Adapting to Sanctions: Evidence from Firm Response and Market Reallocation in Iran

Ebad Ebadi*

January 2022 [Link to the latest version]

Abstract

How do targeted firms respond to international trade sanctions? Although the macroeconomic effects of trade sanctions have been extensively studied, little is known about how trade sanctions shape firm dynamics and their heterogeneous effects in a targeted country. Exploring detailed surveys of Iranian manufacturing firms, I examine firm-level asymmetric effects of the 2012–2013 US and EU trade sanctions imposed against Iran in response to its nuclear program. Empirical analysis shows that the sanctions cut Iranian firms' exports in half and its imports by more than 30% and, on average, reduced firm-level productivity, profit, revenue, and employment. Intriguingly, however, exporting firms were found to mitigate negative effects of sanctions through increased presence in the domestic market, thereby transferring sanction shocks to non-exporting firms. At the same time, importing firms responded to sanctions by sourcing more domestic inputs at the expense of non-importing firms. Based on a stylized model featuring heterogeneous firms with capacity constraints, I show that the export sanctions increased consumer welfare by 4.35% with decreasing domestic prices for a given income level. In contrast, import sanctions led to a 7.5% consumer welfare loss by increasing prices. The stylized model implies that alleviating exporting firm capacity constraints during adverse trade shocks increases positive impacts through export channels.

JEL: F51, F14, F12, O53, D57

Keywords: Asymmetric effects, Capacity constraints, Consumer welfare, Firm behavior, Foreign policy, Increasing marginal cost, International trade, Manufacturing industries, Sanctions

*George Washington University. Department of Economics. ebadi@gwu.edu.I would like to thank my advisors- Maggie X. Chen, Remi Jedwab - for numerous insightful discussions regarding this work. The paper has also benefited from discussions with Yingyan Zhao, Priscilla Toffano, Christian Volpe Martincus, Roberto Samaniego, Stephen Smith, James Foster, Bryan Stuart, Mohammad Sattarifar, Mohammad Hashem Pesaran, seminar participants at the Middle East and Central Asia (MCD) Discussion Forum at International Monetary Fund (IMF), Trade and Development seminar at George Washington University, and the 8th The Washington Area Development Economics Symposium (WADES) at Georgetown University.

1 Introduction

Economic and trade sanctions have become a foreign policy tool to respond to serious geopolitical challenges such as terrorism and conflicts, whereas trade liberalization has been shown to play a central role in the economic development of lower-income countries. In recent years, the US has expanded its use of sanctions by applying and intensifying them against adversaries such as Afghanistan, China, Iran, Russia, Syria, and Venezuela. In particular, the 2012 US-led international economic sanctions against Iran, which had the most significant impact on the economy since the Iran–Iraq war in 1980–1988, drew attention to the efficacy and impacts of sanctions. As a combination of negative international demand and supply shocks, the sanctions cut Iranian exports by $48.5 billion and imports by $10 billion over a year, which led to stagflation with a negative GDP growth of 7% and an inflation rate of 35%. Although the macroeconomic effect of sanctions on Iran has been widely studied, little is known about the firm-level impact of the sanctions inside the country.

This paper investigates the heterogeneous effects of the 2012 sanctions on Iranian firms, exploring Iranian manufacturing firm surveys from 2009–2013 that cover more than 12,500 firms in 136 industries every year. In contrast to previous studies, my paper disentangles the sanctions from other macroeconomic shocks to the economy by mapping sanctions to specific industries based on reports from the US Congress and lists of sanctioned entities published by the Office of Foreign Asset Control (OFAC) at the US Treasury Department. The mapping shows that the international trade sanctions directly targeted the energy, automotive, aviation, and shipping industries, which are the backbone of the Iranian economy. Next, exploring rich data on Iranian manufacturing firms—which includes a range of information from intermediate input values to worker skills—I use difference-in-difference regressions to estimate the causal effect of economic sanctions on a wide range of firm outcomes in the targeted industries.

The empirical evidence shows that, first, international trade sanctions directly impacted Iranian firms by cutting exports in half and dropping imports by more than 30%. In addition, the trade sanctions significantly reduced firm profit by 31% and revenue by 20%. Moreover, the sanctions resulted in a 20% decrease in firm-level productivity by restricting access to foreign intermediate inputs, leading to an overall 16% decline in average productivity due to direct effects of import sanctions as well as propagation of the shock through firm linkages.

Although the international trade sanctions had a sizeable negative effect on firms in targeted industries, my results show that importing and exporting firms were able to mitigate the sanctions' adverse effects.

When sanctions reduced access to imported intermediaries, importing firms partially substituted for them by increasing their demand for domestic intermediate inputs by 16% relative to non-importing firms. As a result, the increase in demand for domestic intermediaries and labor in importing firms shifted the resources from non-importing to importing firms. This caused a drop in revenue among non-importing firms of 24% compared to a 12% drop in importing firms' revenue. On the other hand, targeted exporting firms increased their domestic sales and revenue by 18.5% in the aftermath of sanctions to compensate for their loss in export markets. In contrast, domestic sales and revenue dropped by 15% among non-exporting firms. As a result, resources shifted from non-exporting to exporting firms. Additionally, my results indicate that employment increased by 9% in exporting firms while decreasing by 9.5% in non-exporting firms.

At the same time, sanctions indirectly impacted firms through input–output linkages. Using the Iranian input–output table of 2011, I construct the first-order indirect exposure to sanctions for downstream (upstream) industries by summing the shares of sanctioned industries' products in the total output demands of (the input supplies to) the industry in question. Next, I construct a measure of the full-order indirect exposure that accounts for the full set of input–output linkages among all connected industries (e.g., shocks to an industry's sellers, its seller's sellers, and so on). The first-order and full-order indirect effects show that input–output linkages propagated the sanction shocks in the market and transferred them to non-targeted industries. For instance, one of my results demonstrates that the sanctions indirectly reduced firm-level productivity by 2.7% and 4.7%, respectively, through the full set of downstream and upstream linkages among industries.

This paper quantifies the aggregate economic effects of the sanctions by developing a stylized model featuring heterogeneous firms with increasing marginal costs that stem from capacity constraints.[1] I model the impact of sanctions via import and export channels to describe firm response and market reallocation under the sanctions. The model explains that import sanctions decreased the average productivity and increased the aggregate price in Iran. On the other hand, the model shows that export sanctions reduced the aggregate price because of the increase in exporting firms' domestic sales, leading to an increase in aggregate consumer welfare. Computing the welfare change on the model's sufficient statistics suggests that the sanctions reduced aggregate consumer welfare by 7.5% via import channels while raising welfare by 4.35% via export channels. From the stylized model, when capacity constraints increase, the impacts of international trade sanctions through imported intermediate input and export channels will diminish.

This paper contributes to the literature on economic sanctions by estimating the causal effects of the

[1] Blum et al. (2013) introduced increasing marginal costs to the heterogeneous firm model with capacity constraints in Melitz (2003) to explain the negative relationship between exports and domestic sales for Chilean firms. Further, Ahn and McQuoid (2017) tested for physical and financial constraints across Indonesian firms to support evidence of increasing marginal costs and the negative relationship between a firm's export and domestic sales.

sanctions on firms within a targeted nation. Because it is difficult to find data on firms operating in sanctioned countries, the literature on economic sanctions has mainly relied on cross-country analyses to measure the cost of sanctions in a whole economy (see Askari et al., 2003; Yang et al., 2004; Felbermayr et al., 2019; Afesorgbor, 2019; Crozet et al., 2021, among many others). However, identifying sanctions at the country level does not facilitate the study of heterogeneous impacts. Furthermore, it does not facilitate the disentangling of sanction shocks from other macroeconomic shocks to an economy.[2] Thus, it will be challenging to find a causal effect of sanctions on macroeconomic variables.

In addition, this paper adds to the economic sanction literature by discussing the firm-level asymmetric effects of sanctions, exploring a rich data set of Iranian manufacturing firms. A handful of studies on economic sanctions have used data on publicly listed firms to study the impact of sanctions (see Dizaji and van Bergeijk, 2013; Seyed Amir Godasiaye, 2018;and Ahn and Ludema, 2020). In particular, Ahn and Ludema (2020) used reports on sanctioned Russian entities to identify the targeted firms and estimated causal effects of the sanctions against Russian publicly listed firms. However, the panel data set of my paper enables me to measure the heterogeneous effects of sanctions on more than 12,500 firms in 136 industries—a far more representative sample than a few publicly listed firms. To the best of my knowledge, this paper is the first study of economic sanctions to explain firm response and market reallocation in a targeted country.

This paper is also related to the work on the importance of importing intermediates for productivity growth. Empirically, several studies have found that declines in input tariff or imports of intermediate inputs relate to significant productivity growth (see Amiti and Konings, 2007;Kasahara and Rodrigue, 2008; Topalova and Khandelwal, 2011; and Halpern et al., 2015). In contrast, Gopinath and Neiman (2014) posited that a negative shock to firm imports could cause a drop in productivity, using evidence of the devaluation of Argentinian pesos. My findings align with the majority of the empirical studies on this subject, documenting the negative effects of input trade restrictions.

The remainder of the paper is as follows. In section 2, I briefly provide background on sanctions imposed on Iran and discuss the data used. Section 3 shows baseline results of direct and indirect impacts of sanctions on Iranian firms. Section 4 explains exporting and importing firms' adjustment to sanction shocks and shows how these firms transfer sanction shocks to the domestic market. In section 5, I develop a model featuring heterogeneous firms with capacity constraints to estimate the effect of sanctions on aggregate economic outcomes. Section 6 concludes.

[2]Most recent studies on macroeconomic impacts of economic sanctions construct a measure of sanctions' intensity to give variation to a defined sanction variable over time, separating sanctions from other shocks to an economy (see Lee, 2018, Demir and S.Tabrizy, 2021, and Laudati and Pesaran, 2021).

2 Empirical Approach

Nuclear-related sanctions against Iran in 2012 forced the country into stagflation. After the sanctions were imposed, Iranian GDP decreased by 6.7% and the inflation rate increased by more than 30% within a year. Sanction shocks deteriorated the Iranian economy by reducing oil revenue, GDP and foreign direct investment, while also contributing to rising inflation and unemployment (Dizaji and van Bergeijk, 2013; Gharehgozli, 2017; Laudati and Pesaran, 2021, among others). But what did this shock mean for Iranian firms? How did the exporting and importing firms respond to industry-specific sanctions? To answer such questions, I first identify targeted industries and then examine the asymmetric economic effects of sanctions within the industries.

2.1 Industry-Specific Sanctions

Iran has been under US sanctions for the past forty years. In 1979, the US first imposed sanctions on Iran after US diplomats were taken hostage in Tehran , prohibiting any transactions between US persons and Iranian entities. Although Iran lost access to the US market, it continued to trade with other countries, especially in Europe. However, once Iran's nuclear program was revealed in 2003, Europeans became suspicious of the purpose of the program; in response, France, the UK, and Germany started negotiations with Iran to ensure the peaceful purposes of its nuclear activities. Three years later, in 2006, when negotiations on Iran's nuclear program collapsed, the UN Security Council issued a number of resolutions, imposing limited sanctions in response to Iran's refusal to stop uranium enrichment—a technological process that can be used to produce nuclear fuel or material for an atomic bomb. Iranian President Ahmadinejad dismissed the UN resolutions by calling them "worthless papers," and Iran continued to enrich uranium.

Beginning in 2010, the Obama administration played a more active role in creating a coalition with European countries and US allies to impose strict sanctions to control Iran's nuclear program. In January of 2012, the US and EU countries targeted different sectors of the Iranian economy, applying economic pressure and bringing Iran back to the negotiation table. These sanctions directly targeted the oil, gas, automotive, aviation, shipping and shipbuilding, banking, and insurance industries. By imposing secondary sanctions in 2012, the US further restricted Iranian economic activities and targeted firms in other countries that traded with sanctioned entities in Iran. In 2013, following the economic pressures on Iran, when Rouhani became president, Iran started negotiations with P5+1, five permanent members of the UN Security Council plus Germany, with the European Union. Shortly afterward, in November 2013, a pact known as the Joint Plan of Action (JPOA) was signed between Iran and P5+1. JPOA entailed a temporary halt to parts of Iran's

nuclear program in exchange for a reduction in economic sanctions on the country as the countries worked toward a long-term accord. Finally, after 12 years of negotiations, in 2015, Iran reached an agreement known as the Joint Comprehensive Plan of Action (JCPOA) in exchange for removing all nuclear-related sanctions. [3]

This paper focuses on the international trade sanctions imposed on Iranian manufacturing firms in 2012 and 2013, shedding light on intra- and inter-industry impacts of sanctions.[4] From 2012, the sanctions targeted specific sectors in Iran to weaken its economy and to force the country to negotiate over its nuclear program.[5] The energy, shipping, shipbuilding, banking, and automotive sectors were among those targeted in Iran. Any foreign entities engaged in trading with sanctioned Iranian firms and sectors would be fined by the US Treasury Department.[6]

Sanctions primarily targeted the Iranian energy sector by prohibiting investment and cutting exports. In 2012, President Obama implemented a provision preventing foreign banks from opening accounts in the US and imposing strict restrictions on existing US accounts that conduct significant transactions with the Central Bank of Iran or any Iranian bank listed in the sanction program (Executive Order 13622). The provision applies to foreign central banks only if the transaction with Iran's central bank is to pay for oil purchases. Following the US sanctions on the Iranian energy sector, the EU imposed a ban on Iranian oil and gas imports, including sanctions on insurance for shipping oil or petrochemicals from Iran as well as a freeze of Iranian shipping firms' assets (Katzman, 2013). In addition to the Iranian oil embargo, the US government imposed sanctions on the firms that provided Iran with more than a specific value of goods or services that Iran could use to maintain or improve its oil and gas sectors.[7] For example, transactions with Iran by global oil service firms and the sale of equipment, such as drills and pumps, were subject to sanctions. Following the US and EU sanctions, the world's biggest energy companies, including French oil giant Total

[3]However, when President Trump took office, the US withdrew from the Iran nuclear deal in May 2018 and re-imposed all primary and secondary sanctions against Iran unilaterally.

[4]Different sanctions were imposed on Iran, including trade, banking, financial, and travel bans. The type of sanctions that is in the interest of this paper is trade sanctions. Among other types of sanctions, banking and financial sanctions might impact firms, depending on firms' exposures to foreign financial markets. In general, all Iranian exporting and importing firms were subject to sanctions as they faced difficulty exporting or importing. However, by providing a license from the Office of Foreign Asset Control (OFAC) at the US Treasury Department, non-targeted firms could make international payments, though it became costly for them.

[5]In addition to industry-specific sanctions, some firms in other industries were sanctioned because of their political connections to the government. However, sanctions targeting a number of firms in the industry seemed to be ineffective since the firms could circumvent the sanctions through the non-targeted firms. The non-targeted firms were able to make foreign transactions on behalf of the sanctioned entities in an industry. Further, Iranian banking and insurance services were targeted in 2012. Financial sanctions increased the transaction costs for exporting and importing firms. Hence, the results of this paper show the lower bound of sanction impacts.

[6]For a full discussion on Iran sanctions visit Katzman (2013) and Katzman (2020).

[7]Before the nuclear-related sanctions, in 1987, the US administration barred the importation of Iranian oil into the United States but did not ban the Iranian oil trade overseas. In Nov 2011 and Aug 2012, the US government took steps to further sanction Iranian energy firms by blocking payments of over $20 million for expansion of Iranian oil and gas fields, over $1 million for an increase in production of oil and gas industries, and over $250 for an improvement of Iranian petroleum. Under the Iran Nuclear Deal, the US and EU sanctions on Iran's oil and gas industries were removed (Iran Threat Reduction and Syria Human Rights Act of 2012, and Executive Order 13590).

and British multinational Royal Dutch Shell, exited the Iranian market. Although investments in Iranian oil and gas industries were impactful in the long run, cutting energy firms' exports largely impacted the firms in the short term.

Second, sanctions on automotive industries and vehicle production significantly impacted domestic production. In 2009, when more than 1.3 million vehicles were produced , the automotive industry was the second largest industry in Iran after the oil industry. Domestic vehicles dominated the automotive market in Iran, but these were highly dependent on imported parts, both in assembly and production lines, leaving Iran's automotive industry vulnerable to sanctions. In 2012, foreign car manufacturers, including Peugeot, Renault, and Scania AB, exited the market in compliance with the US and EU sanctions. As a result of these sanctions, vehicle production fell by 60% from 2011 to 2013.[8] Ultimately, sanctions directly impacted vehicle production in Iran by restricting access to imported parts and forcing foreign firms to end their partnerships with Iranian firms.

Finally, the shipbuilding and aircraft industries were sanctioned to restrict Iranian exports and imports. Foreign firms were banned from selling spare parts that could be used in Iranian aircraft, shipping, shipbuilding, and port operations. Following the US and EU sanctions, Maersk shipping company, Air France, Airbus, and other foreign firms canceled their deals with their Iranian partners and exited the market. However, the shipbuilding and aircraft industries were not as large as the energy or automotive industry; thus, the sanctions on these industries did not have a large direct effect on the total economy.

2.2 Data

The main source of data for this paper is from the panel of Iranian manufacturing firms with 10 or more employees for the years 2009–2013. The Statistical Center of Iran (SCI) collected the data through the annual Survey of Manufacturing Firms, which covered between 12,556 and 14,168 firms annually between 2009–2013. Firms' products are reported in only one four-digit International Standard of Industrial Classification (ISIC) industries, which enables me to identify firms by industry.

One shortcoming of Iranian manufacturing firm surveys is that they only cover firms with 10 or more workers. However, the SCI continued to cover these firms even when the number of employees went below 10, anticipating that they would again have more than 10 employees in subsequent years. If the number of workers remained below 10, the SCI dropped the firm from the sample. Dropping firms with fewer than 10 workers does not cause a problem in my analysis because the SCI collected information on firms' survival

[8] In June 2013, the US enforced restrictive secondary sanctions on firms that supplied goods or services to Iran's automotive production sector and blocked foreign banks from the US market if they conducted transactions with Iran's automotive sector (Executive Order 13645). The sanctions on the automotive sector eased under Joint Plan of Actions (JPOA) in 2014, and the auto and manufacturing sectors rebounded after sanctions were lifted in 2016.

even if they were not in the sample. From the data, one can determine whether a firm exited the market or continued to produce.

Annual values of revenue, intermediate input, export, import, wage, investment, and capital stock are reported by their nominal values in the sample. I deflate revenue by *industry-level* PPI measures, which the SCI reports. Further, I deflate intermediate inputs, wages, investments, and capital values by the PPI measure reported by the Central Bank of Iran (CBI). Finally, I deflate exports and imports by the *export* PPI measure, which the CBI reports.

With sanctions imposed on energy, automotive, shipbuilding, and aircraft industries, I map sanctions to 1,178 firms in 11 of the 136 four-digit ISIC industries in the sample data.[9] Targeted firms accounted for 8% of manufacturing firms, and almost half of them are in the "manufacture of parts and accessories for motor vehicles and their engines" industry, followed by the "manufacture of basic chemicals" industry. However, the targeted firms accounted for 20% of employment and half of the output in the manufacturing sector.

Summary statistics are reported in Table (1) in two periods of before and after sanctions. Export and import values dropped by \$4.5 million and \$1 million, respectively, in the targeted industries. The revenue of sanctioned firms was impacted negatively, whereas there was no significant difference in revenue of non-sanctioned firms before and after the sanctions. Additionally, the demand for domestic intermediate inputs was not statistically different before and after sanctions between the two periods. From Table (1), the share of small and medium firms decreased, whereas the share of large firms increased in both sanctioned and non-sanctioned industries, suggesting a higher chance of survival for large firms. In general, Table (1) shows that sanctions significantly affected the targeted firms, whereas the impacts on non-targeted firms were relatively minor.

Figure (1) presents exports and imports of firms in 23 broad two-digit ISIC level industries over total export and import values of total Iranian manufacturing industries. Vehicle, transport, and a large share of firms in coke, refined, and chemical industries (CRC) were sanctioned. CRC had, by far, the highest export shares among all industries in the market. On the other hand, vehicle industries had the highest import share. In addition, Figure (2) presents revenue and employment shares of the broad industries in the Iranian manufacturing sector. Again, CRC had the highest revenue in the market, followed by the vehicle and food industries. Furthermore, the food and non-metallic industries had the highest employment share, followed by the vehicle industry. Lastly, Figures (D.1.a) and (D.1.b) present the share of revenue, employment,

[9]Sanctioned industries are manufacture of coke oven products, manufacture of refined petroleum products, processing of nuclear fuel, building and repairing of ships and boats, manufacture of basic chemicals, manufacture of plastics in primary forms and of synthetic rubber, manufacture of aircraft and spacecraft, manufacture of motor vehicles, manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semitrailers, and manufacture of parts and accessories for motor vehicles and their engines.

export, and import of sanctioned firms among the manufacturing industries. In total, sanctioned industries contributed 76% and 67% of all exports and revenue, respectively in the manufacturing industries. However, these shares reduce to 6% and 19%, respectively, when excluding the energy sector. On the other hand, the employment and import shares of sanctioned firms change only slightly when excluding the energy sector.

In addition to manufacturing firm surveys, I employ the 2011 input–output table for the Iranian economy, which predates the sanctions, to trace upstream and downstream demand linkages between industries in the sample of Iranian manufacturing firms. The Iranian input–output table reported 27 Iranian manufacturing industries. Next, I merge some industries and reduce the number of reported industries to 22 broad industries to link them from the input–output (IO) table to firm-level survey data. Here, I use industry linkages instead of firm linkages and assume no differences in input–output linkages among firms within an industry. From the IO table, one can find the first-order and full-order upstream and downstream linkages between industries. The Leontief inverse matrix of downstream and upstream linkages, reported in the 2011 IO table for the Iranian economy, gives the full chain of linked upstream and downstream demand.

