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The repeal of economic sanctions against Iran: Global economic implications and opportunities for the chemical tanker sector

by

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Acknowledgements

The completion of this thesis marks the culmination of my academic career. As I prepare to graduate and begin my professional life, I cannot help but to reflect on the journey I have made which has brought me to this point.

When I first moved to Rotterdam five years ago, I did not have a particular interest in ports or shipping. In fact, I barely knew that studies such as Maritime Economics & Logistics even existed. Fortunately, my time in this perpetually evolving city has helped me to discover my love for the high seas and international trade, which I plan to pursue in the years to come.

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Abstract

Since the late 1970s, the United States has imposed sanctions against Iran for a multitude of reasons. Only in 2006 did the rest of the international community, through the United Nations Security Council, join in sanctioning Iran over growing concerns that its nuclear program was not peaceful. Facing mounting pressure, November 2013 saw the signing of the so-called “Joint Plan of Action” during nuclear talks in Geneva. This agreement between Iran and the P5+1 marks the first legitimate steps that have been taken to halt the imposition of international economic sanctions that have cut Iran off from participating in world trade and has led to the temporary lifting of sanctions against certain goods and services while negotiations are ongoing. Considering this, it is very realistic to assume that the near future will see a complete lifting of international sanctions against Iran. For this reason, this thesis focuses on how the lifting of economic sanctions will affect one of Iran’s most important and growing industries, the petrochemical industry, and in turn the global chemical tanker sector. Through the use of two different models, the gravity model and the global simulation model, this thesis lays the groundwork for quantifying the effects that sanctions have on bilateral trade and projecting future trade flows in the wake of their removal. The results of this thesis indicate that a lifting of sanctions will greatly benefit the Iranian petrochemical industry, as total output will increase by 12 percent. Other countries will suffer losses, such as China and India, which both do not currently abide by the international sanctions and continue to trade heavily with Iran in a restricted market. A shift in trade flows from Iran back towards Western trade partners such as the US and EU are to be expected. Other countries that once enjoyed good trade relations with Iran, such as South Korea and Switzerland, will also benefit from sanctions’ removal. Other than shifts in maritime traffic from Eastbound to Westbound routes, the chemical tanker sector can expect both an increase in utilization and freight rates, thanks to the removal of shipping restrictions on Iranian cargoes and an increase in the global petrochemicals trade. Additionally, the chemical tanker sector will need to rethink its logistics, as restrictions governing the carriage of hazardous goods results in cargoes that may not be allowed to precede other cargoes aboard a ship. Luckily, the majority of Iranian output is made up of relatively “easy” chemicals such as methanol and xylene, which are approved previous cargoes. This will allow for increased opportunities for backhaul cargo carriage, resulting in less ballast legs and greater ton-mileage for the sector. In short, the thesis finds that the lifting of sanctions will benefit both Iran and sanctions-imposing countries while hurting those countries that have taken advantage of an artificially less competitive market. The reopening of the petrochemicals market will also have a positive impact on the chemical tanker sector.

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List of Abbreviations

AVE	Ad valorem equivalent
B/L	Bill of Lading
BRICS	Brazil, Russia, India, China, South Africa
CISADA	Comprehensive Iran Sanctions, Accountability and Divestment Act
CoC	Contract of Carriage
EEA	European Economic Area
EFTA	European Free Trade Area
EO	Executive Order
EU	European Union
FDI	Foreign Direct Investment
FOSFA	Federation of Oil, Seeds and Fats Associations
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GDPPC	Gross Domestic Product Per Capita
GSIM	Global Simulation Model
IAEA	International Atomic Energy Agency
ILSA	Iran & Libya Sanctions Act of 1996
IMO	International Maritime Organization
IRGC	Iran Revolutionary Guard Corps
JPOA	Joint Plan of Action
NAFTA	North American Free Trade Agreement
NPC	National Petrochemical Company
NTB	Non-Tariff Barrier
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
OPEC	Organization of Petroleum Exporting Countries
P&I	Protection & Indemnity
PPML	Poisson Pseudo-Maximum Likelihood
TCE	Trade Cost Equivalent
UNSC	United Nations Security Council
US	United States of America
WITS	World Integrated Trade Solution
WMD	Weapon of Mass Destruction
WTO	World Trade Organization

1 Introduction

Nearly uninterrupted since 1979, the United States has imposed various economic sanctions on the Islamic Republic of Iran (Torbat, 2005). These sanctions have been used in an attempt to influence the policies and behaviors of the Iranian government in response to various allegations of promulgating international terrorism, turning a blind eye to narcotics trafficking and pursuing the development of nuclear weapons. These sanctions call for sweeping bans on imports from and exports destined for Iran (Office of Foreign Assets Control, 2012). In addition, it forbids both directly and indirectly dealing with various Iranian entities that may do business outside of Iran.

With international relations between Iran and the Western world seemingly continuing to worsen, the United Nations also decided to impose its own sanctions against Iran starting in 2006 with the imposition of *Security Council Resolutions 1737*, *1747*, *1803* and *1929* (United Nations, 2013). These resolutions call on all Member States to abide by the sanctions set out, which, similar to those enacted by the United States, aim to prevent the supply, sale or transfer of various goods and knowledge that may help advance Iran's nuclear or other military agendas. Since this time, the European Union (European External Action Service, 2013), Canada (Canadian Ministry of Justice, 2014) and others have abided by and further imposed their own sanctions against Iran.

On the contrary, countries like Brazil, Russia, Turkey, China and India have actively chosen to ignore the sanctions and continue to maintain diplomatic and trade relations with Iran (O'Sullivan, 2010; Van Kemenade, 2010; Takeyh & Maloney, 2011). The fact that these major players have allowed Iran to look elsewhere for the supply of various goods that were formerly provided by the West has served to undermine the power and intended impacts of the currently imposed sanctions. Because of these developments, the political success of these and other sanctions have been debated (O'Sullivan, 2010).

However, there is no denial that Iran's economy has suffered as a result of these sanctions. It is estimated that these sanctions have cost the Iranian economy approximately 780 million dollars per year from the absence of trade with the United States alone (Torbat, 2005). Not only has the Iranian economy suffered, but also citizens of countries that impose sanctions pay a price. By prohibiting trade with another country, the country that imposes sanctions reduces its own welfare by reducing consumer choice. In addition, business in these countries could suffer lost sales opportunities, higher production costs and future competition from local firms that learn to fill the void left after sanctions are imposed (Losman, 1998; Rarick, 2007).

As of January 2014, a dialogue concerning uranium enrichment has begun between the Islamic Republic of Iran and the E3+3 (United States, Russia, China, the United Kingdom, France and Germany), which has lead to a temporary lifting of sanctions on certain products (European Union, 2013; Neuman, 2014). These new developments show the real possibility that global sanctions against Iran have the potential to be completely lifted in the near future. According to Daly et al. (2014), an end to Iranian sanctions would mean that increased supplies of ethylene, polyethylene and methanol, among other petrochemicals, would enter the world market. This change in global supply dynamics may lead to unique opportunities and threats for chemical tanker owners and operators through both an increase in the demand for transport and potential new backhaul possibilities.

1.1 Research Objectives

This research aims to measure the economic impacts of a full worldwide repeal of sanctions against Iran and, more specifically, those sanctions affecting its petrochemical industry. In addition, the research focuses on the effects to the chemical tanker sector, as this sector is predominately responsible for the international transport of petrochemical cargoes. The research therefore aims to determine what the changes will be to the total amount of trade in petrochemicals between Iran and all other countries in the world, with a focus on the changing trade flows between Iran and North America, Europe and Asia. Additionally, the research will aim to identify the effects that removing sanctions will have on current chemical tanker trade lanes. Due to the repeal of sanctions, worldwide production shifts could potentially occur. In the case of trade lanes that either originate or end in Iran, this may lead to new backhaul opportunities. The scope of this research is thus twofold, focusing on both the changes in the quantities of petrochemical cargoes that will be shipped to and from Iran via chemical tankers and the changes in global trade patterns.

As such, the main research question that this research aims to answer is posed as the following:

“What are the potential economic effects of the universal lifting of sanctions against Iran and how will these effects impact on the chemical tanker sector?”

The main idea behind this research question is that the repeal of sanctions against Iran will lead to a noticeable shift in trade patterns for petrochemicals, as a currently closed source of supply will reopen for many markets with large demand (i.e. the United States and the European Union). With this shift in trade patterns, new opportunities for the backhaul of certain cargoes to or from Iran may also present themselves to the chemical tanker market. Considering the complexity and stringency of the regulations

governing chemical tankers, predetermining and exploiting trade lanes is of the utmost importance as to optimize the amount of ton-miles performed. This serves to minimize the number of ballast legs, where no revenues are being earned for a ship. A major shift in the location of supply would therefore be an important development that could have far-reaching ramifications for the chemical tanker sector.

To sufficiently answer this research question, a number of sub-questions must be answered:

"What is the historical and geopolitical context of the sanctions against Iran and what is the outlook for the future?"

"What are the current petrochemical trade flows between Iran and other countries in the rest of the world?"

"How do we define "economic effects" when it comes to measuring potential economic impact?"

1.2 Relevance

As one of the largest petrochemical producing countries in the world, Iran's changing position in global trade leads to undoubtedly substantial effects. The many years of sanctions against Iran lead by the USA, backed by the United Nations and implemented by, among others, the European Union, has closed certain trade lanes off to many Western companies that must abide by the sanctions and third party companies that have feared weakening business relations by going against the Western status quo of economically choking out Iran in order to achieve a nuclear non-proliferation deal. On the other hand, there are other companies from various nations that are not obliged to abide by the sanctions placed on Iran. Many of these companies have been able to benefit from a decreased amount of competition in the world market for buying, transporting and using Iranian goods. In either case, sanctions have made it impossible for Iran to fully participate in the global markets for petrochemicals, amongst other goods and services.

These sanctions have especially taken their toll on the chemical tanker market, since petrochemicals is one of the largest export cargo groups from Iran and these cargoes have been directly targeted by the sanctions.

The current situation regarding The Islamic Republic of Iran is changing rapidly. Since the beginning of 2014, various policy shifts have been communicated to the public or planned for the near future. In January of this year, a six-month window was opened up

in which sanctions against various commodities groups were eased. After six months, these decisions will yet again be reviewed and further action will be decided upon, dependent on the progress made in reaching a deal with the Iranian government concerning its nuclear program. As the future of Iran and the sanctions against it are uncertain, the consequences surrounding them are yet to be known. Considering the potential effects on global trade flows and, derivatively, the chemical tanker sector, it is an important and relevant issue to be researched.

1.3 Research Design and Methodology

This thesis will employ both quantitative and qualitative methods in order to reach conclusions on how the repeal of sanctions against Iran will affect the chemical tanker sector. In line with state-of-the-art work on estimating economic impacts of international policy shocks (Ecorys, 2009; CEPR, 2013), first a gravity model will be used to measure the current effects of sanctions against Iran concerning the trade of petrochemicals by estimating the coefficient of a sanctions-dummy; a friction-variable approach. Incorporating sanctions into the model will result in a benchmark measurement that will serve to quantify non-tariff barriers (NTBs) that affect global trade growth between Iran and its various trade partners. Secondly, the gravity results will be transformed into ad valorem equivalents (AVEs) and fed into a Global Simulation (GSIM) model. This will allow us to determine both the shifts in trade flows and changes in welfare, and output that would take place following the complete removal of sanctions against Iran.

Depending on the results from the aforementioned quantitative analysis, certain new petrochemical trade lanes may present themselves while others may disappear due to the shifts in global production that may take place. For this reason, it is interesting to look at the new transport opportunities that will arise by reviewing e.g. FOSFA lists of approved and banned previous cargoes for chemical tankers.

Additionally, the Gravity and GSIM models cannot account for start-up delays that may exist i.e. the petrochemical industry is very capital intensive and it may take some time before it can produce/refine at the maximum possible capacity, especially since much Foreign Direct Investment (FDI) is needed and investors may be reluctant to enter a market that is unproven and potentially risky. Also, chemical tankers are technically complex vessels and the global fleet grows more slowly than the fleets of other vessel types. For this reason, it could also take some time before transport capacity matches potential exports. These questions will be addressed through conducting a few informal interviews with employees of various businesses who are knowledgeable on the subject (e.g. Royal Vopak and Ace Tankers) and serve as a qualitative addition to the quantitative analysis. These interviews will shed light on the abovementioned shortcomings.

1.4 Thesis Structure

Chapter 2 describes the history of the sanctions against Iran and analyzes the developments within the global petrochemical industry over the last 35-40 years. Chapter 3 gives a theoretical overview of how sanctions affect economic development, international trade and the maritime sector. Chapter 4 details the quantitative methodology utilized to complete the research, the gravity model and the GSIM model. In addition, a description of the data and argumentation for its use is incorporated in this chapter. In Chapter 5, we present the findings and analysis of both the quantitative and qualitative methods used. Finally, Chapter 6 concludes by summarizing the key findings of the research as well as the implications of said findings. Additionally, suggestions for further research are discussed.

2 History and Future Prospects of Sanctions Against Iran

To fully understand the magnitude of the sanctions against Iran, it is important to summarize the historical occurrences and concurrent legislation that has resulted in the present situation regarding Iran and its position within the global petrochemical market and maritime trade.

2.1 The Carter Years (1977-1980)

Prior to Jimmy Carter taking office in 1977, his predecessor Richard Nixon had continued to nurture the United States' established relationship with Iran's reigning shah[1], Mohammad Reza Pahlavi. Since the Anglo-American staged coup d'état against then Prime Minister Mohammad Mosaddegh, leading to Shah Pahlavi's return to the throne in 1953, Iran had been a cooperative and steadfast ally of the West. As such, it was designated by Nixon as one of two pillars (the other being Saudi Arabia) in protecting American interests in the Persian Gulf region (Sick, 2010).

2.1.1 The Iranian Revolution of 1979

Carter would maintain this relationship in his first two years as president, continuing to provide Iran with whatever military arsenal the shah desired. However, by the end of the seventies, declining oil prices quickly began to expose the large debt that the shah had wracked up through his economic policies and military ambitions. This, coupled with his inclination towards the West, caused the Iranian people to quickly become disgruntled with the monarchy. In particular, religious clerics and the conservative Shi'ite Muslim majority were not fond of the shah's "White Revolution", a series of economic, political and social reforms that aimed to change Iran "from a traditional, conservative, and rural society to one that was industrial, modern, and urban" (Encyclopaedia Britannica, 2014). As such, social unrest began to rise rapidly and by the end of 1978 opposition forces lead by the exiled Ayatollah[2] Ruhollah Khomeini gained control of Tehran, forcing Shah Pahlavi and his family to flee the country. One month later, on 1 February 1979, Ayatollah Khomeini returned to Iran and the monarchy was officially abolished. Over the course of the year, the United States tried to work with the new revolutionary Iranian government and some progress seemed to be made. However, President Carter's decision in November 1979 to permit entry to the fallen shah in order to undergo medical treatment for lymphoma would spark outrage in Tehran. On 4 November, mobs

[1] *Shah* is the historical title used by the former monarchs of Iran, originating from the Persian word *šāh*, meaning king (Oxford University Press, 2014).

[2] *Ayatollah* is the title given to certain clerics under Twelver Shia Islam, to which the majority of Iranians adhere. These clerics are considered to stand in for the "lost" twelfth imam, a prophet of Mohammed, and are thus given the authority to make absolute decisions on religious issues (Cole, 2010).

of students sieged the American Embassy and took all who were inside hostage, "demanding the return of the shah and his financial assets to Iran" (Sick, 2010). The hostages were held for a total of 444 days in what has come to be known as the "Iran Hostage Crisis". Around this time, Ayatollah Khomeini was able to take advantage of an outraged public in order to pass a referendum in which, nearly unanimously, the people of Iran voted to adopt a new constitution, officially instating the Islamic Republic of Iran with Khomeini becoming its supreme leader.

As a response to the hostage crisis, the President Carter passed several Executive Orders (EO), which froze all Iranian assets held in the West (approximately worth $12 billion) and blocked certain transactions with the new Islamic Republic (Sick, 2010; Kattan, 2013). Although these orders were revoked upon the release of the American hostages, these first actions laid the groundwork for the next thirty years of sanctions to come.

2.2 The Reagan Years (1981-1988)

During Ronald Reagan's presidency, a number of events occurred that lead to further and more stringent sanctioning of the Iranian regime. Firstly, the Israeli invasion of Lebanon in 1982 lead to Iran sending 1,000 Revolutionary Guards (IRGC)[3] into Lebanon as a means of support. Iran's presence enabled and fostered the inception of Hezbollah, a Shi'ite resistance movement. At the same time, a multinational convoy of American, Italian and French troops was sent to Lebanon to act as a mediator. In the months following, Iran's arms and aid allowed Hezbollah to grow into a threatening and powerful enemy, carrying out suicide bombings and other acts of terrorism against (among other Western targets) the American Embassy in Beirut (Kemp, 2010). As a result, 1984 saw the State Department of the U.S. designate Iran as a "state sponsor of terror" (Kattan, 2013). This move instated sweeping bans on US-Iran transactions involving the sale of arms, dual-use technologies and foreign aid.

For the entirety of his presidency, Reagan also had to deal with the ongoing Iran-Iraq War. During this time, the U.S. coordinated *Operation Staunch*, a worldwide effort to inhibit the sale or provision of arms and spare parts to Iran (Kemp, 2010). Further fighting and military actions in the Persian Gulf culminated in President Reagan signing *Executive Order 12613* in 1987, which enacted an import ban on all Iranian goods destined for the U.S. (Kattan, 2013).

[3] See: http://www.cfr.org/iran/irans-revolutionary-guards/p14324 for a comprehensive explanation of the *Islamic Revolutionary Guard Corps*.

2.3 The Bush I Years (1989-1992)

Moving into the 1990s, the relationship between the U.S. and Iran changed little under the administration of George H.W. Bush. Even with a common enemy (Iraq) during the Persian Gulf War, the two countries did not engage in collaborative efforts to weaken Saddam Hussein's regime. It has even been suggested that the U.S. showed restrained military force when dealing with Iraq, in order to leave it just powerful enough to leave Iran without an overly powerful position in the region (Haass, 2010).

Following its victory in the war, Bush Sr.'s presidency was characterized by his attempt to bring peace to the Middle East. Together with the President of the Soviet Union, Mikhail Gorbachev, Bush Sr. co-hosted the Madrid Conference of 1991. This conference aimed to formally solve the Arab-Israeli conflict through negotiations and brought delegates from Israel, Palestine, Syria, Egypt, Lebanon and Jordan together for the first time in one forum. Due to the conference, Iran feared its loss of support from allies such as Syria and Lebanon, as peace with Israel would be a hindrance to their relationships based on a common disdain for Israel. In response, Iran chose to rally and further support various terrorist groups, such as Hamas and Palestinian Islamic Jihad, setting off a series of new terrorist attacks across the Middle East. This not only hindered the peace process, but also strengthened the Islamist movement throughout the Middle East.

In response, the Bush Sr. administration enacted the *Iran-Iraq Arms Nonproliferation Act of 1992***,** formally putting sanctions on all foreign entities that supply Iran with technology for weapons of mass destruction (WMDs) and/or significantly large amounts of conventional weapons (Kattan, 2013).

2.4 The Clinton Years (1993-2000)

In the aftermath of the previous decade riddled with war and violence, the main goal of the Clinton administration regarding the Gulf region was to contain both Iran and Iraq in order to limit threatening behavior towards the U.S. and its allies. This containment strategy came in the form of a military presence to deter acts of violence, economic sanctions to deter foreign investment and diplomacy to curb the regimes from supporting terrorism and pursuing nuclear proliferation (Riedel, 2010). The first such sanctions of Clinton's presidency came in the form of a series of EOs in 1995. *Executive Order 12957* saw Clinton declare Iran to be an "extraordinary national security threat". This official declaration allowed him to regulate trade with Iran and each year, the declaration must be (and has been) renewed. *Executive Order 12959* further expanded the original import ban enacted by Reagan in 1987 to completely ban

all trade with and investment in Iran, with the exception of foodstuffs and medical supplies (Kattan, 2013).

One major event that further widened the gap between the two countries was the 1996 attack on Khobar Towers, a complex used by American Air Force personnel in Saudi Arabia. This attack killed 19 Americans and left hundreds wounded. Following the attack, American Intelligence found evidence implicating a terrorist group closely linked the IRGC (Riedel, 2010). Shortly thereafter, the *Iran and Libya Sanctions Act of 1996 (ILSA)* was enacted. This act of Congress placed sanctions on all entities that invest greater than $20 million in the Iranian energy sector. By doing this, the U.S. hoped to cripple Iran's energy market, one of its biggest sources of income, thus diminishing its ability to fund and sponsor terrorist organizations. It also aimed to thwart Iranian efforts towards obtaining WMDs. One year later, Clinton issued another EO, *Executive Order 13059*, which closed loopholes allowing American companies to knowingly export goods via third countries to Iran (Kattan, 2013).

The last sanctions to be placed on Iran during Clinton's presidency came in the form of the *Iran Nonproliferation Act of 2000*. This act gave authorization to the president to sanction targeted individuals or companies found to be aiding WMD programs in Iran (Rice, 2000).

Although President Clinton made various attempts to open dialogue with Iran during his two terms, he was denied each time of the opportunity by the Iranian regime (Riedel, 2010). As such, sanctions were expanded and tightened during his administration.

2.5 The Bush II Years (2001-2008)

Not even one year into his presidency, George W. Bush was faced with the September 11 attacks and their aftermath. Perhaps ironically, these events briefly brought the U.S. and Iran together, as both countries had long supported the opposition force known as the Northern Alliance in Afghanistan. In order to successfully remove the Taliban from power, the U.S. and Iran jointly convinced the Northern Alliance to back Hamid Karzai as the new Afghani president. Both countries also tried to work together in the midst of the fall of Saddam Hussein's regime in Iraq. However, the attempts at collaborative efforts in both Afghanistan and Iraq were found to be short lived, as Iran again began to support Shi'ite extremists in both countries and elsewhere (Hadley, 2010).

As a direct result of September 11, *Executive Order 13224* was signed in 2001. This EO sanctioned all supporters of terrorism and gave the president authorization to "freeze the assets of and bar American financial transactions with entities that support

terrorism" (Kattan, 2013). Although this EO was originally directed at those parties aiding al-Qaeda, it has also been widely used against Iranian entities.

