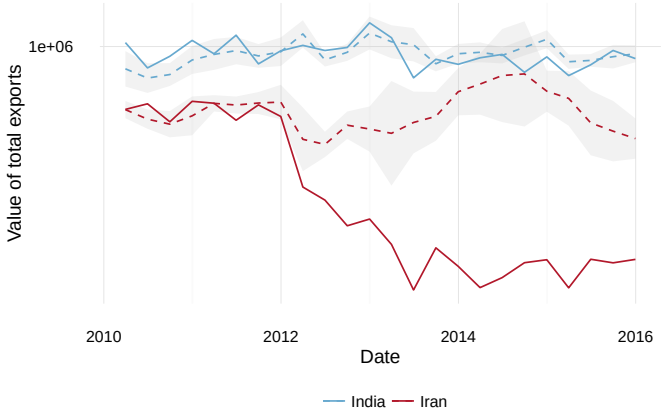
In this chapter, I evaluate and quantify the effects of three recent sanctions episodes with Iran, Russia and Myanmar on exports by sanctioning and sanctioning countries. The "lost trade" due to the use of this tool of foreign policy is significant in magnitude: I find the overall difference between predicted and observed trade flows to total more than US$50 billion in 2014, about 0.4 % of world trade, stemming only from the 3 most prominent sanctions regimes at that time. The analysis builds on recent advances on the literature in international trade on structural gravity equations and perform a general equilibrium counterfactual exercise to predict exports between "treated" country pairs. The methodology rests exclusively on fixed effects, and, using quarterly data on bilateral trade flows, allows me to take short-run effects into account.

The aim of this chapter is to quantify the cost of this frequently used tool of foreign policy—not judge their effectiveness in reaching political aims. However, aside from expected significant economic impact on the side of the *sanctioned* country, I find quantitatively large effects on part of (some of) the *sanctioning* countries. This impact is shown to be very heterogeneous across countries and sanctions episodes. Overall strong pre-sanction ties and severity measures, unsurprisingly, affect the magnitude of the total effect. However, ceteris paribus, the former tend to increase the burden on the *sanctioning* countries, while the latter does so on the *sanctioned* country.

(a) Total exports to Iran



(b) French exports to Iran and India



(c) Total imports from Iran

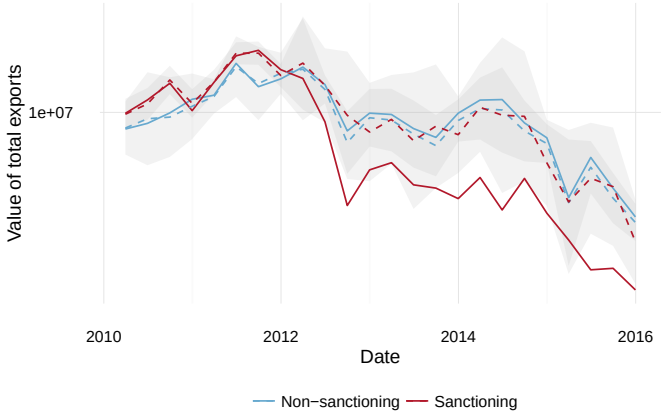
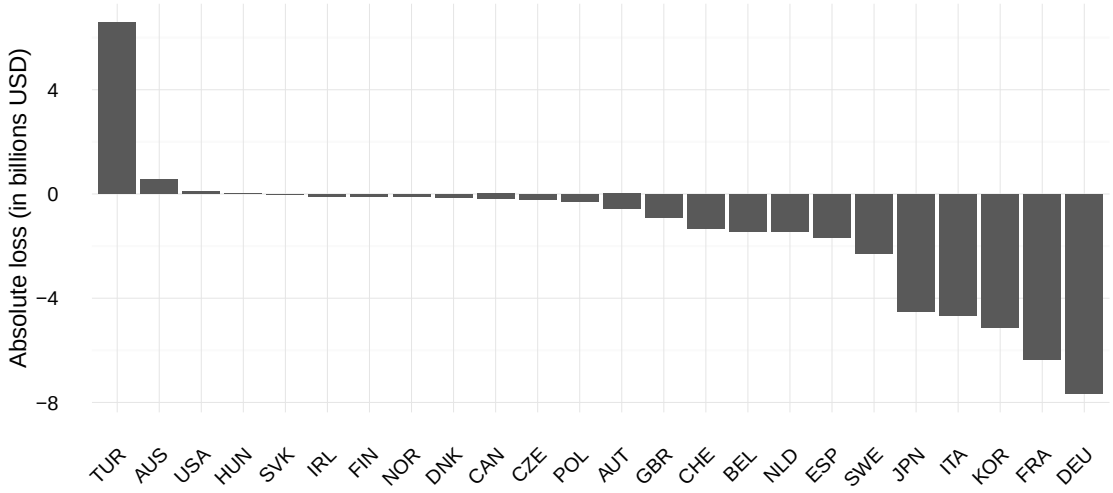