2.3 Empirical Strategy

To examine the impacts of trade sanctions on firms, I estimate a difference-in-differences specification on the sample, comparing the outcome of targeted firms with non-targeted firms before and after the sanctions:

$$Y_{it} = \delta S_{jt} + \alpha_i + \alpha_t + \varepsilon_{it} \tag{1}$$

where Y_{it} shows a firm-specific outcome such as the log profit, log revenue, and log employment for a given firm i at year at year t. S_{jt} shows the sanction variable, which is at the four-digit ISIC industry level. α_i and α_t are firm- and year-fixed effects, respectively. Regression estimates are weighted by the reported weights in the sample, and standard errors are clustered at the four-digit industry-year level (Obs = 12,556-14,168 firms $\times$ 5 years).

The variable of interest S_{jt} represents exogenous sanction shocks to the firms located in targeted industries: energy, automotive, shipbuilding and aircraft. Because these sanctions were unanticipated, my analysis throughout this paper constitutes a semi-natural experiment. However, in order for my identification strategy to work, it is important to make sure that targeted firms would not have experienced drops even in the absence of the sanctions, i.e., that there are no pre-trends. To ensure this, I also implement an event study specification:

$$Y_{it} = \Sigma_{t=2009}^{2013} \delta_t S_j + \alpha_i + \alpha_t + \varepsilon_{it} \tag{2}$$

Examining the differences between targeted and non-targeted firms before and after the sanctions in 2012 and 2013 will help detect the presence of pre-trends in my data.

To measure the heterogeneous effects of sanctions on exporting firms, I use the following specification, comparing the outcome of firms with different export shares before and after the sanctions:

$$Y_{it} = \beta_1 S_{jt} + \beta_2 Export_i \times S_{jt} + \alpha_i + \alpha_t + \varepsilon_{it} \tag{3}$$

where $Export_i$ is a time-invariant variable showing whether firm i is a non-exporting firm, an exporting firm with the export share below the median, or an exporting firm with the share above the median. Export shares are the ratios of export revenue over total revenue, and they are calculated for the years before 2012 so as to predate the sanction shocks. Firms are grouped into three sets based on their relative shares: non-exporting firms, below-median exporters, and above-median exporters.[10]

To estimate the heterogeneous effects of sanctions on importing firms, I substitute $Export_i$ in equation (3) with $Import_i$ in equation (4),

$$Y_{it} = \beta_1 S_{jt} + \beta_2 Import_i \times S_{jt} + \alpha_i + \alpha_t + \varepsilon_{it} \tag{4}$$

where $Import_i$ is a time-invariant variable showing whether firm i is a non-importing firm, an importing firm with the import share below the median, or an importing firm with the share above the median. Import shares are the imported intermediate input costs over the cost of domestic and imported intermediate inputs, and they are calculated for the years before 2012 so as to predate the sanction shocks.[11]

3 Direct and Indirect Effects of Sanctions

This section begins by showing the direct impact of sanctions on the targeted firms, presenting indirect upstream and downstream effects of sanctions using the input–output linkage. In all estimations, I use one sample including all firms in the data (full sample) and one excluding the energy firms (restricted sample).

[10] Figure (D.2) shows distribution of export and import shares for non-targeted firms, targeted firms in the full sample, and targeted firms in the restricted sample. Most exporting firms have relatively small export shares. However, there are superstar firms with high export shares close to one, especially in the energy sector.

[11] Figure (D.3) shows distribution of import shares for non-targeted firms, targeted firms in the full sample, and targeted firms in the restricted sample. Most importing firms have relatively small import shares. However, there are superstar firms with high import shares close to one.

I exclude the energy sector mainly because of the heavy government control of this sector.[12] However, the focus of the paper is on the restricted sample, using the full sample for robustness checks.

3.1 Exports and Imports

Trade sanctions impact firms through export and import channels, either by dropping their revenue in export markets or by restricting their access to imported intermediate inputs. To examine the impact of the sanctions on firms' export and import, I start with OLS estimation, explained in equation (1), in columns (1)-(4) of Table (2). Columns (1) and (2) report OLS estimates using either the logarithm of exports or the logarithm of imports as the dependent variable, dropping the zero trade value observations—only 8% and 15% of firms exhibit positive export and import flows, respectively. The results show a 24% decline in firms' imports in the full and restricted samples. Using the OLS estimation, I find a 37% drop in exports only in the restricted sample.[13] However, the log-linearization gravity equation with zero trade values leads to severely biased results (Silva and Tenreyro, 2006; Helpman et al., 2008; and Silva and Tenreyro, 2011).

Traditional trade literature suggests adding a constant to export and import values, to deal with zero trade values and to keep the observations in estimates when using log values of dependent variables. Therefore, by adding a constant number of 1 to trade values, I estimate the impact of sanctions on $ln(1 + Ex_{it})$ and $ln(1 + Im_{it})$ in columns (3)-(4). However, adding a constant generally leads to inconsistent estimators, while the severity of inconsistency depends on the particular characteristics of the sample and model that are used ((Silva and Tenreyro, 2006, and Silva and Tenreyro, 2011). Thus, to address zero trade values in the presence of heteroscedasticity, I use the Poisson pseudo-maximum-likelihood (PPML) approach proposed by Silva and Tenreyro (2006).[14] The log-linearization of firms' exports and imports may cause selection bias due to ignoring the extensive margin, because the log-linearization regressions drop zero values. However, PPML adequately addresses zero value observations, especially in the presence of heteroskedasticity.

To measure the direct impacts of sanctions on firms' export and import, my baseline specification is of the following form:

$$Trade_{i,t} = exp\left[\delta S_{j,t} + \alpha_t + \alpha_j + X_{i,0}\alpha_t\right]\varepsilon_{i,t} \tag{5}$$

where $Trade_{i,t}$ is the export and import values for firm i at year t, S_{jt} is the variable of interest (which is

[12] The sanctions targeted 452 firms in the energy sector, with an average revenue of $16,067,216 in 2011, and 719 firms in the non-energy sector, with an average revenue of $353,773.

[13] The formula to compute the effect is $(e^{\delta} - 1) * 100$, where δ is the estimated coefficients of sanctions.

[14] After examining several methods to deal with zero trade values, Silva and Tenreyro (2006) argued that estimating trade values in levels using the PPML estimator adequately deals with zero value observations. For a full discussion on comparison between different methods of estimating zero trade values, please see Silva and Tenreyro (2006) and Silva and Tenreyro (2011).

one for firms in a sanctioned four-digit ISIC level industry j in 2012 and 2013, and zero otherwise), α_i and α_t are firm and year fixed effects, $X_{i,0}\alpha_t$ is the interaction of a set of firm-specific pre-sanction controls with the year-fixed effects, and $\varepsilon_{i,t}$ is an error term. Standard errors are clustered at the four-digit industry-year level to allow arbitrary error correlation within industries over time (Obs = 12,556 – 14,168 firms × 5 years).

Columns (5)–(8) present results using PPML fixed-effect estimations. In columns (5) and (6), with firm- and year-fixed effects, there is no evidence of a significant drop in firms' imports, but firms' exports dropped significantly in the full and restricted samples. However, many observations are dropped from the regression because they are either singleton or separated observations. To deal with this issue, I employ industry-fixed effects, α_j, and time-invariant firm variables interaction with year-fixed effects, $X_{i,0}\alpha_t$, in columns (7) and (8) of Table (2). The set of firm-specific controls used in the regressions are size, ownership, share of energy costs, and capital intensity share. Columns (7) and (8) show the baseline results. From my baseline results, the sanctions caused firms' exports to decline by 47% in the restricted sample and imports to fall by 33% and 37% in the full and restricted samples, respectively.

Economic sanctions affected export and import values through intensive margins of trade. Furthermore, to show the adjustment through extensive margins, Table (3) indicates that the number of exporting and importing firms decreased, whereas the numbers increased for non-trading firms. In Table (3), exporting and importing firms are grouped based on their export or import shares. Exporting (respectively, importing) firms are divided into two groups based on whether their export (respectively, import) shares were above or below the median share before the sanctions.

To estimate the impact of sanctions on extensive margins of trade, I use specification in equations (3) and (4). Column (1) explains that the sanctions increased the probability of a non-exporting firm entering an export market by 1.6%. However, the number of exporting firms dropped. In particular, the number of firms with export shares below or above the median reduced by 5.2% and 2.6%, respectively. Column (2) shows that the sanctions increased the probability of a non-importing firm to import by 5.7%. In contrast, the number of importing firms dropped by 5% and 15% for firms with below and above median import shares, respectively. Finally, columns (3) and (4) show that results are robust when excluding energy firms from the sample.

There is some evidence of changes to export values because of the sanctions in the literature. Frank (2018) uses PPML estimates on a panel of countries from 1987–2005 to measure the impact of sanctions on export values and finds that severe sanctions decreased exports by 45%; however, the estimates are not statistically significant. Using non-oil Iranian customs data from 2006–2011, Haidar (2017) argues that Iranian aggregate exports increased when sanctions were imposed on the country because of trade diversion to non-sanctioning

countries. There may be two reasons for why my results differ from Haidar (2017). First, I identify sanctions at an industry level, whereas Haidar (2017) identifies sanctions by the destination of exports. Second, the period of study in Haidar (2017) is 2006–2011, which is when the UN enforced sanctions against Iran, whereas my research focuses on the US and EU economic sanctions in 2012 and 2013.

3.2 Profit, Revenue, Domestic Inputs, and Employment

Through export and import channels, the sanctions impacted targeted firms' profit, revenue, and employment levels. By restricting access to export markets, sanctions directly reduced firms' export revenue and profit. In addition, when sanctions restricted access to the imported intermediate inputs, firms experienced a drop in their production and revenue.[15]

Columns (1) - (3) in Table (4) show the impacts of sanctions on profit, total revenue, and domestic revenue. Sanctions reduced the profit by 20% and the total revenue (hereinafter "revenue") by 12%. When excluding energy firms, profit and revenue decreased further by 31% and 20%, respectively. From (4), domestic revenue was impacted only when we exclude the energy firms, suggesting that domestic sales in the energy sector were not significantly affected. Thus, the results suggest that firms in the energy sector were hit severely through export channels. In contrast, firms in other sanctioned industries, including the automotive industry, were heavily impacted through intermediate input channels.

Although the revenue of firms in sanctioned industries fell, exporting firms could escape sanctions by diverting sales to the domestic market and increasing their revenue (see section 4.1). However, because only a few firms were exporting, revenue, on average, fell for sanctioned industries.

The demands for domestic intermediate inputs and labor decreased in the market as sanctions reduced the firms' production. However, the substitution effect between imported intermediaries and domestic inputs increased importing firms' demand for domestic inputs (see section 4.2). Due to the presence of markups, the marginal rate of transformation exceeded the marginal rate of substitution. Therefore, the decline in the scale of production caused by sanctions reduced the demand for domestic intermediate inputs and labor. Columns (4) and (5) in Table (4) show the decrease in the demand for domestic intermediaries and labor. Demand for domestic intermediate inputs decreased by 31% when excluding energy firms.[16] Furthermore,

[15]The impact of sanctions is mainly due to the restricted access to imported intermediate inputs than the effect from import competition. For the whole economy, less than 15% of the imports are consumer goods. Further, the leading sectors in the interest of this paper impacted very little through the import competition channel. For example, from Iranian custom data in 2011, only less than 5% of automobiles in the Iranian market were imported; however, this industry relies heavily on imported parts in its production process. Moreover, the share of imports in the Iranian energy market is minimal since Iran is an oil-producing country exporting energy-intensive goods. Because of a small share of imported consumer (final) goods, I ignore the effects of sanctions through the import competition channel.

[16]Section 4.2 investigates the substitution effects between imported intermediate inputs and domestic inputs for firms with different import shares and explains that importing firms mitigated sanction shocks by substituting their imported intermediate inputs. The higher the substitution rates, the lower the impacts from the sanctions.

employment levels dropped in the full and restricted samples, although they decreased more when excluding energy firms. Kelishomi et al. (2021) argues that the negative impact on employment caused by the sanctions was largely due to the drop in productivity of industries with high exposure to imported input markets.

Up to now, I have studied the effect of sanctions on the intensive margin, i.e., whether the trade sanctions impacted the growth of existing firms. To measure the dynamic impacts of the sanctions, I use the specification in equation (2), where I let the coefficient vary across years. The estimated coefficients show that sanctions negatively affected the targeted firms in the years 2012 and 2013. The estimated coefficients for the year before the sanctions, 2011, are normalized to zero. Figures (3) - (7) present the dynamic effects, where the estimated coefficients are relative to the coefficient in the year 2011. The event plots showed a clear negative impact on firms when the sanctions were imposed in 2012. The sanctions significantly impacted the targeted firms in 2012 and 2013. However, there is no evidence of adjustment across time over the short period of this study.

My difference-in-differences methodology relies on the parallel trends assumption, i.e., if they had not been sanctioned, sanctioned firms would have experienced the same average change in performance as their non-targeted peers. In other words, the concern may be that some underlying trend—and not economic sanctions—causes targeted firms to underperform their non-targeted peers. Although it seems unlikely that targeted firms were sanctioned because of such trends, unintentional selection bias cannot be ruled out.

Despite the encouraging findings in Figures (3)-(7), which show that there is no difference in pre-treatment trends, there remains a concern that the 2012 decline in relative performance on sanctioned firms is due to some other coincidental shock that impacted those firms harder than their non-targeted counterparts. Sanctioned enterprises, for example, are larger than their non-sanctioned peers, implying that they are more internationally engaged, both as importers and exporters. Perhaps the large Iranian devaluation, or financial sanctions, had a different impact on these firms than on smaller firms. To address this concern, I use nearest-neighbor matching to estimate the average treatment impact (ATE) of sanctions on the performance of sanctioned firms, supporting the results in Table 4 (see Table C.1 in Appendix C).

3.3 Firm-Level Productivity

Sanctions decreased Iranian firm-level productivity by reducing the scale of production and access to a variety of intermediate inputs. The relationship between productivity and imported intermediate inputs is associated with the choice of variety, input quality, and exposure to new technologies (Amiti and Konings, 2007; Goldberg et al., 2010; Topalova and Khandelwal, 2011). In particular, Topalova and Khandelwal (2011) explained a causal link between changes in tariffs on intermediate inputs and firm productivity in the

case of India by showing how the lower tariffs increased firms' productivity. Further, Gopinath and Neiman (2014) posit that a negative shock to firms' import could cause a drop in productivity using evidence of the devaluation of Argentinian pesos.

On the other hand, there is no consensus over the hypothesis of learning-by-exporting, which argues that exporting increases productivity via knowledge and technology transfer from international buyers (Wagner, 2007). Several studies on developing countries suggest that firm-level productivity is improved when firms start to export (Blalock and Gertler, 2004; Van Biesebroeck, 2005; De Loecker, 2007). If exporting enhances firm-level productivity, one expects that negative export shocks, such as trade sanctions, decrease productivity. I follow the baseline specification in equation (1) to measure the impacts of sanctions on the targeted firm-level productivity and use estimates of the total factor productivity (TFP) as the dependent variable.

I employ the methods introduced in Olley and Pakes (1992) and Levinsohn and Petrin (2003) and the correction to these methods by Ackerberg et al. (2015) to measure firms' TFP. Using Iranian manufacturing firm surveys, Esfahani and Yousefi (2017) and Rahmati and Pilehvari (2019) employ the methods of Olley and Pakes (1992) and Levinsohn and Petrin (2003) to estimate Iranian firm-level productivity. However, this paper uses the method introduced in Ackerberg et al. (2015) to correct for simultaneity in the production function (TFP estimation method explained in Appendix A). The results of Table (5) are robust when using different TFP estimation methods, indicating that sanctions reduced firm-level productivity. The results show that sanctions significantly impacted firms' TFPs, reducing them by 13% and 20% in the full and restricted samples, respectively.

Further, I estimate equations (3) and (4) to explore the channels affecting firm-level productivity. Table (5) presents the heterogeneous impact of sanctions on firm-level productivity based on the export and import shares. The results show there are no heterogeneous impacts on TFPs through export channels. On the contrary, TFPs of firms with import shares above the median largely dropped relative to those of non-importing firms in the aftermath of sanctions, supporting an argument that the sanctions impacted firms' productivity through imported intermediate input channels. Compared to non-importing firms, the TFPs of firms with high import shares decreased by 20% and 25% more than the drop in the productivity of non-importing firms in the full and restricted samples, respectively. Therefore, fewer foreign inputs and lower access to input varieties reduced firm-level productivity. In addition, the results show that the sanctions reduced the productivity of non-importing and non-exporting firms. Through firm linkages, downstream sanction shocks reduced firm-level productivity in non-importing and non-exporting firms (see section 3.4).

Column (6) in Table (6) shows that the average productivity in the market decreased when energy firms are excluded from the regressions. The change in the average productivity is due to the impact of sanctions

through intermediate input channels. Through linkages between firms, the reduction in foreign intermediaries of importing firms is transferred to other firms in the market, which results in lower average productivity. However, the impacts through exporting channels are mute. The domestic sales of exporting firms increased in the aftermath of sanctions (see section 4.1); thus, no shock was imposed on firms in downstream industries through export channels. Furthermore, I find no evidence for sanction-driven changes in the firm mass in the market, which could potentially impact the average productivity changes. Thus, the sanctions reduced the average productivity through imported intermediate input channels, amplified by the linkages between firms.

To examine the change in the mass of firms and the extensive margin growth, I extended the existing sample in 2009–2011 to all firms that appeared between 2009 and 2013. I fully balanced the sample between 2009–2013. I then defined an entry dummy as 1 in and after the year a firm entered and an exit dummy as 1 in and after the year a firm exited. This allowed me to measure how the sanctions affected the entry and exit rates of the firms. From columns (1)–(4) in Table (6), we see that the sanctions had an insignificant effect on the entry and exit of firms. The small, insignificant magnitude of the estimated coefficients suggests that targeted firms did not adjust primarily through extensive margins over the short period of this study. Thus, the contraction in manufacturing firms was due mainly to the decline of activity among surviving firms rather than firms exiting. This result is in line with the findings of Salehi-Esfahani (2020), which show that economic sanctions on Iran impacted employment levels through intensive margins.

3.4 Downstream and Upstream Sanction Shocks

Although the sanctions targeted specific industries in the Iranian economy, sanction shock propagated to other industries and indirectly imposed costs on them that were not targeted by the sanctions. After measuring the direct impact of sanctions, I study the indirect effects of sanctions utilizing the Iranian input–output table for 2011 to construct sanction shocks to upstream and downstream industries. The Iranian input–output table for 2011, reported by the Statistical Center of Iran, predates the sanction shocks; thus, the linkages between industries are unlikely to be endogenous to sanctions. Here I investigate the input–output linkages between industries along the lines of Acemoglu et al. (2012) and Acemoglu et al. (2016), wherein each industry's output is used, with varying intensities, as the other industries' input.

In particular, I utilize the reported share of each industry's output used as inputs in the sanctioned industries' production to construct first-order upstream impacts. For example, 33% of the rubber industry's outputs were used to produce chemical goods. Thus, when sanctions decreased the chemical industry's output, the demand for rubber was also negatively impacted. Likewise, when firms in sanctioned industries experienced a drop in their production, they reduced their demand for the output of firms in their upstream

industries. Similarly, to construct the first-order downstream impacts, I use the shares of a sanctioned industry output in the total inputs of its upstream industries. When sanctions decreased firms' output in a targeted industry, they reduced the inputs available to the firms in the downstream industries. The stronger the input–output linkages, the larger the upstream and downstream impacts.

Next, I aggregate each industry's share in the input–output table to measure the total first-order indirect upstream and downstream impacts. Using the 2011 input–output table, I find that the within-industry indirect impacts are stronger than those across industries. In other words, firms in sanctioned industries trade more among themselves than with firms in different industries. Among non-targeted industries, the basic and fabricated metal industries were most exposed to the sanctions through upstream and downstream linkages.

Estimating the changes in a given industry through direct linkages with its upstream buyers, I substitute the sanction variable S_{jt} in equation (1) with $\Sigma_j w_{kj} S_{jt}$. The indirect impacts are weighted based on the reported shares w_{kj} in the Iranian input–output table for 2011. The following specification measures the first-order indirect upstream sanction shock:

$$Y_{it} = \delta \Sigma_j w_{kj} S_{jt} + \alpha_i + \alpha_t + \varepsilon_{it} \tag{6}$$

where w_{kj} is the output share of an industry k as the inputs for a sanctioned industry j. Equation (6) estimates the indirect upstream sanction impact on a firm i located in an industry k. Similarly, to measure the indirect downstream impact of sanctions, I replace the weights in equation (6) with w_{jk}:

$$Y_{it} = \delta \Sigma_j w_{jk} S_{jt} + \alpha_i + \alpha_t + \varepsilon_{it} \tag{7}$$

where w_{jk} is the output share of a sanctioned industry j as the inputs for an industry k. Equation (7) estimates the first-order indirect downstream sanction shocks to a firm i located in an industry j.

Equation (6) accounts for the indirect first-order effect on output demand of an industry k stemming from the changes in demand of its immediate downstream sanctioned buyers. Further, equation (7) estimates the indirect first-order effect on output demand of an industry k resulting from the changes in the supply of its immediate upstream sanctioned sellers. However, equations (6) and (7) ignore further changes in the output supply of sellers' sellers or the demand of buyer's buyers, and so on. To account for the full chain on implied responses, I replace the weights in equations (6) and (7) with the full chain of linked downstream and upstream demand, which is given by a Leontief inverse of the matrix of downstream and upstream linkages. The weights for the full chain of linked downstream and upstream demands are reported in the

2011 input–output table.