In 2002, a secret nuclear site in Natanz, Iran was discovered, leading to international concern regarding the intentions of Iran's nuclear program. This prompted the International Atomic Energy Agency (IAEA) to demand access to the uranium enrichment site in order to establish its purpose. At first, Iran agreed with the IAEA and the international community to voluntarily suspend its uranium enrichment program through the Paris Agreement of 2004. As a result, the U.S. decided to repeal its objection towards Iran joining the World Trade Organization (WTO) and Iran was thus finally able to gain membership. The U.S. also considered lifting licensing bans on spare parts for civilian aircraft, which would help Iran's national carrier to upgrade and maintain its aging fleet (Hadley, 2010).

However, when Mahmoud Ahmadinejad became president of Iran in 2005, he reinstated Iran's nuclear program. This led to the enactment of a series of new EOs and sanctions. Firstly, *Executive Order 13382* (2005) gave the president authorization to freeze assets of entities that were found to be supporting WMD proliferation. The Bush Jr. administration also banned so-called "U-turn transactions" (indirect transactions where a non-Iranian bank acts on behalf of an Iranian bank) in 2006 (Kattan, 2013).

2.5.1 United Nations Sanctions

Due to Ahmadinejad's blatant disregard for the nuclear disengagement desires of the international community, the United Nations Security Council (UNSC) finally took action, marking the first time that sanctions against Iran were not solely instated by the U.S. government. In 2006, *UNSC Resolution 1737* was passed, directing all UN member states to prohibit the supply of materials that could be used towards nuclear of ballistic missile programs. It additionally placed financial sanctions on various corporations and individuals found to be involved in these programs (Starr, 2010; Kattan, 2013). One year later, *UNSC Resolution 1747* was passed, directing member states to prevent the purchase of arms-related materials originating from Iran. Additional companies and individuals were also sanctioned. The last UNSC Resolution to be passed during Bush Jr.'s presidency was *UNSC Resolution 1803* in 2008. This resolution called for member states to limit their dealings with Iranian financial institutions and cautioned states to "exercise vigilance" regarding all financial transactions (Starr, 2010). It also required member states to deny entry into their countries by any sanctioned individual and authorized inspections of cargoes carried by Iran Air Cargo or Islamic Republic of Iran Shipping Lines (IRISL) if the vessel was suspected of carrying illicit goods (Starr, 2010; Kattan, 2013).

2.6 The Obama Years (2009-Present)

Upon entering office, Barack Obama vowed to end the volatile relationship between the U.S. and Iran that has prevailed since the establishment of the Islamic Republic. Multiple attempts by the President to reach out to the Iranian government have been met with similar responses to those of his predecessors, i.e. mixed to negative. For example, the Obama administration aimed to tackle the issue of Iran's nuclear program by brokering a deal with the IAEA that would allow Iran to have access to nuclear fuel. The idea was to allow Iran to export low-enriched uranium to Russia, who would then enrich the uranium and subsequently ship it to France for further conversion into rods This would move the enrichment process out of Iran, safeguarding the international community from worries about its misuse of uranium and its enrichment facilities (Limbert, 2010). Although President Ahmadinejad initially seemed open to the deal, it quickly fell through after the Iranian opposition denounced it. An attempt was made to try to salvage the deal by involving Turkey and Brazil in the negotiation process. The trilateral talks that came out of this saw the original enrichment location changed from Russia to Turkey, making Iran more comfortable since Turkey is a fellow Muslim country with a historically better relationship. However, the time between the original dealings and the agreements made between Iran, Turkey and Brazil were made, Iran continued to enrich its own uranium. This angered the counterparties in the West and thus the deal fell through yet again (Limbert, 2010).

Regardless of his desire to change the status quo, this blunder led to a series of new sanctions against Iran. As such, sanctions have still played a major role in the Obama administration's foreign policy towards Iran. In 2010, the *Comprehensive Iran Sanctions, Accountability and Divestment Act (CISADA)* was passed. This expanded earlier sanctions against Iran's energy sector by forbidding the sale of gasoline and equipment used for gasoline production to Iran. It also further sanctioned individuals identified to have violated human rights regarding the Iranian presidential elections held in 2009 (Clawson, 2010; Kattan, 2013). Additionally, *Executive Orders 13572 and 13590* were both passed in 2011. These EOs blocked IRGC property and amended the *Iran Sanctions Act* (formerly known as ILSA) to sanction any foreign company that supplies Iran with goods or services that could strengthen the oil and gas or petrochemical sectors.

2011 also saw amendments made to the *USA PATRIOT Act*, which classified Iranian banks as money laundering entities under *Section 311*, limiting their abilities to access the American financial sector (Meiburg, 2011). The *National Defense Authorization Act of 2012* furthered financial sanctions by also placing restrictions on foreign banks that carry out transactions with the Iranian Central Bank (Kattan, 2013). In 2012, *Executive Orders 13599, 13606 and 13622* were passed. The first EO blocked all Iranian

government and bank properties. The second EO sanctioned IT service providers that aided in abusing human rights through disrupting the flow of information to and monitoring civilians. The last EO sanctioned foreign banks and other financial institutions that bought Iranian oil or petrochemicals. The last months of 2012 saw the passing of the *Iran Threat Reduction Act*, further again expanding the scope financial and political sanctions, as well as *Executive Order 13628*, which extended the scope *EO 13606*. As of the present moment, the last such act to be passed under Barack Obama is the *National Defense Authorization Act of 2013*, imposing sanctions on companies or countries providing any goods or services to Iran's maritime sectors (shipping, shipbuilding and ports), as well as sanctioning the provision of finished or semi-finished metal goods to Iran (Kattan, 2013).

2.6.1 United Nations Sanctions

In addition to the slew of newly imposed American sanctions during the first term of the Obama administration, the UNSC also decided to increase pressure on the Iranian government through new sanctions of its own following the diplomatic folly that had occurred.

UNSC Resolution 1929, passed in 2010, expanded sanctions banning the sale of arms and weapons technology to Iran, prohibited Iran from making investments in nuclear and missile technologies, gave authorization to all member states to inspect all suspicious Iran-related cargoes and further sanctioned IRISL and its business partners (Limbert, 2010; Starr, 2010; Kattan, 2013).

2.6.2 European Union Sanctions

Stricter sanctions from the U.S. and the UN have not been the only developments during Obama's presidency. For the first time since the American sanctions campaign against Iran began in the 1970s, the European Union (EU) decided to impose sanctions of its own, once again increasing the international pressure on Iran to change its policies regarding nuclear and weapons proliferation and human rights (European External Action Service, 2013).

In 2010, the EU imposed sanctions banning the trade of military goods, the sale of machinery related to the energy sector and the supply of dual-use technologies to Iran. In 2011, the EU published a blacklist of Iranian officials and entities implicated in the violation of human rights. In 2012, blacklisted Iranian banks were cut off from the SWIFT international banking system, making it even more difficult for the Iranian financial sector to engage in international commerce. An oil and natural gas embargo was also instated at this time, as well as bans on the precious metals trade, in order to

weaken Iranian WMD development, shipbuilding and oil storage capacities (Kattan, 2013).

2.6.3 Renewed Negotiations and the Joint Plan of Action

The above-mentioned recent developments have changed the Iran sanctions story from a broadly bilateral issue to a truly multilateral one, in which Iran has found itself in many ways isolated from all highly developed countries in the West. However, the last six months have brought about rapid change regarding sanctions, especially due to the election of a more moderate president in Iran, Hassan Rouhani. This has lead to renewed nuclear negotiations in Geneva, which began in 2013. Officially known as the *Joint Plan of Action (JPOA)*, November 2013 saw official agreements made between the P5+1[4] countries and Iran (Davenport, 2014). The JPOA is a deal that has been concluded for a period of six months, lasting until 20 July 2014. This six-month window has been opened to continue negotiations towards a "comprehensive solution" between Iran and the international community concerning its nuclear program.

In the JPA, Iran has agreed to take a number of voluntary actions, such as reducing its uranium stocks, halting further enrichment and agreeing not to open new enrichment facilities. In addition, Iran has agreed to allow the IAEA greater access to its facilities for in order to ensure better monitoring (Joint Plan of Action, 2013). In return, the P5+1 countries have agreed to temporarily suspend a number of sanctions against Iran, the most important of which include sanctions against the exportation of Iranian petrochemicals and the services associated with it, such as maritime transportation, export finance and insurance (Council of the European Union, 2014; Davenport, 2014).

On 18 July 2014, it was announced that a deal could not yet be met after the original six-month time frame. However, Iran and the P5+1 countries have agreed to an extension of four months. During this extension, Iran will be able to repatriate an additional $2.8 billion of frozen assets. However, no additional sanctions will be eased and the remainder of Iran's estimated $100+ billion abroad remains inaccessible (Charbonneau & Dahl, 2014).

Regarding the extension, German Foreign Minister Frank-Walter Steinmeier stated, "these few months until November could be the last and best chance for a long time to end the nuclear argument peacefully" (Auswärtiges Amt - Federal Foreign Office, 2014).

[4] P5+1 is another name for the group of countries also known as the E3+3.

2.7 Historical Developments within the Iranian Petrochemical Industry

The petrochemical sector in Iran began to take shape in 1963 as a completely nationalized endeavor. Under the rule of Shah Pahlavi, the National Petrochemical Company (NPC) was born and is to this day still under the control of the Iranian government's Ministry of Petroleum (National Petrochemical Company, 2013). However, partial privatization has also begun to slowly take place in recent years. Iran currently holds the world's second largest natural gas reserves and fourth largest crude oil reserves, giving it access to an abundance of cheap feedstock (U.S. Energy Information Administration, 2014). Thanks to Iran's mineral wealth, it has been able to expand its petrochemical industry to become the Middle East's second largest producer of petrochemicals, after Saudi Arabia (Iran Daily, 2011; Daly et al., 2014).

The Iranian government has maintained a strong desire to grow its petrochemical industry, citing it as a key industry in which it holds a considerable comparative advantage on the global scale (Azarbayjani et al., 2009). However, various events in modern history have resulted in Iran's inability to fully realize its desired growth potential. Starting with the Iran-Iraq War after the ousting of Shah Pahlavi and the instatement of the Islamic Republic, the 1980s saw little growth in petrochemical exports. However, since the end of the war, more investments (both domestic and foreign) have been made in petrochemical infrastructure and research and development. From 1995-1999, NPC developed a series of petrochemical sites, nearly quintupling production from 2.4 million tons to 11 million tons (NPC, 2013). Continuing into the 2000s, the Iranian government continued to grow its petrochemical industry despite increasing U.S. sanctions. With alternative trade partners such as the EU and Japan, the demand for petrochemicals such as methanol, ethylene and propylene continued to grow. Below, in Figure 1, the growth in petrochemical production and capacity in the last two decades can be seen (NPC Annual Report, 2011).

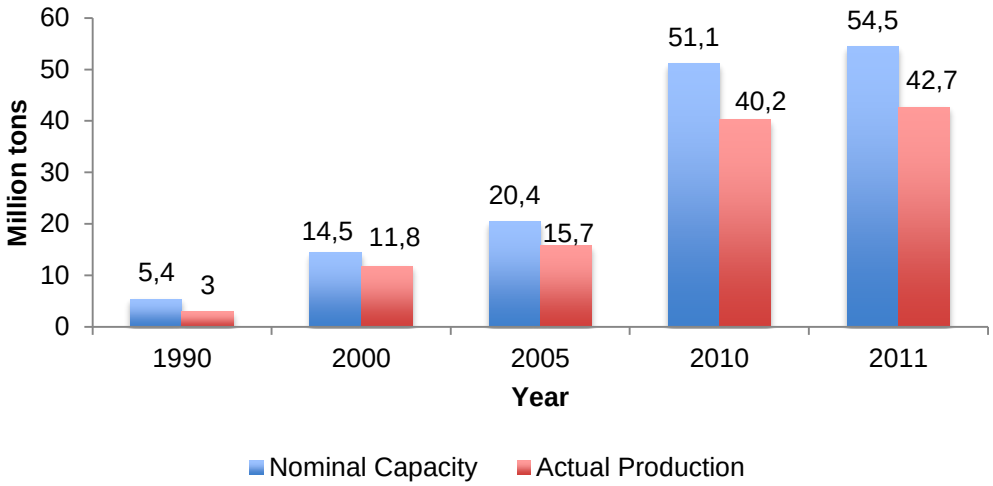

Figure 1: Historical Production of the Iranian Petrochemical Industry
Source: Author via National Petrochemical Company Annual Report 2011

However, the period from 2006-2012 saw mounting pressure put on other Western countries due to the passing of increasingly severe multilateral sanctions by the UNSC. This has resulted in a volatile period regarding trade values for the Iranian export and import of petrochemicals. As European companies had long been buyers and investors of the Iranian oil and gas and petrochemical industries, the EU's decision to finally align itself with the US's sanctions hit Iran hard. For example, since reaching a peak in 2010, Iranian exports of methanol (its most produced petrochemical product) have dropped nearly 30 percent (Thoelke, 2014).

As can be seen in Figure 2, the sharp declines in exports that began in mid-2011 coincide with strengthening sanctions regimes, specifically those affecting EU-related trade. In early 2012, Iranian exports to the EU dropped to virtually nil, which can be partially attributed to new EU sanctions, which banned the import of Iranian petroleum products and barred European P&I Clubs from insuring tankers trading with Iran (U.S. Energy Information Administration, 2014).

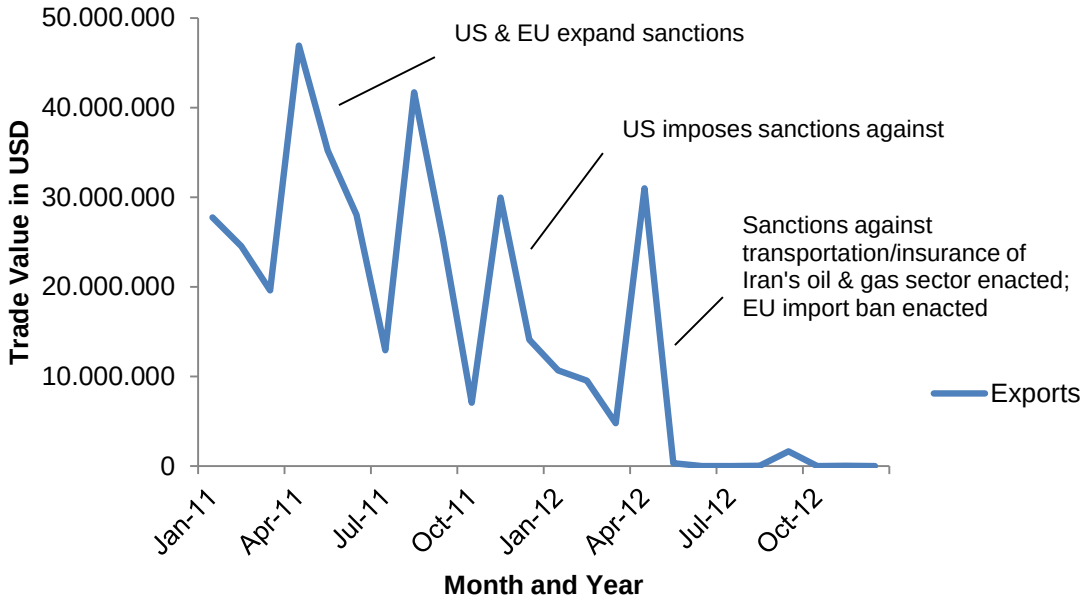

Figure 2: Iran Petrochemical Exports to the EU, January 2011-December 2012
Source: Author via UN Comtrade & U.S. Energy Information Administration

Still, in recent years, Iran has been able to foster new or enhanced trade relationships with alternative partner countries such as China, India and Turkey, which has enabled it to dampen the severity of sanctions on its petrochemical exports (as seen in Figure 3). In other words, although industry growth has surely been stunted, it has managed to sustain. As a result, the Iranian government has announced its plans to approximately double petrochemical production in the near future to 100 million tons per year, in spite of the sanctions in place (Thoelke, 2014).

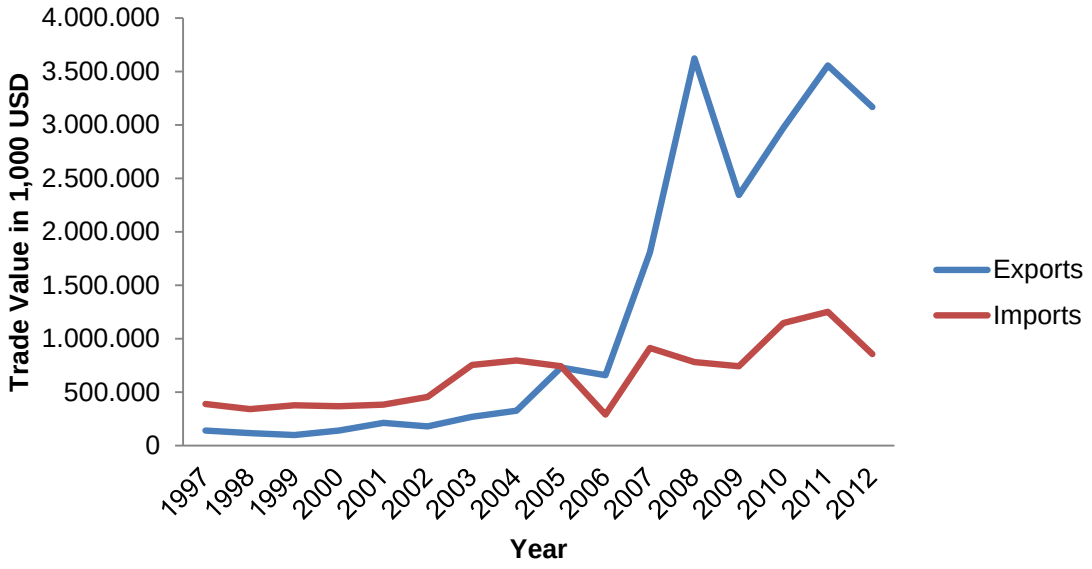

Figure 3: Iranian Petrochemical Imports & Exports, 1997-2012
Source: Author via UN COMTRADE

To conclude, the Iranian petrochemical industry has experienced hardships and the inability to grow at the desired rate due to sanctions, which have led to a lack of much-needed FDI and export difficulties due to a lack of insurance and transport abilities. However, the industry has still managed to increase exports more than twentyfold over the last two decades.

2.8 The Changing Landscape of Chemical Tanker Trade Flows

Although sanctions have been unable to halt the growth of Iran's petrochemical industry completely, it has had a profound effect on the direction of chemical tanker trade flows, as a noticeable shift in Iranian trade has occurred. Officially, all member states of the UN should abide by resolutions passed by the UNSC. However, the reality shows that this is not the case. Certain countries that used to be major trade partners of Iran, such as the United States, EU, South Korea and Japan, have incorporated sanctions into their national laws and have either heavily reduced or completely halted the trade of petrochemicals with Iran. However, other countries have been more reluctant and defiant. For example, China and India still invest heavily in the Iranian petrochemical industry and continue to carry out trade with Iran. These changes can be seen in Figures 4 and 5, indicating a shift in trade from the West to the Far East. This has been possible due to the governments of these countries issuance of sovereign guarantees (replacing traditional P&I cover) and continued support of foreign direct investment flows headed for Iran (Blas, 2012; Luthra & Wagner, 2012; Verma, 2013).

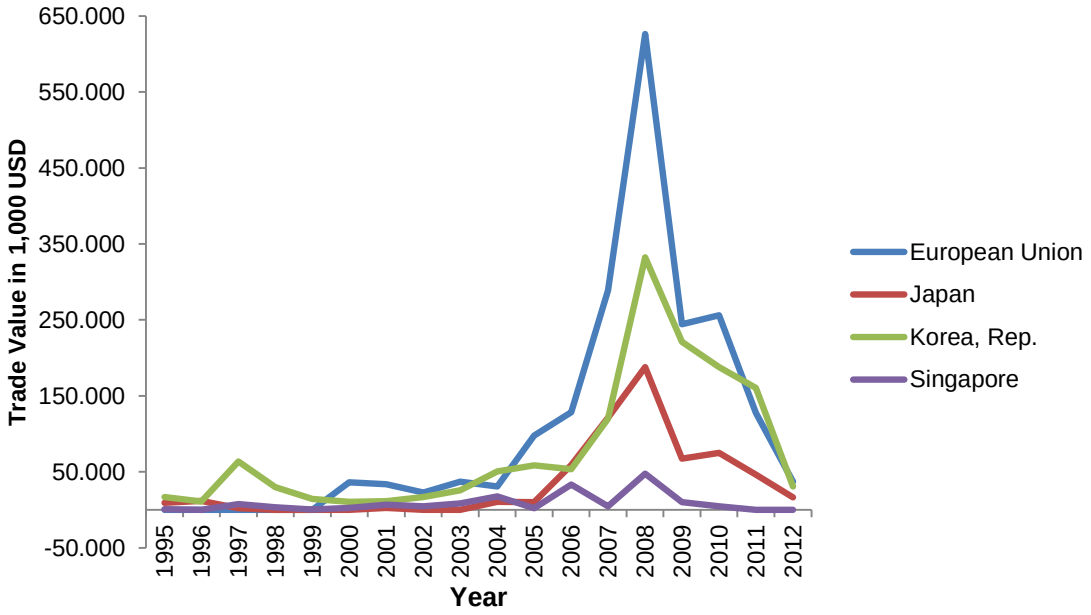

Figure 4: Iranian Petrochemical Exports to EU, Japan, S. Korea & Singapore, 1995-2012
Source: Author via UN COMTRADE

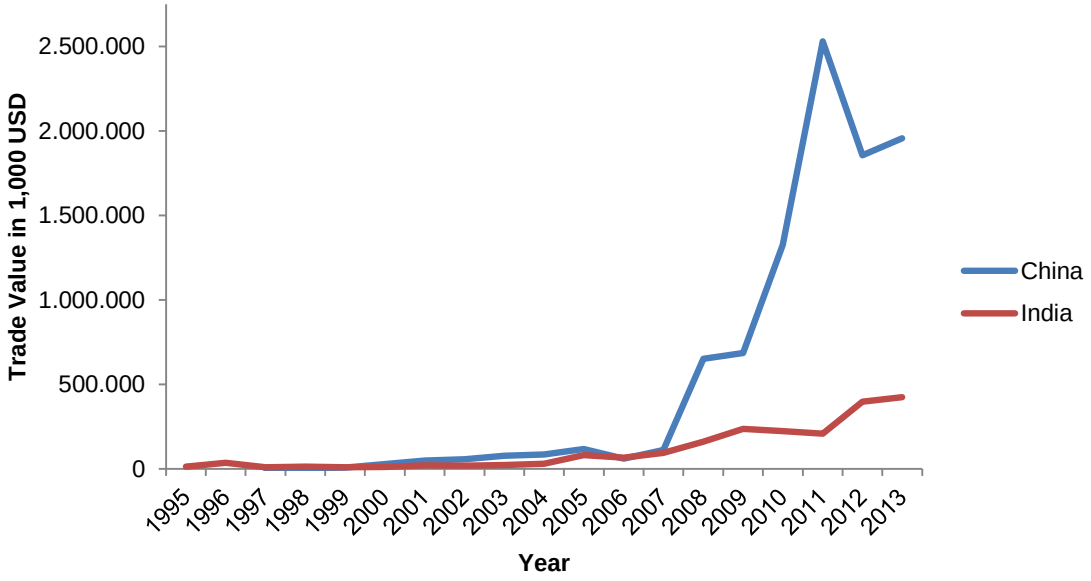

Figure 5: Iranian Petrochemical Exports to China & India, 1995-2013
Source: Author via UN COMTRADE

As a result of the divided attitudes of various countries towards UN-imposed sanctions, Iran has seen a historical change in its largest trade partners. Just before the 1979 Iran

Hostage Crisis, The U.S. was the second largest exporter to Iran (Torbat, 2005). However, by 1994, it had dropped to the smallest of all exporters, as virtually no trade was taking place due to comprehensive sanctions. Although trade with the U.S. has completely deteriorated to a level of non-existence since the 1980s, many other countries continued to maintain economic relations with Iran. During the 1990s and into the 2000s, Iran's largest trading partners were largely European, with Germany maintaining its position as Iran's largest trade partner and Japan, Italy and France following as Iran's top four trade partners. However, the implementation of sanctions across Europe (European Union, Switzerland, Norway) and other Western allies led to a shift and 2009 marked the first time that Iran's trade with Eastern (Asia and the Middle East) countries exceeded its trade with Western countries (Khajehpour, 2013). As of 2013, the gap between Iran's trade with Asia and the rest of the world has widened, with Asia making up 75 percent of all trade. It is expected that sustained sanctions will further lead to increased trade with the East and other emerging economies, such as Brazil and South Africa. Below, in Figures 6 through 13, a series of pie charts helps to visualize the drastic change of trade direction that has taken place regarding Iranian exports from 1995 to 2010.