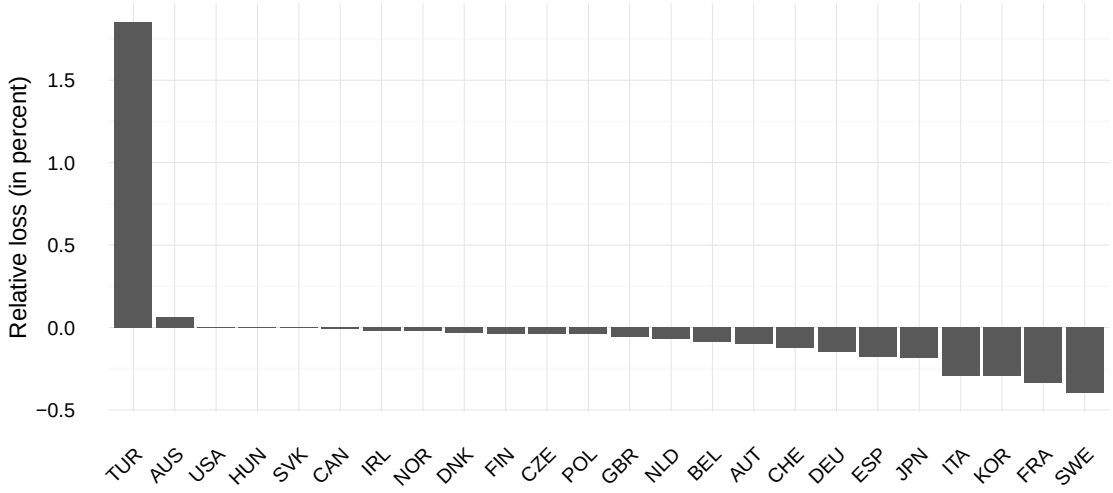
Figure 2: Predicted vs. observed total value of exported goods to/from Iran from sanctioning and non-sanctioning countries. Solid lines display observed trade flows, dashed lines predicted flows. 95% confidence intervals in grey.

Figure 3

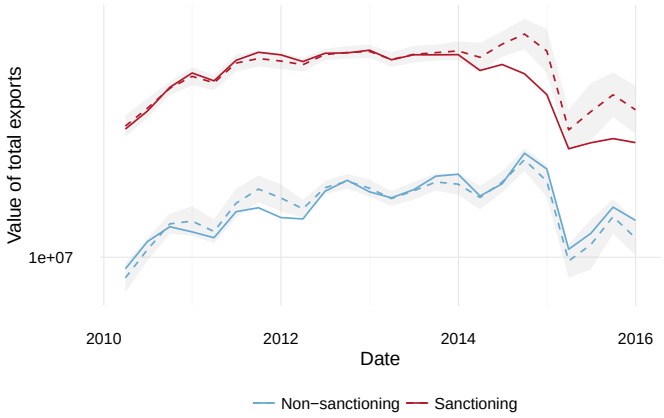
(a) Absolute difference between predicted and observed trade (in $US billion) since 2012



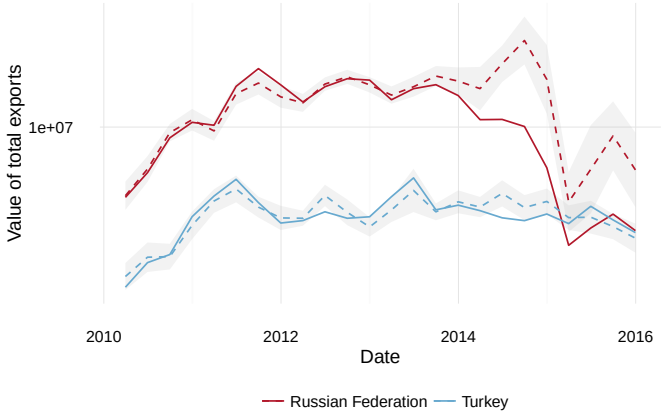
(b) Relative difference between predicted and observed trade (in %) since 2012