Panel (A) in Table (7) presents first-order indirect upstream and downstream sanction effects, using equations (6) and (7). The results show that the impacts of sanctions went beyond the targeted firms, affecting immediate buyers and sellers of the sanctioned industries. Although the magnitudes of estimated coefficients are large, direct upstream and downstream sanction exposures are small. Table (C.2) in Appendix (C) presents direct (first-order) and full (higher-order) indirect exposures to sanctioned industries. Direct downstream and upstream exposures are 0.057 and 0.176, respectively. Based on column (1) of Table (7), the profit of firms exposed directly to sanctioned industries fell by 3.95% and 6.2% through downstream and upstream linkages, respectively. Further, total revenue, employment level, and productivity of firms in downstream and upstream industries to the targeted industries decreased due to the sanctions.

As depicted in Table (C.2), the full indirect downstream exposure is five times larger than direct downstream exposure, whereas the full indirect upstream exposure is only three times larger. Panel (B) in Table (7) presents the full indirect downstream and upstream sanction shocks. Comparing across the two panels of the Table (7), there is a similar pattern in coefficient estimates. In all cases, the coefficients on the first-order exposure measures are larger in magnitude than those on the full exposure measures. Because the first-order exposure measures are considerably smaller than the full exposure measures, larger coefficients do not imply more significant quantitative effects. Based on the full chain of linked downstream and upstream demands, the profit with the mean impact of full downstream sanction shock fell by 3.75% and 6.2% through downstream and upstream linkages, respectively. In addition, revenue, employment level, and the productivity of firms were impacted negatively by the sanctions through the full chain of implied responses. First-order and full-order impacts of sanctions are close in magnitude, suggesting that the direct downstream and upstream impacts account for most of the sanctions' indirect impacts.

4 Exporting and Importing Firms' Adjustments to the Sanctions

Sanctions impacted the targeted Iranian firms by restricting their access to foreign intermediate inputs and export markets. One might expect exporting and importing firms to be impacted more severely because they were more exposed to the international trade sanctions. Intriguingly, exporting firms were found to mitigate the negative effects of sanctions through increased presence in the domestic market, thereby transferring sanction shocks to non-exporting firms. Furthermore, importing firms responded to sanctions by sourcing more domestic inputs at the expense of non-importing firms. In this section, I measure the heterogeneous effects of sanctions on exporting and importing firms.

4.1 Shift from Export Markets to the Home Market

Exporting firms in targeted industries experienced losses in export revenue through intensive and extensive trade margins (see section 3.1). However, they counterbalanced lost revenue in the aftermath of sanctions by increasing their domestic revenue. The higher domestic market share of exporting firms reduced the revenue of non-exporting firms, and resources shifted to exporting firms within the targeted industries. Thus, targeted exporting firms transferred the sanction shocks to non-exporting firms by increasing their domestic sales under the sanctions.

In order to measure the changes in firms' outcomes with different export shares, I use the specification in equation (3). Columns (1)–(3) in Table (8) present the heterogeneous impacts of sanctions on profit and revenue based on their export shares. Considering the full sample in Panel (A), firms with export shares above the median increased their total revenue by 2.5% in the aftermath of sanctions, whereas non-exporting firms experienced a 15% drop. The increase in total revenue of firms with high export shares is related to the rise in their domestic revenue by 18.5%. Excluding energy sectors in Panel (B) shows more significant results; the domestic revenue of firms with high export shares increased by 27%, whereas it decreased by 21% for the non-exporting firms. These findings suggest that firms with high export shares responded to sanctions by diverting their sales to the home market, transferring sanction costs to non-exporting firms.[17]

Because they were more productive, exporting firms were able to charge relatively low prices in the domestic market (Melitz, 2003; Bernard et al., 2003; and Eaton and Kortum, 2002, among many others). More importantly, due to capacity constraints, the Iranian firms faced increasing marginal costs, enabling them to charge lower prices when their exports were reduced (see section 5.1.2). By charging lower prices, the targeted exporting firms gained a greater domestic market share and mitigated the negative effects of trade sanctions at the cost of non-exporting firms.

The negative relationship between domestic sales and exports has been documented for French, Chilean, Portuguese, and Indonesian firms, among others (Vannoorenberghe, 2012, Blum et al., 2013, Esteves and Rua, 2015, and Ahn and McQuoid, 2017). For example, Esteves and Rua (2015) argue that in Portugal, during domestic downturns, firms allocate more resources to exports. However, I argue that the contrary is true for Iranian firms; the firms increased their domestic sales when they experienced a negative shock to their exports.

Exporting firms counterbalanced the loss in their export revenue by increasing their domestic sales. As a result, they raised the demand for intermediate inputs and workers, thereby shifting resources from non-exporting firms to themselves. Columns (4) and (5) in Table (8) show the shift of resources from non-exporting

[17] Table (C.3) in Appendix (C) shows that the results are robust when excluding importing firms from the regressions.

to exporting firms in the aftermath of sanctions. Panel (A) shows that the employment level of firms with high export shares increased by 9%, whereas it dropped by 9% for firms with low exports. Additionally, high exporters increased their demand for domestic intermediaries. Excluding the energy sector in Panel (B), I find a higher employment level only in firms with low export shares compared to non-exporting firms.

4.2 Shift of Resources from Non-Importing to Importing Firms

Economic sanctions made it difficult for importing firms to acquire foreign intermediate inputs, although the firms partially substituted domestic inputs for foreign intermediaries to mitigate the sanctions. As a result, resources were shifted from non-importing to importing firms when the targeted firms increased their demand for domestic inputs.

To measure the effects of sanctions through imported intermediate input channels, I use the specification in equation (4). Table (9) presents heterogeneous impacts of sanctions on firms with different import shares. As seen in the full sample in Panel (A), there is no significant difference between firms with different import shares. However, excluding the energy sector in Panel (B), the results show that firms with high importing shares experienced a milder loss in their revenue relative to non-importing firms. The revenue of firms with import shares above the median decreased by 11%, whereas the revenue of non-importing firms fell by 23%. Although importing firms experienced a loss in sales, non-importing firms were hit harder. The greater impact of sanctions on non-importing firms can be explained by the shift of resources from non-importing firms to importing firms.

Substitution of imported inputs by importing firms resulted in higher prices for domestic intermediate inputs and, thus, non-importing firms' demand decreased. Columns (4) and (5) in Table (9) present the heterogeneous impact of sanctions on the demands for domestic intermediate inputs and labor based on firms' import shares. As seen in the full sample in Panel (A), the employment level decreased less sharply for the importing firms compared to non-importing firms. However, there is no evidence for a significant impact of sanctions on demand for domestic intermediate inputs. However, from the restricted sample in Panel (B), it can be seen that the demand for domestic input among firms with high import shares was impacted less severely than among non-importing firms. Furthermore, firms with high import shares decreased their demand for labor by 9%, whereas the employment level fell by 17.5% for non-importing firms in a sanctioned industry. [18] The results suggest that, due to markup, the marginal rate of transformation exceeded the marginal rate of substitution, and the targeted importing firms decreased their demand for domestic intermediate inputs and labor in total.

[18] Table (C.4) in Appendix (C) shows that the results are robust when excluding exporting firms from the regressions.

To further investigate the substitution effect between imported intermediate inputs and labor, Table (C.5) in Appendix (C) presents the impact of trade sanctions on various employment skill levels for firms with different import shares. Workers in the production lines are categorized into the four International Standard Classification of Occupations (ISCO) skill levels.[19] The workers in the production lines are ordered from the lowest skill level in column (1) (unskilled workers) to the highest skill level in column (4) (technicians). The results show a significant decrease in the employment level of skilled workers and technicians in the full sample. Excluding the energy sector in Panel (B), we get similar results; the employment levels of skilled workers, engineers, and technicians fell by 20%, 10%, and 12%, respectively. Interestingly, the impact of sanctions was significantly different only for unskilled workers among firms with different import shares. In particular, the employment of unskilled workers dropped by 8.6% for non-importing firms, whereas it increased by 6% for firms with high import shares. Therefore, when firms were hit by sanctions, their access to foreign inputs was restricted, and they adjusted to the shocks by hiring more unskilled workers on the production lines.

5 Theoretical Framework

In this section, I develop a theoretical trade model of heterogeneous monopolistic competitive firms facing capacity constraints. I distinguish between import and export sanctions to explain the mechanisms in bringing costs to targeted firms. Import sanctions are defined as sanctions that restrict access to imported intermediate inputs. Similarly, export sanctions are defined as sanctions that limit access to export markets.

5.1 Setup

I start by assuming that the economy has no trade sanctions. There are two types of sanctions, which affect firms through different channels. Import sanctions impact firms by reducing the number of input varieties they use in their production, which increases the marginal cost of production. Export sanctions reduce the demand in a foreign market, resulting in lower exports. For simplicity's sake, I assume one foreign market. Here, I study intensive and extensive margins of adjustment.

5.1.1 Consumer Demand

Consumers have a utility function over a set of varieties Ω with a constant elasticity of substitution (CES) ($\sigma > 1$) in home and foreign markets:

[19] ISCO skill levels serve to deal with the cases when the formal educational backgrounds may not be the most suitable approach in measuring skill levels for occupations.

$$U_H = \left(\int_{\omega \in \Omega} q_H(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}$$
$$U_F = \left(\int_{\omega \in \Omega} \alpha_X q_F(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{8}$$

where α_X is the demand shifter in the export market. Maximizing the home utility function subject to the home budget constraint $\int p_H(\omega) q_H(\omega) \leq Y_H$ gives the demand function for each variety ω:

$$q_H(\omega) = p_H(\omega)^{-\sigma} {P_H}^{\sigma-1} Y_H \tag{9}$$

where $p_H(\omega)$ is the price of variety ω in the home country, $P_H \equiv \left(\int_{\omega \in \Omega} p_H(\omega)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}}$ is the aggregate home price, and Y_H is the home income. Similarly, the demand function for each variety ω in the foreign country is:

$$q_F(\omega) = {\alpha_X}^{\sigma} p_F(\omega)^{-\sigma} {P_F}^{\sigma-1} Y_F \tag{10}$$

where $p_F(\omega)$ is the price of variety ω in the foreign country, $P_F \equiv \left(\int_{\omega \in \Omega} p_F(\omega)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}}$ is the aggregate foreign price, and Y_F is the foreign income. Rearranging the equations (9) and (10), we get the following inverse demand functions:

$$\begin{aligned} p_H(\omega) &= {P_H}^{\frac{\sigma-1}{\sigma}} Y_H^{\frac{1}{\sigma}} q_H(\omega)^{-\frac{1}{\sigma}} \\ p_F(\omega) &= \alpha_X {P_F}^{\frac{\sigma-1}{\sigma}} Y_F^{\frac{1}{\sigma}} q_F(\omega)^{-\frac{1}{\sigma}} \end{aligned} \tag{11}$$

5.1.2 Firm Problem

A representative firm with productivity φ is a firm that imports part of its intermediate inputs or exports a share of its output. The firm in the home country takes into account the demand functions in equations (9) and (10)) and chooses the prices that maximizes the following profit function, acting as a monopolistic competitor:

$$\max_{q_H(\varphi), q_F(\varphi)} p_H(\varphi) q_H(\varphi) + p_F(\varphi) q_F(\varphi) - C(q_H(\varphi), q_F(\varphi)) - f - f_M - f_x \tag{12}$$

where f, f_M and f_x are fixed costs of production, fixed costs to import, and fixed entry cost to export

markets, respectively. $C(q_H(\varphi), q_F(\varphi))$ is the firm cost function:

$$C(q_H(\varphi), q_F(\varphi)) = \frac{1}{\varphi}\left(q_H(\varphi) + q_F(\varphi)\right)^2 \tag{13}$$

where the cost function is a quadratic form of the firm' total production $q = q_H(\varphi) + q_F(\varphi)$. For simplicity's sake and without loss of generality, I assume the quadratic form for the cost function, while with any other cost function with the increasing marginal cost, the results will hold (see proof in Appendix B.4). If a firm does not export, then its cost function is $C(q_H(\varphi)) = \frac{1}{\varphi} q_H(\varphi)^2$ and there is no fixed entry cost to export markets. In international trade structural models, marginal costs are usually constant and do not rely on the quantity of products supplied by the firm. (Melitz, 2003; Helpman et al., 2008; Melitz, 2008, among many others). This implies that the firm's decision in a domestic market does not depend on its decision in an export market; thus, the optimization problem can be resolved separately for each market. To link domestic and export markets, I assume a quadratic cost function, which gives an increasing marginal cost. Blum et al. (2013) introduced fixed firm-level capacity into a standard Melitz trade model to present firms with increasing marginal costs.[20] Furthermore, Ahn and McQuoid (2017) argued that the degree to which marginal costs function is significantly exacerbated by physical and financial capacity constraints. These two constraints are the primary sources for increasing marginal costs. They imply that imperfections in financial markets, which are particularly relevant for developing countries, cause financial constraints. Thus, constrained firms cannot achieve optimal scale because they select capacity with an additional borrowing cost. Ahn and McQuoid (2017) also proposed that the evidence of a negative relationship between exports and domestic sales shows that firms face capacity constraints and that their marginal cost are increasing.

Iran has been under prolonged US financial sanctions since 1995, resulting in physical and (more importantly) financial constraints. Inefficient financial markets in Iran do not allow Iranian firms to achieve optimal scale, and the 2012 sanctions further restricted Iranian firms' access to financial markets. To test for increasing marginal costs for Iranian firms, Table (C.6) in Appendix (C) presents the relationship between domestic sales and exports in different periods. The negative relationship between domestic sales and exports of Iranian firms suggests that, even before the 2012 sanctions, Iranian firms faced the capacity constraint, preventing them from choosing the optimal scale.

■ Importing Firms

Assuming a quadratic cost function and solving the profit maximization problem, I present a firm problem

[20] Bergstrand et al. (2021) addresses theoretically and quantitatively the importance of increasing marginal costs in a heterogeneous firm model to understand the relative impacts on intensive and extensive margins of trade and welfare by reducing fixed and variable trade costs. In particular, the authors find that by allowing increasing marginal costs, the welfare effect of a given change in domestic trade share diminishes.

to study import and export sanctions separately. First, assuming non-exporting firms, closing the channel of export sanctions, a firm maximizes the equation (12) and yields the following optimal price:

$$p_H^*(\varphi) = \left(\frac{\sigma-1}{2\sigma}\right)^{\frac{-1}{\sigma+1}} \varphi^{\frac{-1}{1+\sigma}} P_H^{\frac{\sigma-1}{\sigma+1}} Y_H^{\frac{1}{\sigma+1}} \tag{14}$$

Given the optimal price, each firm's output is:

$$q_H^*(\varphi) = \left(\frac{\sigma-1}{2\sigma}\right)^{\frac{\sigma}{\sigma+1}} \varphi^{\frac{\sigma}{1+\sigma}} P_H^{\frac{\sigma-1}{\sigma+1}} Y_H^{\frac{1}{\sigma+1}} \tag{15}$$

and its revenue is:

$$r_H^*(\varphi) = \left(\frac{\sigma-1}{2\sigma}\right)^{\frac{\sigma-1}{\sigma+1}} \varphi^{\frac{\sigma-1}{1+\sigma}} P_H^{\frac{2(\sigma-1)}{\sigma+1}} Y_H^{\frac{2}{\sigma+1}} \tag{16}$$

The profit can be expressed as:

$$\pi_H^*(\varphi) = \left(\frac{\sigma+1}{2\sigma}\right) r_H^*(\varphi) - f - f_M \tag{17}$$

■ **Exporting Firms**

A quadratic cost function connects a firm's decisions in home and export markets. Maximizing the profit in equation (12) for an exporting firm, we get the following relationship between the firm's domestic sale and export quantities:

$$\frac{q_H(\varphi)}{q_F(\varphi)} = \left[\frac{1}{\alpha_X} \frac{P_H^{\sigma-1} Y_H}{P_F^{\sigma-1} Y_F}\right]^{\sigma} \tag{18}$$

An exporting firm charges the same price in the home and foreign markets:

$$p_H(\varphi) = (P_H^{\sigma-1} Y_H)^{\frac{1}{\sigma+1}} (\frac{\sigma-1}{2\sigma})^{\frac{-1}{\sigma+1}} \varphi^{\frac{-1}{\sigma+1}} \left[1 + \left(\frac{1}{\alpha_X} \frac{P_H^{\sigma-1} Y_H}{P_F^{\sigma-1} Y_F}\right)^{-\sigma}\right]^{\frac{1}{\sigma+1}} \tag{19}$$

Given the optimal price, each firm's output in the domestic market is:

$$q_H(\varphi) = (P_H^{\sigma-1} Y_H)^{\frac{1}{\sigma+1}} (\frac{\sigma-1}{2\sigma})^{\frac{\sigma}{\sigma+1}} \varphi^{\frac{\sigma}{\sigma+1}} \left[1 + \left(\frac{1}{\alpha_X} \frac{P_H^{\sigma-1} Y_H}{P_F^{\sigma-1} Y_F}\right)^{-\sigma}\right]^{\frac{-\sigma}{\sigma+1}} \tag{20}$$

and the firm's output in the export market is:

$$q_F(\varphi) = (\alpha_X)^{\frac{\sigma}{\sigma+1}} (P_F^{\sigma-1} Y_F)^{\frac{1}{\sigma+1}} (\frac{\sigma-1}{2\sigma})^{\frac{\sigma}{\sigma+1}} \varphi^{\frac{\sigma}{\sigma+1}} \left[1 + \left(\frac{1}{\alpha_X} \frac{P_H^{\sigma-1} Y_H}{P_F^{\sigma-1} Y_F}\right)^{\sigma}\right]^{\frac{-\sigma}{\sigma+1}} \tag{21}$$

and its domestic revenue is:

$$r_H(\varphi) = (P_H^{\sigma-1} Y_H)^{\frac{2}{\sigma+1}} (\frac{\sigma-1}{2\sigma})^{\frac{\sigma-1}{\sigma+1}} \varphi^{\frac{\sigma-1}{\sigma+1}} \left[1 + \left(\frac{1}{\alpha_X} \frac{P_H^{\sigma-1} Y_H}{P_F^{\sigma-1} Y_F}\right)^{-\sigma}\right]^{\frac{1-\sigma}{\sigma+1}} \tag{22}$$

and its revenue in the foreign market is:

$$r_F(\varphi) = \left[\frac{1}{\alpha_X} \frac{P_H^{\sigma-1} Y_H}{P_F^{\sigma-1} Y_F}\right]^{-\sigma} r_H(\varphi) \tag{23}$$

The profit is given as:

$$\pi(\varphi) = \left(\frac{\sigma+1}{2\sigma}\right) r_H(\varphi) \left[1 + \left(\frac{1}{\alpha_X} \frac{P_H^{\sigma-1} Y_H}{P_F^{\sigma-1} Y_F}\right)^{-\sigma}\right] - f - f_X \tag{24}$$

5.1.3 Equilibrium Conditions

Firms produce if and only if $\pi(\varphi) \geq 0$. Profit of producers is increasing in φ. Then a firm is active if $\varphi > \varphi^*$ where φ^* is the cutoff productivity to enter the domestic market:[21]

$$\varphi^* = \frac{2\sigma}{\sigma-1} \left(\frac{2\sigma}{\sigma+1}\right)^{\frac{\sigma+1}{\sigma-1}} \left(P_H^{\sigma-1} Y_H\right)^{\frac{2}{1-\sigma}} f^{\frac{\sigma+1}{\sigma-1}} \tag{25}$$

The cutoff productivity to enter the domestic market φ^* decreases when the aggregate price P_H increases due to the import sanctions.[22]

Because profits are increasing in φ, we have $\varphi_m^* > \varphi^*$. First, a firm decides whether to produce or not, considering its productivity. After entering the market, considering the fixed cost of imports, a firm decides whether to import intermediate inputs. The import cutoff productivity φ_m^* is defined in:

$$\varphi_m^* = \frac{2\sigma}{\sigma-1} \left(\frac{2\sigma}{\sigma+1}\right)^{\frac{\sigma+1}{\sigma-1}} \left(P_H^{\sigma-1} Y_H\right)^{\frac{2}{1-\sigma}} (f + f_M)^{\frac{\sigma+1}{\sigma-1}} \tag{26}$$

With an increase in the aggregate price P_H, the import cutoff productivity φ_m^* decreases. However, when

[21] The cutoff productivity for exporting firms is:

$$\varphi^* = \frac{2\sigma}{\sigma-1} \left(1 - \frac{\sigma-1}{2\sigma}.\Psi\right)^{\frac{\sigma+1}{1-\sigma}} \left(P_H^{\sigma-1} Y_H\right)^{\frac{2}{1-\sigma}} f^{\frac{\sigma+1}{\sigma-1}}$$

The cutoff productivity to enter the domestic market is higher for exporting market than the cutoff productivity yielded in equation (25).

[22] See Appendix (B.3) for the proof of an increase in the aggregate price due to import sanctions.

sanctions increase fixed entry costs to import markets f_M, the import cutoff productivity increases.

A firm exports if its productivity is greater than the export cutoff productivity, $\varphi > \varphi_x^*$, which is defined in:

$$\varphi_x^* = \frac{2\sigma}{\sigma - 1}\left(1 - \frac{\sigma - 1}{2\sigma}.\Psi\right)^{\frac{\sigma+1}{1-\sigma}}\left(P_H^{\sigma-1}Y_H\right)^{\frac{2}{1-\sigma}}\left(f + f_X\right)^{\frac{\sigma+1}{\sigma-1}} \tag{27}$$

where $\Psi \equiv \left[1 + \left(\frac{1}{\alpha_X}\frac{P_H^{\sigma-1}Y_H}{P_F^{\sigma-1}Y_F}\right)^{-\sigma}\right]$.