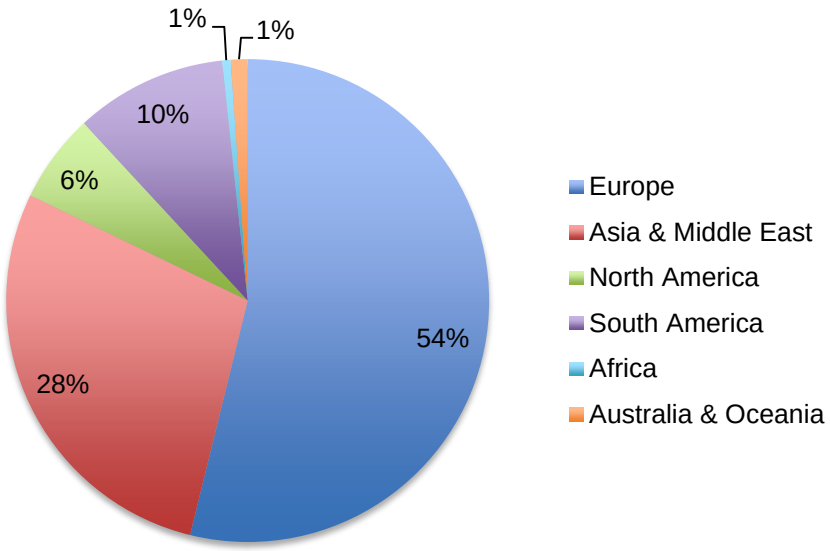

Figure 6: Share of Iran Import Origins, 1995
Source: Author via Observatory of Economic Complexity

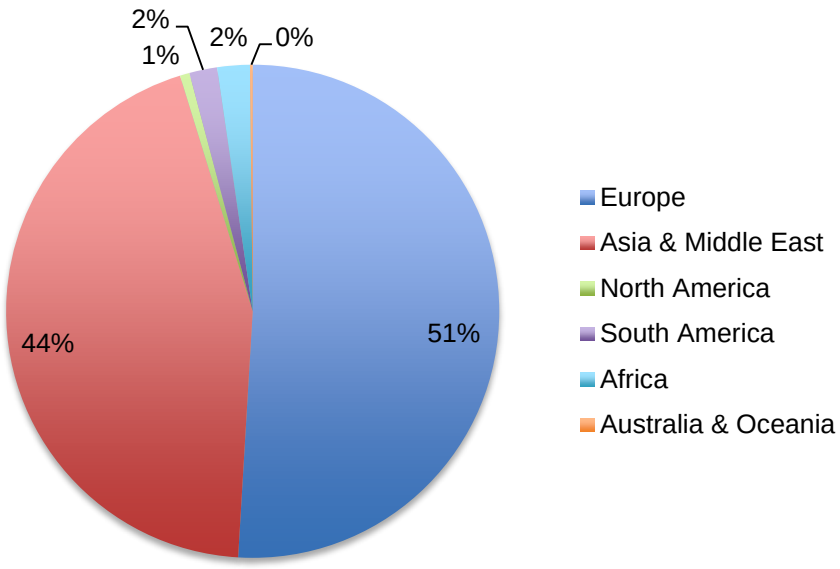

Figure 7: Share of Iran Export Destinations, 1995
Source: Author via Observatory of Economic Complexity

As can be seen, Europe (predominately Germany, Italy, France and Switzerland) was by and large the biggest trade partner for Iran in the mid-nineties. Still, Asia and the Middle East made up a large portion of Iran's exports, nearly matching that of Europe. As the new millennium began, Asian trade growth continued to outpace other regions of the world. Thus, although both increases in Iranian imports and exports occurred in regions such as South America, the percentage of total trade remained dominated by Europe with Asia and the Middle East beginning to catch up.

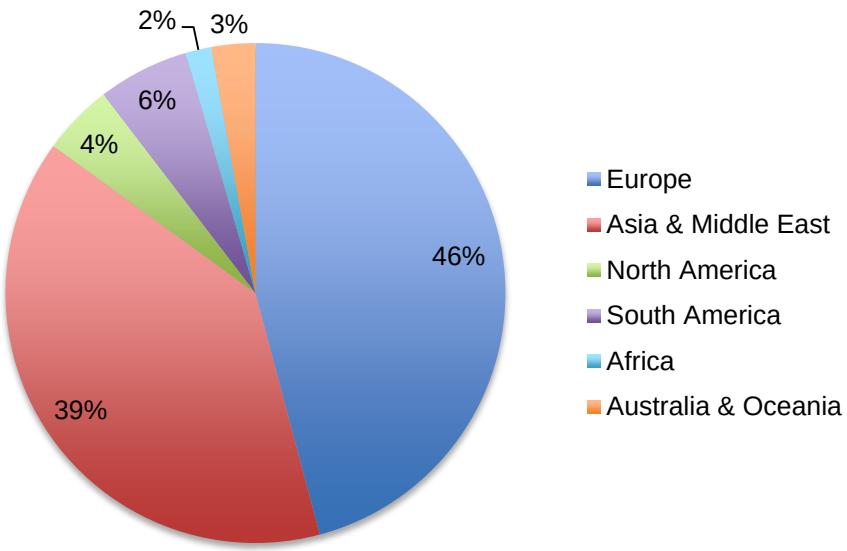

Figure 8: Share of Iran Import Origins, 2000
Source: Author via Observatory of Economic Complexity

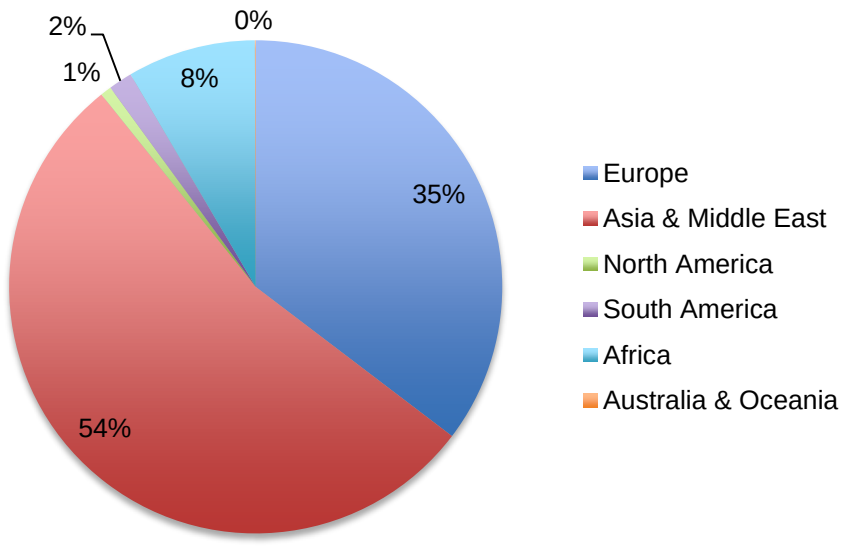

Figure 9: Share of Iran Export Destinations, 2000
Source: Author via Observatory of Economic Complexity

While not much had changed regarding Iranian export destinations from 2000-2005, Iran continued to seek closer ties with Asian trade partners, importing various manufactured goods in exchange for oil and petroleum products. By 2005, Asian

imports nearly equaled the amount of European imports, marking the beginning of Europe's decline as Iran's most important trade partner region.

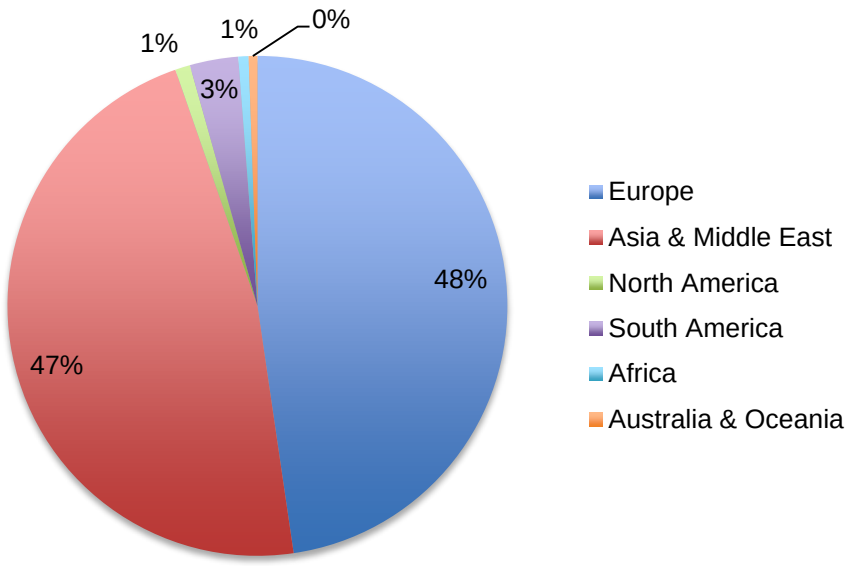

Figure 10: Share of Iran Import Origins, 2005
Source: Author via Observatory of Economic Complexity

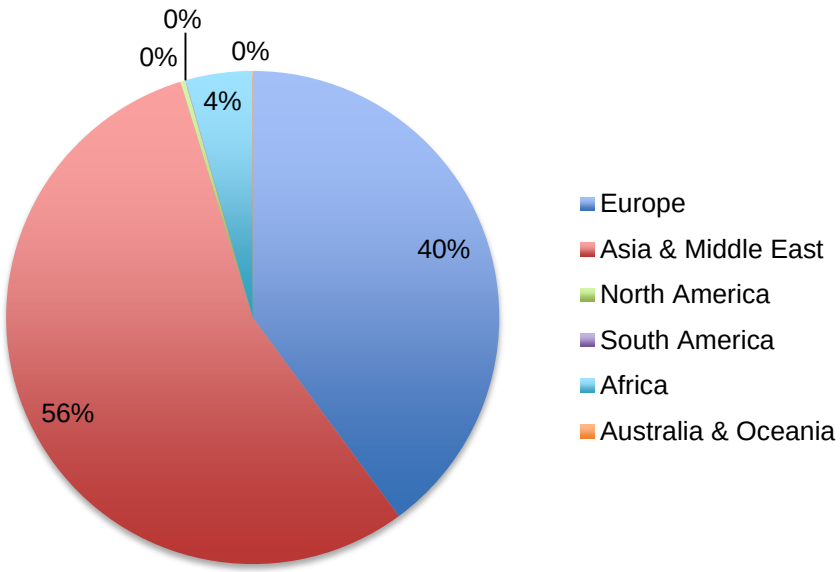

Figure 11: Share of Iran Export Destinations, 2005
Source: Author via Observatory of Economic Complexity

Following the passing of UN sanctions in 2006, the EU and other European partners decided to implement their own sanctions. This further alienated Iran and continued to foster strengthening trade relations with Asia. By 2010, Asian and Middle Eastern destinations such as China, India, the United Arab Emirates and Turkey dominated trade with Iran.

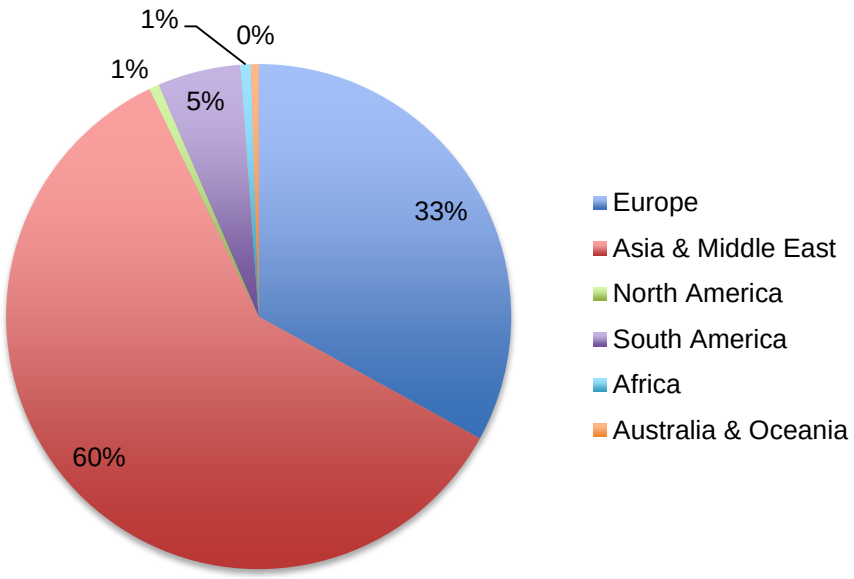

Figure 12: Share of Iran Import Origins, 2010
Source: Author via Observatory of Economic Complexity

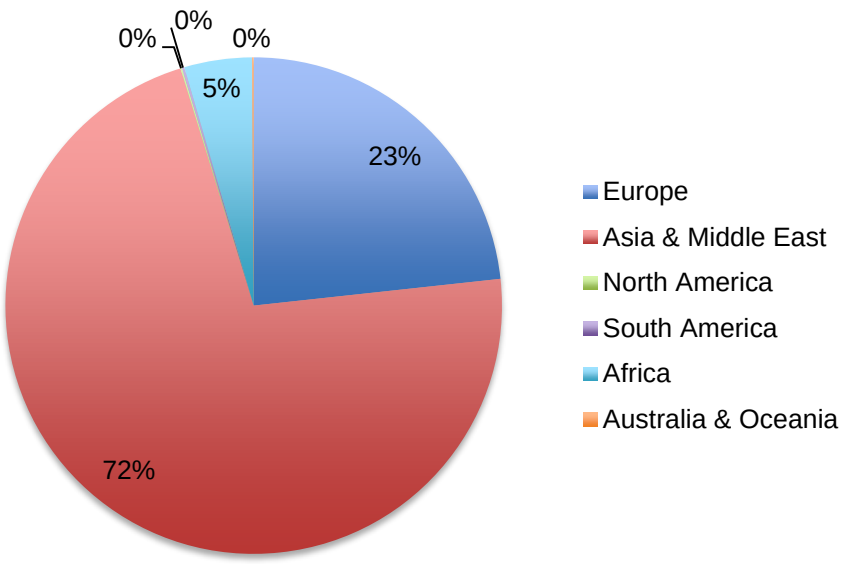

Figure 13: Share of Iran Export Destinations, 2010
Source: Author via Observatory of Economic Complexity

On top of sanctions driving Iranian trade towards the East, global economic development has also contributed to the changing direction of chemical tanker trade flows. Over the last twenty years, global production of organic base chemicals has exploded (e.g. xylene production has increased over 200 percent in this time period). However, at the same time the traditional production leaders, the US, Japan and EU have diminished production, from about two-thirds of the total to less than half (Massey & Jacobs, 2013). This is due to the fact that these base chemicals can be more cheaply produced in regions where feedstock is cheaper, allowing other regions to price more competitively. In addition, these base chemicals are the least technologically intensive to synthesize, so more developed regions have begun to give greater focus towards the production of higher valued specialty and inorganic chemicals.

Consequently, chemical tanker trade lanes for the transport of organic chemicals have shifted greatly from West to East. For those trade lanes originating in Iran, this has been even more drastic, as some of its former largest trade partners have eschewed Iranian business through the implementation of sanctions.

3 Theoretical Effects of Sanctions on Economic Development and Trade

Primarily since the end of World War II, sanctions have been a key policy tool used by the United States in efforts to coax target countries or individuals to comply with demands for change (Caruso, 2003). Since the end of the Cold War era, sanctions have also become a tool utilized by the United Nations in international efforts for change. The effectiveness of the various sanctions placed on a plethora of countries and regimes for myriad reasons are frequently debated (see: Hufbauer et al., 1990; Cortright & Lopez, 2002). In particular, the question is often asked: have sanctions directly led to a change in policy?

Regardless of the effectiveness of sanctions in coercing target regimes to adapt their policies and comply with American or international norms, it cannot be denied that sanctions do affect economic development and hinder international trade for the countries targeted (Hufbauer et al., 1997; Torbat, 2005). Although these impacts vary greatly per case, the negative nature of sanctions is clear and consequently influences the maritime sector.

3.1 How Sanctions Affect Economic Development

Economic indicators are tools often used to track economic development of a nation. Past research shows that a multitude of economic indicators generally react negatively to the introduction of sanctions against a country. A selection of these indicators is discussed below.

3.1.1 GDP Growth Rate

According to research by Neuenkirch & Neumeier (2014), sanctioned countries experience reduced GDP growth rates. The degree of reduction of the GDP growth rate depends on two main factors: (1) whether the sanctions are unilateral or multilateral and (2) the length of time that the sanctions are in place. Across a dataset comprising a sample of 68 sanctioned countries over a period of 36 years, it was estimated that unilateral sanctions reduce GDP growth between 0.5 and 0.9% (depending on comprehensiveness/severity of the sanctions) in the case of US sanctions (unilateral). However this decreases over time and after 7 years is insignificant. In the case of UN sanctions (multilateral) GDP growth rate reduction lies between 2.3 and 5.3% (again depending on comprehensiveness/severity). However this decreases over time and after 10 years is insignificant.

3.1.2 Unemployment Rate & Wages

Due to sanctions, the foreign demand for a sanctioned country's exported products decreases. This leads to a drop in global market prices, which in turn causes production levels to fall. This results in an increased amount of unemployment (Torbat, 2005). Hufbauer et al. (1997) agree, succinctly stating that lost exports result in lost employment. They have also estimated that export jobs earn wages about 12-15% higher than the average wage rate. This indicates that there is a heavy cost to both the country administering sanctions and the country targeted by sanctions, as both will experience a loss of jobs and their associated wages.

3.1.3 Inflation

According to Cevik & Teksoz (2014), economic sanctions have the ability to lead to increased rates of inflation. For one, the increased cost of imports due to trade restrictions and higher transaction costs can increase consumer prices. This was seen in, for example, both the Libyan and South African economies under international economic sanctions. In addition, a reduction in export revenues due to sanctions reduces a country's hard (foreign) currency reserves. This makes it more difficult for governments to fund their often-expensive social programs, such as food subsidies, as seen in Iran (Torbat, 2005; Plaut, 2013). This will further increase the cost of goods for consumers, fueling inflation. Furthermore, sanctions may cause a sharp decrease in the demand for a targeted country's currency, known as depreciation, as this currency can no longer be used to purchase sanctioned goods. At present, the Iranian rial is the least valued (most depreciated) currency in the world. Below, Figure 14 depicts the hyperinflation that has been plaguing Iran for the last few decades. As can be seen, Iran's inflation has consistently remained well above the world and regional averages and has spiked various times (while also decoupling from global trends) in the wake of international sanctions.

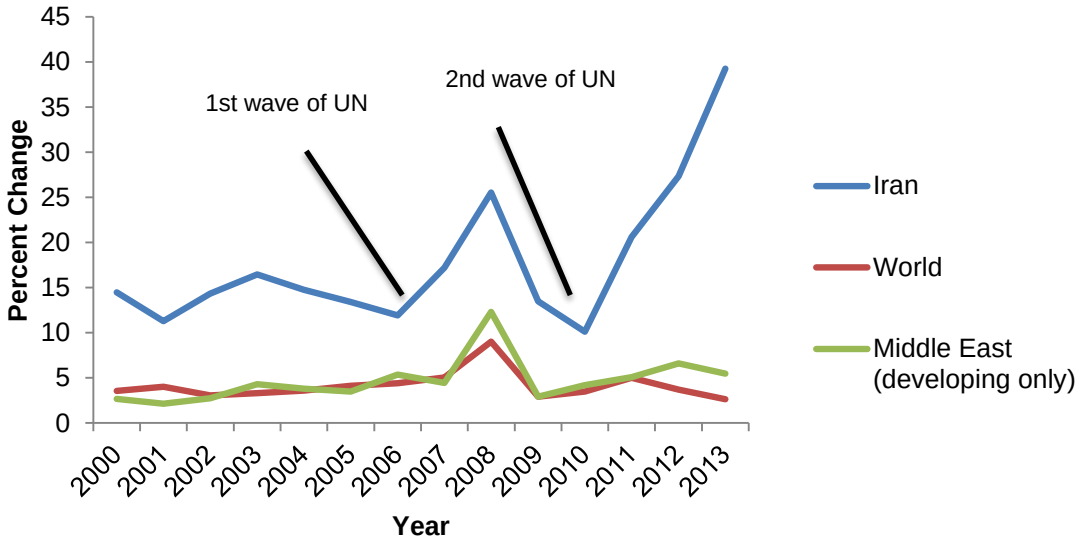

Figure 14: Annual Percent Change in Inflation, 2000-2013
Source: Author via The World Bank

3.1.4 Credit Rating

A sanctioned country can experience a downgrading of its credit rating for multiple reasons. First, institutions such as the World Bank or International Monetary Fund (IMF) may decide to suspend or deny loans to the sanctioned country, especially in the case where multilateral sanctions are in place (Morrow & Carriere, 1999; Torbat, 2005). Secondly, the uncertainty caused by the imposition of sanctions by influential world powers or multinational organizations lead to volatile borrowing environments. This has signaled credit rating agencies to downgrade sanctioned countries in the past, e.g. India and Pakistan in 1998, leading to bearish market sentiment (Morrow & Carriere, 1999; Torbat, 2005).

