On the Heterogeneous Effects of Sanctions on Trade and Welfare: Evidence from the Sanctions on Iran and a New Database

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Abstract

Using a new, comprehensive database, we study the impact of sanctions on international trade and welfare. Specifically, capitalizing on the latest developments in the structural gravity literature, we quantify the partial and general equilibrium effects of sanctions. Starting with a broad evaluation of the impact of sanctions, we carefully investigate the case of Iran. We find that the effects are significant but also widely heterogeneous across sanctioning countries and dependent on the direction of trade, even within the European Union. We also perform a counterfactual analysis of removing the sanctions on Iran, which translates our partial estimates into sizable and heterogeneous (across both countries and sectors), but also intuitive, general equilibrium effects within the same framework.

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“At the beginning of the 21st century, the same as a century earlier, economic sanctions remain an important yet controversial foreign policy tool.”

(Hufbauer et al., 2007)

1 Introduction

From the “Age of Pericles” in Athens of ancient Greece, to the times of Napoleon and Thomas Jefferson in the nineteenth century, and World War I, economic sanctions have served as a prominent and “purposive tool” of coercive statecraft (Drezner, 1999).1 They have been imposed unilaterally or coalitionally and, especially in the post-Cold War era, with increasing frequency.2 Prior to WW II, economics sanctions were inextricably linked to military endeavors, mostly taking the form of trade sanctions and economic blockades under the protective umbrella of the sanctioning states’ naval forces.3 In more recent times, though, the arsenal of weaponry in economic sanctions has been enriched to include boycotts, restrictions on trade in arms, financial sanctions, travel bans, and the withholding of military assistance, among others.4

The growing popularity of economic sanctions among policymakers raises a fundamental question: Do they work? The conventional wisdom (e.g., Pape (1997)) is that “...Economic

1Notable examples of such sanctions include: the Megarian decree of Athenians in 435 B.C.; the US’s sanctions at the time of Jefferson against France and Great Britain during their engagement in the Napoleonic Wars; the sanctions against Italy by the League of Nations in 1935; the Anti-Apartheid Act against South Africa in 1986; the US sanctions against Cuba; the United Nations financial and trade sanctions against Iraq prior to the overthrowing of Saddam Hussein in 2003; the recurrent sanctions on North Korea; the comprehensive and multi-round economic sanctions by EU, the US and other nations against Russia; the imposition of sanctions, under the US leadership, against Iran in 1987, their expansion in 1995 and 2006, and their controversial renewal by the US in 2018; the sanctions against Venezuela under President Hugo Chavez and, more recently, by the Trump administration against President Nicolás Maduro.

2Remarkably, and as we emphasize later on in connection with the content of the Global Sanctions Data Base (GSDB), the number of recorded sanctions during 1950-2016 is 729. Furthermore, over the last 25 years of this period, the number of sanctions more than doubled.

3In some cases, they have served as precursors of armed conflict. As Findlay and O’Rourke (2009) amply document in their impressive discourse of international trade in the second millennium, trade and warfare were inseparable.

4The increased reliance on instruments nowadays—which could be attributed to the liberal order promulgated by the GATT/WTO and the dramatic reduction in transaction costs due to technological advances—may have improved the sanctioning states’ ability to interfere in the sanctioned states’ national affairs. See Ahn and Ludema (2018) for a insightful analysis of targeted sanctions on Russia and Besedes et al. (2018) for an noteworthy analysis of financial sanctions on German economic activity.
Sanctions Do Not Work.” Hufbauer et al. (2007), one of the most comprehensive contributions to the related empirical literature, report that 34% of the cases they examined could be viewed as successful. However, after subjecting this finding into further scrutiny, Pape (1998) contends that the success rate was only 4%.\footnote{Also see Pape (1997), Baldwin (1985; 1999), Drezner (1999) and Kaempfer and Lowenberg (2007) for insightful reviews of various contrasting views in this literature.} Why is it, then, that policymakers continue to favor this policy tool?

The evocative title of Morgan and Schwebach (1997), “Fools Suffer Gladly...” may be in the vicinity of truth. Hufbauer et al. (2007) and Drezner (1999) outline a number of reasons that could explain the seemingly limited success of sanctions. First, the types of sanctions used may be “inadequate” for the specific objective(s) considered. Second, the imposition of sanctions may prompt vociferous opposition in the target country by uniting citizens and domestic interests in “rallies behind the flag.” Third, powerful allies of the sanctioned country may intervene (as “black knights”) to counteract the damaging effects of sanctions. Fourth, uneven sharing of the costs of sanctions among the sender’s allies and business interests may impair unity in multilateral relationships thereby “undermining” their effectiveness. Last, but not least, policy leaders may choose to deploy sanctions because they perceive them as a less damaging substitute for military interventions.

Morgan and Schwebach (1997) propose a theoretical framework and an empirical test that suggests this: the higher the cost of economic sanctions to the target the higher the probability that sanctions will succeed. In addition to emphasizing the above costs, careful theoretical contributions to this problem (e.g., Eaton and Engers (1992; 1999); Drezner (1999)) also suggest that the lower the cost of sanctions to the sender(s), the more likely that sanctions will succeed.

Motivated by these insights, our objective/contribution in this paper is threefold. First, we aim to demonstrate the usefulness of the newly created database, the Global Sanctions...
Data Base (GSDB), in assessments of the impact of economic sanctions. Our second objective is to offer quantitative measures of the costs of sanctions. Focusing on trade as the primary channel of economic pain to the target and capitalizing on the latest developments in the literature on structural gravity, we pursue this objective by assessing the partial and general equilibrium (GE) costs related to it and the effects of these costs on trade, real GDP, and sectoral value added. To the best of our knowledge, this is the first paper to obtain estimates of the GE welfare effects of sanctions and to offer a continuous measure of sanctions effectiveness. Our third contribution is to show that the impact of sanctions is not only significant but also widely heterogeneous across the various dimensions covered by the GSDB. Our methods and the wide heterogeneity in our sanction estimates open promising opportunities for an analysis of the determinants of the effectiveness of sanctions.

We pursue the above objectives with an application to the sanctions on Iran. Our focus on this country is motivated by three factors. First, it is one of the most perplexing and widely discussed cases in recent history. Second, the sanctions on Iran are multi-dimensional, varying in terms of country coverage (e.g., UN vs. US vs. EU sanctions), targets (e.g., on military goods vs. all goods vs. travel vs finance vs. individuals), and time (e.g., EU sanctions were first imposed in 2006 and reached a peak in terms of stringency in 2012). We exploit this multi-dimensionality within the GSDB and identify the heterogeneous effects of these sanctions. Third, because almost all countries in the world have sanctioned Iran, we are able to contribute to the related literature methodologically (i) by obtaining a large set of pair-specific estimates and studying their heterogeneity across countries, while (ii) avoiding

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6. The GSDB has the following valuable characteristics: it provides a detailed description of the various types of sanctions observed during 1950-2016 and the policy objectives associated with each type; it contains a record of whether each sanction type is viewed in policy circles as a “success” or a “failure”; it also contains a descriptive analysis of the evolution of sanctions over time and regions in the world as well as a preliminary analysis of the trade volumes that may be potentially affected by the types of sanctions considered. An important dimension of the GSDB, which we capitalize on in this project, is that it distinguishes between different types of trade sanctions. The GSDB is freely available and we will be happy to share it with interested researchers, who can request the database by e-mail at GSDB@drexel.edu.
the potential problem of extraterritorial effects.\textsuperscript{7} Our discussion of the sanctions on Iran is contained in Section 2.3.

We implement the empirical analysis in two steps. Taking advantage of the rich dimensionality of the GSDB and following the latest recommendations for gravity estimations, in the first step we obtain a series of partial equilibrium estimates of the impact of sanctions on international trade. We highlight several findings from this analysis. While other types of sanctions (e.g., travel sanctions) do not affect trade flows directly, we find that, on average, trade sanctions are effective in impeding international trade. Our explanation is that the effects of other types of sanctions on trade are indirect and operate through general equilibrium forces, which are controlled for and absorbed by the fixed effects in our model.\textsuperscript{8} Our estimates reveal that complete trade sanctions reduce trade flows between sanctioned and sanctioning countries significantly (i.e., by close to 80 percent). In contrast, partial trade sanctions do not have significant effects on overall trade. This finding suggests that even if partial sanctions are effective in reducing trade in some sectors, their impact is offset by the increase in trade in other sectors. We also find that the impact of sanctions is heterogeneous across the trade sanction cases (e.g., the sanction on Iran vs. all other trade sanctions).