(a) Total exports to Russia



(b) German exports to Russia and Turkey



(c) Total imports from Russia

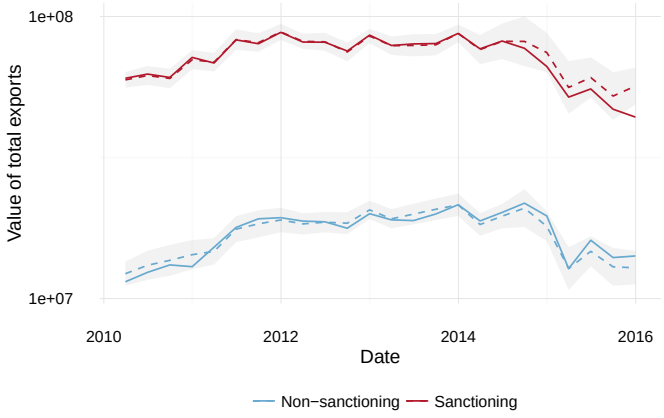
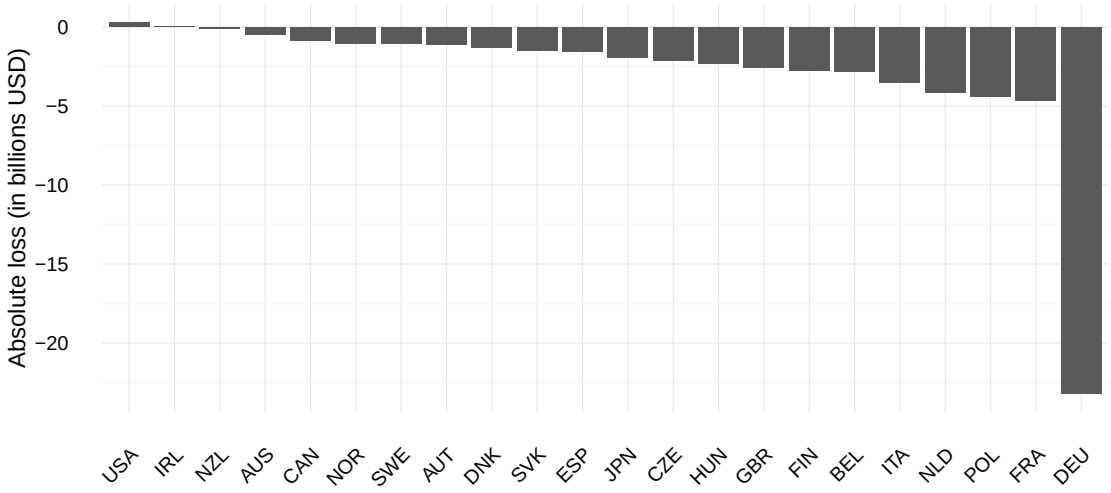


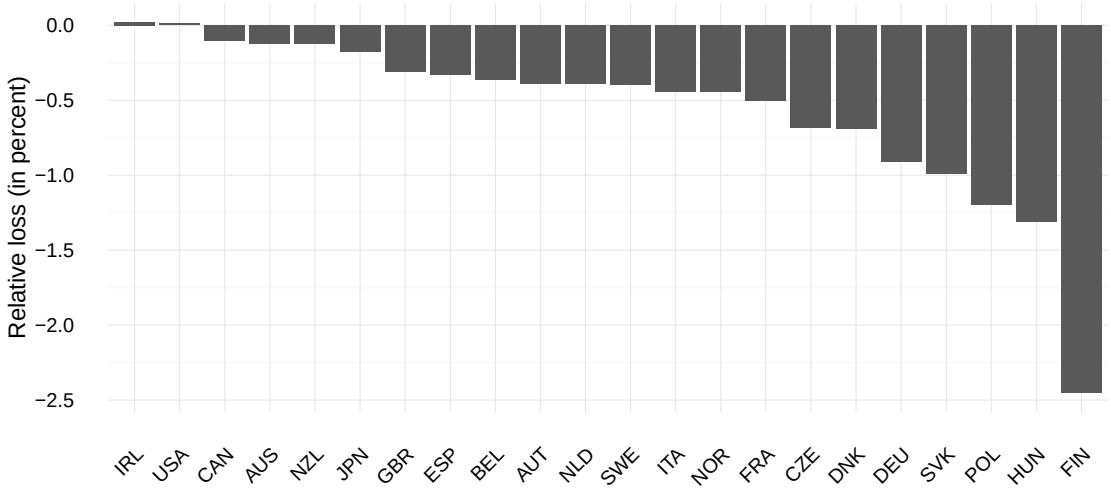
Figure 4: Predicted vs. observed total value of exported goods to/from Russia from sanctioning and non-sanctioning countries. Solid lines display observed trade flows, dashed lines predicted flows. 95% confidence intervals in grey.