As profits are increasing in φ, we get $\varphi_x^* > \varphi^*$. With a decrease in the aggregate home price P_H and in the term Ψ, the export cutoff productivity φ_x^* increases. Furthermore, when sanctions increase fixed entry costs to export markets f_X, the export cutoff productivity increases.

Assuming that firms must pay a fixed entry cost f_e to enter the market and face a constant probability of death η in each period, the free entry condition requires that:

$$\frac{1 - G(\varphi)}{\eta}.E[\pi(\varphi)|\varphi > \varphi^*] = f_e$$

where $p_{in} = Prob(\varphi > \varphi_m^*) = 1 - G(\varphi^*)$ is the probability of successful entry. Furthermore, $p_m = \frac{1-G(\varphi_M^*)}{1-G(\varphi^*)}$ and $p_x = \frac{1-G(\varphi_x^*)}{1-G(\varphi^*)}$ denote the probability of importing and exporting (conditional on successful entry).

The mass of entrants in each period denotes M_e. In a steady state $p_{in}M_e = \eta M$, where M denotes the number of active firms in the market. In addition, the mass of importing firms is $M_m = p_m M$ and the mass of exporting firms is $M_x = p_x M$.

Next, assume that labor is the only factor of production and that each unit of output, fixed costs of production and entry (including both in import and export markets) require one unit of labor at a wage normalized to 1. The labor market clearing condition with the aggregate profit equations determines the number of firms in the markets:

$$\begin{aligned} M_M &= \frac{L}{\overline{r_H^*}} \\ M_X &= \frac{L}{\overline{r_H}\left[1 + \left(\frac{1}{\alpha_X}\frac{P_H^{\sigma-1}Y_H}{P_F^{\sigma-1}Y_F}\right)^{-\sigma}\right]} \end{aligned} \tag{28}$$

where in the case of import sanctions $\overline{r_H^*} = r_H(\tilde{\varphi_m})$ denotes the average revenue. Then, the weighted average productivity is $\tilde{\varphi_m} = \frac{1}{M_M}\left[M(\tilde{\varphi}(\varphi^*))^{\sigma-1} + M_m(\tilde{\varphi}(\varphi_m^*))^{\sigma-1}\right]$, where $\tilde{\varphi}(\varphi^*) \equiv \left[\int_{\varphi^*}^{\infty}\varphi^{\sigma-1}\frac{g(\varphi)}{1-G(\varphi^*)}d\varphi\right]^{\frac{1}{\sigma-1}}$ is the average productivity of non-importing firms and $\tilde{\varphi}(\varphi_m^*) \equiv \left[\int_{\varphi_m^*}^{\infty}\varphi^{\sigma-1}\frac{g(\varphi)}{1-G(\varphi_m^*)}d\varphi\right]^{\frac{1}{\sigma-1}}$ is the average

productivity of importing firms. In the case of exporting firms $\overline{r_H} = r_H(\tilde{\varphi_x})$ denotes the average revenue, and $\tilde{\varphi_x} = \frac{1}{M_X}\left[M(\tilde{\varphi}(\varphi^*))^{\sigma-1} + M_x(\tilde{\varphi}(\varphi_x^*))^{\sigma-1}\right]$ is the weighted average productivity. Here, $\tilde{\varphi}(\varphi^*) \equiv \left[\int_{\varphi^*}^{\infty} \varphi^{\sigma-1} \frac{g(\varphi)}{1-G(\varphi^*)} d\varphi\right]^{\frac{1}{\sigma-1}}$ is the average productivity of non-exporting firms and $\tilde{\varphi}(\varphi_x^*) \equiv \left[\int_{\varphi_x^*}^{\infty} \varphi^{\sigma-1} \frac{g(\varphi)}{1-G(\varphi_x^*)} d\varphi\right]^{\frac{1}{\sigma-1}}$ is the average productivity of exporting firms. The number of varieties in the case of importing and exporting is $M_M = M + M_m$ and $M_X = M + M_x$, assuming one import and export market and that firms produce one variety of products.

The empirical results show no changes in the mass of firms over the short, two-year period in which I study the impact of sanctions. Without changes in the mass of firms, the average productivity in the market will not change unless firms' productivity is impacted. Because the import sanctions exogenously impact firm-level productivity, and because this impact passes through firm linkages to other firms in the market, the average productivity in the case of import sanctions will decrease (see section 3.3).

5.2 Model Predictions: The Effects of Economic Sanctions

First, consider the case of import sanctions which reduces (and, in the case of full sanctions, eliminates) the imported input varieties. I assume that the productivity is an increasing function of imported inputs, $\varphi = \varphi(\textit{imported inputs})$, and the import sanctions reduce firm-level productivity by decreasing its variety of imported intermediate inputs. A decrease in variety of intermediate inputs or an increase in the price of imported varieties reduces firm-level productivity (Amiti and Konings, 2007; Goldberg et al., 2010; Gopinath and Neiman, 2014; Halpern et al., 2015). Furthermore, the results in section 3.3 corroborate the notion that import sanctions reduce firm-level productivity.[23] As a result, marginal cost of production increases when firm-level productivity drops, and the production of importing firms decreases.

Proposition 1: *Import sanctions decrease importing firms' revenues by reducing firm-level productivity.*

Proof: see Appendix (B).

On the other hand, export sanctions decrease exports and increase the domestic sales of exporting firms in the presence of capacity constraints and increasing marginal costs. When firms cannot export their products, they yield a lower marginal cost of production and sell more in the domestic market. I assume that export sanctions impact a firm's export through its demand shifter in the export market, α_X. If there are no

[23]Due to lack of data on the number of imported varieties, I could not test that whether the decrease in the productivity is because of the lower number of imported input varieties. However, the results show the productivity of importing firms dropped significantly when they were sanctioned.

sanctions $\alpha_X = 1$, but if a firm is sanctioned, $0 < \alpha_X < 1$. Thus, the decrease in export demand reduces exports and increases domestic sales.

Proposition 2: *Export sanctions reduce firms' exports and increase exporting firms' domestic sales in the presence of capacity constraints.*

Proof: see Appendix (B).

Now, I examine the welfare changes under import and export sanctions.[24] Import sanctions reduce firm-level productivity, increase marginal costs of production, and increase the home aggregate price level in the domestic market. On the other hand, export sanctions lower the home aggregate price by reducing the marginal cost of production in the presence of capacity constraints. Normalizing a wage to 1, welfare under the trade sanctions relative to the welfare without sanctions is given by:

$$\frac{W_{(2)}}{W_{(1)}} = \frac{P_{H(1)}}{P_{H(2)}} \tag{29}$$

where $W_{(2)}$ denotes welfare in the episode under the sanctions, while $W_{(1)}$ denotes welfare in the period without the sanctions. The home aggregate price increases due to the import sanctions and decreases due to the export sanctions. This finding is summarized below:

Proposition 3: *Import sanctions reduce aggregate consumer welfare, whereas export sanctions increase aggregate consumer welfare in the presence of capacity constraints.*

Proof: see Appendix (B).

The findings in Propositions (2) and (3) depend on the increasing marginal cost assumption. As the degree of the cost function increases (i.e., firms face higher capacity constraints), the impact of import and export sanctions on the aggregate prices decreases:

Proposition 4: *Higher capacity constraints diminish negative impacts of trade sanctions through import channels and diminish positive effects through export channels.*

[24] Since my empirical results show the impact of sanctions in the short run, the zero profit condition presented in a theoretical model might not hold. Therefore, the aggregate welfare changes in this section present the changes in aggregate consumer welfare.

Proof. see Appendix (B).

When the firms' capacity constraints increase, it will result in a lower supply of products by the constrained firms in the market. Hence, the impact of constrained firms on aggregate prices will be much smaller regardless of whether they are importing or exporting firms.

5.3 Quantifying the Welfare Effect of Economic Sanctions

In this section, I estimate aggregate consumer welfare changes resulting from import and export sanctions by finding the changes in the aggregate home price. Here, I concentrate solely on the impact of the sanctions in the restricted sample, excluding the energy firms. First, I show the effect of sanctions through import channels on aggregate consumer welfare and then examine the impacts through export channels.[25]

Using the estimated causal effect of the import sanctions on the average productivity in Table (6), I find the changes in the aggregate home price:

$$\frac{P_{H(2)}}{P_{H(1)}} = \left(\frac{\tilde{\varphi_{m(2)}}}{\tilde{\varphi_{m(1)}}}\right)^{-\frac{1}{2}} \tag{30}$$

Economic sanctions increased the aggregate home price and reduced aggregate consumer welfare through imported intermediate input channels. Aggregate consumer welfare decreased by 7.5%.

Next, to find the impacts of export sanctions on aggregate consumer welfare, I first compute the changes in the export revenue premium, $\Psi \equiv \left[1 + \left(\frac{1}{\alpha_X} \frac{P_H^{\sigma-1} Y_H}{P_F^{\sigma-1} Y_F}\right)^{-\sigma}\right]$, based on estimated changes in the total and domestic revenue of exporting firms:

$$\frac{\Psi_2}{\Psi 1} = \left(\frac{r_{T(2)}(\varphi)}{r_{T(1)}(\varphi)}\right)\left(\frac{r_{H(1)}(\varphi)}{r_{H(2)}(\varphi)}\right) \tag{31}$$

By combining the causal estimated changes in the total and domestic revenue in columns (2) and (3) of Table (8), I find that the term Ψ decreases by 26%. Then, I use the change in the term Ψ, to obtain the changes in the aggregate home price and welfare:

$$\frac{P_{H(2)}}{P_{H(1)}} = \left(\frac{\Psi_2}{\Psi_1}\right)^{\frac{1}{2}} \tag{32}$$

[25]From Table (6), the mass of firms remained unchanged over the short sanctions period in two years, thus, the average productivity of firms will remain the same, due to export sanctions. However, due to exogenous import shock to firm-level productivity and propagation of the shock through the firm linkages, the average productivity impacted negatively by import sanctions.

Export sanctions decreased the aggregate home price in the short run through the changes in the export premium Ψ; thus, export sanctions increased aggregate consumer welfare by 4.35%.

Aggregate consumer welfare changes are caused by intensive margins rather than by extensive margins, as reflected in the fact that the mass of firms in the market was not changed by the sanctions over the short period of this study. Furthermore, the positive impact of sanctions on aggregate consumer welfare through export channels in the short run is highly sensitive to the changes in the degree of the cost function (γ in the general cost function presented in Appendix B.4). The greater the degree of the cost function, the lower the positive (respectively, negative) impact through export (respectively, import) channels on aggregate consumer welfare. Figure (8) presents a sensitivity test for the changes in aggregate consumer welfare by the changes in the degree of the cost function, showing a negative relationship. Thus, increased capacity constraints decrease the positive impacts of sanctions through export channels while also diminishing the adverse effects on aggregate consumer welfare through import channels (see Appendix B.4).

6 Conclusion

In this survey, I provide an overview of the impact of the 2012 international trade sanctions against Iranian manufacturing firms. Sanctions cut firms' exports, reduced imports, and diminished targeted firms' profit, revenue, and productivity. However, the impact of sanctions reached beyond their effects on targeted firms. I find that the shocks propagated to non-targeted firms in upstream and downstream industries through input–output linkages, depending on the strength of connections between industries. Thus, sanction shocks were not contained within targeted industries but instead propagated to industries that had not been targeted. Intriguingly, exporting and importing firms were found to mitigate adverse effects of sanctions at the expense of non-exporters and non-importers in the domestic market.

Furthermore, I develop a stylized model featuring heterogeneous monopolistic competitive firms with capacity constraints to support the empirical results. From the stylized model, trade sanctions were seen to reduce aggregate consumer welfare through import channels and to increase welfare through export channels. However, these effects are diminished when the firms' capacity constraints increase.

The paper's findings extend beyond the study of economic sanctions and can also be applied to cases when firms face adverse trade shocks, regardless of origin. The paper's stylized model enables researchers studying trade shocks in developing countries where firms face capacity constraints- especially financial constraints- to quantify the aggregate effect of trade shocks.

References

Acemoglu, D., D. Autor, D. Dorn, G. H. Hanson, and B. Price (2016). Import competition and the great us employment sag of the 2000s. *Journal of Labor Economics 34*(S1), S141–S198.

Acemoglu, D., V. M. Carvalho, A. Ozdaglar, and A. Tahbaz-Salehi (2012). The network origins of aggregate fluctuations. *Econometrica 80*(5), 1977–2016.

Ackerberg, D. A., K. Caves, and G. Frazer (2015). Identification properties of recent production function estimators. *Econometrica 83*(6), 2411–2451.

Afesorgbor, S. K. (2019). The impact of economic sanctions on international trade: How do threatened sanctions compare with imposed sanctions? *European Journal of Political Economy 56*, 11–26.

Ahn, D. P. and R. D. Ludema (2020). The sword and the shield: the economics of targeted sanctions. *European Economic Review 130*, 103587.

Ahn, J. and A. F. McQuoid (2017). Capacity constrained exporters: Identifying increasing marginal cost. *Economic Inquiry 55*(3), 1175–1191.

Amiti, M. and J. Konings (2007). Trade liberalization, intermediate inputs, and productivity: Evidence from indonesia. *American Economic Review 97*(5), 1611–1638.

Askari, H., J. Forrer, H. Teegen, and J. Yang (2003). *Economic sanctions: Examining their philosophy and efficacy*. Greenwood Publishing Group.

Bergstrand, J. H., S. R. Cray, and A. Gervais (2021). Increasing marginal costs, firm heterogeneity, and the gains from "deep" international trade agreements.

Bernard, A. B., J. Eaton, J. B. Jensen, and S. Kortum (2003). Plants and productivity in international trade. *American economic review 93*(4), 1268–1290.

Blalock, G. and P. J. Gertler (2004). Learning from exporting revisited in a less developed setting. *Journal of development economics 75*(2), 397–416.

Blum, B. S., S. Claro, and I. J. Horstmann (2013). Occasional and perennial exporters. *Journal of International Economics 90*(1), 65–74.

Crozet, M., J. Hinz, A. Stammann, and J. Wanner (2021). Worth the pain? firms' exporting behaviour to countries under sanctions. *European Economic Review 134*, 103683.

De Loecker, J. (2007). Do exports generate higher productivity? evidence from slovenia. *Journal of international economics 73*(1), 69–98.

Demir, F. and S. S.Tabrizy (2021). Gendered effects of sanctions on manufacturing employment: Evidence from iran.

Dizaji, S. F. and P. A. van Bergeijk (2013). Potential early phase success and ultimate failure of economic sanctions: A var approach with an application to iran. *Journal of Peace Research 50*(6), 721–736.

Eaton, J. and S. Kortum (2002). Technology, geography, and trade. *Econometrica 70*(5), 1741–1779.

Esfahani, H. S. and K. Yousefi (2017). Rash credit injection, hasty job creation, and firm bifurcation in iran's manufacturing. In *Conference Paper*.

Esteves, P. S. and A. Rua (2015). Is there a role for domestic demand pressure on export performance? *Empirical Economics 49*(4), 1173–1189.

Felbermayr, G. J., C. Syropoulos, E. Yalcin, and Y. Yotov (2019). On the effects of sanctions on trade and welfare: New evidence based on structural gravity and a new database.

Frank, J. (2018). The effects of economic sanctions on trade: New evidence from a panel ppml gravity approach. Technical report, Hohenheim Discussion Papers in Business, Economics and Social Sciences.

Gharehgozli, O. (2017). An estimation of the economic cost of recent sanctions on iran using the synthetic control method. *Economics Letters 157*, 141–144.

Goldberg, P. K., A. K. Khandelwal, N. Pavcnik, and P. Topalova (2010). Imported intermediate inputs and domestic product growth: Evidence from india. *The Quarterly journal of economics 125*(4), 1727–1767.

Gopinath, G. and B. Neiman (2014). Trade adjustment and productivity in large crises. *American Economic Review 104*(3), 793–831.

Haidar, J. I. (2017). Sanctions and export deflection: evidence from iran. *Economic Policy 32*(90), 319–355.

Halpern, L., M. Koren, and A. Szeidl (2015). Imported inputs and productivity. *American Economic Review 105*(12), 3660–3703.

Helpman, E., M. Melitz, and Y. Rubinstein (2008). Estimating trade flows: Trading partners and trading volumes. *The quarterly journal of economics 123*(2), 441–487.

Kasahara, H. and J. Rodrigue (2008). Does the use of imported intermediates increase productivity? plant-level evidence. *Journal of development economics 87*(1), 106–118.

Katzman, K. (2013). Iran sanctions. LIBRARY OF CONGRESS WASHINGTON DC CONGRESSIONAL RESEARCH SERVICE.

Katzman, K. (2020). Iran sanctions. Washington: Congressional Research Service.

Kelishomi, M. A., R. Nistico, et al. (2021). Employment effects of economic sanctions in iran. Technical report, Institute of Labor Economics (IZA).

Laudati, D. and M. H. Pesaran (2021). Identifying the effects of sanctions on the iranian economy using newspaper coverage.

Lee, Y. S. (2018). International isolation and regional inequality: Evidence from sanctions on north korea. *Journal of Urban Economics 103*, 34–51.

Levinsohn, J. and A. Petrin (2003). Estimating production functions using inputs to control for unobservables. *The review of economic studies 70*(2), 317–341.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *econometrica 71*(6), 1695–1725.

Melitz, M. J. (2008). International trade and heterogeneous firms. *The New Palgrave Dictionary of Economics 2*.

Olley, G. S. and A. Pakes (1992). The dynamics of productivity in the telecommunications equipment industry. Technical report, National Bureau of Economic Research.

Rahmati, M. H. and A. Pilehvari (2019). The productivity trend in iran evidence from manufacturing firms. *Economics of Transition and Institutional Change 27*(2), 395–408.

Salehi-Esfahani, H. (2020). Iran under sanctions: The experience of iran's manufacturing sector under international economic sanctions.

Seyed Amir Godasiaye, M. A. (2018, Spring). Measuring the impact of sanction on targeted firms' market value: Evidence from tehran exchange market after european union sanctions. *Quarterly Energy Economics Review 14*(56).

Silva, J. S. and S. Tenreyro (2006). The log of gravity. *The Review of Economics and statistics 88*(4), 641–658.

Silva, J. S. and S. Tenreyro (2011). Further simulation evidence on the performance of the poisson pseudo-maximum likelihood estimator. *Economics Letters 112*(2), 220–222.

Topalova, P. and A. Khandelwal (2011). Trade liberalization and firm productivity: The case of india. *Review of economics and statistics 93*(3), 995–1009.

Van Biesebroeck, J. (2005). Exporting raises productivity in sub-saharan african manufacturing firms. *Journal of International economics 67*(2), 373–391.

Vannoorenberghe, G. (2012). Firm-level volatility and exports. *Journal of International Economics 86*(1), 57–67.

Wagner, J. (2007). Exports and productivity: A survey of the evidence from firm-level data. *World Economy 30*(1), 60–82.

Yang, J., H. Askari, J. Forrer, and H. Teegen (2004). Us economic sanctions: An empirical study. *The International Trade Journal 18*(1), 23–62.