To deepen our understanding of the heterogeneous effects of trade sanctions, we zoom in on the impact of the sanctions on Iran. First, we obtain a negative, large and significant average estimate of the impact of the sanctions on Iran. We also find that the effects of the sanctions vary across country-pairs within the Iran sanctions (e.g., USA-Iran vs. China-Iran). Our estimates reveal that the impact of the sanctions varies within pairs depending on the direction of trade flows (e.g., Greece-Iran vs. Iran-Greece). Next, using the EU case, we identify the effects of deeper provisions within the Iran sanctions and find that deeper

\textsuperscript{7}Anecdotal evidence suggests that some sanctioning countries impose pressure on third nations to punish their targets (e.g., longstanding US sanctions against Cuba resulted in a settled case with the French Bank Society Generale, due to the bank's handling of dollar transactions with Cuba violating US sanctions against Cuba). We view this as an important policy question and believe that the methods employed in this paper can be extended to address it effectively. However, we leave this interesting agenda for future work.

\textsuperscript{8}For example, some financial sanctions aim to prevent financial institutions from processing payments or to provide trade finance regardless of the direction of trade.
provisions have been effective. However, their impact has also been very heterogeneous across EU members and dependent upon the direction of trade. Finally, we obtain some estimates that are not statistically significant (e.g., Turkey-Iran and China-Iran), reflecting sanctions waivers, and even some positive estimates (e.g., United Arab Emirates-Iran), reflecting trade diversion effects.

In the second step of our empirical analysis, we quantify the general equilibrium effects of the Iran sanction on trade, real GDP, and sectoral value added using the same structural gravity framework that served as the foundation for our estimation analysis. Specifically, the counterfactual experiment employs our partial equilibrium estimates to simulate a hypothetical world without the Iran sanction in place. With respect to trade, we find that the removal of the sanction on Iran would make the country substantially more open to international trade. However, despite the large percentage changes in trade with many developed nations, the new levels of trade between Iran and these countries would still be very low.

Turning to the effects on welfare, unsurprisingly, we find that the biggest winner of terminating the sanctions regime would be Iran: its real per capita income is predicted to rise by about 4.2 percent. The effects on other countries are small but intuitively heterogeneous. For example, we find that the next biggest winner from the removal of the Iran sanctions is Armenia, Iran’s neighboring country. The Western initiators of the sanctions against Iran and UN Security Council members (e.g., USA, France, and Great Britain) are barely affected by the removal of the sanction while Korea, Panama, Ukraine and some oil producing countries are likely to lose. Finally, and expectedly, the model predicts that a termination of the sanctions would benefit Iran’s oil and gas sectors most strongly, with the value added in the gas sector reaching almost a 40 percent increase. Other sectors that would enjoy sizable gains in terms of value added include leather, textile, and transportation. In contrast, losses are concentrated in comparative disadvantage sectors (e.g., many agricultural products including vegetables, sugar and rice).

Our work complements and extends a series of studies that quantify the impact of sanc-
tions. For example, several papers have already used the gravity model to obtain partial
equilibrium estimates of the effects of sanctions (e.g., Hufbauer and Oegg (2003), Caruso
(2003), Yang et al. (2004), and Afesorgbor (2018)). We offer three contributions in relation
to these studies. First, we implement the latest developments in the estimation structural
gravity literature. We use the PPML estimator and obtain country-pair and directional
estimates of the impact of trade sanctions in a setting with asymmetric pair fixed effects
and importer-time and exporter-time fixed effects. Second, we capitalize on the rich dimen-
sionality of the GSDB to obtain novel estimates of the impact of trade sanctions. Third,
we employ the full gravity system to quantify the general equilibrium effects of sanctions on
trade, welfare and sectoral value added in the world.

Our study of the Iran sanctions complements several papers that have also examined
these sanctions (including, for example, Haidar (2017), which uses disaggregated customs
data to study export deflection in Iran and Draca et al. (2017), which studies the incidence
of sanctions on Iranian firms) and papers that consider other sanction cases (e.g., Crozet
and Hinz (2017) and Miromanova (2019), which focus on Russia). We view these studies,
which use firm-level analysis, and our top down approach as complementary both in terms
of methods and findings. Our country-specific partial estimates of the Iran sanction and,
especially, our general equilibrium estimates of the impact of sanctions on Iranian trade, real
GDP, and sectoral value added are novel in relation to these studies.

We view the quantitative exercise as limited in scope and are keenly aware that it alone
cannot fully address the question of the “effectiveness” of sanctions. Our motivation in
pursuing this task is twofold. First, we believe that any attempts to bridge the gap between
scholarship and policy making are doomed to remain unsatisfactory (or fail) if the costs that
senders impose on targets through trade-related channels and the burden of their actions
to themselves are not appraised. We think the analysis in this paper can rectify, or at

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9This is so because the problem we are dealing with is multi-dimensional in nature and has component
parts that are notoriously difficult to quantify and assess. As noted earlier, these difficulties are at least in
part related to the potentially conflicting objectives of politicians and policymakers as well as the nuanced
strategic policy interactions in the global economy.
least mitigate, this problem. Second, while we recognize the importance of earlier efforts to quantify these effects, we believe that the fact that our methodology has solid theoretical and general equilibrium foundations positions it well suited to capture both the significance of the heterogeneous effects of the various types of sanctions considered and the distributional effects on the burden of costs among senders.

The rest of the paper is organized as follows. Section 2 offers some descriptive motivational evidence on the relationship between sanctions and international trade based on the GSDB. Section 3 reviews the structural gravity theory and specifies our econometric model. Section 4 presents and discusses our partial equilibrium estimates of the impact of sanctions as well as the general equilibrium effects of the sanctions on Iran. Section 5 concludes.

2 Trade and Sanctions: Descriptive Evidence

2.1 A New Dataset

To quantify the impact of sanctions on international trade, we have put together a new data base, which we dubbed the Global Sanctions Data Base (GSDB). It covers all publicly traceable multilateral, plurilateral, as well as purely bilateral sanctions over the period 1950-2016. In light of our objectives, in this section we provide a brief description of the main and new dimensions of the GSDB. Then we take a close look at trade sanctions because they play a leading role in our quantitative analysis. For a comprehensive and full data description interested researchers and readers are referred to Felbermayr et al. (2020).\footnote{The GSDB is freely available and we will be happy to share it with interested researchers, who can request it by e-mail at GSDB@drexel.edu. When writing to us with requests for the data, please indicate your name and affiliation.}

The GSDB includes 729 sanction cases, which are classified on the basis of three main dimensions: type, objective, and success.\footnote{In an updated version of the GSDB we are working on, the time of coverage has been extended to the year 2019 and contains new cases for a total of 1045. The updated dataset will be available in December 2020.} First, sanctions are classified by type in six
categories that cover: trade, financial activity, arms, military assistance, travel, and other sanctions. Trade sanctions represent national or international legal actions preventing the transfer of items, material or goods over a defined period. In comparison to existing prominent sanction datasets (such as Hufbauer et al. (2007) and Morgan et al. (2014)) the GSDB not only identifies the existence of trade sanctions between two nations but also specifies the direction of affected trade flows (exports and/or imports), and the type of trade restriction (partial or complete sanctions). Structurally, the GSDB is closer to Hufbauer et al. (2007) because classical trade policy interventions, such as tariffs or anti-dumping measures, are not defined as sanctions. In fact all sanctions listed by Hufbauer et al. (2007) are also part of the GSDB. In addition the GSDB includes information on the political objectives of sanctions and documents on how far listed sanctions are considered successful in achieving defined objectives.