3.1.5 Interest Rates

Due to perceived increased levels of investment risks in countries targeted by sanctions, the interest rates that these countries must pay in order to secure debt (Morrow & Carriere, 1999; Torbat, 2005). In particular, heightened political risks and economic instability that comes with sanctions have lead to skyrocketing interest rates in countries such Iran, where rates can be double the risk-free rate. Thus, in the case of unilateral sanctions, sanctioned countries looking for alternative investors or lenders will often be able to find them, albeit paying the price of a higher interest rate. This is especially evident in cases where not only domestic, but also foreign banks have been

directly targeted by sanctions (Torbat, 2005). Ultimately, an increase in interest rates leads to a loss of bargaining power for the sanctioned country in international markets.

3.1.6 Stock Market

Private investment in a country can also give an indication as to the future levels of both business and consumer confidence. The level of private investment can be measured via the stock market. Morrow & Carriere (1999) found that the announcement of sanctions provoked stock markets to fall and, on the contrary, an announcement of sanctions relief or removal led to the rise of stock markets. Interestingly, even preemptive announcements speculating on sanctions caused the same (although less acute) effects. Damage to investor confidence due to the risky environment that is perceived to exist because of sanctions further add to the ways in which sanctions can damage a sanctioned country's economic development.

3.2 How Sanctions Affect International Trade

Additional indicators have shown that sanctions also negatively impact a country's position in international trade. Not only does the sanctioned country suffer from imposed sanctions, but countries involved in trade relations with a target nation will suffer as well. These indicators are described in detail below.

3.2.1 Exports & Imports

Obviously, in the case of unilateral trade sanctions, bilateral trade flows between two countries will cease to exist. This means that imports and exports between the two involved countries will effectively be zero for those goods that are sanctioned. In the short run, these sanctions can reduce income and increase costs for the sanctioned country (Torbat, 2005). Yet, in the long run the effectiveness of sanctions often begins to wear off, since the sanctioned country can begin to fill voids through their own production of sanctioned goods (Cortright & Lopez, 2005). Along with Torbat (2005), Morrow and Carriere (1999) also recognize that unilateral sanctions are easily undermined because there are often countries that are willing to export the same or substitute goods covered by sanctions. In fact, unilateral sanctions also create a competitive advantage for firms willing to do business with sanctioned countries, as the sanctioning country's suppliers are unable to compete. Haidar (2014) reiterates these findings, noting that although exports to sanctioning countries decline, exports overall do not. This is due to both trade diversion and transshipment possibilities. As such, globalization has rendered unilateral sanctions to be ineffective, meaning that they do little long-term damage to the target country. However, multilateral sanctions have been recognized as effective in drastically reducing bilateral trade, in some cases even

reducing trade flows by 89% (Caruso, 2003). In addition to this, sanctions can lead to lost export opportunities and thus further hamper the economic situation by denying a target country revenue generating opportunities (Torbat, 2005). For example, the construction of two oil pipelines from Kazakhstan and Azerbaijan to Iran was halted due to new rounds of economic sanctions, leading to an estimated loss in revenues of over $286 million per year for Iran government.

3.2.2 Transaction Costs

Neuenkirch & Neumeier (2014) point out that economic sanctions often result in higher transaction costs and the unproductive use of resources. Haidar (2014) also acknowledges that sanctions lead to trade diversion, which raises the transaction costs of trade. This increase in transaction costs occur because many transactions need to take place in roundabout or elusive ways, e.g. through black markets or *hawala*[5] payments systems such as is the case in Iran, thus increasing the overall cost of doing business (Breljakovic, 2012).

3.2.3 International Capital Flows

Due to sanctions, a country may experience restricted access to international credit markets, since investors may have concerns regarding the solvency of a sanctioned regime or its ability to pay (Neuenkirch & Neumeier, 2014). The withdrawal of FDI, foreign aid and/or foreign grants is also commonplace in the wake of sanctions (Torbat, 2005). Export and import financing is often also restricted under sanctions, leading to further contractions of international capital flows, especially for developing countries that rely on this type of financing for major industrial projects (Morrow & Carriere, 1999).

3.3 Consequences of Sanctions for the Maritime Sector

Economic theory states that the demand for transport services is a derived demand (Button, 2010). As such, the cost of maritime trade is dependent on a number of factors, namely the cost of the production of goods needing to be transported and the demand for those goods abroad. Since sanctions act as an abrupt distortion to free market economics, as seen in the abovementioned impacts on global economies and trade, they also in turn lead to changes in the maritime sector. These changes take shape in various ways and are summarized below.

[5] Hawala is an alternative remittance system operating outside of the traditional financial sector. For a comprehensive report on hawala see: Jost & Sandhu (2003).

3.3.1 Contracts of Carriage

The implementation of sanctions against the import or export of cargoes result in complications regarding contracts of carriage (CoC). Due to sanctions, processes regarding charter parties (CP), bills of lading (B/L), freight forwarding agreements (FFA) and the like must be much more thorough than usual, as all parties to these types of contracts, i.e. shipowner, charterer, freight forwarder, consignee, and so forth, can potentially be held liable in the case where sanctions are violated (Lux & Shour, 2011). This is especially important, as history has shown sanctioned countries and entities to actively attempt to conceal their trade activities through the use of *shell companies*[6] or third parties. This implies that sanctions lead to more stringent protocols regarding the vetting of vessels and cargo checking. To mitigate risk for both ship and cargo owners alike, both BIMCO and INTERTANKO have created sanctions clauses that clearly stipulate how to deal with CoCs that violate sanctions. Because these clauses are viewed as "owner friendly", many charterers have become reluctant when dealing with CoCs related to sanctioned countries or entities (Lux & Shour, 2011; Shamgholi, 2012).

In some cases, time charter contracts may also be rendered worthless virtually overnight with the introduction of sanctions. This leads to an immediate loss of business for carriers and, as a consequence, an increase in available tonnage. This increase in tonnage results in lower freight rates, which the carrier has no choice but to accept in order to regain hires. On the other side, carriers willing to transport pariah cargoes are at a great advantage and are able to command large premiums in the CIF price for carrying cargoes affected by sanctions (Van den Berg, 2012). Simply put, the introduction of sanctions can tighten the supply of shipping tonnage, resulting in an increase of the CIF price for transporting cargoes. Sanctions also distort demand, either by forcefully reducing it, or consequently displacing it to market actors who are non-complaisant with the imposed sanctions.

3.3.2 Financing

Since contracts in the shipping industry are predominately based on U.S. dollar transactions, the extraterritorial nature of U.S. financial sanctions can have far reaching effects. In the event that any transactions passing through an American financial institution can be traced back to sanctioned governments, entities or individuals, assets are at risk of being frozen. In addition, banks found to have carried out said transactions are eligible to be heavily fined (sometimes hundreds of millions of dollars) and could potentially have their trading licenses revoked, barring them from participating in all

[6] "Shell companies – which exist on paper only, with no real employees or offices – have legitimate uses. But the untraceable shell also happens to be the vehicle of choice for money launderers, bribe givers and takers, sanctions busters, tax evaders and financiers of terrorism" (The Economist, 2012).

future U.S. dollar-denominated business (McCarthy, 2012). As the onus of due diligence lies with the banks involved in said transactions, many banks choose to invoke sanctions clauses or deny financial services involving sanctioned countries altogether (Lux & Shour, 2011). Even in situations where transactions are not illegal, the delays and complications that come along with heightened levels of compliance checks cause many financial institutions to simply not offer their services in order to avoid the burden. As a result, a lack of financing available to the maritime sector for trade with a sanctioned country leads to a decrease in overall port calls in that country, as well as shifts in transit to countries that take a more lenient approach to commercial dealings with a sanctioned country (Shamgholi, 2012).

3.3.3 Protection & Indemnity

In the event that a shipowner is engaging in sanctioned activities, whether knowingly or not, the Protection and Indemnity Club (P&I Club) to which it is member will cease to insure him (The London P&I Club, 2014). In fact, many P&I Clubs choose to discontinue all insurance and reinsurance services relating to sanctioned countries as a cautionary measure (Lux & Shour, 2011). The largest insurance market in the world, Lloyd's of London, has also restricted insurance on shipments made to sanctioned countries and actively warns members to avoid such risky transactions. Again, lost business by actors in countries affected by the imposition of sanctions results in gained business in other countries that either do not fall under the sanctions regime or are willing to work around it. This is possible through the setup of private (sovereign) P&I Clubs, either within the sanctioned country itself or abroad (Shamgholi, 2012).

What the abovementioned demonstrates is that the implementation of sanctions, both unilateral and multilateral, may indeed lead to a decrease in maritime trade. On top of this, sanctions can also ultimately lead to a shift in maritime trade flows. The direction in which these flows shift will depend on the sanctioning party and its target, as well as third parties that will be affected.

In this case, sanctions have made it extremely unattractive for many Western entities to engage in maritime trade with Iran. This has therefore led to a reduction in maritime trade flows from Iran to the West and vice versa. In the meantime, however, certain nations continue to protect their companies that choose to maintain trade relations with Iran. As a result, the multilateral sanctions against Iran have led to a change in the geography of trade in petrochemical cargoes. The changes that have occurred to global trade flows are discussed in detail in Sections 2.7 and 2.8 above. The ways in which these trade flows will change as a result of repealing sanctions against Iran will be estimated in the following chapters.

4 Research Methodology and Data

Considering the changes that have taken place in the petrochemical industry as a result of the economic sanctions placed on Iran, this chapter aims to introduce the quantitative tools that will be used to estimate the effects on the petrochemical industry should sanctions be lifted in the future. These quantitative methods will focus on the changing values of bilateral trade flows, since this will allow for the derivation of a need for transport by the chemical tanker sector.

As this thesis aims to analyze the impact of sanctions on bilateral trade flows, it is imperative to understand the relationships that exist between these trade flows and various economic factors that are present. This can be achieved through the analysis of historical statistical data via the use of a gravity model, which will allow for the determination of the current expectation of trade between partners. In addition, the thesis aims to predict the shifts in trade flows that will occur in the future as a result of sanctions being lifted. As the gravity model does not have the ability to predict future flows, the GSIM model will be used.

As such, this chapter aims to introduce the econometric models and data that are utilized in the research, their objectives and their purposes. Firstly, the gravity model will be introduced. Secondly, the GSIM model will be introduced. Finally, the chapter concludes with a detailed description of the data inputs needed to successfully run the models.

4.1 The Gravity Model

The “gravity model” or “gravity equation” is an econometric model that originates from the law of gravity first put forth by Sir Isaac Newton. Newton’s gravity equation (Equation 1) explained that the force of attraction between any two objects is directly related to the product of the masses of the objects and inversely related to the distance between the objects.

$$F_{ij} = G\ \frac{m_i * m_j}{d_{ij}} \qquad \text{(Equation 1)}$$

This concept of gravity and the corresponding equation was first applied to the field of international economics in the now famous work by Jan Tinbergen (1962), in which he related *bilateral trade* to the *force of attraction* and a country’s *income level* to *mass* in order to explain trade flows between two countries. This work has been expanded upon greatly in the last 50 years to add a theoretical foundation to the model, which it originally lacked (Bergstrand, 1985; Anderson & Van Wincoop, 2003). Although the lack

of a strong theoretical foundation has made it difficult (if not impossible) to use the gravity equation as a predictor of trade flows, the myriad cases[7] of empirical successes have confirmed its statistical validity and reliability. Following the elaboration of Tinbergen's original work in 1962, a basic gravity equation for the analysis of international trade flows can generally be depicted in the following manner:

$$X_{ij} = \beta_0 (Y_i)^{\beta_1} (Y_j)^{\beta_2} (D_{ij})^{\beta_3} (A_{ij})^{\beta_4} u_{ij} \qquad \text{(Equation 2)}$$

Where:

X_{ij} = the trade flow value from an origin country *i* to a destination country *j* in USD
Y_i = the GDP of origin country *i*
Y_j = the GDP of destination country *j*
D_{ij} = the distance between the capital cities or economic centers of *i* and *j*
A_{ij} = any factors that either aid or hinder trade between *i* and *j*
u_{ij} = a normally distributed random error term

4.1.1 Econometric Specifications of the Gravity Model: A Methodological Debate

Although the original gravity equation is multiplicative in nature, it has been common to rewrite it in the log-linear form as suggested by both Tinbergen (1962) and Linnemann (1966). The work of Hufbauer et al. (1997) also measures the impact of sanctions on trade in this way. By using the log-linear form, we are able to interpret the results of the regression coefficients as elasticities, or percent changes in the dependent variable for each one percent change of an independent variable. For example, an estimated coefficient of 0.5 for an independent variable $ln(Y_i)$ would indicate that a ten percent change in the GDP of *country i* increases bilateral trade (the dependent variable) between *country i* and *country j* by five percent.

Thus, the gravity equation can be modeled as a common *ordinary-least-squares (OLS) regression*. The primary advantage of an OLS regression is that it is able to estimate the effect that each independent factor has on the dependent variable while holding all other variables' effects constant (Hufbauer et al., 1997; Yang et al., 2004). As an OLS regression, the gravity model would appear as in Equation 3 below.

$$lnX_{ij} = \beta_0 + \beta_1 \ln(GDP_i * GDP_j) + \beta_2 \ln(GDPPC_i * GDPPC_j) + \beta_3 \ln(DIST) + \beta_4(BORD) + \beta_5(LANG) + \beta_6(BLOC) + \beta_7(SANC) + \varepsilon_{ij} \qquad \text{(Equation 3)}$$

[7] See, for example, Bergstrand (1985), Hufbauer et al. (1997), Caruso (2003) and Yang et al. (2004).

Where:

lnX_{ij}	=	the natural logarithm of the trade flow value from an origin country *i* to a destination country *j* in USD
$lnGDP_i$	=	the natural logarithm of the nominal GDP of country *i*
$lnGDP_j$	=	the natural logarithm of the nominal GDP of country *j*
$lnGDPPC_i$	=	the natural logarithm of the nominal GDP per capita of country *i*
$lnGDPPC_j$	=	the natural logarithm of the nominal GDP per capita of country *j*
lnDIST	=	the natural logarithm of the distance between the capital cities of *i* and *j*
BORD	=	a dummy variable indicating whether or not *i* and *j* share a border
LANG	=	a dummy variable indicating whether or not *i* and *j* have a common language
BLOC	=	a dummy variable indicating whether or not *i* and *j* are members of the same trade bloc or union (i.e. NAFTA, GCC, EEA, etc.)
SANC	=	a dummy variable indicating whether or not *i* imposes sanctions on *j*
ε_{ij}	=	a normally distributed random error term

However, the use of an OLS regression may lead to misspecification, specifically for three reasons. First, due to the log-linearization of the equation, all zero values must be dropped, as the logarithm of zero is undefined. These dropped zeroes can result in biased results for the estimates of the independent variables' coefficients, leading to heteroscedasticity, where the variances of error terms are non-constant. Second, with trade flows it may actually be the case that a zero trade flow is indeed a zero trade flow (not a missing data point) – a distinction that implies dropping the zeroes actually means removing correct data points. Lastly, using the log-linear form of the equation results in the issue known as Jensen's inequality, since $\ln E(y) \neq E \ln(y)$. In the presence of heteroscedasticity, Jensen's inequality can lead to further biasing of the coefficients as given by the OLS regression (Santos Silva & Tenreyro, 2006; Berden et al., 2014; Van den Bosse, 2014).

An alternative specification of the gravity model, known as the *Heckman model*, includes sample selection. This allows for the differentiation between actual zero trade flows and missing values, through the use of a probit maximum likelihood selection equation. The Heckman model then uses a trade equation similar to OLS, however it must also include a variable that influences the presence or absence of trade, while at the same time does not influence the amount of trade. Although the Heckman model solves the issue arising from zero values in bilateral trade, it does not address the problems arising from the use of a log-linear equation as discussed above (Van den Bosse, 2014).

Yet another specification of the gravity equation is the *Poisson model*. As the Poisson model does not rely on log-linearization of the regression equation, it solves the three

issues that arise when using an OLS regression. Thus, zero trade flow values, heteroscedasticity and Jensen's inequality ultimately cannot lead to bias in the estimates of the dependent variable (Van den Bosse, 2014).

There are many iterations of the Poisson model that have been used as the basis for the estimation of the gravity model. One such iteration, the so-called *Poisson Pseudo-Maximum Likelihood (PPML)* estimator, has begun to gain more attention following the work of Santos Silva & Tenreyro (2006). The PPML is consistent when presented with fixed effects such as dummy variables as found in the gravity model. It also naturally includes zero value trade flows and remains consistent when dealing with heteroscedasticity. Finally, the PPML allows for straightforward interpretation of the coefficients, in that the coefficients of independent variables entered in logarithm form are interpreted as elasticities and those entered in value form are treated as semi-elasticities (exactly as when using OLS). These properties make the PPML estimator a more correct approach than the more simple OLS estimation approach in applying the gravity model (Santos Silva & Tenreyro, 2006; Shepherd, 2013).

4.1.2 The Expanded Gravity Model

From the discussion above, it is clear that the use of the gravity model is only as powerful in applied research as the specification of the model allows it to be. In normal situations of bilateral trade, zero values are to be expected for simple reasons. First, not all countries have the ability to produce all goods. Secondly, not all countries that are able to produce a certain good choose to export said good to all potential partners.

Considering that this paper focuses on the analysis of sanctions and their effects on trade, it is obvious that one could expect to observe significantly more zero values than would otherwise be found precisely if sanctions are effective. For this reason, this research utilizes the PPML specification of the gravity model in order to quantitatively assess the factors that influence bilateral trade flows.

Accordingly, the gravity equation to be used in this research is as detailed in Equation 4 found below:

$$\begin{aligned} lnX_{ij} = \; exp\,[C &+ \beta_1 \ln(GDP_i * GDP_j) + \beta_2 \ln(GDPPC_i * GDPPC_j) \\ &+ \beta_3 \ln(DIST) + \beta_4(BORD) + \beta_5(LANG) + \beta_6(BLOC) \\ &+ \beta_7(SANC)] + \varepsilon_{ij} \end{aligned} \qquad \text{(Equation 4)}$$

Where all variables indicate the same as has been specified in Equation 3 above and *exp* indicates the exponentiated value of the bracketed term.

The results of this gravity model will be in the form of coefficients for the independent variables. These coefficients will indicate whether or not each independent variable has a significant effect on the dependent variable and, where there is an effect, its size. Our focus of attention is on the sign, size and statistical significance of the SANC dummy variable as this variable captures the impact of the sanctions on trade flows.

We then take the coefficient value for the SANC variable and convert it into an ad valorem trade cost equivalent (AVE), which will later be included in the second matrix of the GSIM model as an NTB. This conversion is done using the following equation (Ecorys, 2009):

$$\mathrm{TCE} = e^{(\beta/E)} - 1 \qquad \text{(Equation 5)}$$

Where:

TCE = ad valorem trade cost equivalent
e = base of the natural logarithm
β = coefficient of the independent variable
E = Price elasticity of demand

The subsequent use of these AVEs (as estimates of NTBs) in the GSIM model will be further explained in the following section.

4.2 The Global Simulation (GSIM) Model

Now that we have established the degree to which sanctions affect the amount of trade that occurs between Iran and a selection of countries with which it formerly or currently trades, we must look at the ways in which trade flows would respond to a policy change that results in the worldwide repeal of sanctions. In order to analyze the changes in trade flows that can be expected, this research utilizes the GSIM model, developed by Francois & Hall (2003). The GSIM model was created to be used "for the analysis of global, regional and unilateral trade policy changes" (Wörz et al., 2007). It is a multi-region partial equilibrium model that assumes traded goods to be imperfect substitutes. Although this approach is limited in comparison to the more robust computed general equilibrium model, it also requires much less data and computational power to successfully run. As such, it allows for valuable inferences to be drawn at the industry level with regards to trade policy changes. The GSIM model results in measurements for changes in trade flows as well as welfare effects, i.e. consumer and producer surplus and tariff revenues. Thus, the calculated effects of a policy change as determined by the GSIM model are relevant for importers, exporters and governments alike.