Tables

Table 1: Summary Table

	Sanctioned			Non-Sanctioned		
	pre-sanctions	post-sanctinos	difference	pre-sanctions	post-sanctinos	difference
Revenue	221	123	-98*	6.87	6.48	-0.39
	2700.00	1400.00		60.00	68.00	
Domestic Revenue	194	106	-88 *	6.40	6.00	-0.40
	2500.00	1300.00		54.00	62.00	
Intermediate Inputs	97.50	86.10	-11.40	4.59	4.54	-0.05
	880.00	930.00		35.00	39.00	
Exports	16.40	9.85	-6.55 *	0.42	0.31	-0.11 *
	170.00	98.00		9.40	5.40	
Imports	91.00	32.00	-59.00 *	18.70	15.40	-3.30 *
	240.00	140.00		65.00	59.00	
Small Size Firms	0.28	0.21	-0.07 ***	0.35	0.26	-0.09 ***
	0.45	0.40		0.48	0.44	
Medium Size Firms	0.45	0.36	-0.09 ***	0.49	0.41	-0.08 ***
	0.50	0.48		0.50	0.49	
Large Size Firms	0.27	0.43	0.16 ***	0.16	0.33	0.17 ***
	0.44	0.50		0.37	0.47	
State-owned enterprises	0.03	0.02	-0.01 *	0.03	0.02	0.00 ***
	0.18	0.15		0.16	0.14	
Labor	210.00	190.00	-20.00	77.00	77.00	0.00
	910.00	860.00		260.00	270.00	

Notes: Table reports mean and standard deviation of variables of interest across sanctioned firms for pre and post-sanctions. Values are in billion tomans (10 billion IRR). The table covers 12,556 and 14,168 firms annually between 2009-2013. International trade sanctions were enforced in 2012 and 2013 on firms in the energy, automotive, shipbuilding, and aircraft industries. Significance levels: * 10%, ** 5%, *** 1%

Table 2: Impact of Sanctions on Firms' Exports (Ex) and Imports (Im)

	OLS		OLS		PPML		PPML	
	$\ln(Ex_{it})$	$\ln(Im_{it})$	$\ln(1+Ex_{it})$	$\ln(1+Im_{it})$	Ex_{it}	Im_{it}	Ex_{it}	Im_{it}
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: All Firms								
$Sanctions_{jt}$	-0.128	-0.192	0.028	-0.275	-0.241*	-0.089	-0.092	-0.406***
	(0.097)	(0.144)	(0.058)	(0.246)	(0.125)	(0.144)	(0.157)	(0.153)
Observations	6317	12103	79409	79409	9036	24697	45244	71917
(Adj./Pseudo) R-squared	0.803	0.825	0.630	0.398	0.964	0.831	0.734	0.548
Panel B: Excl. Energy Firms:								
$Sanctions_{jt}$	-0.463*	-0.277*	0.072	-0.449*	-0.647*	-0.072	-0.634*	-0.465***
	(0.242)	(0.165)	(0.067)	(0.266)	(0.381)	(0.149)	(0.325)	(0.167)
Obs	5739	12103	76773	76773	8361	23912	43713	69636
(Adj./Pseudo) R-squared	0.763	0.825	0.604	0.400	0.891	0.834	0.590	0.555
Firm FEs + Year FEs	✓	✓	✓	✓	✓	✓	X	X
Industry FEs + Year FEs	X	X	X	X	X	X	✓	✓
Control × Year FEs	X	X	X	X	X	X	✓	✓

Notes: In all regressions, I include year fixed effects. Robust standard errors are corrected for clustering at the industry-year level in parentheses. OLS regressions are weighted by the reported firms' weights in surveys. In first two columns, zero export and import values are dropped from regressions. In column 3 and 4, I added a constant number 1 to export and imports to keep zero traded values in regressions. In the last four columns, Poisson pseudo-maximum-likelihood used to deal with zero traded values. In columns 5 and 6, including firm fixed effects, large number of observation dropped because of singleton or separated observations. Instead of firm fixed effects, columns 7 and 8, include industry fixed effects with time-invariant firm observation interaction with year fixed effects to not drop the observations from the regressions. Adjusted R2s are reported for OLS regressions, and Pseudo R2s are reported for PPML estimations.
Significance levels: * 10%, ** 5%, *** 1%

Table 3: Extensive Margin of Trade

	All industries		All industries (excl. energy)	
	$Exporting_{it}$	$Importing_{it}$	$Exporting_{it}$	$Importing_{it}$
$Sanctions_{jt}$	0.016***	0.057***	0.011**	0.064***
	(0.005)	(0.014)	(0.005)	(0.020)
Below Median Exporters * $Sanctions_{jt}$	-0.068**		-0.053	
	(0.029)		(0.041)	
Above Median Exporters * $Sanctions_{jt}$	-0.042**		-0.075	
	(0.021)		(0.062)	
Below Median Importers * $Sanctions_{jt}$		-0.101***		-0.131***
		(0.022)		(0.016)
Above Median Importers * $Sanctions_{jt}$		-0.198***		-0.201***
		(0.028)		(0.043)
Obs	64205	67130	62017	64920
Adjusted R-squared	0.609	0.454	0.593	0.456
Firm FEs + Year FEs	✓	✓	✓	✓

Notes: In all regressions, I include firm and year fixed effects. Robust standard errors are corrected for clustering at the industry-year level in parentheses. I define an exporting dummy as 1 in the year that a firm exported and an importing dummy as 1 in the year that a firm imported its inputs. Exporting (importing) firms are divided into two groups based on whether they export (import) shares above or below the median before the sanctions.
Significance levels: * 10%, ** 5%, *** 1%

Table 4: Impact of Sanctions on Targeted Firms

Dep var are in log	$\text{Profit}_{i,t}$	$\text{Total Rev}_{i,t}$	$\text{Domestic Rev}_{i,t}$	$\text{Domestic inputs}_{i,t}$	$\text{Employment}_{i,t}$
Panel A: All Firms					
Sanctions_{jt}	-0.229**	-0.136**	-0.121	-0.136	-0.062*
	(0.092)	(0.069)	(0.078)	(0.100)	(0.037)
Obs	56183	64201	63914	67091	67281
Adjusted R-squared	0.688	0.827	0.812	0.772	0.912
Firm FEs + Year FEs	✓	✓	✓	✓	✓
Panel B: Excl. Energy Firms					
Sanctions_{jt}	-0.358***	-0.228***	-0.219***	-0.373***	-0.157***
	(0.062)	(0.056)	(0.057)	(0.051)	(0.015)
Obs	54324	62015	61761	64883	65062
Adjusted R-squared	0.677	0.820	0.806	0.764	0.910
Firm FEs + Year FEs	✓	✓	✓	✓	✓

Notes: In all regressions, I include firm and year fixed effects. Robust standard errors are corrected for clustering at the industry-year level in parentheses. Dependent variables are in log values. Panel A presents results with all firms in the sample, and panel B excludes energy firms from the sample.
Significance levels: * 10%, ** 5%, *** 1%

Table 5: Impact of Sanctions on Firm-level Productivity

Dep var are in log	$\text{TFP}_{i,t} : OP - ACF$		$\text{TFP}_{i,t} : LP - ACF$	
	All industries	Excl. energy sector	All industries	Excl. energy sector
Sanctions_{jt}	-0.141*	-0.225***	-0.139*	-0.223***
	(0.077)	(0.075)	(0.076)	(0.072)
Obs	52103	50384	52103	50384
Adjusted R-squared	0.847	0.847	0.965	0.966
Exporting channel:				
Sanctions_{jt}	-0.153**	-0.209***	-0.146**	-0.210***
	(0.069)	(0.062)	(0.068)	(0.059)
Below Median Exporters * Sanctions_{jt}	-0.100	-0.164	-0.091	-0.159
	(0.120)	(0.124)	(0.120)	(0.126)
Above Median Exporters * Sanctions_{jt}	0.157	0.078	0.121	0.142
	(0.128)	(0.197)	(0.133)	(0.177)
Importing channel:				
Sanctions_{jt}	-0.064	-0.124*	-0.073	-0.134**
	(0.081)	(0.064)	(0.080)	(0.062)
Below Median Importers * Sanctions_{jt}	-0.033	-0.014	-0.023	-0.021
	(0.077)	(0.063)	(0.077)	(0.066)
Above Median Importers * Sanctions_{jt}	-0.222***	-0.289***	-0.193***	-0.247***
	(0.071)	(0.083)	(0.070)	(0.080)
Firm FEs + Year FEs	✓	✓	✓	✓

Notes: In all regressions, I include firm and year fixed effects. Robust standard errors are corrected for clustering at the industry-year level in parentheses. Dependent variables are in log values. Exporting (importing) firms are divided into two groups based on whether they export (import) shares above or below median before the sanctions.
Significance levels: * 10%, ** 5%, *** 1%

Table 6: Firm Entry and Exit - Industry Average Productivity

	All Firms			Excl. Energy Firms		
	Entry_{it}	Exit_{it}	logTFP_{jt}	Entry_{it}	Exit_{it}	logTFP_{jt}
Sanctions_{jt}	0.000	0.002	-0.065	0.000	0.011	-0.173**
	(0.000)	(0.009)	(0.078)	(0.000)	(0.010)	(0.075)
	79409	79409	67359	76773	76773	65138
Adjusted R-squared	0.981	0.506	0.995	0.980	0.505	0.995
Firm FEs + Year FEs	✓	✓	X	✓	✓	X
Industry FEs + Year FEs	X	X	✓	X	X	✓

Notes: In all regressions, I include firm and year fixed effects. Robust standard errors are corrected for clustering at the industry-year level in parentheses. I define an entry dummy as 1 in and after the year a firm entered, and an exit dummy as 1 in and after the year a firm exited.
Significance levels: * 10%, ** 5%, *** 1%

Table 7: Downstream and Upstream Sanction Shocks

Dep var are in log	$\text{Profit}_{i,t}$	Total $\text{Rev}_{i,t}$	$\text{Emp}_{i,t}$	$\text{TFP}_{i,t}$
A. First Order Indirect Shock				
Downstream Sanction Shock	-0.693***	-0.433***	-0.268***	-0.528***
	(0.142)	(0.123)	(0.050)	(0.155)
Upstream Sanction Shock	-0.353**	-0.180	-0.144**	-0.314**
	(0.176)	(0.125)	(0.072)	(0.123)
B. Full (Higher-Order) Indirect Shock				
Downstream Sanction Shock	-0.149***	-0.091***	-0.050***	-0.111***
	(0.042)	(0.033)	(0.017)	(0.039)
Upstream Sanction Shock	-0.115***	-0.066**	-0.039**	-0.090***
	(0.042)	(0.031)	(0.018)	(0.033)
Firm FEs + Year FEs	✓	✓	✓	✓

Notes: In all regressions, I include firm and year fixed effects. Robust standard errors are corrected for clustering at the industry-year level in parentheses. Dependent variables are in log values. Panel A presents first order downstream and upstream shocks, while panel B shows the full indirect sanctions shocks using Leontief inverse matrix .
Significance levels: * 10%, ** 5%, *** 1%

Table 8: Heterogeneous Effects on Exporting Firms

Dep var are in log	$\text{Profit}_{i,t}$	$\text{Total Rev}_{i,t}$	$\text{Domestic Rev}_{i,t}$	$\text{Domestic inputs}_{i,t}$	$\text{Employment}_{i,t}$
Panel A: All Firms					
Sanctions_{jt}	-0.265***	-0.164**	-0.167**	-0.175	-0.100***
	(0.083)	(0.067)	(0.066)	(0.108)	(0.033)
Below Median Exporters * Sanctions_{jt}	0.084	0.036	0.038	0.038	0.118***
	(0.107)	(0.090)	(0.090)	(0.139)	(0.036)
Above Median Exporters * Sanctions_{jt}	0.170	0.189*	0.337**	0.254**	0.187***
	(0.189)	(0.109)	(0.165)	(0.116)	(0.027)
Obs	56183	64201	63914	67091	67281
Adjusted R-squared	0.688	0.827	0.812	0.772	0.912
Firm FEs + Year FEs	✓	✓	✓	✓	✓
Panel B: Excl. Energy Firms					
Sanctions_{jt}	-0.350***	-0.241***	-0.242***	-0.382***	-0.175***
	(0.068)	(0.057)	(0.056)	(0.056)	(0.014)
Below Median Exporters * Sanctions_{jt}	0.001	0.062	0.069	0.008	0.160***
	(0.127)	(0.095)	(0.094)	(0.169)	(0.051)
Above Median Exporters * Sanctions_{jt}	-0.155	0.226	0.488**	0.170	0.069
	(0.245)	(0.194)	(0.230)	(0.120)	(0.063)
Obs	54324	62015	61761	64883	65062
Adjusted R-squared	0.677	0.820	0.806	0.764	0.910
Firm FEs + Year FEs	✓	✓	✓	✓	✓

Notes: In all regressions, I include firm and year fixed effects. Robust standard errors are corrected for clustering at the industry-year level in parentheses. Dependent variables are in log values. Exporting firms are divided into two groups based on whether they export shares above or below median before the sanctions. Panel A presents results with all firms in the sample, and panel B excludes energy firms from the sample.
Significance levels: * 10%, ** 5%, *** 1%

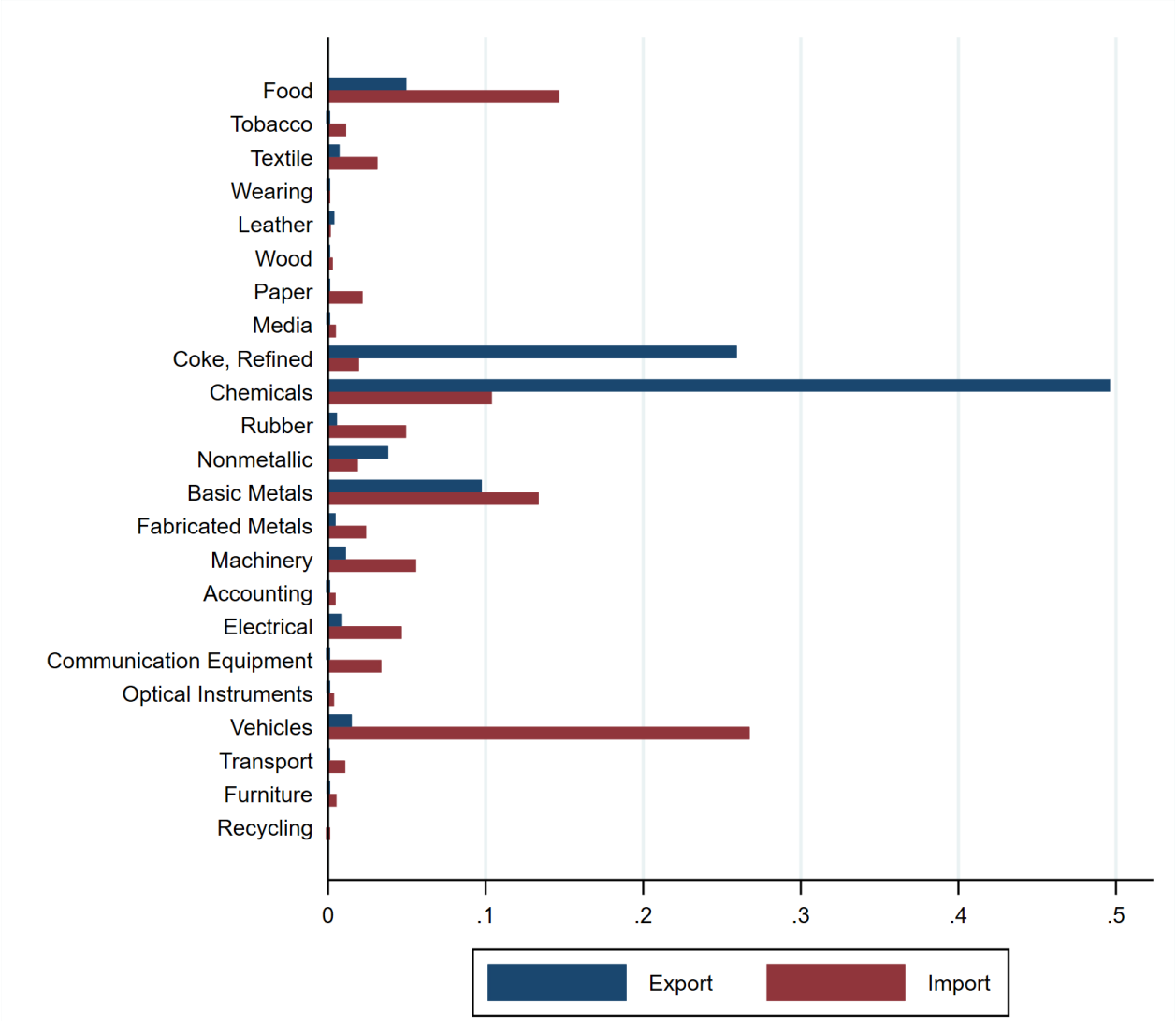
Table 9: Heterogeneous Effects on Importing Firms

Dep var are in log	$\text{Profit}_{i,t}$	$\text{Total Rev}_{i,t}$	$\text{Domestic Rev}_{i,t}$	$\text{Domestic inputs}_{i,t}$	$\text{Employment}_{i,t}$
Panel A: All Firms					
Sanctions_{jt}	-0.194*	-0.140*	-0.124	-0.173	-0.078*
	(0.109)	(0.077)	(0.081)	(0.120)	(0.045)
Below Median Importers * Sanctions_{jt}	-0.018	-0.017	0.001	0.010	-0.010
	(0.113)	(0.069)	(0.080)	(0.066)	(0.026)
Above Median Importers * Sanctions_{jt}	-0.102	0.028	0.010	0.121	0.062**
	(0.097)	(0.066)	(0.072)	(0.118)	(0.027)
Obs	56183	64201	63914	67091	67281
Adjusted R-squared	0.688	0.827	0.812	0.772	0.912
Firm FEs + Year FEs	✓	✓	✓	✓	✓
Panel B: Excl. Energy Firms					
Sanctions_{jt}	-0.349***	-0.272***	-0.270***	-0.463***	-0.193***
	(0.101)	(0.060)	(0.059)	(0.078)	(0.022)
Below Median Importers * Sanctions_{jt}	-0.022	-0.005	0.016	0.025	0.026
	(0.146)	(0.092)	(0.103)	(0.075)	(0.026)
Above Median Importers * Sanctions_{jt}	-0.008	0.146**	0.148**	0.270**	0.099***
	(0.098)	(0.068)	(0.068)	(0.130)	(0.032)
Obs	54324	62015	61761	64883	65062
Adjusted R-squared	0.677	0.820	0.806	0.764	0.910
Firm FEs + Year FEs	✓	✓	✓	✓	✓

Notes: In all regressions, I include firm and year fixed effects. Robust standard errors are corrected for clustering at the industry-year level in parentheses. Dependent variables are in log values. Importing firms are divided into two groups based on whether they import shares above or below median before the sanctions. Firms in the energy sector are excluded. Panel A presents results with all firms in the sample, and panel B excludes energy firms from the sample.
Significance levels: * 10%, ** 5%, *** 1%

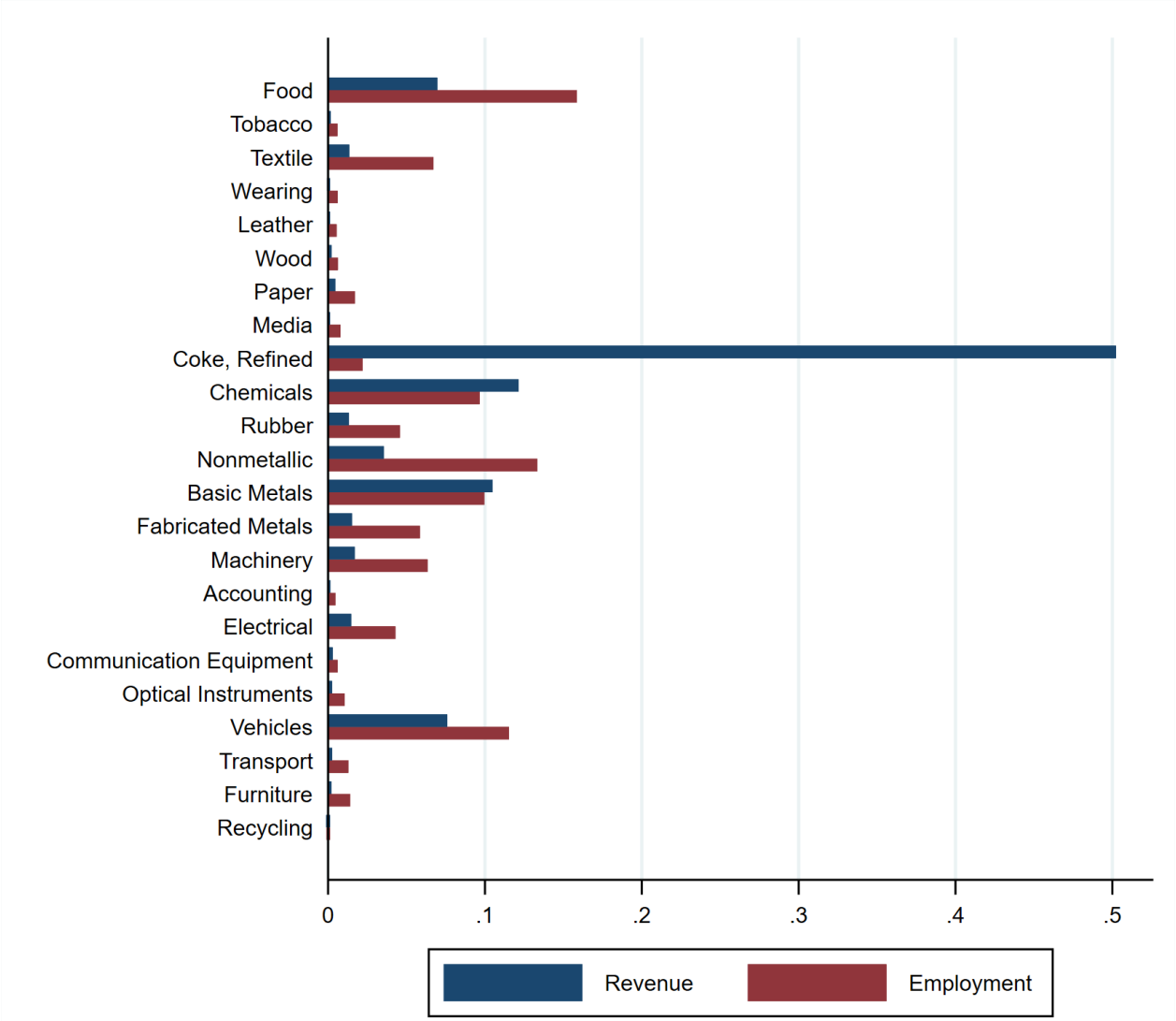
Figures

Figure 1: Industry Export and Import Shares



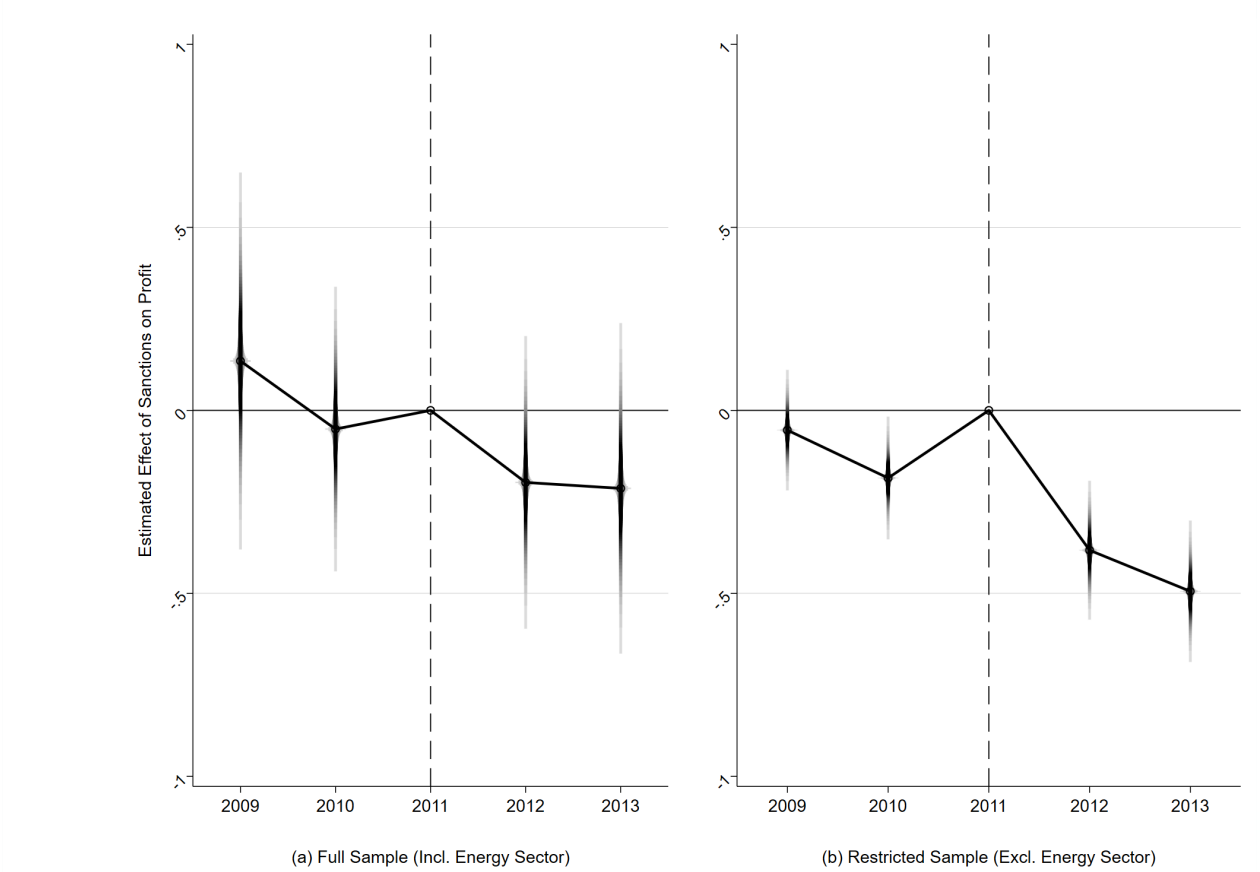
Notes: Figure shows export and import shares of each broad industry relative to total export and import of the manufacturing sector. Each broad industry is at 2digit ISIC level. Sample contains 136 4digit ISIC level industries in 23 broad 2digit ISIC level industries. Sanctioned industries are identified at 4digit ISIC level, located in Coke, Refined, Chemicals, Vehicles, and Transport broad industries. However, not all sub-industries in Coke, Refined, and Chemicals broad industries were sanctioned.