Fig. 1 depicts the evolution of all identified sanctions between 1950 and 2015. For each year, panel (a) of Fig. 1 reports the number of newly imposed sanctions and the cases that were initiated in previous years. Three distinct time intervals can be identified. During the 1950-1990 period, we observe a gradual and steady rise in the use of sanctions. A strong increase in new sanctions is observed in the early 90s. In the succeeding decade, until 2004, both the total number of sanctions in force and the newly initiated cases fall. However, a strong and steady increase of initiated sanctions policies is observed in the following years until the end of the sample period (which also continues today). Overall, the number of sanctions has been steadily rising over the last 65 years. We view this as evidence that the popularity of sanctions as a tool of coercive diplomacy has been on the rise. As a consequence, one may also suspect that the economic impact of sanctions will have been

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12 The most widely used database released in 1983 and updated several times over the past years is offered by Hufbauer et al. (2007). It focuses on around 200 identified cases of trade and financial sanctions. First published in 2006, Morgan et al. (2014) offer the Threat and Imposition of Economic Sanctions database (TIES), covering not only imposed sanctions but also threats of sanctions. The TIES database has also an economic and financial focus. However, it differs from Hufbauer et al. (2007) and from the GSDB by defining additionally measures of trade defence like anti-dumping as economic sanctions. Sanctions in the TIES database include tariffs, export controls, embargoes, import bans, travel bans, freezing assets, cutting foreign aid, and blockades. As a result the number of identified sanctions amount to over 1400 cases.
Panel (a): number of sanctions in force inherited from last year, and number of total (inherited plus new) sanctions in force per year. Panel (b): number of sanctions by type (trade sanctions, arms sanctions, military assistance sanctions, financial sanctions, travel sanctions, and other sanctions), stacked.

In the GSDDB, trade sanctions are broadly defined as limitations of trade flows. The GSDDB distinguishes between several types of trade sanctions depending on coverage, direction and participating countries. First, it is possible that only exports to or imports from a specific country are temporarily banned, or that both exports and imports are not permitted during the sanctions period. Accordingly, depending on the direction of banned trade flows, the

\[ \text{Number of all (i.e. pre-existing and new) sanctions in force} \]

\[ \text{Number of pre-existing sanctions} \]

\[ \text{Other Sanctions} \]

\[ \text{Travel Sanctions} \]

\[ \text{Financial Sanctions} \]

\[ \text{Military Assistance Sanctions} \]

\[ \text{Arms Sanctions} \]

\[ \text{Trade Sanctions} \]

Panel (b) of Fig. 1 presents the evolution of the number of sanctions by type.\textsuperscript{13} Several findings stand out: First, trade sanctions are the main type of sanctions implemented between 1950 and the late 70s. During this period, all other types of sanctions played a minor role. Second, over the years two specific policy measures have been applied with increasing frequency: financial and arms sanctions. Travel bans, restrictions on military assistance and other sanctions have also been imposed at an increasing rate. In contrast, the number of trade sanctions remained constant over the years, which, in combination with the increasing number of other sanctions, suggests that the number of trade sanctions is relatively smaller. This raises the question of whether trade sanctions, which have been treated with particular care in the GSDDB, are still an important and effective policy tool.

\textsuperscript{13} The exact number of countries that have been sanctioned with a specific type of sanction can be found in Felbermayr et al. (2020).
GSDB distinguishes between sanctions on exports from the sender to the target, sanctions on imports from the target to the sender, and sanctions that simultaneously apply to both the exports and the imports between the two sides. Second, trade sanctions may apply only to specific goods (partial trade sanctions) or to exports and/or imports as a whole (complete trade sanctions). Thus, the GSDB distinguishes between “partial” and “complete” sanctions within each of the three dimensions, depending on the direction of banned trade flows. Finally, an important aspect of sanctions is the scope of participating countries that can vary from one country (a unilateral sanction) to, for example, a sanction imposed multilaterally by all members of the United Nations. To perform the structural empirical analysis, we capitalize on the variation across each of the three dimensions of trade sanctions in the GSDB.

Fig. 2 tracks partial and complete trade sanctions over time. Interestingly, in the early 1950s, all countries participating in import sanctions restricted imports to the full extent. However, in the succeeding years, an increasing number of countries restricted imports only partly. In 2015, their share stood at around 70% of all countries applying import sanctions. In contrast, as illustrated in panel (b) of Fig. 2, over the past 65 years, countries have been less eager to impose restrictions on all exports. Between 1950 and 1990, around 70% of countries sanctioning exports imposed partial restrictions. In the following period of 20 years, almost half of all export restricting countries applied complete export sanctions, whereas in recent years two thirds of the countries participating in export sanctions applied only partial sanctions. These patterns illustrate the importance of identifying the differing extent of trade sanctions as partial vs. complete and export vs. import sanctions. In the

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14 For a range of cases the GSDB additionally includes detailed trade ban information (e.g., export controls of small aviation, helicopter, aviation parts and electronics, or export restrictions of high-tech products). The partial character of this type of trade sanctions is very heterogeneous as the product ranges differ substantially.

15 A prominent example of a complete unilateral sanction is the full trade sanction policy imposed by the United states on Cuba, which was introduced by President John F. Kennedy in February 1962. The UN sanction on Iran based on resolution 1996 is an example for a (partial) sanction policy that is imposed by all UN member states. The different dimensions of trade sanctions in the GSDB are explained in detail in Felbemayr et al. (2020)
Figure 2: Partial versus Complete Trade Sanctions

(a) Import Sanctions

(b) Export Sanctions

Partial and complete import (Panel (a)) and export (Panel (b)) sanctions over time (1950 to 2015).

econometric analysis below we demonstrate that the effectiveness of sanctions varies across these dimensions.

Who imposes sanctions on whom? Fig. 3 offers two radial dendrograms by major regions. Arrows starting in a specific region and pointing to a particular region indicate the number of imposed trade sanctions. Panel (a) of Fig. 3 illustrates the sanction activities between regions for the year 2015. Countries from North-Western Europe (NW Europe) imposed the largest number of trade sanctions in Africa (brown arrow). At the same time, however, not a single state from Africa imposed a trade Ban against a North-Western European state. Interestingly, some regions are barely sanctioned by other regions while at the same time others have been confronted with sanctions of almost every listed region. For example, East and South Asia have been sanctioned by almost all regions, at least in 2015. Panel (b) of Fig. 3 offers a radial dendrogram that illustrates the sanction activities between regions for the year 1950. For the sake of comparability, we hold the regional classification of countries constant to that in 2015. The figure illustrates a much smaller variety and number of sanctions policies among different regions. The biggest share of arrows indicate that trade sanctions took place between members of the Eastern and Western blocks at that time. The GSDB also illustrates that the USA and the EU countries have been the most active nations in imposing trade sanctions against other states, followed by North-African
The descriptive analysis of trade sanctions reveals that they are used by many countries in an intricate network. Overall the GSDB suggests that trade sanctions are relevant. Still, an important question in the context of measuring the cost and efficiency of trade sanctions, which we have not addressed thus far, is related to the extent of international economic integration of sanctioned countries. If a nation is barely trading with the rest of the world, the probability that it will succeed in a foreign policy pursuit with trade sanctions is small because the economic costs on the target(s) are expected to be small. In other words, while the number of trade sanctions and the composition of the regions and countries involved is important, what is also important is the potential economic impact of those sanctions, which in our case is the potential trade volume that could be affected by sanctions. Figs. 4 and 5 shed further light on this issue.
2.2 The US and the EU: Major Players

Motivated by the fact that the United States and the European Union countries have been the most active senders, Fig. 4 depicts the exposure share of world trade to U.S. sanctions (panel (a)), and to EU sanctions (panel (b)). Panel (a) reveals that the US sanctions had the potential to negatively impact 2.5 percent of global trade in 2015. Interestingly, the share of global trade potentially affected by EU sanctions turns out to be substantially less volatile (but similarly sized). Moreover, in recent years EU sanctions have been threatening an increasingly larger share of global trade than US sanctions. The EU and US are jointly responsible for affecting negatively about two third of global trade with sanctions policies. The main message from Fig. 4 is that, individually and in combination, the U.S. and EU sanctions have the potential to affect a significant fraction of trade flows, and therefore economic activity, in the world.

Fig. 5 complements the analysis of the impact of U.S. and EU sanctions by illustrating the total potential impact on trade that could be caused by all trade sanctions in the world during a given year.\textsuperscript{16} The left panel of Fig. 5 reports the impact on trade volumes in levels, measured in trillions of current U.S. dollars. Three periods with a stepwise increase in

\textsuperscript{16}In case of unilateral sanctions the graph accounts for imports and exports of sanctioning countries while for cases with reciprocal sanctions only both import volumes have been accounted for.
potentially affected global trade volume can be identified. In the mid 1970s, sanctions started to have some bite, but the extent of their impact remained very minor. After the fall of the iron wall in 1989, potentially affected trade volumes quickly rose to something like 200 bn. U.S. dollars. The most dramatic increase occurred after 2002; the trade volume potentially affected by sanctions stood at more than 2 trillion U.S. dollars in recent years. Clearly, the increasing economic integration over the last decades is one reason for the exponential pattern depicted in Fig. 5.