The GSIM model is structured in such a way that it can be broken down into a series of equations. First, import demand is modeled as the following function:

$$M_{(i,v),r} = f(P_{(i,v),r}, P_{(i,v),s\neq r}, y_{(i,v)}) \quad \text{(Equation 6)}$$

Where:

$M_{(i,v),r}$ = demand for product *i* from country *r* in country *v*
$y_{(i,v)}$ = total expenditure on imports of *i* in country *v*
$P_{(i,v),r}$ = internal price for goods from region *r* within country *v*
$P_{(i,v),s\neq r}$ = price of other varieties

Next, composite demand for national product varieties and national supply functions must be defined using Equations 7 and 8.

$$P_{(i,v),r} = (1 + t_{(i,v),r})P_{(i,r)}{}^{*} = T_{(i,v),r}P_{(i,r)}{}^{*} \quad \text{(Equation 7)}$$

Where:

$P_{(i,v),r}$ = internal price for a good
$P_{(i,r)}$* = export price received by exporter *r* on world markets
$T_{(i,v),r}$ = proportional price markup achieved by tariff *t*

$$X_{i,r} = ks_{i,r}(P^{*}{}_{(i,r)})^{es_{(i,r)}} \quad \text{(Equation 8)}$$

Where:

$X_{i,r}$ = export supply of *i* from country *r* to world markets
ks = constant term
es = elasticity of supply

Finally, composite demand for a region can be defined as a constant function of elasticity.

$$E_{(i,v)} = ka_{(i,v)}P_v{}^{NA_v+1} \quad \text{(Equation 9)}$$

Where:

$E_{(i,v)}$ = composite demand
$ka_{(i,v)}$ = a demand equation constant that is set in calibration
P_v^{NAv+1} = a composite elasticity function of the regional composite price index

In addition, a series of welfare effects are calculated in the GSIM model. First, producer surplus is modeled as shown below in Equation 10, the mathematical representation of the area formed between the export supply curve and the price curve.

$$\Delta PS_{(i,r)} = R^0{}_{(i,r)} \times \hat{P}^*{}_{i,r} + \frac{1}{2} R^0{}_{(i,r)} \times \hat{P}^*{}_{i,r} \times \hat{X}_{i,r} \quad \text{(Equation 10)}$$

Where $R^0{}_{(i,r)}$ stands for the benchmark export revenues valued at world prices. To determine consumer welfare, Equation 11 first defines the composite good function:

$$Q_{i,v} = A_v \times \left[\sum_{i=1}^{r} \gamma_{(i,v),r} M^{\rho}_{(i,v),r} \right]^{1/\rho} \quad \text{(Equation 11)}$$

As the benchmark equilibrium defines the price of the composite good to be 1, the proportional change in Q's price can be modeled as in Equation 12.

$$\hat{P} = \frac{dP}{P} = \sum_{i=1}^{r} \theta_{(i,v),r} \times \hat{P}_{(i,v),r} \quad \text{(Equation 12)}$$

Where $\theta_{(i,v),r}$ is the demand expenditure share at internal prices. This is thus the composite price equation to be used in the GSIM model and build on the model found in Equation 13.

$$\frac{dP_{(i,v),r}}{P_{(i,v),r}} = \frac{(P_{(i,v),r})_1}{(P_{(i,v),r})_0} - 1 \quad \text{(Equation 13)}$$

Finally, consumer surplus is modeled as seen in Equation 14. This defines the change in the area of the demand curve and price curve for the composite good.

$$\Delta CS_{(i,r)} = \left(\sum_r R^0{}_{(i,v),r} \times T^0_{(i,v),r} \right) \times \left(\frac{1}{2} E_{M,(i,v)} \hat{P}_{(i,v)}{}^2 \times sign\left(\hat{P}_{(i,v)}\right) - \hat{P}_{(i,v)} \right) \quad \text{(Equation 14)}$$

$$where\ \hat{P}_{(i,v)} = \sum_r \theta_{(i,v),r}\, \hat{P}^*_r + \hat{T}_{(i,v),r}$$

4.2.1 GSIM Model Scenarios

As the sanctions story is fairly straightforward regarding Iran, we test only one scenario as part of this research. The scenario tested is a full repeal of economic sanctions against Iran from all countries. Because the efforts to denuclearize Iran are international in nature, it is unlikely that upon reaching an agreement any one particular country (even the US) would maintain its own unilateral sanctions. It is also clear that the sanctions will not be lifted gradually over time but instantaneously, as has been seen through the JPOA and the temporary lifting of certain sanctions. For these reasons, the scenario tested is one in which sanctions-related AVEs are completely removed from the model, with all other trade costs remaining constant.

One issue with the GSIM model is that it cannot generate trade flow projections from a zero starting point. Considering the nature of this research, this will become an issue due to the lack of trade flows stemming from sanctions. However, a workaround for the model has been utilized, in which the situation will be reversed. In this case, the GSIM model will measure the effects of imposing sanctions on a theoretical Iran, one where trade takes place with all partners. This will be done by creating a benchmark for Iran through comparison with similar countries in the region, e.g. Saudi Arabia. The results will then show the mirror image of what would happen if sanctions were to be removed. Still, the original findings from a GSIM model in which actual trade flows (or lacks thereof) are used should directionally and proportionally corroborate with these findings.

4.3 Data

In order to run both the gravity and GSIM models, it is necessary to collect or compute large amounts of relevant data. This data can predominately be found through the consultation of various publicly accessible databases. A detailed description of the various data used to complete this research and justification for their use can be found below.

4.3.1 Gravity Model Data

Before designing the gravity model, the scope of the research has been narrowed and refined. Firstly, a decision has been made to utilize the 2-digit aggregate HS Code 29, which includes all products in the category “Organic Chemicals”. This nomenclature accounts for 75% of Iran’s chemical production capacity[8], and all products that are traded with Iran under this nomenclature are liquid bulk, meaning they are typically transported by chemical tanker[9].

[8] Own calculations, based on data obtained through Royal Vopak N.V.

[9] It is also possible to transport certain petrochemicals via pipeline. Within Iran, some pipelines exist and transport, for example, ethylene from the South to the Northwest of the country. However, no such

The first type of data needed to be able to run the gravity model is the dependent variable, bilateral trade flows, which in this research is denoted by the variable X_{ij}. In order to be able to analyze bilateral trade flows, partner countries must be selected. For this research, 24 trade partners of Iran have been selected, giving a total of 25 countries and 600 bilateral trade flows per year. These 25 countries together account for between 75% and 90% of global chemical trade, depending on the year. Taking the period from 2002-2012 results in 6,000 bilateral trade flows. This period was chosen, as most of the data was readily available for the desired countries and product codes and includes years both before and after the implementation of multilateral sanctions against Iran. Through the use of the United Nations Commodity Trade (UN Comtrade) database, accessible via the World Bank's World Integrated Trade Solution (WITS) platform, export data for the 25 countries in question could be retrieved. Due to some countries' patchy reporting, some mirror data has been used to complete the dataset.

A number of selection criteria have been implemented in order to come up with the 24 trade partners to be analyzed in this research. First, countries that have been Iran's largest trade partners (pre-sanctions) or are currently Iran's largest trade partners (post-sanctions) have been included. Secondly, countries that impose autonomous sanctions on Iran have been included. Thirdly, a selection of *Organization of the Petroleum Exporting Countries* (OPEC) and *Organization for Economic Co-operation and Development* (OECD) members has been included in the dataset. Finally, the *BRICS* countries have been included in the dataset. A comprehensive overview of the selection criteria and the countries chosen can be seen in Table 1 below.

Selection Criteria	Countries
Former & Current Largest Trading Partners	(1) Brazil, (2) Canada, (3) China, (4) European Union, (5) India, (6) Indonesia, (7) Japan, (8) Oman, (9) Singapore, (10) South Africa, (11) South Korea, (12) Turkey, (13) United Arab Emirates, (14) United States
Sanctions Imposers	(15) Australia, *Canada*, *European Union*, *Japan*, (16) Norway, *South Korea*, (17) Switzerland, *United States*
OPEC	(18) Nigeria, (19) Qatar, (20) Saudi Arabia, *United Arab Emirates*, (21) Venezuela
BRICS	*Brazil*, *China*, *India*, (22) Russian Federation, *South Africa*
OECD	*Australia*, *Canada*, (23) Chile, *Japan*, (24) Mexico, *Norway*, *South Korea*, *Switzerland*, *Turkey*, *United States*

Table 1: Summary of Selection Criteria and Chosen Trade Partners of Iran

pipelines currently exist to transport petrochemicals between Iran and any of its trading partners, although various proposals have been made in previous years (e.g. an Iran-Europe pipeline).

Source: Author

In the period 2002-2012, these 24 trade partners have on average accounted for approximately 90% and 75% of Iranian HS29 exports and imports, respectively.

For each of the countries chosen, a series of independent variables have been defined and are needed to successfully run the gravity model. Firstly, nominal GDP and nominal GDP per capita have been used as measures of a country's income level. The use of nominal GDP over real GDP has been common practice in gravity equations as seen in the research of Bergstrand (1981), Hufbauer et al. (1997), Anderson & Van Wincoop (2003), Caruso (2003) and Yang et al. (2004), among others. This data has been collected through databases provided by *The World Bank*. Additionally, distance between two countries must be included as an independent variable. This research utilizes the traditional sense of distance as the physical distance in kilometers between two countries' capital cities. This data has been retrieved from a database provided by Dr. Kristian Skrede Gleditsch[10], professor at the University of Essex and research associate of the International Peace Research Institute.

The next series of independent variables serve as dummy variables to account for fixed effects. The first dummy variable, *BORD*, accounts for contiguity between countries. For the purpose of this research, contiguity means that the countries share a land border (i.e. maritime borders do not meet the requirement for *BORD=1*). The next dummy variable, *LANG*, considers whether or not countries share a common official language. Official languages data comes from the most current online version of the *CIA World Factbook*[11]. The dummy variable *BLOC* describes whether or not two countries are members of the same trade bloc or union. For this paper, only full-fledged trade unions and free trade areas[12] have been considered and membership data has come from each organization's respective website. The last dummy variable, *SANC*, accounts for the fact that some countries impose autonomous sanctions and others do not. This data was deduced through official press releases and legal documents that were obtained via national government websites.

4.3.2 GSIM Model Data

As previously stated, the GSIM model is an attractive tool when analyzing policy changes and their effects on trade due to the limited amount of data needed to

[10] See: http://privatewww.essex.ac.uk/~ksg/data-5.html

[11] See: https://www.cia.gov/library/publications/the-world-factbook/

[12] The following have been considered: Association of Southeast Asian Nations (ASEAN), European Free Trade Association (EFTA), European Economic Area (EEA), Gulf Cooperation Council (GCC), Southern Common Market (Mercosur) and North American Free Trade Agreement (NAFTA).

successfully run the model. Specifically, the inputs necessary to run the GSIM model are as follows: (1) bilateral trade flows, (2) initial AVE rates, (3) final AVE rates, (4) composite demand elasticities, (5) supply elasticities and (6) elasticities of substitution.

As in the gravity model, bilateral trade data is based on data retrieved from the UN Comtrade database. Trade flows are in the form of export values of the HS29 commodities aggregate. Differing from the gravity model, the GSIM model usually aggregates certain countries into regional groups. For example, it would normally be commonplace to group the OECD and BRICS countries together. However, as the goal of this research is to track changes in maritime trade flows, grouping countries together that are not geographically adjacent (e.g. Australia and Canada or China and Brazil) would make it impossible to do so. For this reason, the most important trade partners of Iran have been included separately and all other countries have been aggregated into a group known as “Rest of World” (ROW), to account for the entirety of world trade in HS29 petrochemicals. Accordingly, the completed first matrix of the GSIM model, in which bilateral trade flows from the year 2012 are placed, can be viewed in Appendix 1.

The next component of the GSIM model requires that tariff data be filled in. The initial tariff rates for the model are calculated as the sum of both real, applied tariffs and NTBs that affect trade. For the real tariffs, the weighted average of all actual imposed tariffs for the HS29 product group, which has been retrieved through the TRAINS database, accessible via the WITS platform. Where the import tariffs for a particular country were not available, alternative sources were utilized, such as the World Trade Organization (WTO) and national governments’ customs websites. The values for NTBs are composed of two measures. Firstly, the average of ad valorem equivalents of core NTBs for HS29 is found using data provided by the World Bank and based on the work of Kee et al. (2009). Here, “core” is used to indicate NTBs such as voluntary export restraints and quotas. Secondly, the ad valorem equivalent for sanctions as will be reliant upon the outcomes of the gravity model will be added to the core NTBs. The total of these two measures will count as the entire NTB for an importing country. Thus, adding both the real tariff and the NTB equivalent results in the final value to be used as the total initial tariff, as illustrated by Figure 11 below.

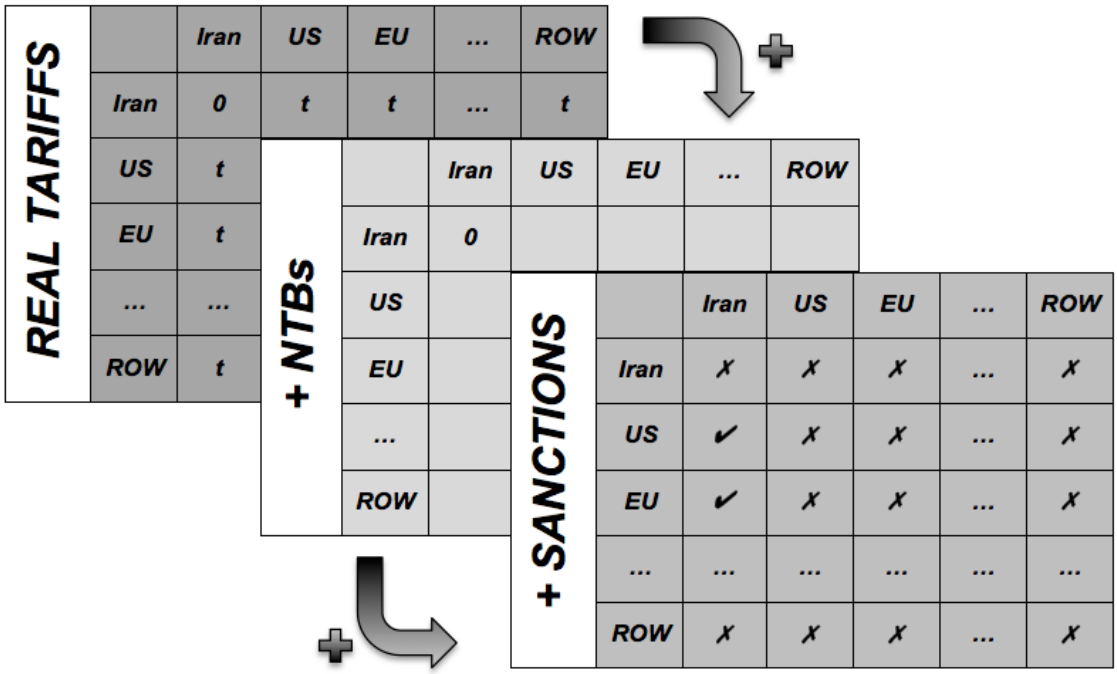

Figure 15: Layered Diagram of Initial Tariff Components

Source: Author

The final tariff rates for the model are calculated by simply removing the value of the sanctions ad valorem tariff equivalent from the corresponding initial tariff rates (thus, the foremost layer of Figure 15), as this research works under the assumption that only sanctions-related costs will disappear.

Below, Table 2 contains a truncated version of Appendix 2, where the individual components of each country pair's imposed tariff equivalents are shown.

Origin	Destination	Tariff (t)	NTB (n)	Sanctions (s)	Total (1+t+n+s)
Iran	US	0.027	0.540	0.57	2.137
Iran	EU	0.043	0.291	0.30	1.634
Iran	Australia	0.007	0.393	0.74	2.140
…	…	…	…	…	…
US	Iran	0.12	0.359	0.57	2.049
EU	Iran	0.12	0.359	0.30	1.779
Australia	Iran	0.12	0.359	0.74	2.219
Brazil	Iran	0.12	0.359	*n/a*	1.479
…	…	…	…	…	…

Table 2: Total Tariff Equivalent Calculations (Truncated)

Source: Author

The last types of data needed to run the GSIM model are the supply, demand and substitution elasticities. A demand elasticity of 5.0 has been used, as a standard average elasticity of demand for the petrochemical industry[13]. Regarding supply and substitution elasticities, the GSIM model comes preloaded with standardized values for them of 1.5 and 10.0, respectively. What the supply elasticity means for the petrochemical industry is that the supply of base organic chemicals is sensitive to price. The high substitutability of these base petrochemicals is also captured through the high value of the substitution elasticity, in that the larger the value, the more easily substitutable the product is. The effects of these elasticities will be tested as part of a sensitivity analysis. As such, no additional data for these matrices is necessary.

Additional data has been synthesized in order to account for the aforementioned issue with GSIM. Because sanctions lead to instances of zero value trade flows, the GSIM model has difficulty in projecting future trade flows to the expected scale. For this reason, we have deduced a workaround that allows us to implement the GSIM model in the analysis of sanctions removal on global trade flows (see section 5.2.1 above). In order to run the model in the reverse from what has been described above (see section 5.3 below), a benchmark has been created to estimate the amount of trade that Iran would carry out with partner countries, were there no sanctions in place. For this iteration of the GSIM model, Saudi Arabian trade data has been used as the Iranian benchmark, mainly because they are geographically located in the same region and both have immense feedstock resources, which are used to manufacture petrochemicals. Currently, Saudi Arabia is the largest petrochemical producer in the Middle East, even though it has 75% fewer natural gas reserves than Iran and not even double the oil reserves (U.S. Energy Information Administration, 2014). For these reasons, it is plausible to assume that Iranian trade flows could at the very least match those seen between Saudi Arabia and its trade partners.

[13] Based on a private conversation with Dr. Koen Berden

5 Results and Data Analysis

Following the argumentation above, the two models have been employed and have used the abovementioned data. First, the results of both the OLS and PPML gravity models will be described and analyzed. The reason for first running the OLS regression is that it will be performed as a sensitivity check for the gravity model, in order to truly determine whether sanctions are a significant factor in determining bilateral trade. Stemming from the output of the gravity model and the abovementioned tariff and elasticity data, the GSIM model has been run. Accordingly, the results of the GSIM model will also be described and analyzed in this chapter. A sensitivity analysis has also been carried out with respect to the GSIM model, which is included in this chapter.

In addition to the quantitative analysis found in this chapter, a discussion on how the results of the models translate into changes for the chemical tanker sector is also included. This will detail and analyze how the current fleet and trade lane patterns will need (or be expected) to change in response to the predicted changes in petrochemical trade values and flows.

5.1 Gravity Model Results

Below, a summary of the results of the OLS and PPML gravity models concerning the petrochemical trade between Iran and 24 of its trade partners can be found in Table 3 on the following page. This table contains the coefficients and p-values (shown in parentheses) of each independent variable for both specifications of the gravity model.

OLS Regression *Dependent Variable: ln X_{ij}*		**PPML Regression** *Dependent Variable: X_{ij}*	
Name	*Coefficient*	*Name*	*Coefficient*
Constant	**- 38.82816*** **	Constant	**- 24.86113*** **
	(0.000)		*(0.000)*
ln GDP_i	**1.174221*** **	ln GDP_i	**0.7953408*** **
	(0.000)		*(0.000)*
ln GDP_j	**1.127852*** **	ln GDP_j	**0.8840213*** **
	(0.000)		*(0.000)*
ln $GDPPC_i$	**- 0.2295851*** **	ln $GDPPC_i$	**0.0364818**
	(0.003)		*(0.621)*
ln $GDPPC_j$	**- 0.3076736*** **	ln $GDPPC_j$	**- 0.1956687** **
	(0.000)		*(0.015)*
ln $DIST_{ij}$	**- 1.129246*** **	ln $DIST_{ij}$	**- 0.966366*** **
	(0.000)		*(0.000)*
BORD	**- 0.5093929**	BORD	**- 0.4088848**
	(0.413)		*(0.321)*
LANG	**0.9492512*** **	LANG	**0.4716979** **
	(0.007)		*(0.035)*
BLOC	**- 0.0647799**	BLOC	**- 0.2911271**
	(0.921)		*(0.625)*
SANC	**- 2.174389***	SANC	**- 2.015657*** **
	(0.080)		*(0.000)*
Observations = 5,116 R-squared = 0.4622		Observations = 5,335 R-squared = 0.6760	
Notes: ***** significant at the 1% level** **** significant at the 5% level** *** significant at the 10% level**		Notes: ***** significant at the 1% level** **** significant at the 5% level** *** significant at the 10% level**	

Table 3: Summary of OLS and PPML Gravity Model Results

Source: Author

As expected, the OLS regression has turned out to be far less explanatory than the PPML specification of the gravity model. When met with a large amount of zero values (more than 200 observations were dropped by the OLS regression, even after manually controlling for and removing arbitrary zeroes beforehand), the model does not fit very well with the data, as the R^2 value of 46 percent shows. Regardless, the signs and sizes of the coefficients are for the most part as expected. For instance, the model confirms that the GDPs of both the exporter and the importer are very significant determinants of bilateral trade. According to the OLS regression, a one percent change in the GDP of either the exporter or importer nation will lead to a 1.17 or 1.13 percent change,

respectively, in the amount of bilateral trade in organic chemicals. The physical distance between two trade partners also results in a decrease in trade. Specifically, the OLS estimates that a one percent increase in distance results in 1.13 percent less trade. Also statistically significant is the effect that sharing a common language has on trade, which is positive. As also hypothesized and expected, the effect that sanctions have on trade is negative, although only at the 10% significance level.

Now looking at the results of the PPML gravity model (where no observations have been dropped thanks to the elimination of the logarithmic nature of the dependent variable), a large increase in the R^2 value can be seen. With such a coefficient of determination, nearly 68% of the variation in the dependent variable, X_{ij}, can be explained by the variance in the independent variables. This confirms that the PPML model fits the data much better than the OLS model. Other than an increase in the coefficient of determination, nearly all the signs and sizes of the coefficients have remained about the same. Notable is the slight decrease in the degree of the effect that GDP plays on trade, as the coefficients of GDP_i and GDP_j are now 0.80 and 0.88, respectively. These values are both in line with earlier findings by Santos Silva & Tenreyro (2006) and Berden et al. (2013). Of additional interest is the fact that, although the value of the coefficient has decreased slightly from -2.17 to -2.02, the dummy variable for sanctions is now significant at the 1% level, with a p-value of zero.

Following from Equation 5, the coefficient results found for the sanctions variable can be converted into an ad valorem tariff equivalent, which will be used in the GSIM model. Accordingly, the ad valorem tariff equivalent found using the PPML gravity model is equal to $e^{(-2.02/5)} - 1 = -0.33$, which indicates that sanctions leads to a deadweight cost of 33 percent or – in other words – an AVE of 33%. This percentage can be modeled as an NTB and entered into the GSIM model.

Following the initial results, it is also possible to break down the sanctions variable in the gravity model country by country - allowing for country specific differences. This can be achieve by interacting the sanctions dummy with the country fixed effects in the gravity regression. As such, the model is able to estimate a separate coefficient of the sanctions variable for each sanctions-imposing nation. Once these coefficients have been estimated they are straightforwardly converted into ad valorem tariff equivalent values. The results of this adapted model and the corresponding deadweight cost estimates are found in Table 4.