Figure 2: Industry Revenue and Employment Shares



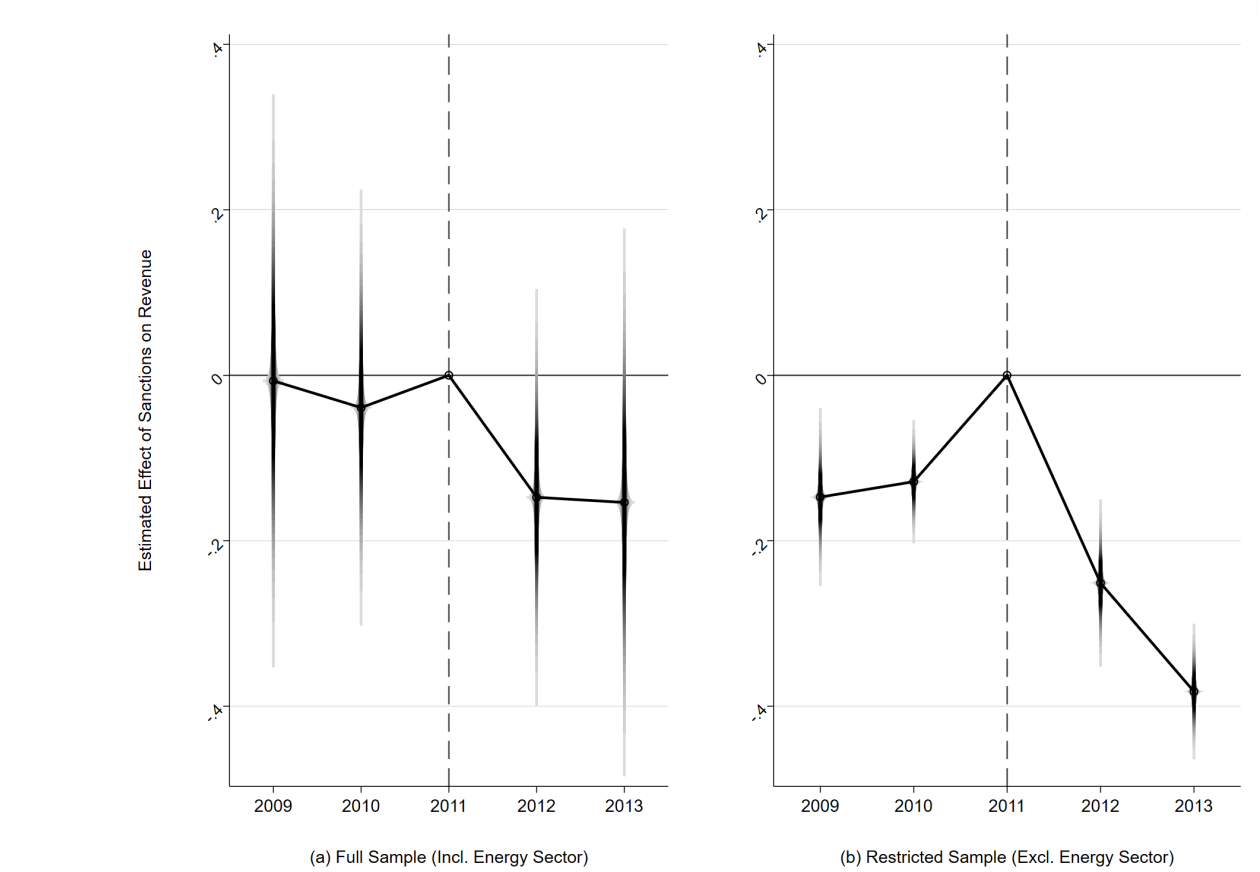
Notes: Figure shows revenue and employment shares of each broad industry relative to total export and import of the manufacturing sector. Each broad industry is at 2digit ISIC level. Sample contains 136 4digit ISIC level industries in 23 broad 2digit ISIC level industries. Sanctioned industries are identified at 4digit ISIC level, located in Coke, Refined, Chemicals, Vehicles, and Transport broad industries. However, not all sub-industries in Coke, Refined, and Chemicals broad industries were sanctioned.

Figure 3: Event Plot - Profit



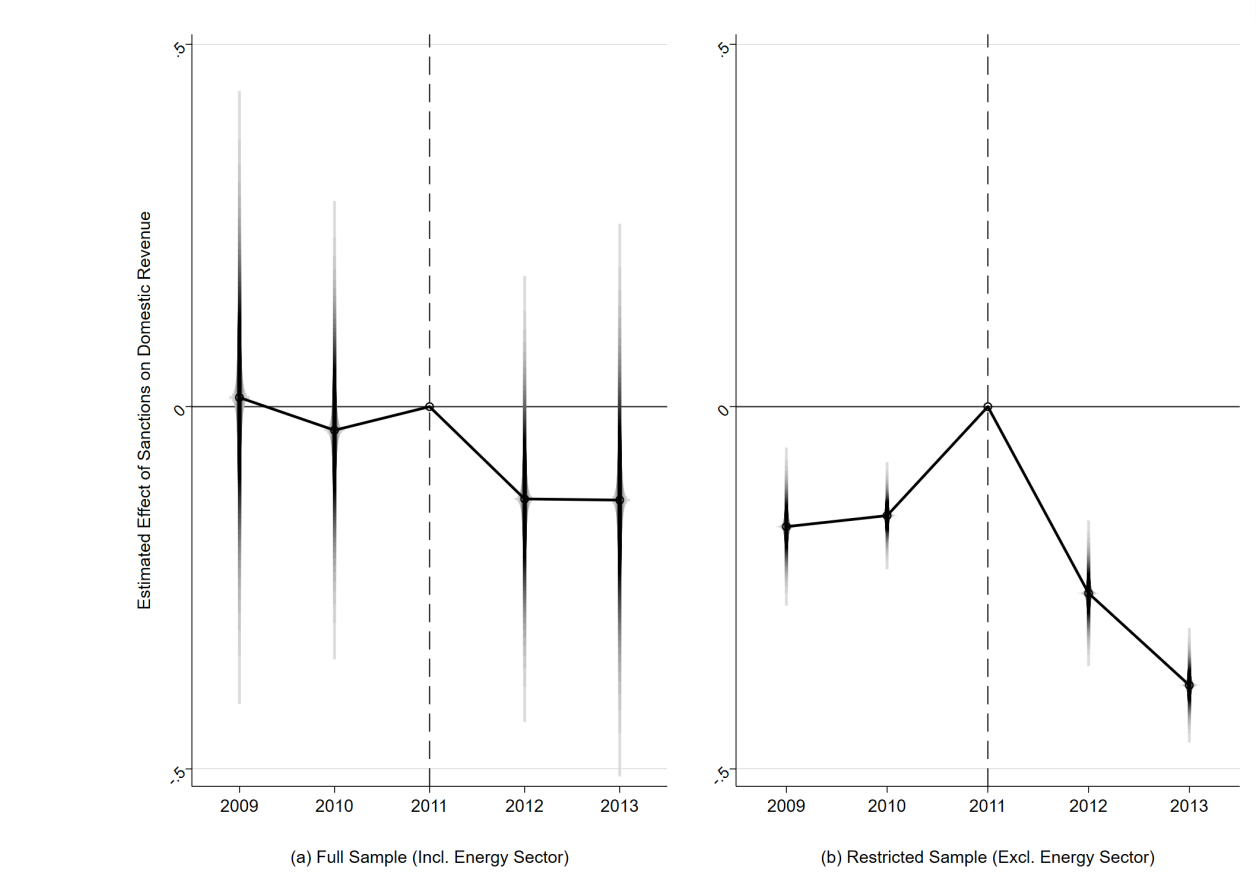
Notes: Figures 3a and 3b plot estimated effects of sanctions on profit of sanctioned firms in the full and restricted samples, respectively. The dependent variable is log firm profit. The estimated coefficients with 95% confidence interval based on standard errors clustered at the industry-year level are from two-way linear fixed effects regressions. Each line is normalized to equal zero in the pre-sanctions year 2011 via a parallel shift upwards or downwards. Sample contains between 54,324-56,183 firms over 2009-2013.

Figure 4: Event Plot - Total Revenue



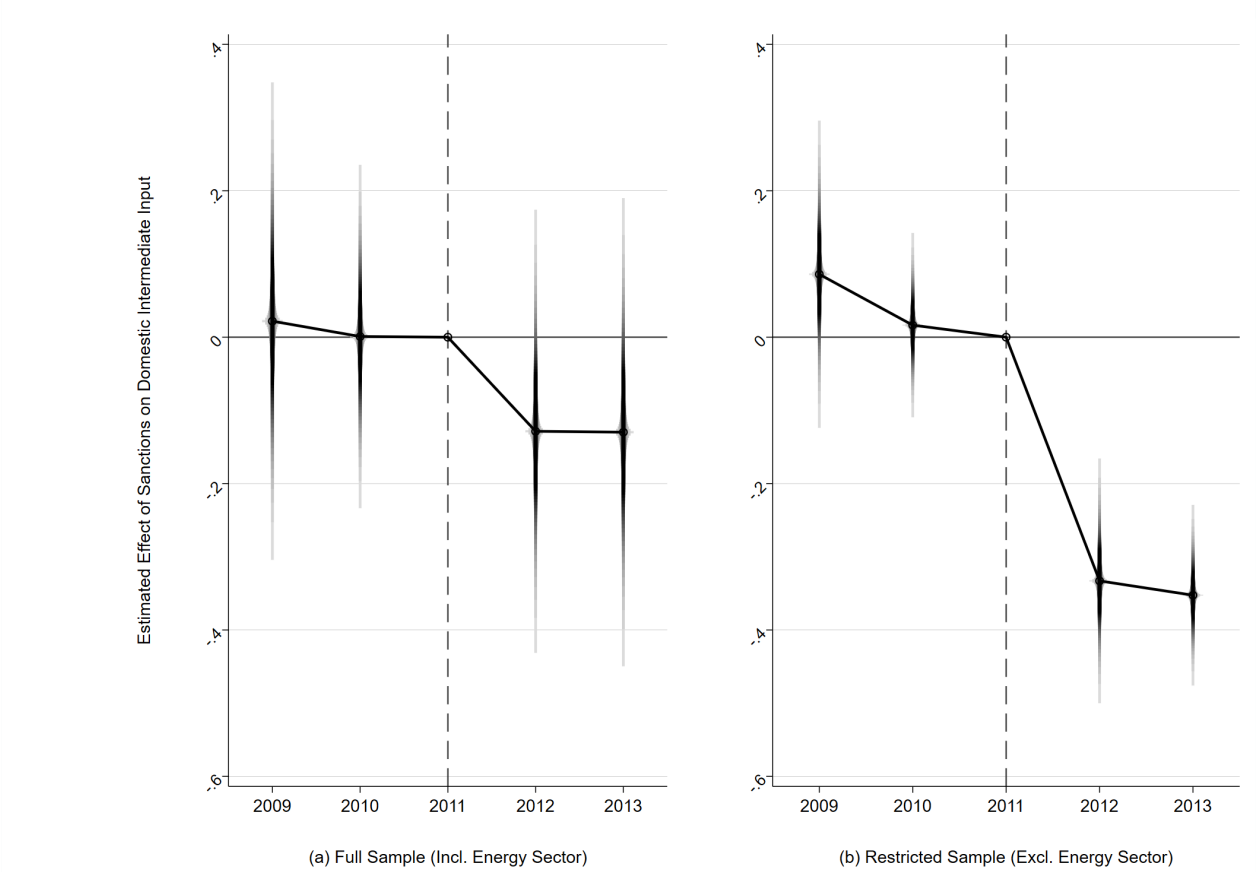
Notes: Figures 4a and 4b plot estimated effects of sanctions on total revenue of sanctioned firms in the full and restricted samples, respectively. The dependent variable is log firm total revenue. The estimated coefficients with 95% confidence interval based on standard errors clustered at the industry-year level are from two-way linear fixed effects regressions. Each line is normalized to equal zero in the pre-sanctions year 2011 via a parallel shift upwards or downwards. Sample contains between 62,015-64,201 firms over 2009-2013.

Figure 5: Event Plot - Domestic Revenue



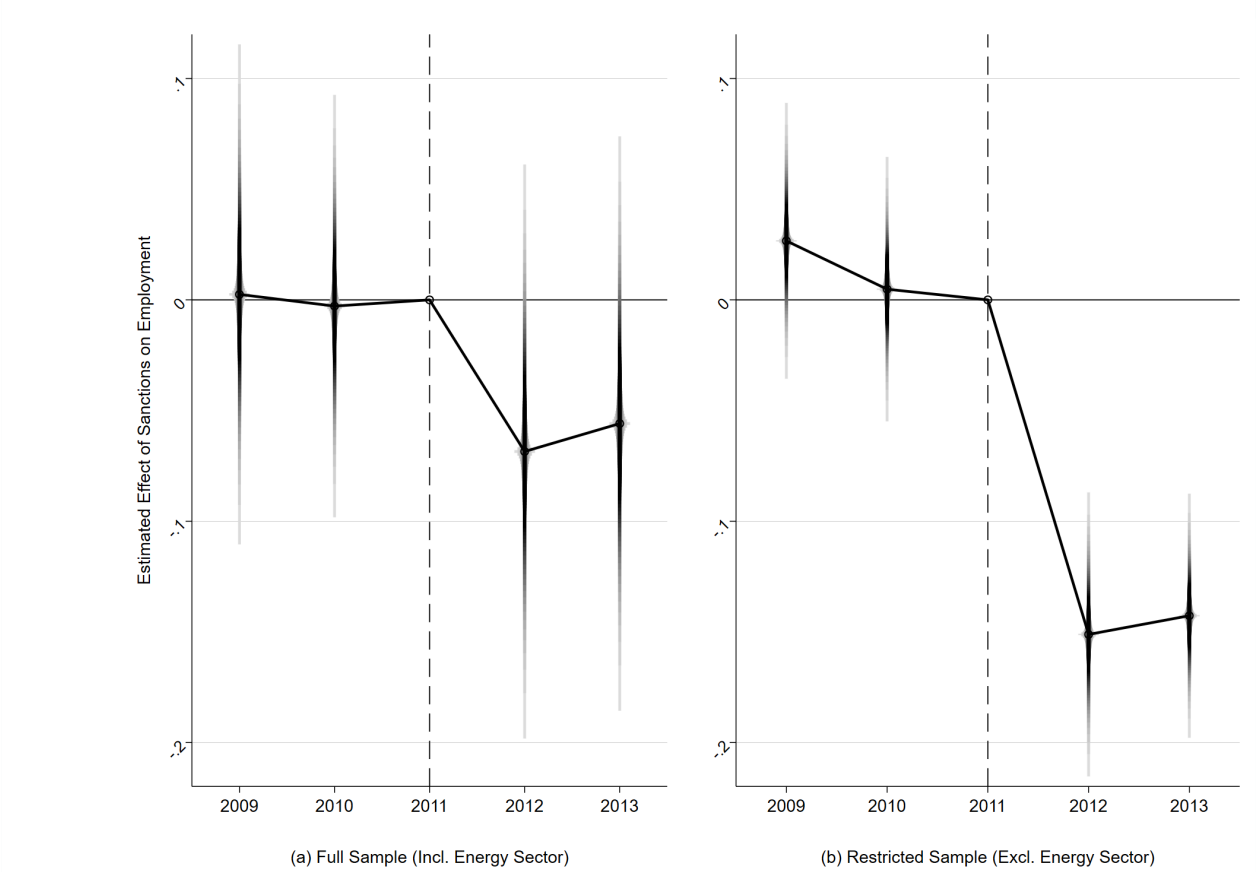
Notes: Figure 5a and 5b plot estimated effects of sanctions on domestic revenue of sanctioned firms in the full and restricted samples, respectively. The dependent variable is log firm domestic revenue. The estimated coefficients with 95% confidence interval based on standard errors clustered at the industry-year level are from two-way linear fixed effects regressions. Each line is normalized to equal zero in the pre-sanctions year 2011 via a parallel shift upwards or downwards. Sample contains between 61,761-63,914 firms over 2009-2013.

Figure 6: Event Plot - Domestic Input



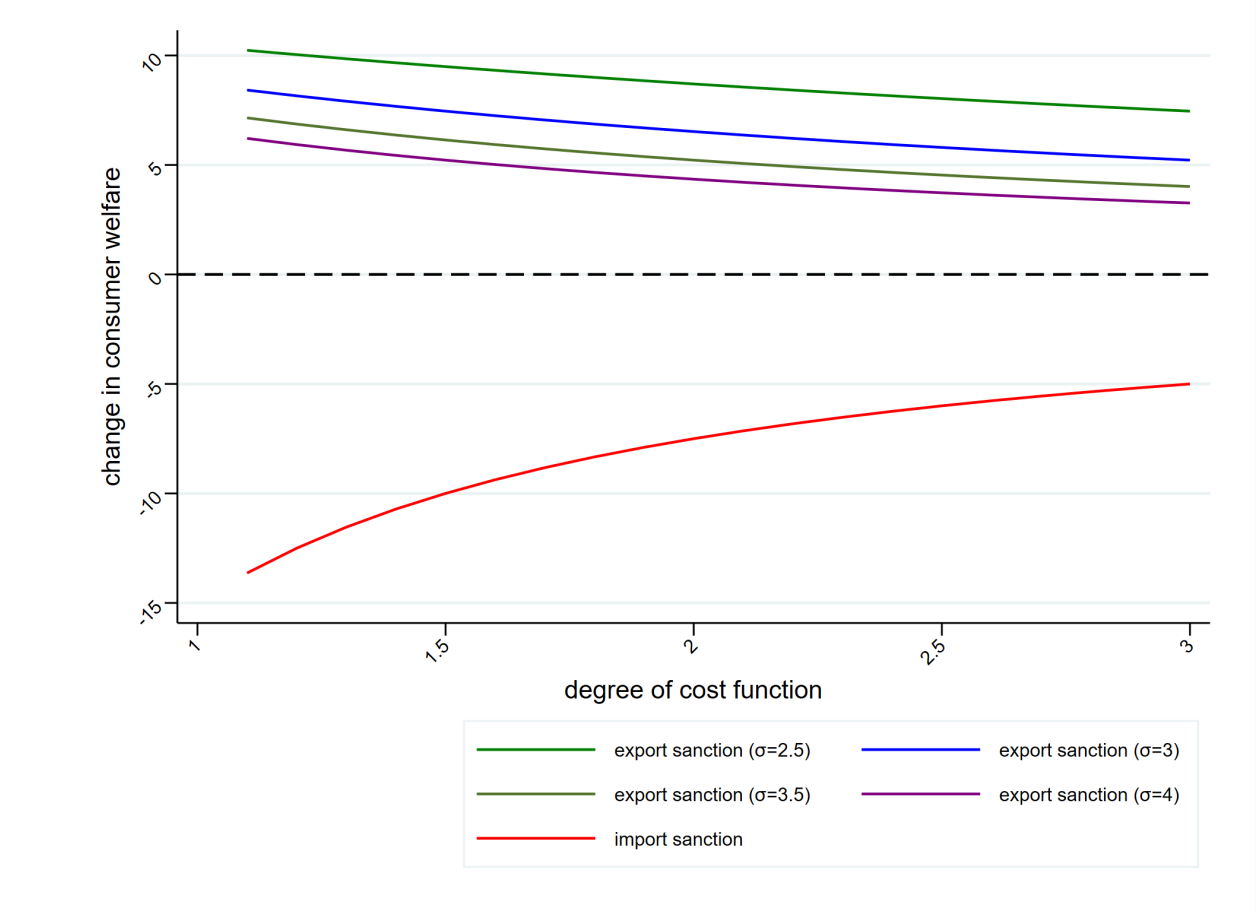
Notes: Figure 6a and 6b plot estimated effects of sanctions on domestic intermediate input of sanctioned firms in the full and restricted samples, respectively. The dependent variable is log firm domestic input. The estimated coefficients with 95% confidence interval based on standard errors clustered at the industry-year level are from two-way linear fixed effects regressions. Sample contains between 64,883-67,091 firms over 2009-2013.