In order to gauge the relative importance of sanctions for international trade, Panel (b) of Fig. 5 translates the levels from panel (a) of the same figure into percentages. The share of world trade potentially impacted by sanction policies has risen steadily since 1950, reaching 7 percent of world trade in recent years. In contrast to the development in nominal trade volume the potentially affected trade in relative terms turns out to be less exponential in its development. A major message of these statistics is that the size of economic damage achievable by sanction policies through the trade channel has reached quite a significant volume. This validates our focus on measuring the impact of sanctions on international trade as an important component of the overall effectiveness of sanctions. Our empirical analysis below complements and reinforces the descriptives presented in this section by demonstrating that
the EU and US sanctions have been among the most effective ones in influencing trade flows in our application. In addition, we show that the impact of sanctions is very heterogeneous even across the EU members.

### 2.3 The Sanctions Against Iran

As discussed in the introduction, we find the sanction on Iran especially interesting (i) because it is one of the most prominent and most discussed cases in recent history, (ii) because it is multi-dimensional, and (iii) because it has been imposed by almost all countries in the world, thus allowing us to obtain a large set of pair-specific estimates and to study their heterogeneity across countries. This section offers further details on the nature and evolution of the sanctions on Iran.

Over the past decades the United Nations security council passed several resolutions that imposed increasingly tighter sanctions on Iran. The triggering event of more recent UN sanctions against Iran has been the report by the International Atomic Energy Agency (IAEA) regarding Iran’s nuclear activities in particular, the country’s Uranium enrichment activities. The first UN resolution imposing economic sanctions on Iran came into force when the country rejected the security council’s request to suspend uranium enrichment activities. The first economic sanctions against Iran started in July 2006 based on the UN security council resolution 1696 and were extended and continuously tightened in the succeeding years. Starting with trade sanctions on goods that could be used in Iran’s nuclear and ballistic missile program, sanctions were extended by increasing the number of goods whose trade was banned, financial sanctions and travel bans for individual people. On top of the UN resolutions listed in Table 1, the USA and the EU additionally imposed their own sanctions on Iran. In 1979 the US imposed sanctions after Iranian students stormed the US embassy in Tehran (import sanctions). Moreover, in 1984 the USA imposed further sanctions on Iran because of the country’s support for acts of international terrorism. In 1995 the US formulated an executive order to prohibit bilateral trade between Iran and the
Table 1: UN security council resolutions imposing sanctions on Iran - since 2006

<table>
<thead>
<tr>
<th>Resolution</th>
<th>Date</th>
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<tbody>
<tr>
<td>1696</td>
<td>from July 2006.</td>
</tr>
<tr>
<td>1737</td>
<td>from December 2006.</td>
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<tr>
<td>1747</td>
<td>from March 2007.</td>
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<tr>
<td>1803</td>
<td>from March 2008.</td>
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<tr>
<td>1835</td>
<td>from September 2008.</td>
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<tr>
<td>1929</td>
<td>from June 2010.</td>
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<tr>
<td>1984</td>
<td>from June 2011.</td>
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<tr>
<td>2049</td>
<td>from June 2012.</td>
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<tr>
<td>2105</td>
<td>from June 2013.</td>
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<tr>
<td>2159</td>
<td>from June 2014.</td>
</tr>
</tbody>
</table>

USA. European sanctions reached their peak in January 2012 when the EU introduced an oil embargo and froze assets of Iran’s central bank. Sanctions covered foreign trade, financial services, and in addition banned the provision of insurance by insurers in member states to Iran. Finally, all Iranian banks identified as institutions in breach of US or EU sanctions were disconnected from the SWIFT, the global payment system that connects banks.

3 Quantifying the Impact of Sanctions on Trade

To quantify the heterogeneous impact of sanctions on trade and welfare we rely on the structural gravity model of international trade. Owing to its remarkable empirical performance, solid theoretical foundations, and flexibility to accommodate various extensions, the gravity model has established itself as the workhorse framework for trade policy analysis. We offer a brief review of the theoretical foundations of structural gravity in Section 3.1. Then, guided by theory and implementing the latest developments in the empirical gravity literature, in Section 3.2 we specify an econometric gravity model that enables us to obtain heterogeneous partial equilibrium estimates of the impact of sanctions on trade across various dimensions of the new sanctions database.
3.1 The Structural Gravity Model of Trade: A Brief Review

This section presents the Armington-CES version of the gravity model of international trade,\(^\text{17}\) which is the foundation for our estimations as well as for the general equilibrium analysis. Anderson (1979) is the first to derive a structural gravity model of trade under the assumptions that goods are differentiated by place of origin (Armington, 1969) and that consumer preferences are homothetic, identical across countries, and approximated by a CES utility function. Anderson and van Wincoop (2003) refine and popularize the ideas of Anderson (1979) by delivering the following structural gravity system of international trade:

\[
X_{ij,t} = \frac{Y_{i,t}E_{j,t}}{Y_t} \left( \frac{t_{ij,t}}{P_{j,t} \Pi_{i,t}} \right)^{1-\sigma}, \quad (1)
\]

\[
\Pi_{i,t}^{1-\sigma} = \sum_j \left( \frac{t_{ij,t}}{P_{j,t}} \right)^{1-\sigma} \frac{E_{j,t}}{Y_t}, \quad (2)
\]

\[
P_{j,t}^{1-\sigma} = \sum_i \left( \frac{t_{ij,t}}{\Pi_{i,t}} \right)^{1-\sigma} \frac{Y_{i,t}}{Y_t}, \quad (3)
\]

\[
p_{j,t} = \left( \frac{Y_{j,t}/Y_t}{\gamma_j \Pi_{j,t}} \right)^{\frac{1}{\gamma_j}}. \quad (4)
\]

Here, at each point of time \(t\), \(X_{ij,t}\) denotes trade flows from exporter \(i\) to destination \(j\); \(E_{j,t}\) is the total expenditure in importer \(j\); \(Y_{i,t}\) is the value of total production in exporter \(i\); \(Y_t\) is the value of world output; \(t_{ij,t}\) denotes bilateral trade frictions between partners \(i\) and \(j\); \(\sigma > 1\) is the elasticity of substitution among goods from different countries. Equation (1)

\(^{17}\)It is now well established that the same gravity system can be obtained from a series of alternative micro foundations (Arkolakis et al. (2012)). In addition to the original demand-side gravity model of Anderson (1979) and Anderson and van Wincoop (2003) that we review in this section, the same gravity system can be derived on the supply side (i.e., as in Eaton and Kortum (2002)), as a sectoral model on the demand side (as in (Larch and Wanner (2017) and Anderson and Yotov (2016)), and as a sectoral model from the supply side, following Costinot et al. (2012). Caliendo and Parro (2015) extend the gravity model of Eaton and Kortum (2002) to a sectoral model with intermediates. In Section 4.2, we rely on the Caliendo and Parro (2015) version of the gravity model to perform the general equilibrium analysis. Finally, Dekle et al. (2007) and Dekle et al. (2008) derive a structural gravity system in changes, which is very convenient for computational purposes. We will capitalize on that, in combination with the sectoral gravity model with intermediates of Caliendo and Parro (2015), in the counterfactual analysis where we use the system in changes to obtain general equilibrium effects of sanctions. We refer the reader to Anderson (2011), Costinot and Rodríguez-Clare (2014), and Larch and Yotov (2016) for surveys of the theoretical gravity literature.
intuitively links bilateral exports to market size (the first term on the right-hand side) and trade frictions (the second term on the right-hand side). The numerator of the trade cost term includes bilateral trade frictions \((t_{ij,t})\), which we model explicitly below as a function of the possible impact of sanctions among other variables that have been recognized as significant determinants of trade flows in the existing literature. \(P_{j,t}\) and \(\Pi_{i,t}\) defined in equations (2)-(3) are the multilateral resistance terms (MRs, inward and outward, respectively), coined by Anderson and van Wincoop (2003).