PPML Regression with Fixed Effects *Dependent Variable: X_{ij}*		
Name	*Coefficient*	*Ad Valorem TCE*
SANC2 *Australia*	**- 6.760335***** *(0.000)*	**-0.74**
SANC4 *Canada*	**- 3.717858***** *(0.000)*	**-0.52**
SANC5 *Switzerland*	**- 0.7738658***** *(0.009)*	**-0.14**
SANC8 *European Union*	**- 1.806983***** *(0.000)*	**-0.30**
SANC12 *Japan*	**- 3.339554***** *(0.000)*	**-0.49**
SANC13 *South Korea*	**0.140931** *(0.439)*	*n/a*
SANC16 *Norway*	**- 8.295164***** *(0.000)*	**-0.81**
SANC21 *Singapore*	**- 0.2512795** *(0.479)*	*n/a*
SANC23 *United States*	**- 4.258209***** *(0.000)*	**-0.57**
Notes: ***** significant at the 1% level** **** significant at the 5% level** *** significant at the 10% level**		

Table 4: Summary of Country Fixed Effects Coefficients and Ad Valorem TCEs

Source: Author

Interestingly, adding the interaction between the sanctions dummy and country fixed effects , yields non-significant results for two countries, Singapore and South Korea. At first glance, this may seem puzzling because for all other countries the sanctions are both economically and statistically significant. However, looking at the realities of both countries' trade patterns with Iran can explain these results. Firstly, Singapore has never relied on Iran for its petrochemical imports. On the one hand, it is a large producer of petrochemicals itself. Secondly, Singapore has maintained much stronger trade relations with countries such as the US and China for more than two decades, as shown by historical trade data. Thus, although the country has chosen to implement sanctions into its national legislature as a means of showing solidarity with the West, Singapore has never relied much on Iranian petrochemicals, thus leading to insignificant unilateral effects of its sanctions. When it comes to South Korea, however, the story is very different. Firstly, before the implementation of sanctions, South Korea

was one of Iran's largest trade partners. In the past, both countries have enjoyed strong bilateral trade relations in many various sectors, including petrochemicals (Chang, 2014). As such, the sanctions regime against Iran has always been a mixed affair for South Korea: wanting to side with its Western allies on the one hand, but being economically exposed to Iran on the other. This has culminated in the granting of sanctions waivers by the US and EU, allowing South Korea to continue doing business with Iran, albeit at slightly lower levels than before. Consequently, the fact that the sanctions enacted by the South Korean government are much less severe – some even say: appear to be symbolic only rather than prohibitive – can explain the insignificance in results stemming from the gravity model.

Now that the sanctions' impacts on bilateral trade have been converted into trade cost equivalents, they can be implemented in the second matrix of the GSIM model as a portion of the total NTB measurement. These TCEs will also be the AVE amounts that are removed in matrix three in order to mimic the "shock" to the system that will result from a sudden and complete removal of sanctions. As such, we treat the sanctions as a prohibitive trade cost, just as a tariff, quota or other trade barriers. This allows us to simulate their effects on trade values and model what would occur should a policy change take place that would remove them.

5.2 GSIM Model 1 Results

Having now converted the coefficient for the independent variable, "SANC", into NTBs to be included in the second matrix of the GSIM model, global trade projections for a future without sanctions can be estimated.

5.2.1 Trade Projections

After removing the sanctions' ad valorem trade cost equivalents from the final tariff rates in the third GSIM matrix (see Appendix 3), trade projections have been generated for Iran and its trade partners. In the aftermath of removing sanctions, various shifts are expected to occur regarding the global petrochemicals trade. The expected percentage increase or decrease in bilateral trade flows between all relevant trade partners are summarized in Figure 16 below.

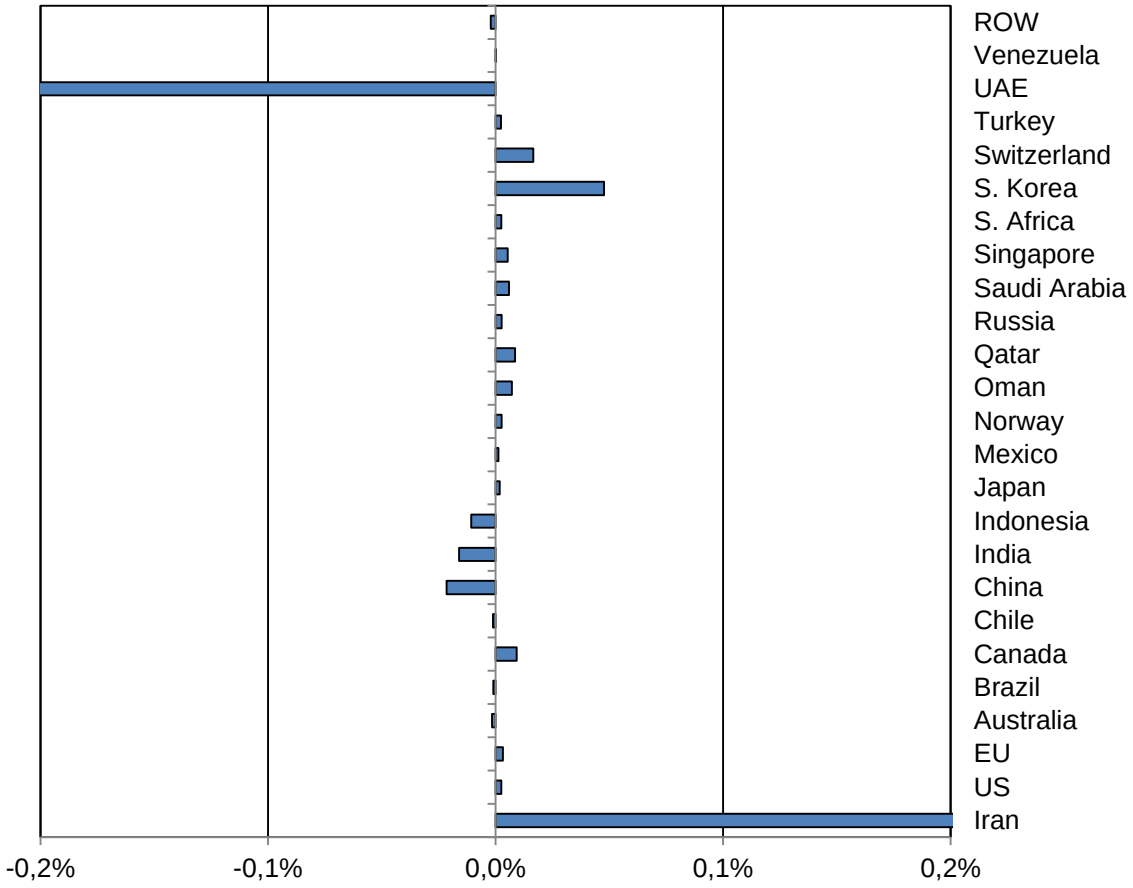

Figure 16: GSIM Model 1 Percentage Change in Output
Source: Author

From these findings, it is clear that Iran has the most to gain in terms of increases in global trade (one percent growth in output). With the lifting of sanctions, Iran will once again have full access to lucrative markets such as the US, EU, Norway and Switzerland, who have reduced or completely ceased trade since the imposition of sanctions. Due to Iran's reentry into the global petrochemical trade, the United Arab Emirates will suffer most (experiencing a contraction in output of 0.4 percent). Since it is Iran's neighbor, with similar access to feedstock and transport costs that are roughly the same, many countries that formerly traded with Iran substituted sanctioned petrochemicals with those goods from the UAE. However, as Iran is able to produce at a higher level and thus a lower price, many countries will likely switch back to purchasing Iranian chemicals once again.

South Korea will also gain, as Iran has historically been a very important trade partner and although it officially imposes sanctions against Iran, bilateral ties have not been

truly severed. South Korea will therefore be able to take advantage of the newly opened doors to Iran more quickly than other exporting nations.

5.2.2 Welfare Effects

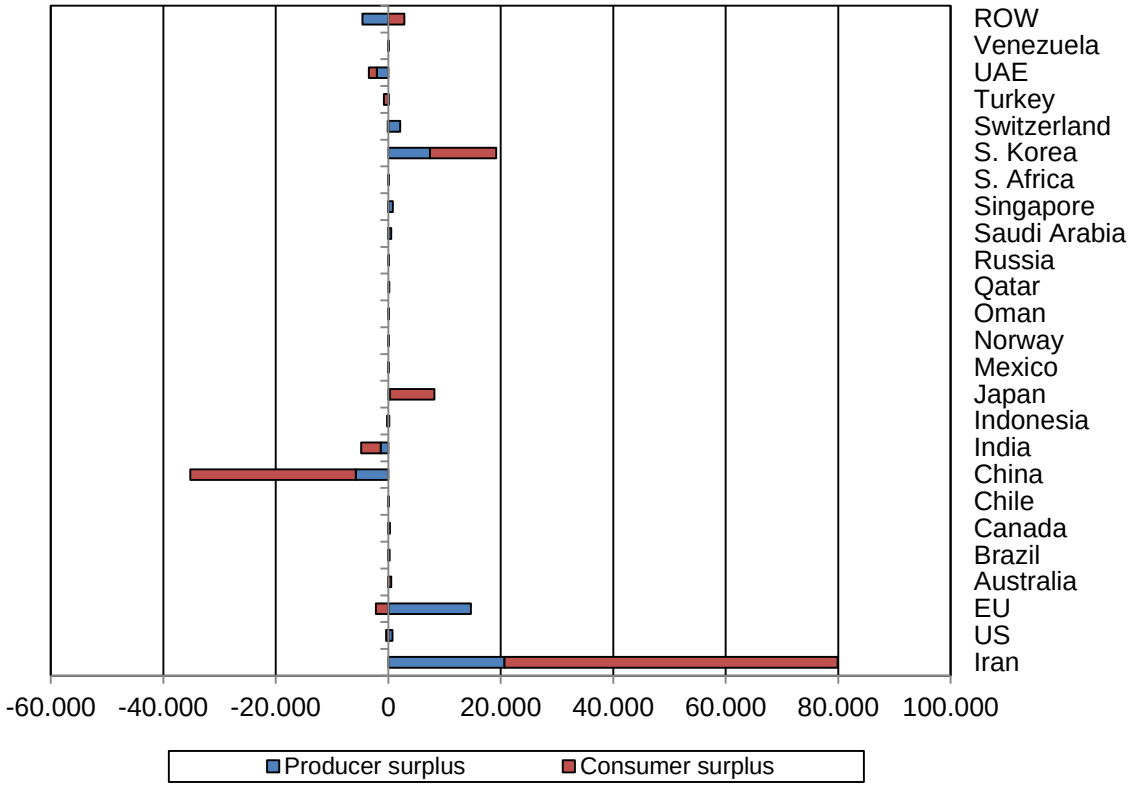

Figure 17: GSIM Model 1 Change in Consumer and Producer Surplus (in 1,000 USD)
Source: Author

Iran will also experience the greatest increase in consumer surplus. As the market will open up, more competition will drive prices down, since the few exporting countries that currently still trade with Iran will not be able to charge premiums under the guise of increased trade risk. EU producer surplus will also see a large increase. As one of Iran's largest trading partners prior to the most recent sanctions having been enacted in the last few years, the EU will once again begin to trade petrochemicals with Iran in large quantities. In terms of welfare, the losers here are China and India, who at the moment have served to fill the void left by sanctioning countries in the West. However, in a post-sanctions future, the attractiveness of both China and India as trade partners will decrease for Iran. Due to increased competition from abroad and more attractive alternatives for Iranian export, both consumer and producer surplus will decline.

5.3 GSIM Model 2 Results

Upon initial completion of the analysis above, it seems that sanctions do not appear to affect the global petrochemical trade on as major a scale as had been expected, although the outcomes appear logical in terms of the directions in which output and welfare changes occur. However, the explanation for this lies in the limitations of the GSIM model. As previously stated, the GSIM model is unable to make accurate projections out of zero values. Thus, by modeling the current situation, where certain country pairs' bilateral trade flows are (close to) zero, the GSIM model is unable to generate accurate output predictions. For this reason, the use of the GSIM model has been repurposed in order to better achieve the goal of this research. Accordingly, *GSIM Model 2* is an alternative iteration of the GSIM model, which uses nearly identical data. Where the model differs is that potential Iranian trade flows have been estimated for all of its trade partners, thus this version of the model imagines a world in which sanctions were never imposed. This means that, additional to changes in the trade flow matrix, the initial tariff matrix consists only of actual tariffs and other non-tariff barriers, but not sanctions-related barriers as estimated by the gravity model. Next, the sanctions will be *added* to the third GSIM matrix, final tariffs. This will simulate the changes in output and welfare effects that would occur, were sanctions imposed on a hypothetical Iran that has maintained steady trade relations throughout the last decades. The preliminary results of *GSIM Model 2* therefore depict the mirror image of what it is this research aims to achieve. Thus, by taking these results and multiplying them all by negative one (-1), conclusions regarding the removal of sanctions can be drawn.

5.3.1 Trade Projections

Upon running GSIM Model 2 in the manner described above, new trade projections following the removal of sanctions have been generated. The expected percentage increase or decrease in bilateral trade flows between all relevant trade partners are summarized in Figure 18 below.

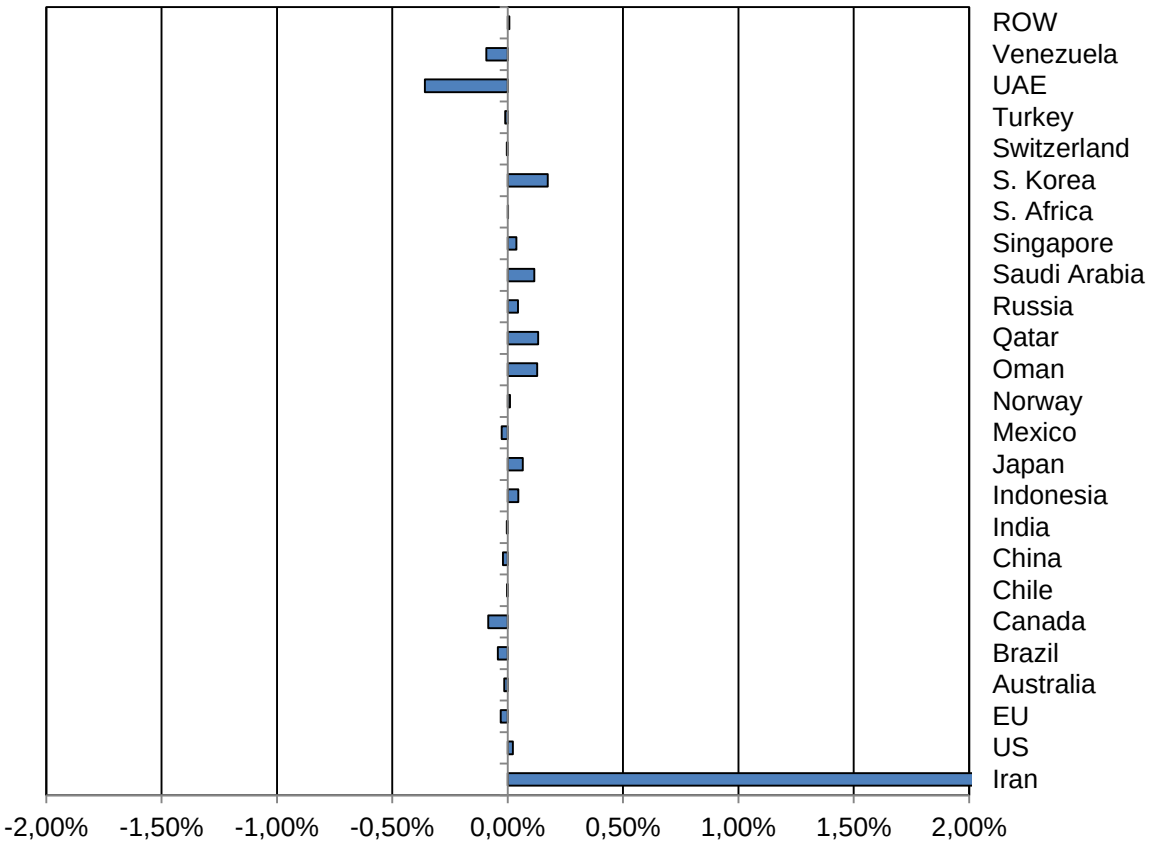

Figure 18: GSIM Model 2 Percentage Change in Output

Source: Author

The findings from the second iteration of the GSIM model show a much larger percentage change in the output of Iran (12.30%), while all other countries' percentage gains and losses in output have not changed in comparison to the original model. These new findings appear to be logical, considering that, although global petrochemical output is expected to continue to grow in the coming years, sanctions against Iran have not affected other countries' individual outputs, but instead diverted them to alternative markets. As such, the United Arab Emirates will remain the largest loser, albeit its output will only decrease by 0.36 percent. Other countries that will experience minor decreases (less than one percent) in output are the EU, Australia, Brazil, Canada, China, Mexico, Switzerland, Turkey and Venezuela. Countries that will see slight increases (less than one percent) are the United States, Indonesia, Japan, Norway, Oman, Qatar, Russia, Saudi Arabia, Singapore, South Korea and South Africa.

5.3.2 Welfare Effects

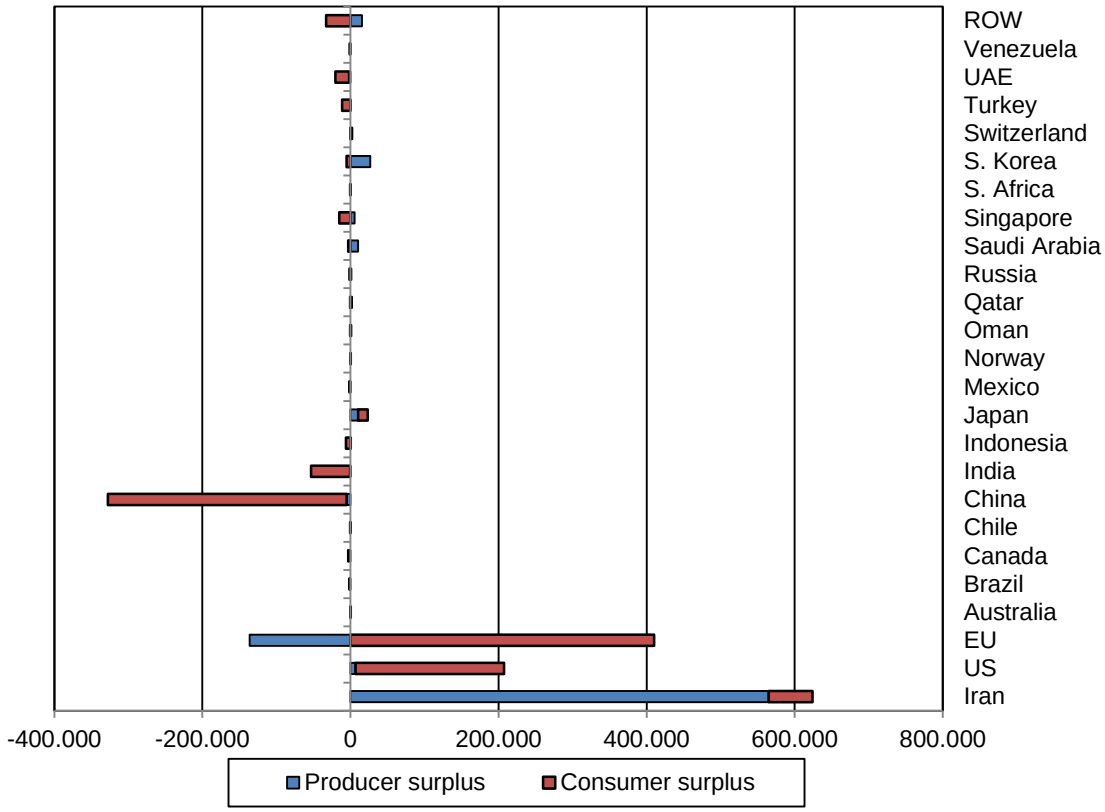

Figure 19: GSIM Model 2 Change in Consumer and Producer Surplus (in 1,000 USD)
Source: Author

The welfare effects measured by the second iteration of the GSIM model show a staggering increase in the scale of producer and consumer surplus gains and losses. Whereas the first model indicated a producer surplus of 20.7 million dollars for Iran, the new model measures a gain of 564.8 million dollars. In addition to this, the removal of sanctions will lead to large gains in consumer surplus for the US and EU (200.4 million and 410.1 million dollars, respectively), while consumer surplus in China and India will decrease by 322.1 million and 52.9 million dollars, respectively. Changes in both consumer and producer surplus for the rest of the countries, while by no means negligible, are significantly smaller.

5.3.3 GSIM Model Sensitivity Analysis

In order to test the steadfastness of the GSIM model, a sensitivity analysis has been done in which the elasticities of demand and substitution were altered. The organic chemicals that this research focuses on are used to produce many more complicated

chemicals and other manufactured products. For example, organic chemicals such as methanol, propylene and xylene are necessary inputs for synthesizing intermediary chemicals such as formaldehyde and acetone, which are then used to produce paints, cosmetics, polyesters, rubber and other final goods (Massey & Jacobs, 2013). Because there are not always chemical substitutes for the production of downstream products, the elasticity of substitution of these basic input chemicals should be relatively low.

However, there are a multitude of countries that have the capacity to produce these chemicals and, since they are basic, the chemicals produced in one country can be easily swapped out for another country's chemicals. For this reason the substitution elasticity will in any case remain high, in the sense that one country's base chemicals are not technologically or physically superior to those chemicals produced in another country. This indicates that they can be easily substituted.

In the case of the demand elasticity, these chemicals are not final goods because their purpose is to be used for the production of a plethora of end-user products. As the demand elasticities for these products varies, so too will the elasticities of the organic chemicals that go into making them. For this reason, changes in magnifications of the effects of lifting sanctions can be seen when increasing the elasticity of demand. Simply put, the more elastic the price elasticity of demand for organic chemicals becomes, the more organic chemicals will be shipped.

The results of the performed sensitivity analysis have shown that, although small changes in the degree of the effects do take place depending on the elasticities, the directions and relativity of effects between countries remains the same. Thus, it can be concluded that the effects, though dependent on a number of various market conditions, remain valid indicators of what an end to the Iranian sanctions regime would mean for the petrochemical industry and chemical tanker sector.

5.4 Trade Lane Analysis

Now that the changes in output have been measured, it is possible to determine how the lifting of sanctions will affect global petrochemical trade lanes concerning Iran. Currently, there are no (or a negligibly small amount of) petrochemicals being traded between Iran and the US, EU, and other countries that have imposed sanctions. However the lifting of sanctions will change this picture drastically. As seen in Figure 20, Iranian exports to the US and EU are expected to increase greatly upon the removal of sanctions, by approximately 1.16 billion and 2.03 billion dollars, respectively. Additionally, exports to South Korea and Japan will pick up by about $53 million and $107 million, respectively. At the same time, exports to China ($1.38 billion), India ($328 million), the UAE ($97 million) and Turkey ($64 million) are expected to fall.