Figure 5

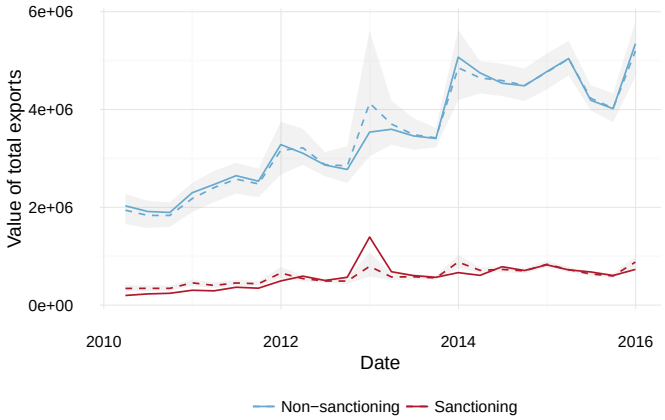
(a) Absolute losses (in $US billions) since 2012



(b) Monthly relative losses (in %) since 2012



(a) Total exports to Myanmar



(b) Total imports from Myanmar

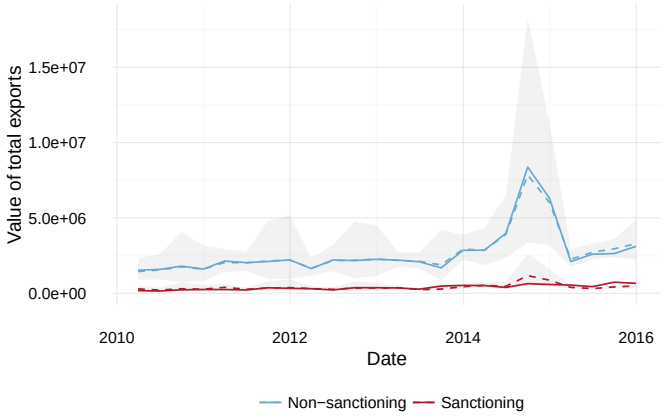


Figure 6: Predicted vs. observed total value of exported goods to/from Myanmar from sanctioning and non-sanctioning countries. Solid lines display observed trade flows, dashed lines predicted flows. 95% confidence intervals in grey.

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A Country-level Data

Table 1: Descriptive statistics for exports in 2012

Country	Mean exports	Sdd. deviation of exports	Total Exports	Exports under sanctions	Share exports under sanctions
Australia	1284407.69	3389033.50	241468646.00	446494.00	0.00
Austria	765047.10	1842084.06	143828854.00	274341.00	0.00
Belgium	2107978.54	4233773.47	396299966.00	403979.00	0.00
Brazil	1024137.39	1875442.82	192537830.00	0.00	0.00
Canada	2330052.39	12250191.56	438049849.00	113120.00	0.00
Switzerland	1450074.34	2558257.66	272613976.00	495337.00	0.00
Chile	379994.74	775489.27	71439011.00	0.00	0.00
China	7639164.19	13756301.62	1436162868.00	0.00	0.00
Colombia	250011.71	789617.84	47002202.00	0.00	0.00
Czech Republic	767248.40	1867573.54	144242700.00	53720.00	0.00
Germany	6670704.36	8141963.61	1254092419.00	3284234.00	0.00
Denmark	495668.72	864852.80	93185720.00	151922.00	0.00
Ecuador	110011.72	392447.63	20682204.00	0.00	0.00
Spain	1203048.95	2210559.80	226173203.00	641549.00	0.00
Finland	314426.78	459747.11	59112235.00	69459.00	0.00
France	2546188.11	4210134.51	478683365.00	1038588.00	0.00
United Kingdom	2081905.73	3130950.12	391398277.00	156472.00	0.00
Hungary	444452.27	981993.05	83557026.00	22007.00	0.00
Indonesia	910666.71	1625377.46	171205342.00	0.00	0.00
India	933866.63	1509172.43	175566926.00	0.00	0.00
Ireland	585322.87	1256372.86	110040699.00	65083.00	0.00
Iran, Islamic Republic of	436948.25	1201246.04	78650685.00	33799630.00	0.43
Israel	268047.17	649600.64	50392868.00	0.00	0.00
Italy	2127176.36	3300557.78	399909156.00	1806732.00	0.00
Japan	3641387.97	7513229.53	684580938.00	654858.00	0.00
Kazakhstan	395463.29	847720.43	74347099.00	0.00	0.00
Korea, Republic of	2314126.88	5308649.02	435055854.00	6295269.00	0.01
Morocco	94274.42	216886.11	17723591.00	0.00	0.00
Mexico	1900749.02	10390334.11	357340816.00	0.00	0.00
Myanmar	52938.44	162502.19	9528920.00	59058.00	0.01
Malaysia	1041485.02	1911080.17	195799184.00	0.00	0.00
Netherlands	2934564.09	6334108.81	551698049.00	476230.00	0.00
Norway	813695.27	1793407.53	152974710.00	27524.00	0.00
New Zealand	176525.88	406235.76	33186866.00	0.00	0.00
Peru	218223.77	409894.56	41026069.00	0.00	0.00
Philippines	243342.36	520692.32	45748363.00	0.00	0.00
Poland	853706.59	1812846.44	160496838.00	53890.00	0.00
Qatar	643568.11	1672401.21	120990804.00	0.00	0.00
Russian Federation	2215408.49	3532217.21	398773529.00	0.00	0.00
Singapore	1633417.40	2967687.51	307082471.00	0.00	0.00
Slovakia	396562.75	802455.01	74553797.00	13280.00	0.00
Sweden	801858.24	1122889.65	150749350.00	142290.00	0.00
Thailand	967129.68	1552568.43	181820380.00	0.00	0.00
Turkey	481249.87	759981.18	90474975.00	9922688.00	0.11
Taiwan, Province of China	1273280.31	3202830.20	239376699.00	0.00	0.00
United States	7067537.14	13213829.50	1328696982.00	258627.00	0.00
South Africa	306833.07	513995.76	57684618.00	0.00	0.00
Argentina	330010.26	648530.98	62041929.00	0.00	0.00