The MRs are consistent aggregates of bilateral trade costs for each country and are interpreted as buyers’ and sellers’ incidence of the global system of trade costs respectively (Anderson and Yotov, 2010). The multilateral resistances are a key vehicle that enables us to translate the partial equilibrium estimates we obtain of the impact of sanctions on bilateral trade among sanctioned and sanctioning countries into general equilibrium effects on trade and welfare on all countries in the world. This is so because the MRs represent the endogenous structural links between the changes in bilateral trade costs and their impact on consumer prices, nominal income and real income at the country level.\(^{18}\)

Finally, equation (4) captures the link between trade and national income (through the multilateral resistances). Equation (4), where \(\gamma_j\) is the CES share parameter, is a restatement of the market-clearing condition \((Y_{i,t} = \sum_j X_{ij,t})\), which unveils an inverse relationship between the outward multilateral resistance that captures the incidence of trade costs on the producers in \(j\) and the factory-gate price in \(j\). The intuition for this result, with an application to sanctions, is that when a country is sanctioned, producers in this country will suffer higher outward MRs, i.e., higher incidence of trade costs, which according to equation (4), translates into lower factory-gate prices. Similarly, producers in the sanctioning countries will also suffer increases in their outward MRs that lead to lower factory-gate prices. The lower factory-gate prices translate into lower nominal income, which defines the value of

\(^{18}\)For further analysis of the MRs and their importance in the structural gravity system, we refer the reader to Larch and Yotov (2016), who offer a detailed discussion of the properties of the multilateral resistances and highlight their practical uses and their relevance in general equilibrium analysis.
production in country \( j \) and, therefore, via equation (1), affects negatively bilateral trade flows not only between the sanctioned and sanctioning countries, but also between them and any other country in the world. In Section 4.2, we will be able to quantify such general equilibrium effects within the structural gravity framework in case of the sanction on Iran.

### 3.2 Structural Gravity and Sanctions: From Theory to Empirics

Guided by the theoretical foundations of the gravity model from the previous section and capitalizing on the rich dimensionality of the new database on sanctions, we set an econometric gravity model that corresponds to the structural gravity equation (1), and which will enable us to obtain partial equilibrium estimates of the effects of sanctions on international trade:\(^{19}\)

\[
X_{ij,t} = \exp\left[ SANCT_{ij,t} \alpha + GRAV_{ij,t} \beta + \mu_{ij} + \pi_{i,t} + \chi_{j,t} \right] + \epsilon_{ij,t}. \tag{5}
\]

As noted earlier, \( X_{ij,t} \) denotes nominal trade flows from exporter \( i \) to importer \( j \) at time \( t \). Most important for our purposes, \( SANCT_{ij,t} \) is the vector of sanction variables that take central stage in our analysis. In order to demonstrate the importance of properly capturing the heterogeneous impact of sanctions on Iran’s trade, in the estimation analysis we start with a baseline of sanction variables and then gradually decompose them across the key dimensions of interest to us. We motivate and describe each step of decomposing vector \( SANCT_{ij,t} \) in detail in Section 4 below.\(^{20}\)

The rest of the variables in equation (5) are standard in the gravity literature. The vector \( GRAV_{ij,t} \) includes standard time-invariant gravity covariates such as the logarithm of bilateral distance and indicator variables for colonial relationships, common language,

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\(^{19}\)We refer the reader to Baldwin and Taglioni (2006), Head and Mayer (2014), and Piermartini and Yotov (2016) for surveys of the empirical gravity literature.

\(^{20}\)To obtain estimates of the partial impact of sanctions on trade, we implement the latest developments in the empirical gravity literature. Nonetheless, there are certain aspects of sanctions (e.g., their potential multilateral and extraterritorial impact), which require special attention in the interpretation of our results. We discuss these features and their implications for our findings when we present our estimates.
and common borders. In addition, we control for the presence of regional trade agreements (RTAs) with a dummy variable \((RTA_{ij,t})\), which takes a value of one if there is an RTA between countries \(i\) and \(j\) at time \(t\), and it is equal to zero otherwise. \(\pi_{i,t}\) denotes the set of time-varying exporting-country dummies, which control for the outward multilateral resistances of Anderson and van Wincoop (2003) as well as for any other observable and unobservable exporter-specific factors that may influence bilateral trade. Similarly, \(\chi_{j,t}\) encompasses the set of time-varying destination-country dummy variables that account for the inward multilateral resistances as well as for any other observable and unobservable importer-specific characteristics that may influence international trade.

Finally, \(\mu_{ij}\) denotes the set of country-pair fixed effects, which serve two main purposes. First, the pair fixed effects are the most flexible and comprehensive measure of time-invariant bilateral trade costs because they absorb any observable and unobservable time-invariant bilateral determinants of trade costs. Second, as demonstrated by Baier and Bergstrand (2007), the pair fixed effects absorb most of the linkages between the potentially endogenous RTAs and the error term \(\epsilon_{ij,t}\) in order to control for potential endogeneity of RTAs. Similarly, and more important for our analysis, the pair fixed effects mitigate endogeneity concerns with respect to sanctions.\(^{21}\) In the robustness analysis we also add linear bilateral time trends. Furthermore, to obtain our main results, we follow Baier et al. (2016) and employ directional bilateral fixed effects. The benefits are: (i) the directional fixed effects allow and control for the presence of asymmetric trade costs; and (ii) this treatment is consistent with the fact that many of the sanctions in our database are directional.

We employ panel data to obtain the estimates for all specifications of equation (5) that we present in this section. In addition to improving efficiency, the panel data allow for the use

\(^{21}\)Another factor that mitigates potential endogeneity concerns with respect to sanctions is that, by definition, sanctions are usually imposed in response to actions/inactions that are specific to the target country. Therefore, the use of exporter-time and importer-time fixed effects in our econometric specification completely controls for any such target-specific linkages. The downside of the use of country-time fixed effects is, of course, that they will also absorb any multilateral effects of sanctions. Therefore, our estimates of the bilateral impact of sanctions should be interpreted as lower bounds. We will return to this discussion in the next section when we present our estimates.
of country-pair fixed effects and enable us to study the impact of deeper sanction provisions within the same specification. Finally, following the recommendations of Santos-Silva and Tenreyro (2006), we rely on the Poisson Pseudo Maximum Likelihood (PPML) estimator to obtain our main results. The benefits of using PPML are: (i) this estimator handles successfully the heteroskedasticity in trade data which would otherwise lead to inconsistent OLS estimates; and (ii) due to its multiplicative form, the PPML estimator enables us to take advantage of the information contained in the zero trade flows. In sensitivity analysis, we demonstrate that our main findings are robust to the use of the standard OLS estimator.

4 On the Heterogeneous Effects of the Sanctions on Iran

The analysis in this section quantifies the impact of sanctions on Iran’s trade. In Section 4.1, we obtain partial equilibrium estimates, which reveal widely heterogeneous effects across countries. Then, in Section 4.2, we translate the partial estimates into general equilibrium effects on trade, welfare, and sectoral value added within a multi-sector structural gravity model with input-output linkages. Our GE estimates capture additional wide heterogeneity in the impact of sanctions across countries and across sectors too.

4.1 Partial Equilibrium Estimates

This section presents the results from a series of specifications, which gradually zoom in to quantify the partial equilibrium (direct) impact of sanctions on Iran’s international trade flows. Our main results are presented in Table 2.22 As described in the previous section, the estimates are obtained with the PPML estimator and directional exporter-time, importer-time, and pair fixed effects. Due to the rich structure of fixed effects, we can only identify the impact of time-varying bilateral covariates. Furthermore, due to size constraints, we only

22Three sets of sensitivity experiments, including PPML estimates with standard gravity variables instead of pair fixed effects, OLS estimates with the full set of fixed effects, and PPML estimates with bilateral time trends, which are available upon request, confirm the robustness of our main findings.
report the estimates of sanctions and, in some cases, we employ graphical representation of our findings.\textsuperscript{23}

We start with a model, in column (1) of Table 2, which includes four sanction variables designed to identify the impact of: (i) complete trade sanctions ($TRADE\_SANCT\_COMPL$); (ii) partial trade sanctions ($TRADE\_SANCT\_PARTL$); (iii) all other (i.e., non-trade) sanctions ($OTHER\_SANCT$); and (iv) the sanctions targeted specifically at Iran’s trade ($SANCT\_IRAN$). In order to ease interpretation, all sanction variables are constructed so that they are mutually exclusive. Thus, all estimates in column (1) should be interpreted in levels rather than as deviations from each other.