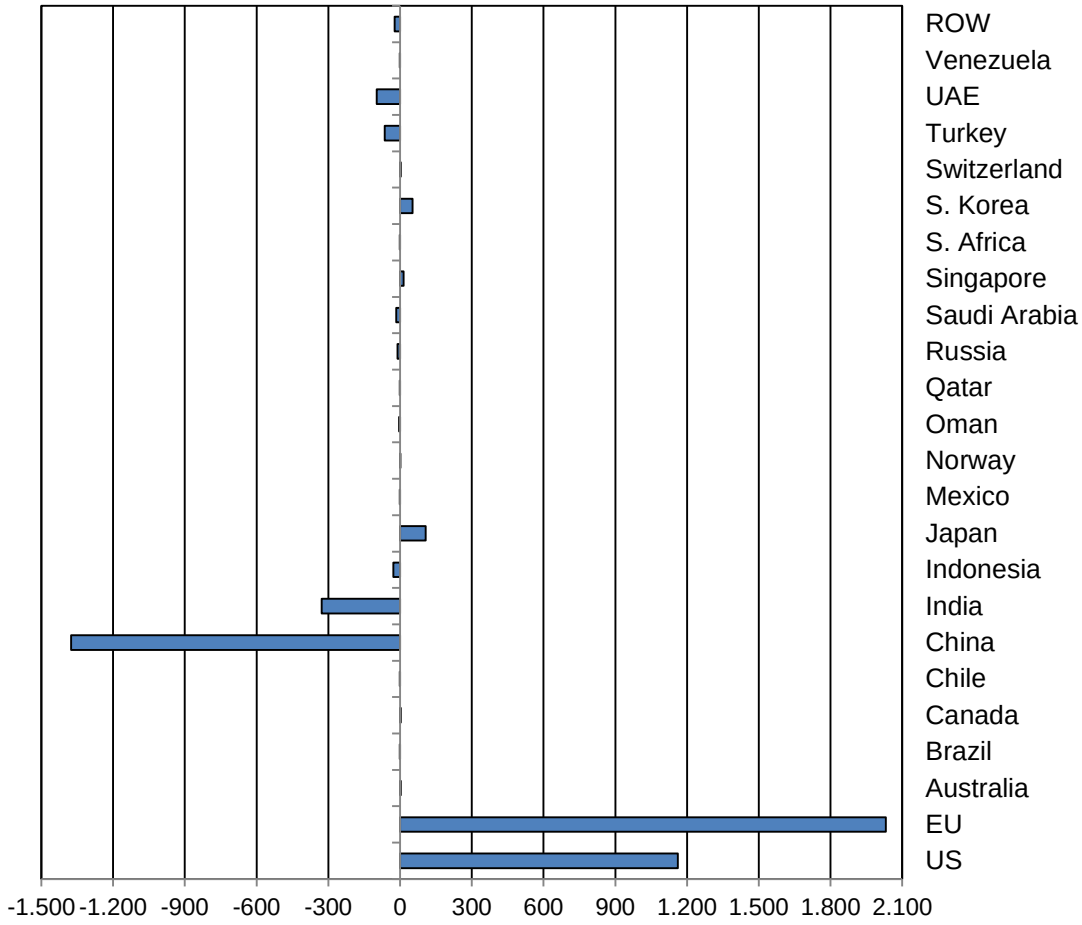

Figure 20: Change in Iranian Exports by Trade Partner (in 1,000,000 USD)
Source: Author

Changes in the countries from which Iran imports petrochemicals will also occur, as can be seen in Figure 21.

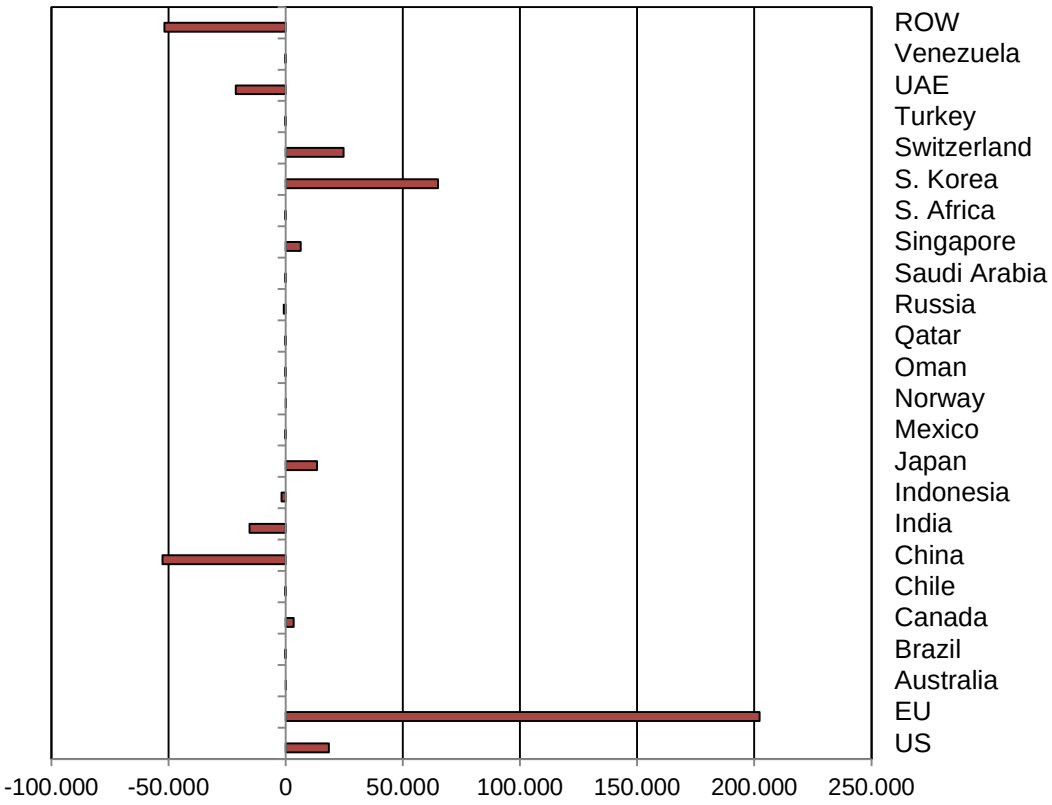

Figure 21: Change in Iranian Imports by Trade Partner (in 1,000 USD)
Source: Author

As can be seen, the EU will once again begin to export petrochemicals to Iran in large quantities (increasing exports by over 202 million dollars), as will South Korea (increase of about $65 million) and Switzerland (increase of approximately $25 million), with the US also increasing exports (by approximately $18.5 million), albeit at lower levels than the sanctioning countries that do not have as long of a rough political history with Iran. Again, China, India and the UAE will suffer from lost export opportunities to Iran, with China taking the largest loss at about 52.5 million dollars.

These changes in export and import values indicate that maritime transport capacity will have to increase on the trade lanes between the US, EU and Iran, while other trade lanes will see a decrease in maritime traffic regarding petrochemical cargo flows.

Table 5 below gives an overview of the largest changes to bilateral trade flows that will occur in the wake of a full sanctions repeal, giving an indication as to which trade lanes will contract and grow in both size and importance.

Origin	Destination	Current Trade Flow (in 1,000 USD)	Post-Sanctions Trade Flow (in 1,000 USD)
Iran	US	-	$1,161,233
US	Iran	-	$18,482
Iran	EU	$40,479	$2,071,600
EU	Iran	$105,032	$307,358
Iran	China	$2,079,133	$703,884
China	Iran	$350,010	$297,488
Iran	India	$498,617	$170,766
India	Iran	$102,111	$86,691
US	EU	$10,648,845	$10,606,785
EU	US	$24,155,754	$23,920,446
US	China	$3,243,481	$3,291,306
China	US	$6,232,857	$6,168,460
US	India	$867,978	$879,127
India	US	$1,744,332	$1,724,620
EU	China	$3,721,569	$3,788,232
China	EU	$6,407,570	$6,398,728
EU	India	$1,490,579	$1,514,445
India	EU	$2,777,164	$2,770,638
China	India	$4,757,039	$4,830,389
India	China	$1,022,934	$1,039,657

Table 5: Current and Post-Sanctions Bilateral Trade Flows

Source: Author

As can be seen, the EU and the US will overtake China and India as the largest trade partners with Iran following the repeal of sanctions. The sanctions repeal will also lead to changing volumes on current trade routes. For example, China will remain a large importer of major HS29 chemicals such as methanol and toluene. However, the model predicts that both China and India will increase imports from the US and EU, while its Iranian sourced imports will fall. The fact that American and European chemicals are generally more expensive than their Middle Eastern counterparts can explain the loss of consumer surplus that countries such as China and India will experience. This indicates shifting trade patterns and changes in traffic between the Middle East and the West as well as the West and the Far East.

Due to these changes in bilateral trade flows, certain consequences will arise for the chemical tanker sector in a variety of ways. Firstly, the lifting of sanctions against Iran could have an impact on chemical tanker order book decisions. In addition, freight rates will be affected by such a policy change. Lastly, logistical complications regarding forward and backhaul of base chemicals will need to be pondered by chemical tanker owners. These issues are each discussed in further detail below.

5.4.1 Global Chemical Tanker Order Book

Like many other shipping sectors, the chemical tanker sector experienced rapid and exorbitant growth before the onset of the financial crisis. From 2008 to 2011, the chemical tanker fleet expanded by over 25 percent, due to large orders being placed in times of optimism (SPI Marine, 2013). The global economic crisis that ensued thereafter led to a depressed demand for chemical trade. As chemical tankers are technically complex and often contain segregated tanks (enabling them to carry multiple cargoes at once), economies of scale does not always equal better. Unfortunately, the majority of newbuilds (62%) that entered the market from 2008 onwards were large, coated tankers that are incapable in carrying all types and quantities of cargoes. These tankers are less flexible and versatile than their smaller, more complex, stainless steel counterparts. As such, the chemical tanker sector has struggled with depressed freight rates and low utilization rates over the last few years. The last years, however, have seen healthy levels of demolition and low volumes of new deliveries, allowing for the global fleet to slow the pace of growth.

Fortunately, global demand for chemical shipping has also continued to grow steadily, by approximately five percent per annum (SPI Marine, 2013). However, it will still take a few years until the fleet size shrinks to the level of demand for freight that exists.

Regardless, the current inability for ships to transport Iranian cargoes has lead to further depression in the market (Odfjell, 2012). Consequently, the removal of sanctions against the shipment of Iranian petrochemicals will aid in increasing the demand for chemical transport. This will lead to better utilization rates for tankers.

5.4.2 Freight Rates

In addition to low utilization rates, the overcapacity that exists in the chemical tanker fleet has also resulted in unsustainably low freight rates. Western trade routes (e.g. US Gulf to South America or Northwest Europe) saw year-over-year rates drop by 20-30 percent between January of 2012 and 2013 (SPI Marine, 2013). However, Middle Eastern trade routes (both Eastbound and Westbound) fared better, albeit still poorly, by experiencing freight rate increases of 2-5% over the same one-year period.

With the lifting of sanctions, large trade volumes will once again leave Iran destined for Western countries. This means the freight rates for Middle East-US and Middle East-Europe transport could experience significant growth in the near future, similar to intra-Asian freight rate growth of 13-22 percent from 2012-2013, aiding in the recovery of the chemical tanker sector.

5.4.3 Forward and Backhaul

Due to the nature of chemical products, chemical tankers are the most technically complex vessels in the shipping industry. Firstly, many chemicals are corrosive, meaning that chemical tankers must be designed with special epoxy, zinc or other types of coatings or be built with stainless steel tanks. Secondly, the storage of certain chemicals relies on either heating or cooling to precise levels, meaning that chemical tankers must be built with reliable, complex climate and atmospheric control systems. Lastly, many chemicals have the potential to interact with other chemicals or gases in the air, making them difficult to store without compromising their quality. In addition, certain unwanted chemical interactions are potentially hazardous, which is why chemical tankers must have strong and reliable segregations.

Governing the many regulations surrounding chemical tankers is the International Maritime Organization (IMO), through the International Bulk Chemical Code, which sets out the standards to which chemical tankers must be built. On top of the technical requirements put on chemical tankers by the IMO, FOSFA publishes lists of acceptable and banned previous cargoes governing the backhaul possibilities of these ships.

For example, Iran's largest chemical export is methanol, which is an acceptable previous cargo (FOSFA, 2013). This means that a vessel can sail from Asaluyeh, Iran to Rotterdam, the Netherlands with a shipment of methanol and return with certain vegetable oils without having to first clean the ship's tanks. This enables a shipowner to minimize ballast legs and thus maximize the amount of ton-miles performed by a ship.

Since most of the chemical products that are produced in Iran are acceptable previous cargoes, the opening up of the Iranian export market will allow for chemical tanker owners and cargo owners alike to take advantage of increased backhaul opportunities between the West and the Middle East. Therefore, the removal of sanctions can help to improve the utilization, and thus the profitability, of the global chemical tanker fleet.

6 Conclusions

This final chapter will serve to summarize the findings of the research and map out the implications thereof. In addition, some shortcomings of the research and its methods will also be mentioned as well as suggestions for further research related to the topic and field of study.

6.1 Key Findings

In the case of Iran, the gravity model has proven that the effects of sanctions on bilateral trade flows are not only significant for most sanctions-imposing countries, but also substantial. With measurements between -0.14 and -0.81, the degree to which sanctions affects trade varies between countries. However, all but South Korea and Singapore have shown notable negative effects.

Furthermore, the GSIM model has allowed us to project trade flows following a full repeal of sanctions against Iran. The GSIM model has indicated that a change in both output and trade direction is to be expected. Firstly, Iran's total petrochemical exports will increase by more than 12 percent. It will also trade more with the United States and EU (increasing from virtually zero to over one billion and two billion dollars, respectively) than with China and India (both decreasing by approximately 66 percent) in the future. Flows between the US/EU and China/India will consequently increase, in order to meet China and India's increasing demands for petrochemicals. Though smaller in size, other countries will also experience positive growth in trade with Iran, such as Japan, South Korea and Switzerland, while current key Iranian trade partners, Turkey and the UAE, will suffer.

In turn, the chemical tanker sector will face certain changes if the sanctions against Iran are lifted. Firstly, global production shifts will occur, leading to newly expanded trade routes, primarily between Iran and the US and Western Europe. At the same time, trade routes between Iran and the East will contract, as large players, such as China and India, that have served to fill the void left by sanctions will become slightly less relevant.

Secondly, if trade growth increases greatly, there may be a lack of capacity in the market leading to an increase in freight rates. Because chemical tankers are technically complex vessels, the average time needed to complete newbuildings and increase the global fleet lags in comparison to other ship types. For this reason, it may take some time for the transport market to adjust to the effects stemming from a repeal of sanctions. As a result, transportation costs for these chemicals will increase.

6.2 Implications

The implications of these findings should resonate most with petrochemical producers chemical tanker owners and charterers. As freight rates are currently struggling to remain at sustainable levels, due to the overextension of the chemical tanker fleet, owners will be satisfied to see an increase in international petrochemical output, which will tighten the market and push up freight rates. In addition, producers of products whose inputs are base organic chemicals will benefit from the lifting of sanctions, as prices can be expected to drop. Current buyers of Iranian products may be unpleasantly surprised at the negative effects that opening the market will have on their imports and exports. Since countries such as China are currently able to buy Iranian petrochemicals below market price, due to the limited options of Iranian exporters, Chinese importers will suffer from a return to global market prices for Iranian goods.

6.3 Limitations of the Research

Although the results of this paper are telling, there are a few limitations, which must be kept in mind in order to fully appreciate and interpret the results. Firstly, we use the partial equilibrium GSIM model instead of a general equilibrium CGE model. We believe that there is merit in this approach due to the increase in the sector from an initial zero trade flow, but it also means that the ability to model inter-industry effects and to look at secondary income effects is lost. The advantage of GSIM over CGE lies in the fact that the limited amount of factors accounted for in the GSIM allows for quick and transparent analysis regarding changes in multi-national trade policy.

Additionally, neither of the two models used above have been built to mimic the effects of potential start-up delays. As the petrochemical industry is very capital intensive, it could take time for the refining capacity to catch up to the potential export ability as predicted by the GSIM model. Because the reality of a full repeal of sanctions will remain uncertain until a nuclear agreement is achieved, it is likely that there will be little lead time between their removal and the ability for Iranian petrochemicals to enter the world market. This period of time in between the official announcement of an end to international sanctions and the ability to for the Iranian petrochemical industry to reach its full potential is yet to be known. Additional lead time issues occur regarding the chemical tanker sector as well, since chemical tankers are more complex than other types of ships and therefore require a longer period of time to build and grow the world fleet. As a consequence, if a sudden growth in output were to occur, there might not be enough capacity to immediately transport it.

6.4 Suggestions for Further Research

As this paper concerns current events surrounding the position of Iran in the international community and how it affects trade, there are endless directions in which this research could be taken further. Firstly, this paper has only focused on basic petrochemicals and their transport, a relatively niche shipping market. It would also be interesting for similar research to be done for the entire economy and all sectors. Since there have also been targeted sanctions against crude oil and certain types of metals, the analysis of these sectors would be pertinent. In addition, it could also be worthwhile to analyze how non-sanctioned sectors, such as the agriculture industry, have fared in the wake of international sanctions.

Aside from the Iranian situation, sanctions have also been implemented against other countries for a variety of reasons. Most recently, sanctions against Russia have arisen due to the current political crisis surrounding Ukraine. This paper has served to lay the groundwork for utilizing certain econometric specifications of the gravity model and the GSIM model in analyzing the effects of sanctions, a task made difficult by the presence of many zero value trade flows. This methodology could therefore be applied to other research that aims to measure the effects of sanctions against Russia, or any other countries that are currently affected by the implementation of unilateral or multilateral sanctions against them.

This paper also touched on the complications that chemical tankers face due to restrictions concerning subsequent carriage of certain cargoes. However, this paper only deals with forward and backhaul carriage opportunities in a qualitative manner, as the models have analyzed an aggregated group of goods. Future research may want to disaggregate trade flows and further analyze the logistical issues regarding the transport of chemicals.

In closing, the speed at which the geopolitical arena is changing with regards to Iranian policy and diplomacy leads to many exciting, if not daunting, challenges ahead. A future in which Iran is able to fully partake in the global trades of petrochemicals and many other goods is probably nearer than many would have expected just two short years ago. How Iran reintegrates into the international community will depend on not only foreign willingness to invest in a resource-rich country, but also Iranian willingness to cooperate with established international norms. The role that sanctions play in our modern world is manifold and the use of sanctions as a pillar of foreign policy does not seem to be dwindling. As such, the ways in which they affect their intended targets will continue to be important areas of research for the foreseeable future.

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Appendix 1: Trade Flow Values for GSIM Matrix 1

Origin	Destination	Trade Value in 1,000 USD
Iran	US	$1.00
Iran	EU	$40,479.01
Iran	Australia	$645.00
Iran	Brazil	$143.00
Iran	Canada	$2.00
Iran	Chile	$1.00
Iran	China	$2,097,133.00
Iran	India	$498,617.00
Iran	Indonesia	$42,181.80
Iran	Japan	$16,737.00
Iran	Mexico	$1.00
Iran	Norway	$1.00
Iran	Oman	$5,780.00
Iran	Qatar	$504.00
Iran	Russia	$15,326.00
Iran	Saudi Arabia	$23,282.37
Iran	Singapore	$660.00
Iran	S. Africa	$471.00
Iran	S. Korea	$123,725.00
Iran	Switzerland	$58.00
Iran	Turkey	$96,685.00
Iran	UAE	$153,546.70
Iran	Venezuela	$50.00
Iran	ROW	$75,140.96
US	Iran	$4,934.85
US	EU	$10,648,845.43
US	Australia	$392,566.72
US	Brazil	$342,535.76
US	Canada	$3,348,255.68
US	Chile	$374,529.53
US	China	$3,243,480.63
US	India	$867,977.54
US	Indonesia	$183,517.53
US	Japan	$2,412,071.56
US	Mexico	$6,978,950.51
US	Norway	$55,886.87

US	Oman	$67,322.58
US	Qatar	$15,415.85
US	Russia	$43,145.62
US	Saudi Arabia	$118,896.10
US	Singapore	$834,513.78
US	S. Africa	$121,077.27
US	S. Korea	$2,004,535.45
US	Switzerland	$274,521.13
US	Turkey	$333,261.59
US	UAE	$140,901.23
US	Venezuela	$1,352,185.22
US	ROW	$12,014,904.42
EU	Iran	$105,031.89
EU	US	$24,155,754.07
EU	EU	$610,597,893.00
EU	Australia	$664,284.66
EU	Brazil	$866,389.27
EU	Canada	$1,187,700.05
EU	Chile	$135,142.28
EU	China	$3,721,569.44
EU	India	$1,490,579.30
EU	Indonesia	$259,966.29
EU	Japan	$3,891,452.56
EU	Mexico	$1,082,521.24
EU	Norway	$663,729.42
EU	Oman	$280,266.41
EU	Qatar	$13,779.47
EU	Russia	$1,350,331.61
EU	Saudi Arabia	$281,559.46
EU	Singapore	$836,853.30
EU	S. Africa	$418,761.92
EU	S. Korea	$1,721,173.19
EU	Switzerland	$9,428,737.30
EU	Turkey	$1,938,924.71
EU	UAE	$272,388.80
EU	Venezuela	$459,556.01
EU	ROW	$16,092,236.93
Australia	Iran	$6.84
Australia	US	$34,787.63

Australia	EU	$70,934.59
Australia	Brazil	$11,584.90
Australia	Canada	$1,469.68
Australia	Chile	$447.95
Australia	China	$5,464.92
Australia	India	$5,125.16
Australia	Indonesia	$10,957.42
Australia	Japan	$9,112.27
Australia	Mexico	$4.56
Australia	Norway	$695.47
Australia	Oman	$0.24
Australia	Qatar	$82.13
Australia	Russia	$422.99
Australia	Saudi Arabia	$415.25
Australia	Singapore	$12,375.09
Australia	S. Africa	$1,956.30
Australia	S. Korea	$12,540.55
Australia	Switzerland	$14,168.28
Australia	Turkey	$5.37
Australia	UAE	$527.27
Australia	Venezuela	$1.00
Australia	ROW	$42,596.79
Brazil	Iran	$30.78
Brazil	US	$940,098.55
Brazil	EU	$983,744.41
Brazil	Australia	$1,961.26
Brazil	Canada	$41,440.08
Brazil	Chile	$47,555.77
Brazil	China	$158,478.86
Brazil	India	$37,943.28
Brazil	Indonesia	$21,362.59
Brazil	Japan	$135,203.59
Brazil	Mexico	$162,748.40
Brazil	Norway	$4,126.68
Brazil	Oman	$0.22
Brazil	Qatar	$2.66
Brazil	Russia	$6,580.04
Brazil	Saudi Arabia	$1,946.91
Brazil	Singapore	$12,422.69