Figure 7: Event Plot - Employment



Notes: Figure 7a and 7b plot estimated effects of sanctions on employment of sanctioned firms in the full and restricted samples, respectively. The dependent variable is log firm employment level. The estimated coefficients with 95% confidence interval based on standard errors clustered at the industry-year level are from two-way linear fixed effects regressions. Sample contains between 65,062-67,281 firms over 2009-2013.

Figure 8: Sensitivity Analysis - Changes in Aggregate Consumer Welfare



Notes: Figure shows the negative relationship between the degree of cost function γ and the impacts of sanctions through export and import channels on aggregate consumer welfare. Further, with higher elasticity of substitution between goods, lower σ, the positive impacts of adverse trade shocks on consumer welfare through export channels is larger. In contrast, effects through import channels are not sensitive to the changes in the elasticity of substitution.

A TFP estimation

To construct a measure of firm-level total factor productivity (TFP), I follow the methodology of Ackerberg et al. (2015), which corrects for a functional dependence problem in production function estimation techniques introduced by Olley and Pakes (1992) and Levinsohn and Petrin (2003). Ackerberg et al. (2015) introduces an alternative estimation that inverts input demand functions conditional on labor input, while OP/LP input demand functions are unconditional.[26] Using the Ackerberg et al. (2015) method for LP intermediate input function, firm's raw material inputs are used as a proxy for unobserved productivity shocks to correct for simultaneity in the production function. I assume a Cobb–Douglas production function for each industry. Due to the small number of firms at four-digit industry levels, the production function parameters were estimated for two-digit ISIC industry levels. Therefore, for each two-digit industry level, I estimate the following equation:

$$y_{ijt} = \beta_0 + \beta_1 l^S_{ijt} + \beta_2 l^U_{ijt} + \beta_3 k_{ijt} + \omega_{ijt} + \epsilon_{ijt}$$

where y denotes value-added, l^S denotes skilled labor, l^U denotes unskilled labor, and k denotes capital. All variables are in natural logarithm form. The simultaneity problem arises from the time-varying firm-specific productivity level, ω_{ijt}, which may be correlated with the firm's inputs. If the demand function of intermediate input, m, is strictly monotonic in firm's productivity of all level of capital, $m_{ijt} = f_t(k_{ijt}, l^S_{ijt}, l^U_{ijt}, \omega_{ijt})$, then intermediate input m_{ijt} serves as a valid proxy. Inverting the raw materials demand function gives an expression for productivity as a function of capital and other firm-level inputs: $\omega_{ijt} = f_t^{-1}(k_{ijt}, l^S_{ijt}, l^U_{ijt}, m_{ijt})$. Substituting this expression in the value-added equation, I estimate the coefficients on the variable inputs using semi-parametric techniques. In a second stage, the coefficients on the firm's inputs are estimated using GMM techniques to identify assumptions. Productivity follows a Markov process, and capital adjusts to productivity with a lag.

B Proofs

B.1 Proposition 1

Import sanctions decrease importing firms' revenue by reducing firm-level productivity.

Proof.

[26] See Ackerberg et al. (2015) for a detailed discussion of the methodology.

Firm-level productivity is an increasing function of imported intermediate inputs. Import sanctions reduce firm-level productivity by restricting firms' access to the imported intermediaries. Therefore, the impact of import sanctions comes through the decrease in firm-level productivity.

Plugging the optimal price $p_H^*(\varphi)$, given by equation (14), into the aggregate price index, yields:

$$\begin{aligned} P_H &= \left[\int p_H^*(\varphi)^{1-\sigma} M_M \mu(\varphi) d\varphi\right]^{\frac{1}{1-\sigma}} \\ &= \left(\frac{\sigma-1}{2\sigma}\right)^{\frac{-1}{2}} Y_H^{\frac{1}{2}} M_M^{\frac{\sigma+1}{2(1-\sigma)}} \tilde{\varphi}^{\frac{-1}{2}} \end{aligned} \tag{33}$$

where $\mu(\varphi)$ is the productivity distribution and the average productivity is $\tilde{\varphi} = \left[\int \varphi^{1-\sigma} \mu(\varphi) d\varphi\right]^{\frac{1}{1-\sigma}}$. Plugging the aggregate price index above into equation (16), gives:

$$r_H^*(\varphi) = \left(\frac{\varphi}{\tilde{\varphi}}\right)^{\frac{\sigma-1}{\sigma+1}} Y_H . \frac{1}{M_M} \tag{34}$$

because $\frac{\delta(\frac{\varphi}{\tilde{\varphi}})}{\delta\varphi} > 0$, considering no changes in Y_H and M_M, we get $\frac{\delta r_H^*(\varphi)}{\delta\varphi} > 0$.

The revenue of an importing firm depends on the ratio of its productivity relative to the average productivity of the firms. The ratio of an importing firm relative to the average productivity decreases as import sanctions reduce firms' productivity, which results in lower revenue for an importing firm.

Also, by plugging the above aggregate price index into equation (15), we get:

$$q_H^*(\varphi) = \left(\frac{\sigma-1}{2\sigma}\right)^{\frac{1}{2}} Y_H^{\frac{1}{2}} M_M^{\frac{1}{2}} \tilde{\varphi}^{\frac{1}{2}} \left(\frac{\varphi}{\tilde{\varphi}}\right)^{\frac{\sigma}{(\sigma+1)}} \tag{35}$$

Taking derivatives with respect to φ:

$$\begin{aligned} \frac{\delta q_H^*(\varphi)}{\delta\varphi} = &\left(\frac{\sigma-1}{2\sigma}\right)^{\frac{1}{2}} Y_H^{\frac{1}{2}} \left(\frac{1}{2} - \frac{\sigma}{\sigma+1}\right) M_M^{\frac{1}{2}} \varphi^{\frac{\sigma}{\sigma+1}} \tilde{\varphi}^{\frac{-\sigma}{\sigma+1}-\frac{1}{2}} \frac{\delta\tilde{\varphi}}{\delta\varphi} + \\ &\left(\frac{\sigma-1}{2\sigma}\right)^{\frac{1}{2}} Y_H^{\frac{1}{2}} \left(\frac{\sigma}{\sigma+1}\right) M_M^{\frac{1}{2}} \varphi^{\frac{-1}{\sigma+1}} \tilde{\varphi}^{\frac{1}{2}-\frac{\sigma}{\sigma+1}} + \\ &\left(\frac{\sigma-1}{2\sigma}\right)^{\frac{1}{2}} Y_H^{\frac{1}{2}} \frac{1}{2} M_M^{\frac{-1}{2}} \varphi^{\frac{\sigma}{\sigma+1}} \tilde{\varphi}^{\frac{1}{2}-\frac{\sigma}{\sigma+1}} \frac{\delta M_M}{\delta\varphi} \end{aligned} \tag{36}$$

Import sanctions increase the cutoff productivity (see section 5.1.3); therefore, the number of firms in the market will be lower under the import sanctions when firm-level productivity decreases, $\frac{\delta M_M}{\delta\varphi} > 0$. In

addition, the decrease in firm-level productivity among importing firms reduces average productivity in the market. Therefore, import sanctions decrease the production of importing firms, $\frac{\delta q_H^*(\varphi)}{\delta \varphi} > 0$, by reducing firm-level productivity.

B.2 Proposition 2

Export sanctions reduce firms' export and increase exporting firms' domestic sales in the presence of capacity constraints.

Proof.

From equation (23), we get the following relationship between domestic sales and export values:

$$\frac{r_H(\varphi)}{r_F(\varphi)} = \left[\frac{1}{\alpha_X} \frac{P_H^{\sigma-1} Y_H}{P_F^{\sigma-1} Y_F}\right]^{\sigma} \tag{37}$$

Export sanctions reduce α_X; considering no changes in aggregate prices and incomes in home and foreign markets, it is easy to see that domestic revenue increases relative to foreign revenue $\frac{r_H(\varphi)}{r_F(\varphi)}$ increases. However, the home country's aggregate price index changes because I assumed increasing marginal costs for the firms. In fact, the export sanctions increase the aggregate home price index (see the proof of Proposition 3). An increase in the aggregate home price, combined with a decrease in firms' foreign demand of the firms, increases an exporting firm's domestic sales relative to its exports.

Optimal demand for a firm's products in the home country can be written as:

$$q_H(\varphi) = \left(P_H^{\sigma-1} Y_H\right)^{\frac{1}{\sigma+1}} \left(\frac{\sigma-1}{2\sigma}\right)^{\frac{\sigma}{\sigma+1}} \varphi^{\frac{\sigma}{\sigma+1}} \Psi^{\frac{-\sigma}{\sigma+1}} \tag{38}$$

where $\Psi \equiv \left[1 + \left(\frac{1}{\alpha_X} \frac{P_H^{\sigma-1} Y_H}{P_F^{\sigma-1} Y_F}\right)^{-\sigma}\right]$. Next, I take derivatives with respect to α_X:

$$\begin{aligned} \frac{\delta q_H(\varphi)}{\delta \alpha_X} = {} & Y_H^{\frac{1}{\sigma+1}} \left(\frac{\sigma-1}{2\sigma}\right)^{\frac{\sigma}{\sigma+1}} \varphi^{\frac{\sigma}{\sigma+1}} \frac{(\sigma-1)\sigma}{\sigma+1} \Psi^{\frac{-\sigma}{\sigma+1}} P_H^{\frac{\sigma-1}{\sigma+1}-1} \frac{\delta P_H}{\delta \alpha_X} \\ & + Y_H^{\frac{1}{\sigma+1}} \left(\frac{\sigma-1}{2\sigma}\right)^{\frac{\sigma}{\sigma+1}} \varphi^{\frac{\sigma}{\sigma+1}} \frac{\sigma}{\sigma+1} \Psi^{\frac{-\sigma}{\sigma+1}-1} P_H^{\frac{\sigma-1}{\sigma+1}} \frac{\delta \Psi}{\delta \alpha_X} \end{aligned} \tag{39}$$

It is easy to see that the term Ψ decreases when the demand in the foreign market reduces, $\frac{\delta \Psi}{\delta \alpha_X} > 0$. Furthermore, the aggregate home price index decreases due to export sanctions, $\frac{\delta P_H}{\delta \alpha_X} > 0$ (see the proof

of Proposition 3). Therefore, I get $\frac{\delta q_H(\varphi)}{\delta \alpha_X} < 0$, showing that the domestic production of exporting firms increases when they are subject to export sanctions, and when they face a negative demand shock in their export markets, α_X decreases.

Proposition 3

Import sanctions reduce aggregate consumer welfare, while export sanctions increase aggregate consumer welfare in the presence of capacity constraints.

Proof. *Import sanctions reduce aggregate consumer welfare.*

Expressing the changes in the aggregate welfare in equation (29), here, I explain the changes in the aggregate home price index under sanctions to find the impacts on the welfare. For import sanctions, I take derivatives with respect to φ from equation (33):

$$\frac{\delta P_H}{\delta \varphi} = \left(\frac{\sigma-1}{2\sigma}\right)^{\frac{-1}{2}} Y_H^{\frac{1}{2}} \left[\frac{\sigma+1}{2(1-\sigma)} \tilde{\varphi}^{\frac{-1}{2}} M_M^{\frac{\sigma+1}{2(1-\sigma)}-1} \frac{\delta M_M}{\delta \varphi} - \frac{1}{2} M_M^{\frac{\sigma+1}{2(1-\sigma)}} \tilde{\varphi}^{\frac{-3}{2}} \frac{\delta \tilde{\varphi}}{\delta \varphi}\right] < 0 \tag{40}$$

Import sanctions increase the cutoff productivity (see section 5.1.3); thus, the number of firms in the market will be lower under the import sanctions when firm-level productivity decreases, $\frac{\delta M_M}{\delta \varphi} > 0$. Therefore, import sanctions increase the aggregate home price index, $\frac{\delta P_H}{\delta \varphi} < 0$, and by increasing the aggregate home price, the aggregate welfare decreases.

Proof. *Export sanctions increase aggregate consumer welfare.*

To show the changes in the aggregate welfare in equation (29) due to export sanctions, I first yield the following aggregate home price index by plugging in the optimal price from equation (19):

$$\begin{aligned} P_H &= \left[\int p_H(\varphi)^{1-\sigma} M_X \mu(\varphi) d\varphi\right]^{\frac{1}{1-\sigma}} \\ &= M_X^{\frac{1+\sigma}{2(1-\sigma)}} (\frac{2\sigma}{\sigma-1})^{\frac{1}{2}} Y_H^{\frac{1}{2}} \Psi^{\frac{1}{2}} \tilde{\varphi}^{\frac{-1}{2}} \end{aligned} \tag{41}$$

where $\Psi \equiv \left[1 + \left(\frac{1}{\alpha_X} \frac{P_H^{\sigma-1} Y_H}{P_F^{\sigma-1} Y_F}\right)^{-\sigma}\right]$. Taking derivatives with respect to α_X:

$$\frac{\delta P_H}{\delta \alpha_X} = \frac{P_H}{M_X}\left(\frac{\sigma+1}{2(1-\sigma)}\right)\frac{\delta M_X}{\delta \alpha_X} + \frac{P_H}{\Psi}\frac{1}{2}\frac{\delta \Psi}{\delta \alpha_x} + \frac{P_H}{\tilde{\varphi}}(-\frac{1}{2})\frac{\delta \tilde{\varphi}}{\delta \alpha_X} \tag{42}$$

Export sanctions increase the cutoff productivity level (see section 5.1.3); thus, the number of firms in the market will be lower, $\frac{\delta M_X}{\delta \alpha_X} > 0$. Additionally, by increasing the cutoff productivity level, firms' average productivity increases, $\frac{\delta \tilde{\varphi}}{\delta \alpha_X} < 0$. Furthermore, the term Ψ decreases when the direct impact of sanctions exceeds the indirect impact of sanctions through the changes in the aggregate prices. In other words, the impacts through the decrease in demand in the foreign market α_X dominate the impact through the aggregate home price P_H. Therefore, export sanctions reduce the term Ψ, and we have $\frac{\delta \Psi}{\delta \alpha_X} > 0$. Thus, export sanctions, by decreasing α_X, decrease aggregate home price, $\frac{\delta P_H}{\delta \alpha_X} > 0$, and increase the aggregate welfare, assuming a quadratic cost function.

Proposition 4

Higher capacity constraints diminish negative impacts of trade sanctions through import channels and diminish positive effects through export channels.

Proof.

Here, instead of assuming a quadratic cost function, I take a general case:

$$C(q_H(\varphi), q_F(\varphi)) = \frac{1}{\varphi}\left(q_H(\varphi) + q_F(\varphi)\right)^{\gamma} \tag{43}$$

Maximizing the profit of importing firms, assuming no exports, I yield the following optimal price:

$$p_H^*(\varphi) = \left(\frac{\sigma-1}{\sigma}\right)^{\frac{-1}{(\gamma-1)\sigma+1}} \gamma^{\frac{1}{(\gamma-1)\sigma+1}} \varphi^{\frac{-1}{(\gamma-1)\sigma+1}} P_H^{\frac{(\gamma-1)(\sigma-1)}{(\gamma-1)\sigma+1}} Y_H^{\frac{\gamma-1}{(\gamma-1)\sigma+1}} \tag{44}$$

Given the optimal price, each firm's output is:

$$q_H^*(\varphi) = \left(\frac{\sigma-1}{\sigma}\right)^{\frac{\sigma}{(\gamma-1)\sigma+1}} \gamma^{\frac{-\sigma}{(\gamma-1)\sigma+1}} \varphi^{\frac{\sigma}{(\gamma-1)\sigma+1}} P_H^{\frac{\sigma-1}{(\gamma-1)\sigma+1}} Y_H^{\frac{1}{(\gamma-1)\sigma+1}} \tag{45}$$

Plugging the optimal price $p_H^*(\varphi)$, into the aggregate price index, I yield:

$$
\begin{aligned}
P_H &= \left[\int p_H^*(\varphi)^{1-\sigma} M_M \mu(\varphi) d\varphi\right]^{\frac{1}{1-\sigma}} \\
&= \left(\frac{\sigma-1}{\sigma}\right)^{\frac{-1}{\gamma}} \gamma^{\frac{1}{\gamma}} Y_H^{\frac{\gamma-1}{\gamma}} M_M^{\frac{(\gamma-1)\sigma+1}{\gamma(1-\sigma)}} \tilde{\varphi}^{\frac{-1}{\gamma}}
\end{aligned}
\tag{46}
$$

For simplicity's sake, I assume that the number of firms in the market M_M does not change due to import sanctions, and that the changes in the aggregate home price depend only on the changes in average productivity $\tilde{\varphi}$. Taking derivatives with respect to φ, I get:

$$
\frac{\delta P_H}{\delta \varphi} = -\frac{1}{\gamma} \frac{P_H}{\tilde{\varphi}} \frac{\delta \tilde{\varphi}}{\delta \varphi} < 0 \tag{47}
$$

because $\frac{\delta \tilde{\varphi}}{\delta \varphi} > 0$, then $\frac{\delta P_H}{\delta \varphi} < 0$; thus, import sanctions increase the aggregate home price. Taking derivatives with respect to γ from the above equation, I yield:

$$
\frac{\delta\left(\frac{\delta P_H}{\delta \varphi}\right)}{\delta \gamma} = \frac{1}{\gamma^2} \frac{P_H}{\tilde{\varphi}} \frac{\delta \tilde{\varphi}}{\delta \varphi} > 0 \tag{48}
$$

Therefore, as firms face higher capacity constraints (i.e., larger γ), the negative impact of import sanctions on aggregate welfare declines.

Proof. *Higher capacity constraints diminish positive effects through export channels.*

Again, by assuming the general cost function in equation (43) and by maximizing the profit of exporting firms, I yield the following optimal price:

$$
p_H(\varphi) = \left(\frac{\sigma-1}{\sigma}\right)^{\frac{-1}{(\gamma-1)\sigma+1}} \gamma^{\frac{1}{(\gamma-1)\sigma+1}} \varphi^{\frac{-1}{(\gamma-1)\sigma+1}} \Psi^{\frac{\gamma-1}{(\gamma-1)\sigma+1}} \left(P_H^{\sigma-1} Y_H\right)^{\frac{1}{(\gamma-1)\sigma+1}} \tag{49}
$$

where $\Psi \equiv \left[1 + \left(\frac{1}{\alpha_X} \frac{P_H^{\sigma-1} Y_H}{P_F^{\sigma-1} Y_F}\right)^{-\sigma}\right]$. Given the optimal price in the domestic market, each firm's domestic output is:

$$
q_H(\varphi) = \left(\frac{\sigma-1}{\sigma}\right)^{\frac{\sigma}{(\gamma-1)\sigma+1}} \gamma^{\frac{-\sigma}{(\gamma-1)\sigma+1}} \varphi^{\frac{\sigma}{(\gamma-1)\sigma+1}} \Psi^{\frac{(1-\gamma)\sigma}{(\gamma-1)\sigma+1}} \left(P_H^{\sigma-1} Y_H\right)^{\frac{1}{(\gamma-1)\sigma+1}} \tag{50}
$$

Plugging the optimal price $p_H(\varphi)$, into the aggregate home price index, I yield:

$$P_H = (\frac{\sigma-1}{\sigma})^{\frac{-1}{\gamma\sigma-2\sigma+2}} \gamma^{\frac{1}{\gamma\sigma-2\sigma+2}} \tilde{\varphi}^{\frac{-1}{\gamma\sigma-2\sigma+2}} \Psi^{\frac{1}{\gamma\sigma-2\sigma+2}} Y_H^{\frac{1}{\gamma\sigma-2\sigma+2}} M_X^{\frac{(\gamma-1)\sigma+1}{(1-\sigma)(\gamma\sigma-2\sigma+2)}} \tag{51}$$

For simplicity's sake, I assume that the mass of firms in the market M_X does not change due to import sanctions, and that the changes in the aggregate home price depend only on the changes in average productivity $\tilde{\varphi}$, and the term Ψ. Taking derivatives with respect to α_X, I get:

$$\frac{\delta P_H}{\delta \alpha_X} = \left(\frac{1}{\gamma\sigma-2\sigma+2}\right)\left(\frac{P_H}{\Psi}.\frac{\delta\Psi}{\delta\alpha_X} - \frac{P_H}{\tilde{\varphi}}.\frac{\delta\tilde{\varphi}}{\delta\alpha_X}\right) \tag{52}$$

Because $\frac{\delta\Psi}{\delta\alpha_X} > 0$ and $\frac{\delta\tilde{\varphi}}{\delta\alpha_X} < 0$, export sanctions increase the aggregate home price, $\frac{\delta P_H}{\delta\alpha_X} > 0$, as $\gamma \geq 2$, showing a decrease in the aggregate home price due to export sanctions.