Three findings stand out from column (1). First, we offer evidence for the intuitive argument that complete trade sanctions are more effective as compared to partial trade sanctions. The estimate on $TRADE\_SANCT\_COMPL$ suggests that, all else equal, trade flows between the sanctioning countries and their targets decreased by more than 77 percent ($\exp(-1.480) - 1 \times 100$) when complete sanctions were imposed. This is strong evidence in support of the effectiveness of sanctions in impeding international trade. Second, we do not offer evidence that non-trade sanctions (e.g., travel sanctions) have a direct impact on trade. A possible explanation for the insignificant estimates on $OTHER\_SANCT$ is that their effects are indirect and captured by the country-time fixed effects in the empirical gravity model, along with other general equilibrium forces.\textsuperscript{24} Finally, the negative, large, and statistically significant estimate on $SANCT\_IRAN$ implies that, all else equal, the sanctions decreased Iranian trade with the sanctioning countries by about 55 percent.

In column (2) of Table 2 we separate the indicator variable for the Iran sanctions into two dummies, one for Iranian exports to the sanctioning countries ($SANCT\_IRAN\_EXP$)

\textsuperscript{23}The complete sets of gravity estimates are available upon request.

\textsuperscript{24}For example, some countries have used ‘secondary sanctions’ to go after a target’s country global transactions. In addition, some financial sanctions aim to prevent financial institutions from processing payments or to provide trade finance regardless of the direction of trade. Similarly, in some cases insurers cannot offer freight insurance. Such multilateral effects are absorbed by the sanctioning country fixed effects and point to the need for more careful modeling of the structural impact of non-trade sanctions on international trade. The implication for our estimates is that, by capturing only the impact of bilateral trade sanctions on international trade, they represent a lower bound for the possible impact of sanctions on trade.
Table 2: Estimates of the Effects of Sanctions on Iran

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</table>

Notes: This table reports estimates of the heterogeneous effects of trade sanctions on Iran. The dependent variable is trade in levels. All estimates are obtained with the PPML estimator and exporter-time, importer-time and directional country-pair fixed effects. In addition, we control for the presence of RTAs, trade sanctions on exports and imports, complete trade sanctions, and all other sanctions. Column (1) obtains a single average estimate of the effects of the sanctions on Iran. Column (2) decomposes the impact of the Iranian sanctions on the exports vs. imports of Iran. Column (3) further allows for differential effects across country pairs and in each direction of trade flows. Finally, column (4) captures the impact of the stricter EU sanctions on Iran post 2011. Standard errors are clustered by country pair. † p < 0.10, * p < 0.05, ** p < 0.01. See text for further details.
and another for Iranian imports from the sanctioning countries \((SANCT\_IRAN\_IMP)\). Two main findings stand out from the estimates in column (2). First, the estimates on \(SANCT\_IRAN\_EXP\) and \(SANCT\_IRAN\_IMP\) are both negative and statistically significant. The implication is that, on average, the sanctions on Iran have been effective in reducing its exports as well as its imports. Second, the estimates on \(SANCT\_IRAN\_EXP\) and \(SANCT\_IRAN\_IMP\) are not statistically different from each other. The implication is that, all else equal, the impact of the sanctions on Iran has been symmetric in each direction of trade flows.

In column (3) of Table 2 we allow for directional pair-specific sanction effects. Specifically, we isolate the effects on Iranian exports and imports with a series of individual countries and regions (e.g., the United States vs. the European Union). Our choice of sanctioning countries is based on the three criteria: (i) Identifying the major exporters to Iran (e.g., United Arab Emirates, Germany, China) and the main destinations for Iranian exports (e.g., Japan, China, Turkey) at the beginning of the sanctioning period; (ii) selecting countries that imposed individual sanctions on Iran (e.g., USA, Canada, and Australia); (iii) isolating the impact of sanctions whose stringency changed over time (e.g., the stringency of the EU sanctions on Iran reached a peak in 2012).\(^{25}\) In order to ease interpretation, we subtracted the directional pair-specific sanctions dummies from the corresponding indicators for Iranian exports to sanctioning countries and for Iranian imports from sanctioning countries. Thus, the estimates on the new sanction dummies should be interpreted independently and not as deviations from \(SANCT\_IRAN\_EXP\) and \(SANCT\_IRAN\_IMP\).

Several findings stand out from the results in column (3) of Table 2. First, most of the estimates on the country-specific sanction effects are negative, statistically significant, and

\(^{25}\)The countries that are included individually in our estimations based on the three criteria noted above account for more than 83% of Iranian trade with sanctioning countries at the beginning of the sanctioning period. In principle, our methods allow us to identify the impact of the sanctions on Iran separately for each possible sanctioning country in our sample. It is also possible to identify the extraterritorial impact of the sanctions on Iran on third countries. We experimented with such specifications and found that they do not affect our main partial estimates and general equilibrium results significantly. A possible explanation is that, due to the imposition of the UN sanctions on Iran, almost all countries in our sample are technically involved in the sanction. Therefore, for brevity, we only focus on the selected countries for our main analysis.
large in terms of magnitude. Twenty-six of the twenty-eight individual sanction estimates are negative and twenty-three of them are statistically significant. Second, the negative effects of the sanctions on Iran are widely heterogeneous across countries. The estimates on the trade sanctions of US and Canada are among the largest. A possible explanation for this finding is that these countries imposed individual sanctions on Iran. Third, we also observe significant heterogeneity and asymmetries between the impact of the sanctions on exports vs. imports within country pairs. In most cases, our estimates of the sanction effect on Iranian exports are larger (e.g., for exports to US and to Switzerland), but in some cases the impact of the sanction on Iranian imports is larger (e.g., for imports from Russia and from Japan).

We also note that some of the estimates in column (3) are insignificant and/or positive, e.g., the results for Iran’s trade with China, Turkey, and India. The estimates on the directional effects on the sanctions on trade between China and Iran are not statistically significant, while only the impact of the sanction on Turkey’s and India’s exports to Iran is significant, and marginally so. The explanation for the insignificant estimates of the impact of the sanction on Iran for trade with China and Turkey is that these countries were given a sanction waiver. The single positive and significant estimate we obtain is on exports from the United Arab Emirates to Iran, suggesting the presence of ‘trade creation’ effects.

The estimates from column (4) of Table 2 allow for additional (presumably stronger) effects of the sanctions on the European Union on Iran. The motivation for this specification is that the EU sanctions reached a peak in 2012 with the imposition of a series of new provisions and additional sanctions on Iran. To capture these effects we introduce two new indicator variables for the EU sanctions on Iranian exports to EU post 2011 (SANCT_IRN_EU_2012) and for the EU sanctions on Iranian imports from EU post 2011 (SANCT_EU_IRN_2012). Since the new variables are not subtracted from the original dummies for the EU sanctions, the estimates on SANCT_IRN_EU_2012 and SANCT_EU_IRN_2012 should be interpreted as deviations from SANCT_EU_IRN and SANCT_IRN_EU. Consistent with our expectations, the estimates from column (4)
of Table 2 indicate that, on average, the impact of the EU sanctions on Iran more than doubled during the period post-2011.

We conclude the analysis in this section by going a step deeper in studying the heterogeneous effects of sanctions. Specifically, we zoom in on the impact of the EU sanctions on Iran by allowing for directional and pair-specific effects; that is, we allow for differential effects of the EU sanction on Iran for exports from Germany to Iran vs. imports of Bulgaria from Iran. Our specification includes all variables from column (4) of Table 2 but we replace the EU covariates with a series directional and pair-specific dummies for the impact of the sanctions on Iran for each EU member. Due to the large number of additional estimates, instead of a table format, we use a graphical presentation. The top panel of Fig. 6 presents estimates of the effects on EU exports to Iran, while the bottom panel reports results for the corresponding effects on Iran’s exports to the EU countries. As before, we also allow for differential effects of the post-2011 provisions of the EU sanction on Iran. The countries on the x-axis of each panel of Fig. 6 are ordered based on the size of the gravity estimates of the pre-2011 effects of Iran’s sanction. These estimates appear on the graph as blue circles. The red diamonds in Fig. 6 capture the total effects of the sanction on Iran on trade with the EU members, i.e., they take into account the impact of the post-2011 provisions.