B Quantification of Lost Trade by Case

Table 2: Lost trade due to Iran sanctions

Country	Absolute loss (in USD billions)	Relative loss (in percent of total exports)
Iran, Islamic Republic of	-45.18	-16.40
Australia	0.56	0.06
Austria	-0.58	-0.10
Belgium	-1.43	-0.09
Canada	-0.19	-0.01
Switzerland	-1.33	-0.13
Czech Republic	-0.23	-0.04
Germany	-7.67	-0.15
Denmark	-0.13	-0.04
Spain	-1.69	-0.18
Finland	-0.09	-0.04
France	-6.35	-0.34
United Kingdom	-0.92	-0.06
Hungary	0.00	0.00
Ireland	-0.08	-0.02
Italy	-4.68	-0.29
Japan	-4.51	-0.19
Korea, Republic of	-5.11	-0.29
Netherlands	-1.45	-0.07
Norway	-0.10	-0.02
Poland	-0.29	-0.04
Slovakia	-0.01	-0.00
Sweden	-2.27	-0.40
Turkey	6.59	1.85
United States	0.11	0.00
World	-77.03	-0.23

Table 3: Lost trade due to Russia sanctions

Country	Absolute loss (in USD billions)	Relative loss (in percent of total exports)
Russian Federation	-35.83	-5.35
Australia	-0.48	-0.12
Austria	-1.13	-0.39
Belgium	-2.80	-0.36
Canada	-0.87	-0.10
Czech Republic	-2.11	-0.69
Germany	-23.22	-0.91
Denmark	-1.27	-0.69
Spain	-1.53	-0.33
Finland	-2.75	-2.47
France	-4.67	-0.51
United Kingdom	-2.54	-0.31
Hungary	-2.30	-1.32
Ireland	0.05	0.02
Italy	-3.50	-0.44
Japan	-1.95	-0.17
Netherlands	-4.12	-0.39
Norway	-1.05	-0.44
New Zealand	-0.08	-0.13
Poland	-4.38	-1.20
Slovakia	-1.49	-1.00
Sweden	-1.07	-0.39
United States	0.30	0.01
World	-98.77	-0.64

Table 4: Lost trade due to Myanmar sanctions

Country	Absolute loss (in USD billions)	Relative loss (in percent of total exports)
Myanmar	-0.34	-1.78
Austria	0.01	0.00
Belgium	-0.00	-0.00
Canada	-0.02	-0.00
Czech Republic	-0.00	-0.00
Germany	-0.08	-0.00
Denmark	-0.00	-0.00
Spain	-0.00	-0.00
Finland	-0.01	-0.01
France	-0.09	-0.01
United Kingdom	-0.02	-0.00
Hungary	-0.01	-0.01
Ireland	-0.00	-0.00
Italy	-0.07	-0.01
Netherlands	-0.01	-0.00
Norway	-0.01	-0.00
Poland	-0.01	-0.00
Slovakia	-0.00	-0.00
Sweden	-0.01	-0.00
United States	-0.13	-0.00
World	-0.82	-0.01