Brazil	S. Africa	$16,110.12
Brazil	S. Korea	$85,465.96
Brazil	Switzerland	$58,970.72
Brazil	Turkey	$5,357.71
Brazil	UAE	$937.64
Brazil	Venezuela	$39,588.51
Brazil	ROW	$613,387.39
Canada	Iran	$976.26
Canada	US	$3,606,273.87
Canada	EU	$127,631.94
Canada	Australia	$5,269.59
Canada	Brazil	$28,787.76
Canada	Chile	$1,494.87
Canada	China	$543,521.47
Canada	India	$21,003.81
Canada	Indonesia	$1,009.59
Canada	Japan	$10,276.36
Canada	Mexico	$37,627.15
Canada	Norway	$45,316.79
Canada	Oman	$265.72
Canada	Qatar	$1.11
Canada	Russia	$272.72
Canada	Saudi Arabia	$917.34
Canada	Singapore	$6,075.46
Canada	S. Africa	$428.63
Canada	S. Korea	$7,329.19
Canada	Switzerland	$17,057.74
Canada	Turkey	$304.16
Canada	UAE	$4,538.98
Canada	Venezuela	$1,499.45
Canada	ROW	$171,456.00
Chile	Iran	$1.00
Chile	US	$7,080.77
Chile	EU	$1,319.71
Chile	Australia	$445.97
Chile	Brazil	$157,754.08
Chile	Canada	$17.51
Chile	China	$178.46
Chile	India	$1,061.54

Chile	Indonesia	$44.34
Chile	Japan	$2,056.67
Chile	Mexico	$1,991.87
Chile	Norway	$8.33
Chile	Oman	$1.00
Chile	Qatar	$1.00
Chile	Russia	$1.00
Chile	Saudi Arabia	$1.00
Chile	Singapore	$12.88
Chile	S. Africa	$111.43
Chile	S. Korea	$28.55
Chile	Switzerland	$22.39
Chile	Turkey	$1.00
Chile	UAE	$597.74
Chile	Venezuela	$604.37
Chile	ROW	$14,176.13
China	Iran	$350,010.31
China	US	$6,232,857.30
China	EU	$6,407,570.17
China	Australia	$543,370.65
China	Brazil	$1,615,020.93
China	Canada	$322,087.65
China	Chile	$194,680.68
China	India	$4,757,039.02
China	Indonesia	$972,208.40
China	Japan	$2,894,439.53
China	Mexico	$627,503.22
China	Norway	$22,435.77
China	Oman	$4,341.79
China	Qatar	$4,707.38
China	Russia	$600,894.66
China	Saudi Arabia	$194,222.59
China	Singapore	$681,181.63
China	S. Africa	$337,005.45
China	S. Korea	$2,355,486.65
China	Switzerland	$321,561.27
China	Turkey	$467,937.54
China	UAE	$204,693.99
China	Venezuela	$143,364.05

China	ROW	$10,153,793.64
India	Iran	$102,110.81
India	US	$1,744,331.72
India	EU	$2,777,164.08
India	Australia	$73,149.54
India	Brazil	$314,742.11
India	Canada	$225,821.90
India	Chile	$15,996.70
India	China	$1,022,933.67
India	Indonesia	$730,144.54
India	Japan	$290,823.53
India	Mexico	$207,732.71
India	Norway	$5,322.78
India	Oman	$14,987.19
India	Qatar	$9,871.53
India	Russia	$41,095.51
India	Saudi Arabia	$305,207.04
India	Singapore	$627,983.34
India	S. Africa	$143,714.78
India	S. Korea	$342,894.88
India	Switzerland	$204,580.39
India	Turkey	$318,460.72
India	UAE	$287,954.73
India	Venezuela	$6,505.71
India	ROW	$2,736,158.35
Indonesia	Iran	$11,169.24
Indonesia	US	$131,288.17
Indonesia	EU	$269,915.15
Indonesia	Australia	$18,142.03
Indonesia	Brazil	$25,107.71
Indonesia	Canada	$13,937.86
Indonesia	Chile	$620.97
Indonesia	China	$626,118.82
Indonesia	India	$111,387.08
Indonesia	Japan	$234,373.51
Indonesia	Mexico	$6,427.93
Indonesia	Norway	$1,477.89
Indonesia	Oman	$3,504.56
Indonesia	Qatar	$110.39

Indonesia	Russia	$18,459.28
Indonesia	Saudi Arabia	$10,802.06
Indonesia	Singapore	$43,553.67
Indonesia	S. Africa	$14,701.46
Indonesia	S. Korea	$259,548.36
Indonesia	Switzerland	$2,816.60
Indonesia	Turkey	$19,683.13
Indonesia	UAE	$6,075.53
Indonesia	Venezuela	$699.89
Indonesia	ROW	$981,577.57
Japan	Iran	$4,187.40
Japan	US	$3,132,510.14
Japan	EU	$2,283,815.63
Japan	Australia	$71,821.28
Japan	Brazil	$335,329.08
Japan	Canada	$28,248.37
Japan	Chile	$7,809.39
Japan	China	$7,517,325.41
Japan	India	$304,292.22
Japan	Indonesia	$343,134.49
Japan	Mexico	$44,392.27
Japan	Norway	$9,370.66
Japan	Oman	$7,120.83
Japan	Qatar	$476.76
Japan	Russia	$21,084.86
Japan	Saudi Arabia	$70,176.12
Japan	Singapore	$293,899.39
Japan	S. Africa	$17,241.10
Japan	S. Korea	$4,701,685.73
Japan	Switzerland	$181,507.75
Japan	Turkey	$19,203.04
Japan	UAE	$28,635.98
Japan	Venezuela	$11,143.44
Japan	ROW	$3,970,337.58
Mexico	Iran	$0.73
Mexico	US	$632,863.73
Mexico	EU	$423,619.40
Mexico	Australia	$1,726.52
Mexico	Brazil	$543,080.89

Mexico	Canada	$69,140.13
Mexico	Chile	$10,372.82
Mexico	China	$161,581.68
Mexico	India	$34,334.97
Mexico	Indonesia	$3,077.70
Mexico	Japan	$6,010.45
Mexico	Norway	$2,045.37
Mexico	Oman	$24.49
Mexico	Qatar	$1.53
Mexico	Russia	$326.39
Mexico	Saudi Arabia	$814.58
Mexico	Singapore	$11,754.54
Mexico	S. Africa	$10,096.19
Mexico	S. Korea	$7,712.90
Mexico	Switzerland	$41,277.84
Mexico	Turkey	$8,406.26
Mexico	UAE	$3,085.55
Mexico	Venezuela	$173,540.09
Mexico	ROW	$490,790.14
Norway	Iran	$8.67
Norway	US	$38,199.94
Norway	EU	$1,176,048.96
Norway	Australia	$35.41
Norway	Brazil	$2,174.56
Norway	Canada	$890.65
Norway	Chile	$124.18
Norway	China	$293,451.35
Norway	India	$4,124.22
Norway	Indonesia	$113.19
Norway	Japan	$95,591.12
Norway	Mexico	$1,097.11
Norway	Oman	$113.67
Norway	Qatar	$99.54
Norway	Russia	$296.49
Norway	Saudi Arabia	$1,305.20
Norway	Singapore	$813.94
Norway	S. Africa	$508.98
Norway	S. Korea	$121.58
Norway	Switzerland	$3,812.38

Norway	Turkey	$1,502.01
Norway	UAE	$993.93
Norway	Venezuela	$212.87
Norway	ROW	$1.00
Oman	Iran	$1.00
Oman	US	$1.00
Oman	EU	$24,436.73
Oman	Australia	$30.09
Oman	Brazil	$1.00
Oman	Canada	$1.00
Oman	Chile	$52.65
Oman	China	$380,056.48
Oman	India	$442,549.78
Oman	Indonesia	$47,466.38
Oman	Japan	$8.76
Oman	Mexico	$1.00
Oman	Norway	$1.00
Oman	Qatar	$1.00
Oman	Russia	$1.00
Oman	Saudi Arabia	$178,191.31
Oman	Singapore	$25,591.24
Oman	S. Africa	$1.00
Oman	S. Korea	$57,343.77
Oman	Switzerland	$1.00
Oman	Turkey	$18,737.62
Oman	UAE	$3,674.56
Oman	Venezuela	$1.00
Oman	ROW	$433,566.98
Qatar	Iran	$10.04
Qatar	US	$41,000.63
Qatar	EU	$147,264.17
Qatar	Australia	$16,101.98
Qatar	Brazil	$57,625.97
Qatar	Canada	$1.00
Qatar	Chile	$1.00
Qatar	China	$268,831.46
Qatar	India	$536,349.29
Qatar	Indonesia	$67,791.92
Qatar	Japan	$4,649.57

Qatar	Mexico	$1.00
Qatar	Norway	$1.00
Qatar	Oman	$68,785.65
Qatar	Russia	$1,078.96
Qatar	Saudi Arabia	$9,739.29
Qatar	Singapore	$242,362.05
Qatar	S. Africa	$30,542.39
Qatar	S. Korea	$19,800.09
Qatar	Switzerland	$1,870.64
Qatar	Turkey	$17,519.23
Qatar	UAE	$186,171.48
Qatar	Venezuela	$76,241.77
Qatar	ROW	$556,405.99
Russia	Iran	$5,104.57
Russia	US	$16,821.33
Russia	EU	$1,554,341.85
Russia	Australia	$2,372.47
Russia	Brazil	$6,025.15
Russia	Canada	$1,022.20
Russia	Chile	$94.94
Russia	China	$790,852.63
Russia	India	$45,999.08
Russia	Indonesia	$14,294.05
Russia	Japan	$5,394.17
Russia	Mexico	$560.61
Russia	Norway	$742.08
Russia	Oman	$66.27
Russia	Qatar	$279.21
Russia	Saudi Arabia	$129.56
Russia	Singapore	$76.42
Russia	S. Africa	$243.71
Russia	S. Korea	$6,505.07
Russia	Switzerland	$3,952.65
Russia	Turkey	$597,798.54
Russia	UAE	$165.66
Russia	Venezuela	$1,182.98
Russia	ROW	$1,464,076.69
Saudi Arabia	Iran	$1.00
Saudi Arabia	US	$487,002.35

Saudi Arabia	EU	$1,665,517.45
Saudi Arabia	Australia	$874.50
Saudi Arabia	Brazil	$6,681.13
Saudi Arabia	Canada	$1,263.51
Saudi Arabia	Chile	$167.45
Saudi Arabia	China	$5,894,693.05
Saudi Arabia	India	$1,222,561.91
Saudi Arabia	Indonesia	$664,668.57
Saudi Arabia	Japan	$441,416.45
Saudi Arabia	Mexico	$40.64
Saudi Arabia	Norway	$53.85
Saudi Arabia	Oman	$39,460.91
Saudi Arabia	Qatar	$7,303.83
Saudi Arabia	Russia	$41,314.93
Saudi Arabia	Singapore	$1,280,061.16
Saudi Arabia	S. Africa	$240,873.95
Saudi Arabia	S. Korea	$845,472.26
Saudi Arabia	Switzerland	$7,949.17
Saudi Arabia	Turkey	$269,357.31
Saudi Arabia	UAE	$1.00
Saudi Arabia	Venezuela	$15,754.35
Saudi Arabia	ROW	$1.00
Singapore	Iran	$11,723.62
Singapore	US	$314,036.05
Singapore	EU	$6,307,473.60
Singapore	Australia	$224,605.73
Singapore	Brazil	$38,430.53
Singapore	Canada	$47,698.17
Singapore	Chile	$3,423.58
Singapore	China	$2,615,684.66
Singapore	India	$1,225,787.71
Singapore	Indonesia	$1,345,596.02
Singapore	Japan	$370,845.54
Singapore	Mexico	$40,681.29
Singapore	Norway	$423.14
Singapore	Oman	$9,969.99
Singapore	Qatar	$165.28
Singapore	Russia	$579.40
Singapore	Saudi Arabia	$17,821.62

Singapore	S. Africa	$7,027.18
Singapore	S. Korea	$684,429.96
Singapore	Switzerland	$2,803.56
Singapore	Turkey	$3,157.98
Singapore	UAE	$62,532.77
Singapore	Venezuela	$3,473.30
Singapore	ROW	$8,758,753.60
S. Africa	Iran	$63.98
S. Africa	US	$369,276.09
S. Africa	EU	$228,609.93
S. Africa	Australia	$6,329.64
S. Africa	Brazil	$62,425.16
S. Africa	Canada	$329.90
S. Africa	Chile	$1,847.78
S. Africa	China	$89,692.31
S. Africa	India	$62,258.99
S. Africa	Indonesia	$2,753.01
S. Africa	Japan	$28,126.65
S. Africa	Mexico	$294.60
S. Africa	Norway	$1.71
S. Africa	Oman	$1.50
S. Africa	Qatar	$1,142.45
S. Africa	Russia	$259.24
S. Africa	Saudi Arabia	$1,646.50
S. Africa	Singapore	$99,903.69
S. Africa	S. Korea	$12,759.37
S. Africa	Switzerland	$239.68
S. Africa	Turkey	$18,024.65
S. Africa	UAE	$43,068.96
S. Africa	Venezuela	$158.07
S. Africa	ROW	$340,478.20
S. Korea	Iran	$121,771.14
S. Korea	US	$1,397,620.55
S. Korea	EU	$544,516.23
S. Korea	Australia	$66,231.72
S. Korea	Brazil	$154,465.14
S. Korea	Canada	$55,395.25
S. Korea	Chile	$23,606.14
S. Korea	China	$13,439,024.39

S. Korea	India	$931,703.29
S. Korea	Indonesia	$235,472.35
S. Korea	Japan	$1,286,720.80
S. Korea	Mexico	$44,892.58
S. Korea	Norway	$60.05
S. Korea	Oman	$35,250.05
S. Korea	Qatar	$4,444.33
S. Korea	Russia	$52,898.97
S. Korea	Saudi Arabia	$261,500.63
S. Korea	Singapore	$282,886.49
S. Korea	S. Africa	$54,229.96
S. Korea	Switzerland	$20,633.28
S. Korea	Turkey	$69,621.03
S. Korea	UAE	$158,851.17
S. Korea	Venezuela	$18,324.70
S. Korea	ROW	$4,024,616.16
Switzerland	Iran	$31,113.56
Switzerland	US	$1,902,239.23
Switzerland	EU	$9,900,283.17
Switzerland	Australia	$30,468.14
Switzerland	Brazil	$518,697.28
Switzerland	Canada	$165,461.70
Switzerland	Chile	$2,174.89
Switzerland	China	$406,146.90
Switzerland	India	$234,461.53
Switzerland	Indonesia	$40,223.35
Switzerland	Japan	$584,378.85
Switzerland	Mexico	$141,448.48
Switzerland	Norway	$1,971.43
Switzerland	Oman	$37.48
Switzerland	Qatar	$312.09
Switzerland	Russia	$9,542.89
Switzerland	Saudi Arabia	$10,505.61
Switzerland	Singapore	$1,060,889.27
Switzerland	S. Africa	$20,226.95
Switzerland	S. Korea	$68,242.34
Switzerland	Turkey	$88,912.81
Switzerland	UAE	$5,141.29
Switzerland	Venezuela	$24,984.70

Switzerland	ROW	$3,845,958.66
Turkey	Iran	$1.00
Turkey	US	$78,242.30
Turkey	EU	$331,803.54
Turkey	Australia	$1.84
Turkey	Brazil	$808.60
Turkey	Canada	$94.50
Turkey	Chile	$431.28
Turkey	China	$54,072.89
Turkey	India	$12,733.62
Turkey	Indonesia	$928.71
Turkey	Japan	$235.50
Turkey	Mexico	$143.86
Turkey	Norway	$7,072.02
Turkey	Oman	$20.20
Turkey	Qatar	$0.39
Turkey	Russia	$6,629.52
Turkey	Saudi Arabia	$3,239.78
Turkey	Singapore	$290.25
Turkey	S. Africa	$142.65
Turkey	S. Korea	$1,125.14
Turkey	Switzerland	$2,200.54
Turkey	UAE	$4,997.23
Turkey	Venezuela	$2,109.38
Turkey	ROW	$139,570.36
UAE	Iran	$163,887.00
UAE	US	$6,856.84
UAE	EU	$259,944.55
UAE	Australia	$362.66
UAE	Brazil	$95.17
UAE	Canada	$76.93
UAE	Chile	$1.00
UAE	China	$49,273.59
UAE	India	$71,050.93
UAE	Indonesia	$127,761.43
UAE	Japan	$1.00
UAE	Mexico	$69.16
UAE	Norway	$1.00
UAE	Oman	$43,393.23

UAE	Qatar	$6,070.77
UAE	Russia	$21,189.54
UAE	Saudi Arabia	$11,918.42
UAE	Singapore	$27,521.42
UAE	S. Africa	$812.93
UAE	S. Korea	$265.68
UAE	Switzerland	$58.80
UAE	Turkey	$30,840.83
UAE	Venezuela	$1.00
UAE	ROW	$1.00
Venezuela	Iran	$1.00
Venezuela	US	$382,587.75
Venezuela	EU	$211,784.13
Venezuela	Australia	$1.00
Venezuela	Brazil	$79,663.34
Venezuela	Canada	$5,570.42
Venezuela	Chile	$854.01
Venezuela	China	$49.30
Venezuela	India	$51.46
Venezuela	Indonesia	$181.08
Venezuela	Japan	$1.00
Venezuela	Mexico	$8,437.86
Venezuela	Norway	$3,633.27
Venezuela	Oman	$1.00
Venezuela	Qatar	$1.00
Venezuela	Russia	$642.81
Venezuela	Saudi Arabia	$1.00
Venezuela	Singapore	$0.83
Venezuela	S. Africa	$762.56
Venezuela	S. Korea	$1.20
Venezuela	Switzerland	$1,596.89
Venezuela	Turkey	$1,143.82
Venezuela	UAE	$1.00
Venezuela	ROW	$1.00
ROW	Iran	$341,128.80
ROW	US	$8,943,752.02
ROW	EU	$18,430,348.13
ROW	Australia	$1,336,138.87
ROW	Brazil	$4,747,157.27

ROW	Canada	$588,549.10
ROW	Chile	$145,594.99
ROW	China	$17,484,678.07
ROW	India	$2,324,292.15
ROW	Indonesia	$1,768,193.34
ROW	Japan	$5,617,692.06
ROW	Mexico	$409,506.60
ROW	Norway	$190,094.18
ROW	Oman	$166,036.68
ROW	Qatar	$54,975.59
ROW	Russia	$1,140,182.23
ROW	Saudi Arabia	$758,459.14
ROW	Singapore	$584,502.14
ROW	S. Africa	$249,497.89
ROW	S. Korea	$1,035,440.53
ROW	Switzerland	$2,856,325.92
ROW	Turkey	$739,775.10
ROW	UAE	$1.00
ROW	Venezuela	$1.00
ROW	ROW	$248,045,383.30

Appendix 2: Calculation of Tariff Equivalents for GSIM Matrix 2 (Initial Tariffs)

Origin	Destination	Tariff (t)	NTB (n)	Sanctions (s)	Total (1+t+n+s)
Iran	US	0.027	0.540	0.57	2.137
Iran	EU	0.043	0.291	0.30	1.634
Iran	Australia	0.007	0.393	0.74	2.140
Iran	Brazil	0.055	0.36	n/a	1.415
Iran	Canada	0.001	0.491	.52	2.012
Iran	Chile	0.060	0.255	n/a	1.315
Iran	China	0.050	0.577	n/a	1.627
Iran	India	0.072	0.141	n/a	1.212
Iran	Indonesia	0.045	0.361	n/a	1.406
Iran	Japan	0.021	0.320	0.49	1.831
Iran	Mexico	0.009	0.295	n/a	1.304
Iran	Norway	0.000	0.288	0.81	2.098
Iran	Oman	0.041	0.526	n/a	1.567
Iran	Qatar	0.041	0.359	n/a	1.400
Iran	Russia	0.048	0.328	n/a	1.376
Iran	Saudi Arabia	0.041	0.359	n/a	1.400
Iran	Singapore	0.000	0.248	0.10	1.348
Iran	South Africa	0.005	0.453	n/a	1.458
Iran	South Korea	0.052	0.000	0.10	1.152
Iran	Switzerland	0.000	0.205	0.14	1.345
Iran	Turkey	0.050	0.350	n/a	1.400
Iran	UAE	0.041	0.359	n/a	1.400
Iran	Venezuela	0.058	0.258	n/a	1.316
Iran	ROW	n/a	n/a	n/a	1.300
…	…	…	…	…	…

Appendix 3: Calculation of Tariff Equivalents for GSIM Matrix 3 (Final Tariffs)

Origin	Destination	Tariff (t)	NTB (n)	Sanctions (s)	Total (1+t+n)
Iran	US	0.027	0.540	0.57	1.567
Iran	EU	0.043	0.291	0.30	1.334
Iran	Australia	0.007	0.393	0.74	1.400
Iran	Brazil	0.055	0.36	n/a	1.415
Iran	Canada	0.001	0.491	.52	1.492
Iran	Chile	0.060	0.255	n/a	1.315
Iran	China	0.050	0.577	n/a	1.627
Iran	India	0.072	0.141	n/a	1.212
Iran	Indonesia	0.045	0.361	n/a	1.406
Iran	Japan	0.021	0.320	0.49	1.341
Iran	Mexico	0.009	0.295	n/a	1.304
Iran	Norway	0.000	0.288	0.81	1.288
Iran	Oman	0.041	0.526	n/a	1.567
Iran	Qatar	0.041	0.359	n/a	1.400
Iran	Russia	0.048	0.328	n/a	1.376
Iran	Saudi Arabia	0.041	0.359	n/a	1.400
Iran	Singapore	0.000	0.248	0.10	1.248
Iran	South Africa	0.005	0.453	n/a	1.458
Iran	South Korea	0.052	0.000	0.10	1.052
Iran	Switzerland	0.000	0.205	0.14	1.205
Iran	Turkey	0.050	0.350	n/a	1.400
Iran	UAE	0.041	0.359	n/a	1.400
Iran	Venezuela	0.058	0.258	n/a	1.316
Iran	ROW	n/a	n/a	n/a	1.300
…	…	…	…	…	…