Three salient findings emerge from the top panel of Fig. 6. First, we note that all estimates (both pre- and post-2011) are negative. This means that the EU sanction on Iran has been effective in decreasing EU exports to this country. More importantly, the graph captures very wide heterogeneity in terms of the magnitude of the sanction effects, both before and after the additional provisions from 2011 took place. In terms of impact of the

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26EU member states decide on sanctions policies within the framework of the Common Foreign and Security Policy (CFSP) as set out in Article 21 of the Treaty on European Union. Restrictive measures such as sanctions are either implemented at EU or at national level. Measures such as arms embargoes or restrictions on admission are implemented directly by EU members, which are legally bound to act in conformity with CFSP Council Decisions. Further measures interrupting or reducing, in part or completely, economic relations with a third country, such as freezing funds and economic resources, are implemented by means of a regulation, adopted by the Council (A detailed explanation of the procedure can be found in the EU’s guidelines on restrictive measures). Because all EU regulations are binding for member states one could argue that sanctions should have uniform effects for EU member states.
Figure 6: On the Heterogeneous Impact of the EU sanctions on Iran

Note: These figures presents estimates of the impact of the sanction on Iran’s trade with the countries from the European Union. The top panel reports estimates of the effects on EU exports to Iran, while the bottom panel includes results for the corresponding effects on Iran’s exports to the EU countries. We allow for differential effects of the post-2011 provisions of the EU sanction on Iran. The countries on the x-axis of each panel are ordered based on the size of the gravity estimates of the pre-2011 effects of Iran’s sanction on the exports of Iran to each of the EU members. These estimates appear on the graph as blue circles. The red diamonds capture the total effects of the sanction on Iran on trade with the EU members.
pre-2011 sanctions, we find that countries from Eastern and Central Europe (e.g., Hungary, Poland, Bulgaria) were affected the most, while France, Croatia and Cyprus are on the other side of the spectrum. In terms of additional, post-2011, effects, we see small impact for some countries, especially those that experienced strong pre-2011 effects, e.g., Hungary and Bulgaria, and very large effects for other EU members, e.g., UK and Cyprus. The total effects of the sanction on EU exports to Iran are very large and very heterogeneous, ranging between 77.6 percent (for Cyprus) and 98.5 percent (for Great Britain).

The bottom panel of Fig. 6 reports results for the impact of the sanction on Iran’s exports to the EU countries. Our estimates reveal that the sanction has been effective in limiting Iran’s exports to the EU. All of the estimates of the total effects of the sanction are negative and statistically significant. In addition, all but one of the estimates of the pre-2011 effects of the sanction are also negative. The exception is Greece, whose estimate is positive but not statistically significant. Once again, we see wide heterogeneity in the estimates on Iran’s exports to the EU countries, which, in terms of volume effects, range from completely eliminating trade, e.g., a decrease of 99.8 percent in the case of Finland, to a significantly smaller but still sizable decrease of 57.9 percent in the case of Greece. Finally, a comparison between the estimates in the two panels of Fig. 6 reveals that, while the impact of the sanction on Iran’s trade in each direction is similar for some countries, e.g., Hungary and Poland, it is very asymmetric for others, e.g., Greece, where we see a big effect on the country’s exports to Iran but no impact on its imports from Iran.

We draw six main conclusions on the basis of our analysis in this section. First, our results demonstrate that the impact of sanctions is quite heterogeneous across sanctions (e.g., the sanction on Iran vs. all other trade sanctions). Second, we find that the effects of sanctions vary significantly across country-pairs within sanctions (e.g., USA-Iran vs. China-Iran). Third, our estimates reveal that the impact of sanctions also vary within pairs depending on the direction of trade flows (e.g., Greece-Iran vs. Iran-Greece). Fourth, we find that the additional provisions in the EU sanctions on Iran have been very effective on average.
However, fifth, we also document very heterogeneous effects of sanctions even within the European Union. Finally, we also obtain some estimates that are not statistically significant (e.g., Turkey-Iran and China-Iran), reflecting sanctions waivers, and even some positive estimates (e.g., United Arab Emirates-Iran), reflecting trade creation effects.

### 4.2 General Equilibrium Effects on Trade and Welfare

We conclude by quantifying the general equilibrium effects of the sanctions on Iran on trade, real GDP, and sectoral value added. To this end, we rely on the gravity framework of Aichele and Heiland (2016), who calibrate a multi-sector version of the gravity model presented in Section 3.1, which, following Caliendo and Parro (2015), also includes intermediate linkages for 130 countries and 57 sectors using the GTAP data.\(^{27}\) The baseline year for the analysis is 2014 and the counterfactual experiment employs our pair-and-direction-specific estimates from the previous section to simulate a hypothetical world in the absence of the sanctions on Iran. Since our empirical estimates relate only to the goods market and do not vary across sectors, in the counterfactual simulations, we assume a uniform shock on trade costs for all goods sectors and a uniform trade elasticity of 3.5 (the average value across sectors from Aichele and Heiland (2016). The sectoral trade cost shocks relate the counterfactual level of iceberg trade costs \(\tau'_{i,j}\) to their baseline levels \(\tau_{i,j}\) such that \(\hat{\tau}_{i,j} \equiv \tau'_{i,j}/\tau_{i,j}\).\(^{28}\)

First we describe the effects on bilateral trade. The estimates in Table 5 are constructed as the ratio of counterfactual to baseline expenditure shares \(\hat{\pi}_{i,j} \equiv \pi'_{i,j}/\pi_{i,j}\).

For brevity and clarity of exposition, we focus on four countries: Iran, Germany, USA and China. For \(i = j = \{\text{IRN}\}\), \(\pi_{\text{IRN,IRN}} = 63.8\) and \(\pi'_{\text{IRN,IRN}} = 68.1\), implying \(\hat{\pi}_{\text{IRN,IRN}} = \)

\(^{27}\)The model assumes perfect competition. Trade is Ricardian in the sense that countries purchase only the cheapest available variety of each good. A key feature of the model is the intersectoral linkages, both intra- and internationally. Production requires labor and a composite of inputs drawn from other sectors. Wages are equalized across sectors so that sectoral variation results only from reallocation effects. While the values of imports and exports need not coincide at the country level, the trade balance normalized by GDP is assumed constant. See Aichele and Heiland (2016) and Caliendo and Parro (2015) for additional details.

\(^{28}\)For the pairs involving Iran, the average trade cost shock is 0.84; that is, in the counterfactual, trade costs are 16 percent lower than in the baseline. The median is 0.79, the minimum of 0.24 is for US imports from Iran; the maximum of 1.22 is for Iranian imports from the United Arab Emirates.
Table 3: Counterfactual Analysis: Trade Effects (% of Baseline)

<table>
<thead>
<tr>
<th>Exporter</th>
<th>Importer</th>
<th>$\pi'$</th>
<th>$\pi$</th>
<th>$\pi'/\pi$</th>
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<tr>
<td>IRN</td>
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<td>0.38</td>
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<td>0.01</td>
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<td>IRN</td>
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<td>63.84</td>
<td>68.05</td>
<td>0.94</td>
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<tr>
<td>DEU</td>
<td>CHN</td>
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<td>0.21</td>
<td>1.00</td>
</tr>
<tr>
<td>DEU</td>
<td>IRN</td>
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<td>0.08</td>
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<td>DEU</td>
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<td>1.03</td>
<td>1.00</td>
</tr>
<tr>
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<td>1.56</td>
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</tr>
<tr>
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<td>1.94</td>
<td>1.00</td>
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<td>2.29</td>
<td>1.00</td>
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<td>CHN</td>
<td>CHN</td>
<td>72.51</td>
<td>72.45</td>
<td>1.00</td>
</tr>
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</table>

Notes: This table reports the results of counterfactual simulations. $\pi'/\pi$ relates counterfactual (no sanctions) to baseline (sanctions) equilibrium.
0.94, which means that undoing the sanctions makes the country substantially more open to international trade. The share of German expenditure that falls on Iranian goods would go up from 0.01 to 0.19 percent, so that \( \hat{\pi} = 27 \), whereas the share of US expenditure falling on Iranian goods would increase from virtually zero to 0.06 percent, an increase by a factor of 176. These trade changes are dramatic, but the new levels of trade are still very low. Similarly, Iran’s expenditure on German and US products goes up as well, by a factor of 9 and by a factor of 29, respectively. The share of Iran’s spending on Chinese goods goes down from 4.8 to 3.6 percent, reflecting the reduction in trade diversion due to sanctions. This loss of trade is even more pronounced for Chinese spending on Iranian goods, where the expenditure share falls from 0.38 to 0.16 percent. For country pairs not directly affected by sanctions, such as USA-Germany or Germany-China, expenditure shares do not change significantly.