Taking derivatives with respect to γ from the above equation, I obtain:

$$\frac{\delta\left(\frac{\delta P_H}{\delta\alpha_X}\right)}{\delta\gamma} = \frac{\sigma}{(\gamma\sigma-2\sigma+2)^2}\left(\frac{P_H}{\tilde{\varphi}}.\frac{\delta\tilde{\varphi}}{\delta\alpha_X} - \frac{P_H}{\Psi}.\frac{\delta\Psi}{\delta\alpha_X}\right) < 0 \tag{53}$$

Therefore, as firms face higher capacity constraints (i.e., larger γ), the positive impact of sanctions on aggregate welfare through export channels declines.

C Tables

Table C.1: Robustness Check: Matching Estimations

Dep var are in log		Profit$_{i,t}$	Total Rev$_{i,t}$	Domestic Rev$_{i,t}$	Domestic inputs$_{i,t}$	Employment$_{i,t}$
Panel A: All Firms						
ATE	Sanctions$_{jt}$	-0.083	-0.119***	-0.109***	-0.135***	-0.022
		(0.051)	(0.030)	(0.032)	(0.044)	(0.021)
Obs		40861	42679	42620	42958	42957
Panel B: Excl. Energy Firms						
ATE	Sanctions$_{jt}$	-0.288***	-0.281***	-0.204***	-0.182***	-0.043**
		(0.069)	(0.051)	(0.054)	(0.068)	(0.021)
Obs		39478	41223	41169	41497	41493

Notes: Robust standard errors in parentheses. ATE is the average treatment effect over sanction cohorts, using the nearestneighbor matching on lagged log of revenue and lagged log employment. The sample is restricted to firms that report some data prior to 2012. Matching reduces the mean difference by order of magnitude. The ATE indicates that, even between matched pairs, the impact of sanctions is to decrease the relative performance of sanctioned firms. For all performance measures, the ATEs are statistically significant at the 5% level in the restricted sample, and the magnitudes are in line with my baseline results reported in Table (4).
Significance levels: * 10%, ** 5%, *** 1%

Table C.2: Downstream and Upstream Sanction Exposure

	Mean/SD	Median	Min	Max
First-order indirect exposure:				
Downstream exposure	0.057	0.013	0	0.489
	(0.115)			
Upstream exposure	0.176	0.158	0	0.591
	(0.186)			
Full (higher-order) indirect exposure:				
Downstream exposure	0.252	0.033	0	1.96
	(0.523)			
Upstream exposure	0.542	0.361	0.09	2.05
	(0.563)			

Table C.3: Heterogeneous Impacts on Exporting Firms (Excl. Importing Firms)

Dep var are in log	$\text{Profit}_{i,t}$	$\text{Total Rev}_{i,t}$	$\text{Domestic Rev}_{i,t}$	$\text{Domestic inputs}_{i,t}$	$\text{Employment}_{i,t}$
Panel A: All Firms					
Sanctions_{jt}	-0.187*	-0.164**	-0.168**	-0.161	-0.088**
	(0.111)	(0.078)	(0.077)	(0.144)	(0.044)
Below Median Exporters * Sanctions_{jt}	-0.099	-0.006	-0.003	0.058	0.109
	(0.190)	(0.209)	(0.209)	(0.249)	(0.081)
Above Median Exporters * Sanctions_{jt}	-0.137	0.220	0.448***	0.112	0.141***
	(0.176)	(0.143)	(0.131)	(0.186)	(0.045)
Obs	27233	32084	31952	33784	33903
Adjusted R-squared	0.633	0.775	0.762	0.732	0.876
Firm FEs + Year FEs	✓	✓	✓	✓	✓
Panel B: Excl. Energy Firms					
Sanctions_{jt}	-0.320***	-0.275***	-0.276***	-0.452***	-0.194***
	(0.103)	(0.054)	(0.053)	(0.107)	(0.022)
Below Median Exporters * Sanctions_{jt}	-0.010	0.041	0.066	0.179	0.182
	(0.215)	(0.213)	(0.211)	(0.250)	(0.121)
Above Median Exporters * Sanctions_{jt}	-0.912**	-0.154	-0.039	0.180	0.064
	(0.397)	(0.338)	(0.344)	(0.229)	(0.066)
Obs	26312	30969	30857	32658	32772
Adjusted R-squared	0.618	0.766	0.754	0.724	0.872
Firm FEs + Year FEs	✓	✓	✓	✓	✓

Notes: In all regressions, I include firm and year fixed effects. Robust standard errors are corrected for clustering at the industry-year level in parentheses. Dependent variables are in log values. Exporting firms are divided into two groups based on whether they export shares above or below median before the sanctions. Importing firms are excluded from the sample. Panel A presents results with all firms in the sample, and panel B excludes energy firms from the sample.
*Significance levels: * 10%, ** 5%, *** 1%*

Table C.4: Heterogeneous Impacts on Importing Firms (Excl. Exporting Firms)

Dep var are in log	$\text{Profit}_{i,t}$	$\text{Total Rev}_{i,t}$	$\text{Domestic Rev}_{i,t}$	$\text{Domestic inputs}_{i,t}$	$\text{Employment}_{i,t}$
Panel A: All Firms					
Sanctions_{jt}	-0.163	-0.166**	-0.164**	-0.166	-0.090**
	(0.113)	(0.077)	(0.076)	(0.137)	(0.044)
Below Median Importers * Sanctions_{jt}	-0.183	-0.064	-0.063	-0.105	-0.032
	(0.121)	(0.080)	(0.082)	(0.083)	(0.032)
Above Median Importers * Sanctions_{jt}	-0.196	0.045	0.046	0.145	0.024
	(0.138)	(0.082)	(0.083)	(0.125)	(0.037)
Obs	42542	49533	49523	51523	51626
Adjusted R-squared	0.595	0.769	0.767	0.722	0.879
Firm FEs + Year FEs	✓	✓	✓	✓	✓
Panel B: Excl. Energy Firms					
Sanctions_{jt}	-0.296***	-0.278***	-0.273***	-0.456***	-0.196***
	(0.111)	(0.053)	(0.051)	(0.088)	(0.021)
Below Median Importers * Sanctions_{jt}	-0.104	-0.028	-0.032	0.037	0.032
	(0.157)	(0.091)	(0.093)	(0.084)	(0.021)
Above Median Importers * Sanctions_{jt}	-0.065	0.142*	0.144*	0.323**	0.079**
	(0.125)	(0.079)	(0.080)	(0.127)	(0.037)
Obs	41521	48235	48225	50216	50313
Adjusted R-squared	0.595	0.767	0.765	0.718	0.879
Firm FEs + Year FEs	✓	✓	✓	✓	✓

Notes: In all regressions, I include firm and year fixed effects. Robust standard errors are corrected for clustering at the industry-year level in parentheses. Dependent variables are in log values. Importing firms are divided into two groups based on whether they import shares above or below median before the sanctions. Exporting firms are excluded from the sample. Firms in the energy sector are excluded. Panel A presents results with all firms in the sample, and panel B excludes energy firms from the sample.
Significance levels: * 10%, ** 5%, *** 1%

Table C.5: Employment Adjustment in Production Line

Dep var are in log	Unskilled workers$_{i,t}$	Skilled workers$_{i,t}$	Engineers$_{i,t}$	Technicians$_{i,t}$
		Full Sample		
Sanctions$_{jt}$	0.018	-0.130***	-0.043	-0.062*
	(0.038)	(0.043)	(0.034)	(0.037)
Observations	61783	62100	42278	34900
Adjusted R-squared	0.706	0.763	0.802	0.770
Importing channel:				
Sanctions$_{jt}$	-0.024	-0.159***	-0.035	-0.049
	(0.041)	(0.056)	(0.037)	(0.044)
Below Median Importers * Sanctions$_{jt}$	0.043	0.062	-0.027	-0.049
	(0.042)	(0.058)	(0.050)	(0.044)
Above Median Importers * Sanctions$_{jt}$	0.111**	0.051	-0.002	-0.005
	(0.045)	(0.052)	(0.035)	(0.064)
Obs	61783	62100	42278	34900
Adjusted R-squared	0.706	0.763	0.802	0.770
Firm FEs + Year FEs	✓	✓	✓	✓
		Restricted Sample		
Sanctions$_{jt}$	-0.033	-0.220***	-0.103***	-0.126***
	(0.041)	(0.025)	(0.032)	(0.030)
Observations	59773	60071	40538	33489
Adjusted R-squared	0.705	0.759	0.790	0.757
Importing channel:				
Sanctions$_{jt}$	-0.090***	-0.268***	-0.118***	-0.117***
	(0.034)	(0.039)	(0.021)	(0.038)
Below Median Importers * Sanctions$_{jt}$	0.042	0.069	0.034	-0.037
	(0.041)	(0.058)	(0.060)	(0.049)
Above Median Importers * Sanctions$_{jt}$	0.150***	0.098	0.021	0.000
	(0.051)	(0.066)	(0.045)	(0.083)
Obs	59773	60071	40538	33489
Adjusted R-squared	0.705	0.759	0.790	0.757
Firm FEs + Year FEs	✓	✓	✓	✓

Notes: In all regressions, I include firm and year fixed effects. Robust standard errors are corrected for clustering at the industry-year level in parentheses. Dependent variables are in log values. Importing firms are divided into two groups based on whether they import shares above or below median before the sanctions. Firms in the energy sector are excluded.
Significance levels: * 10%, ** 5%, *** 1%

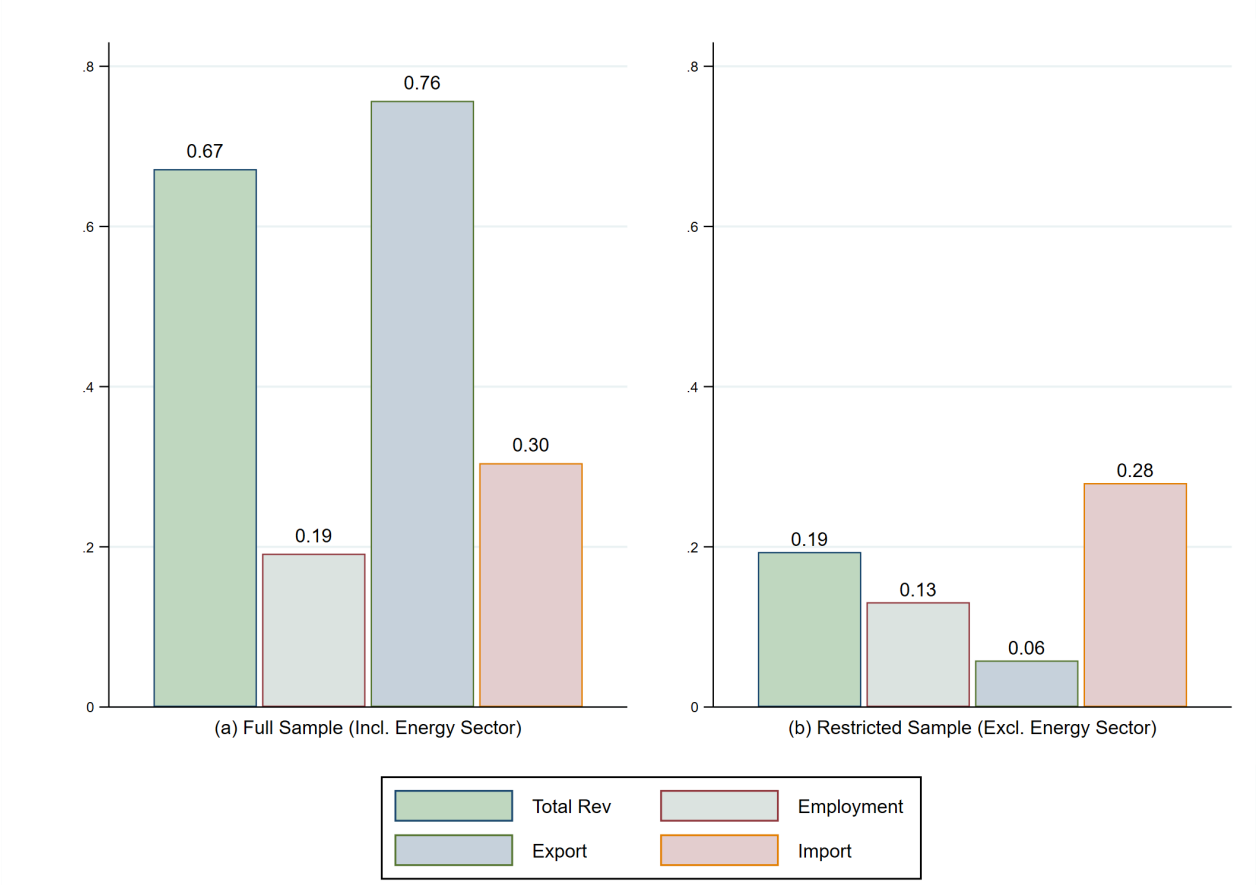
Table C.6: Negative Relationship between Domestic Sales and Exports

Dep var: ln Domestic Sale$_{it}$	Year: 2003-2013		Year: 2009-2013		Year: 2009-2011	
	(1)	(2)	(3)	(4)	(5)	(6)
ln Export$_{it}$	-0.062***	-0.094***	-0.085***	-0.117***	-0.095***	-0.112***
	(0.018)	(0.015)	(0.022)	(0.019)	(0.026)	(0.030)
ln TFP$_{it}$		0.285***		0.261***		0.232***
		(0.025)		(0.027)		(0.030)
Obs	6085	5319	4878	4202	2585	2238
Adjusted R-squared	0.907	0.915	0.908	0.916	0.936	0.934
Firm FEs + Industry-Year FEs	✓	✓	✓	✓	✓	✓

Notes: In all regressions, I include firm and industry-year fixed effects. Robust standard errors are corrected for clustering at the industry-year level in parentheses. The negative relationship between domestic sale and exports were persistent for all the years before the sanctions, suggesting the capacity constraint that Iranian firms faced even before the 2012 sanctions.
Significance levels: * 10%, ** 5%, *** 1%

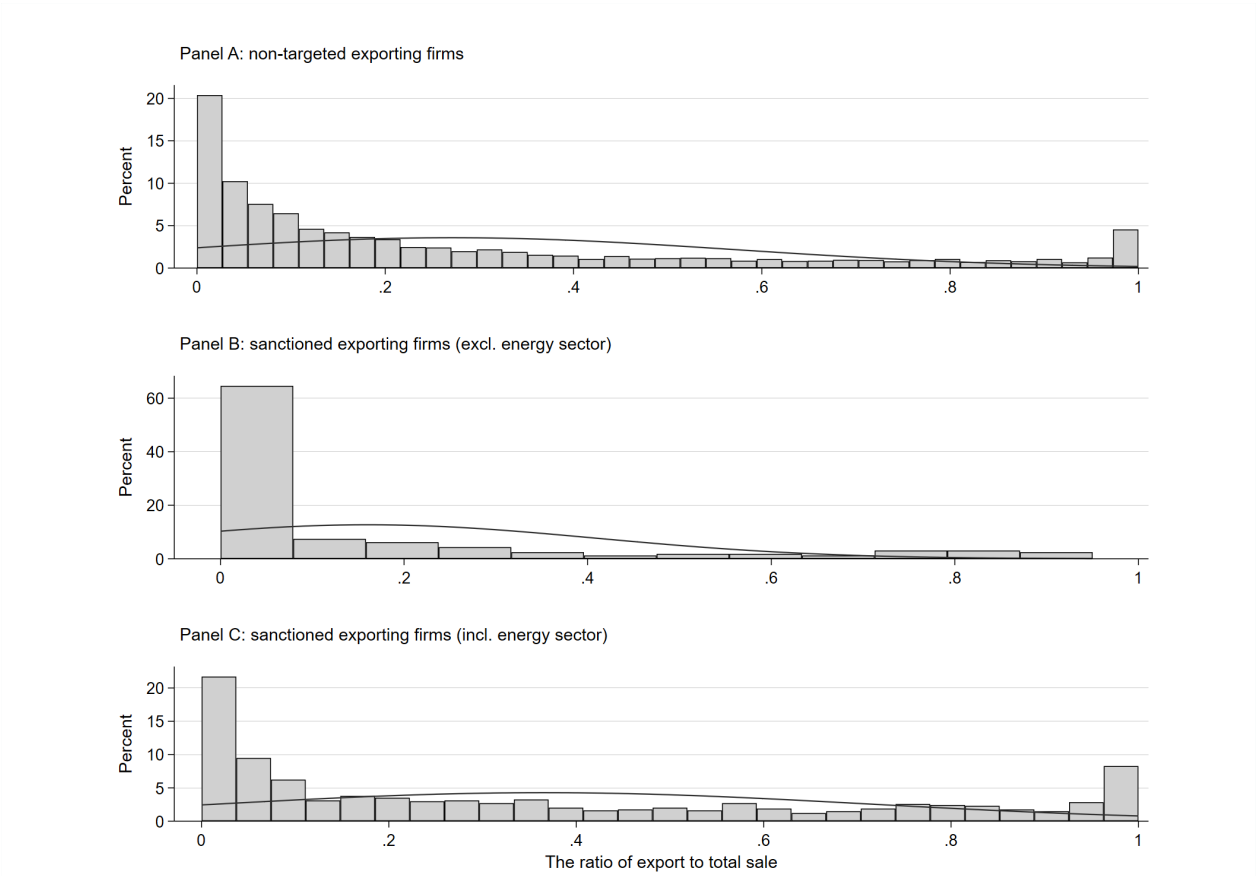
D Figures

Figure D.1: Share of Sanctioned Firms



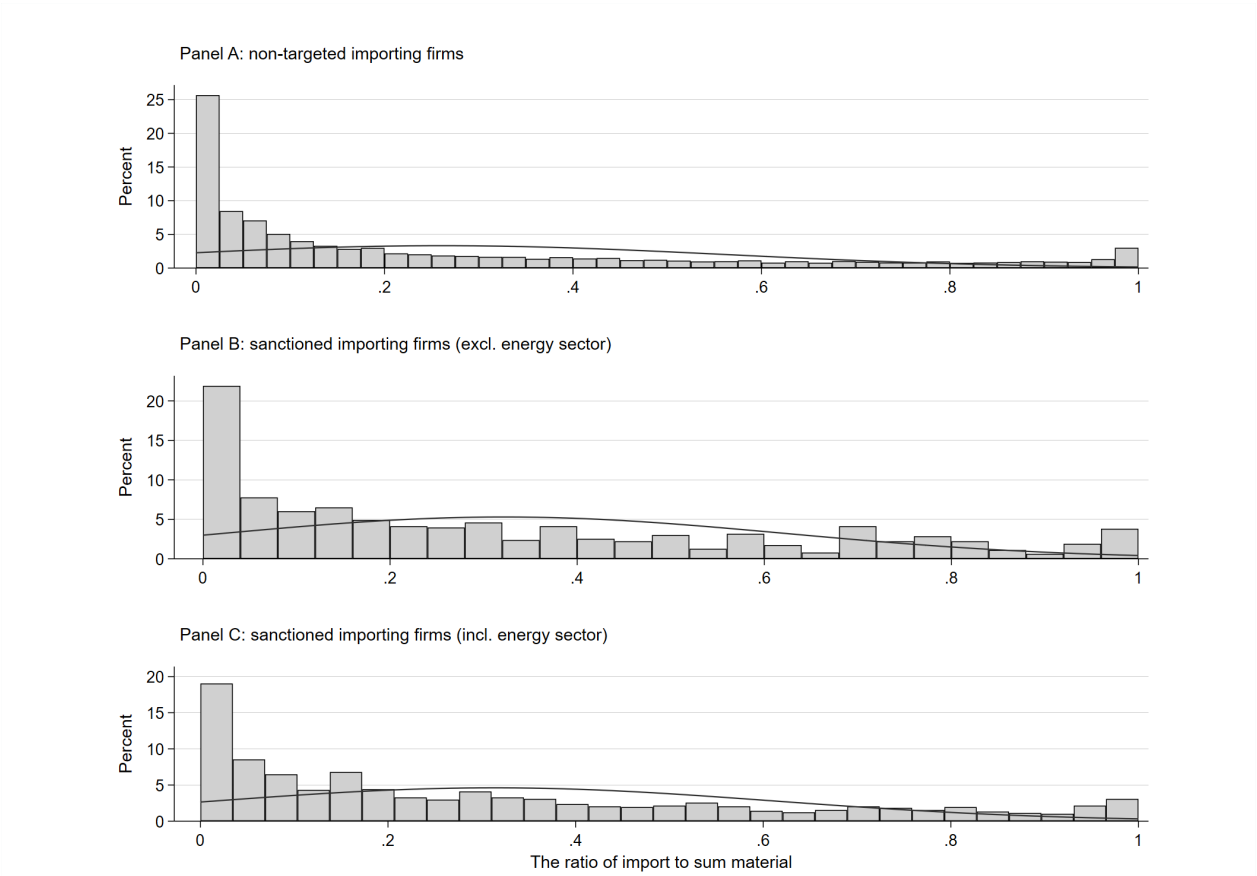
Notes: Figure D.1a and D.1b show revenue, employment, export, and import shares of sanctioned firms in the manufacturing sector in the full and restricted sample, respectively. Comparing two panels, energy sector contributed to the large share of revenue and export of sanctioned industries. However, excluding energy sector, the employment and import share of sanctioned industries did not change significantly.

Figure D.2: Distribution of Export Share



Notes: Figure D.2a, D.2b, and D.2c present distribution of export share across non-targeted firms, targeted firms in the restricted sample, and targeted firms in the full sample. Comparing the panels, targeted firms, including the energy sector, had higher export shares compared to non-targeted firms. However, excluding the energy sector, the mean of distribution moves to the lower export shares.

Figure D.3: Distribution of Import Share



Notes: Figure D.3a, D.3b, and D.3c present distribution of import share across non-targeted firms, targeted firms in the restricted sample, and targeted firms in the full sample. Comparing the panels, targeted firms had higher import shares compared to non-targeted firms. However, excluding the energy sector does not impact the distribution of import share as energy firms were importing very little of their intermediate inputs.