Next, we turn to the effects of undoing sanctions on real income, our welfare measure. The results are visualized in Fig. 7. The biggest winner of terminating sanctions, not surprisingly, is Iran. It’s real per capita income is predicted to rise by about 4.2 percent. This might seem small; but the overall gains from trade in this quantitative model are usually estimated to be rather small; see Costinot and Rodriguez-Clare (2015). So, it may not be overly surprising that the termination of sanctions does not imply higher gains for Iran. Also note that services sectors are affected only indirectly, as demand for their output in manufacturing sectors may fall. Moreover, the sanctions have led to considerable trade diversion, especially to China, so that Iran’s overall openness has not been reduced by much either. The country with the next largest welfare gain from the removal of the sanctions on Iran is Armenia, a neighboring country to Iran. This is intuitive, since Armenia has difficult political and economic relations with its other neighbors such as Azerbaijan and Turkey. So, it relies overproportionately on trade with Iran, and lower income in Iran worsens Armenia’s terms of trade.

Amongst the 15 countries most positively affected form the removal of the Iran sanction,
Figure 7: Counterfactual Analysis: Welfare Effects (% of baseline)

Note: Percent changes in real per capita income resulting from an end of sanctions against Iran. Only countries with largest effects are shown: Iran (IRN), Armenia (ARM), Moldova (MDA), Malta (MLT), Sri Lanka (LKA), Mongolia (MNG), Malawi (MWI), Kyrgyzstan (KGZ), Georgia (GEO), Kenya (KEN), South Africa (ZAF), Cyprus (CYP), Cambodia (KHM), Oman (OMN), Greece (GRC).

are small nations such as Malta, Cyprus and Greece, which provide shipping services to Iran’s oil industry, and other geographically close countries such as Georgia or the centralasian countries Mongolia and Kyrgyzstan. Gains for third countries are typically small: they lie between about 0.4 percent for Armenia and 0.07 percent for Greece. The Western initiators of the sanctions against Iran and the UN Security Council members, such as the USA, France, and Great Britain, are barely affected; gains from undoing the sanctions lie below 0.03 percent of GDP; the UK is even predicted to lose a tiny amount. In contrast, the normalization of trade relationships between these countries and Iran hurts those who have benefitted from trade diversion. The largest losses are predicted to occur in Korea, Panama and the Ukraine. Oil producing countries also tend to lose from undoing the sanctions as the additional supply of Iranian oil drives down the world price of oil.

Finally, we turn to the effects on sectoral value added, which appear in Fig. 8. Even though, by design, the trade cost shocks are uniform across sectors, the sectoral structure of comparative advantage of Iran and its trading partners implies a rich pattern of changes in their terms of trade which, in turn, affect sectoral value added. Not surprisingly, the model
Figure 8: Counterfactual Analysis: Sectoral Value Added Effects (% of baseline)

Note: Percent changes in sectoral value added resulting from an end of sanctions against Iran in Iran (IRN), China (CHN), and Germany (DEU).

predicts that an end to the sanctions would benefit Iran’s oil and gas sectors most strongly. Value added would rise most in this area, reaching almost 40 percent in the gas sector, where substitution effects in the face of sanctions are difficult due to a rigid system of pipelines. Sizable gains also occur in Iran’s leather, textile, and transportation sectors. In the former two, the country enjoys a comparative advantage relative to its trade partners; in the latter, the effects are driven by additional demand for transportation services as trade picks up. Some positive effects are predicted in agri-food, in particular in nuts production. Iran is an important producer of almonds. But those gains lie below 10 percent.

In contrast, losses are concentrated in comparative disadvantage sectors. Again, the impact on agri-food looms large. Arid Iran is a net importer of vegetables, sugar and rice, so that ending the sanctions drives up imports even more in these sectors leading to their shrinkage. For many services sectors, which are not directly affected by sanctions as modeled in our exercise, value added effects are very close to zero. The transportation sector mentioned above is an interesting exception. Sectoral value-added effects are smaller by almost two orders of magnitude in the US, China or Germany. They do not exhibit any clear sectoral pattern, but they tend to be positive for Germany and negative for China,
reflecting trade creation and trade diversion, respectively.

5 Conclusion

Through their imposition of various restrictions on trade, financial transactions and travel, sanctioning countries aim to induce sanctioned countries to comply with policy requests by raising the economic costs of noncompliance. According to this logic, the effectiveness of sanctions policies crucially depends on the strength of their adverse effects on sanctioned countries.

This study illustrates that sanctions policies can be effective in the sense that they significantly reduce trade with the target. Importantly, we also show that impact of trade sanctions turns out to be heterogeneous depending on whether they are complete or partial and also depending on whether they are imposed on the exports or on the imports of the target country. The specific sanctions on Iran we have analyzed, illustrate that their direct/partial equilibrium effects on bilateral trade differ significantly across countries and depending on the direction of trade, even within the European Union. We complemented the partial sanction estimates with general equilibrium analysis, which showed that the impact of the Iran sanction on trade and welfare was widely but intuitively heterogeneous both across countries and across sectors.

Our analysis illustrates that Germany has suffered the biggest export losses to Iran since the introduction of the restrictive Iran sanctions in 2006. In particular, the cooperative ban on trade in oil resulted in a strong drop in bilateral trade with Iran. At the same time trade losses for the US turn out to be significantly lower in absolute terms. These differences in economic relations between important powers like EU countries and US have implications for the policy objectives standing behind the sanctions policies. Given these differing economic interests between various countries, it is no surprise that the assessment of whether the Iran sanctions have been successful or not, also differs. While the EU considers the Iran deal
that followed the sanctions as a major success, the US administration has started to increase pressure on Iran to renegotiate the conditions for removing the sanctions. In light of the extensive heterogeneity in economic interests, it is not obvious how countries can resolve their differences.
References


Appendix

Classification of regions based on UN geoscheme


Northern America: Bermuda, Canada, Greenland, Saint Pierre and Miquelon, United States of America.

Central America: Belize, Costa Rica, Clipperton Island, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Caribbean Anguilla, Antigua and Bermuda, Aruba, Bahamas, Barbados, Bonaire, Sint Eustatius and Saba, British Virgin Islands, Cayman Islands, Cuba, Curacao, Dominica, Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Montserrat, Navassa Island, Puerto Rico, Saint-Barthelemy, Saint Kitts and Nevis, Saint Lucia, Saint Martin, Saint Vincent and the Grenadines, Sint Maarten, Trinidad and Tobago, Turks and Caicos Islands, United States Virgin Islands.

Southern America: Argentina, Bolivia, Bouvet Island, Brazil, Chile, Colombia, Ecuador, Falkland Islands, French Guiana, Guayana, Paraguay, Peru, Suriname, Uruguay, Venezuela.

Northwestern Europe: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Faroe Island, Finland, France, Germany (Federal Republic), Guernsey, Hungary, Iceland, Isle of Man, Jersey, Latvia, Lichtenstein, Lithuania, Luxembourg, Monaco, Netherlands, Norway, Poland, Republic of Ireland, Romania, Slovakia, Sweden, Switzerland, United Kingdom.

Southern Europe: Albania, Andorra, Bosnia and Herzegovina, Croatia, Gibraltar, Greece, Italy, Republic of Macedonia, Malta, Montenegro, Portugal, San Marino, Serbia, Kosovo, Slovenia, Spain, Vatican.

Eastern Europe: Belarus, Republic of Moldova, Russian Federation, Ukraine.

Western Asia: Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, State of Palestine, Syria, Turkey, United Arab Emirates, Yemen.

Central Asia: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan.

Southern Asia: Afghanistan, Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan,
Sri Lanka.

**Southeastern Asia:** Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, Vietnam.

**Eastern Asia:** China, Taiwan, Hong Kong, Japan, Macau, Mongolia, DPR Korea, Republic of Korea.

**Oceania, Australia:** Christmas Island, Cocos (Keeling) Island, New Zealand, Norfolk Island, Fiji, New Caledonia, Papua New Guinea, Solomon Islands, Vanuatu, Guam, Kiribati, Marshall Islands, Micronesia, Nauru, Northern Mariana Islands, Palau, American Samoa, Cook Islands, French Polynesia, Niue, Pitcairn Islands, Samoa, Tokelau, Tonga, Tuvalu, Wallis and Futuna.