CHAPTER 8

Effects of Oil Sanctions on Iran's Economy and Household Welfare: New Evidence from A CGE Model

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Introduction

This chapter[1] treats the economic and welfare consequences of Western-backed oil-export sanctions[2] against Iran. Oil sanctions were imposed on post-revolutionary Iran with the supposed goal of changing its government's political behavior. We aim to answer the following questions: (a) What were the likely effects of oil sanctions on the Iranian macroeconomic variables? (b) What were the likely effects of oil sanctions on Iran's household welfare?

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Sanctions-induced economic pressures are meant to effect change in the target state's political behavior. Yet, Hufbauer et al. (2007) show that in the long term, the success-to-failure ratio of sanctions in changing the target country's political behavior decreases significantly. The success-to-failure ratio is 2.4 during the first year after the sanction shock, reaches 2.3 in two years, and remains constant at 0.6 thereafter (Dizaji and van Bergeijk 2013).[3] The reason for the falling success ratio of sanctions is the targeted economy's process of adjusting to a new equilibrium. Indeed, an economy under sanctions can attempt to offset the reduction in its revenues (e.g., oil revenues, as is the case for Iran) by increasing taxes, reforming the subsidy system, or reallocating resources. If such painful policies are managed well and do not lead to political instability, then sanctions lose their effectiveness in the long term.

Iran has been the target of various sanctions ever since the 1979 Islamic Revolution. Yet, sanctions imposed on Iran became more severe beginning in 2006, coinciding with Mahmoud Ahmadinejad's presidential term. Between 2006 and 2010, sanctions mostly aimed to block the supply of heavy weapons and technologies that could be used in the Iranian military and nuclear projects. They did not target the Iranian economy in any particular way. The United Nations Security Council (UNSC) Resolution 1929, however, sent a strong signal that sanctions might be placed on Iranian oil (UNSC 2010). Whereas the Iranian government's right to diversify its energy portfolio was recognized, the resolution emphasized that "chemical process equipment and materials required for the Iranian petrochemical industry have much in common with those required for certain sensitive nuclear fuel cycle activities." This resolution was the basis of subsequent practical oil embargos imposed against Iran.

The Iranian government underplayed the threat, with President Ahmadinejad stating that: "From right and from left, they adopt sanctions, but for us they are annoying flies, like a used tissue" (The Telegraph, June 10, 2010). Soon, however, the European Union (EU) invoked UNSC Resolution 1929 to ban its member states from the sale and supply of equipment and technologies that could be used in the Iranian petrochemical industry. In July 2012, the EU banned the imports, purchase, and transport of Iranian crude oil. Oil sanctions were also combined with international financial, banking, and insurance sanctions.

Iran's oil production was reduced from more than 4 million bbl./d in 2005 to approximately 3 million bbl./d in 2012/2013 (U.S. Energy Information Administration 2013). According to the country's Minister of

Economic Affairs and Finance, Ali Tayebnia, Iran's GDP decreased by 5.8 percent in 2013. Taking into account population growth, this figure corresponds to a 7 percent reduction in per capita income (as a welfare driver) in a single year (BBC 2014). Yet, according to the Central Bank of Iran, the country's non-oil exports increased by approximately 25 percent from 2010 through 2012 (CBI 2015).[4]

On July 14, 2015 Iran signed an international agreement with P5+1 (the five permanent members of the United Nations Security Council—China, France, Russia, United Kingdom, United States—plus Germany) referred to as the Joint Comprehensive Plan of Action (JCPOA). Under JCPOA, Iran agreed to significant revisions in its nuclear program in return for the removal of the imposed sanctions. Pursuant to internationally agreed nuclear commitments, the EU and the UN Security Council lifted sanctions and the United States "ceased the application" of sanctions on many of the relevant sectors in Iran. In consequence, Iran's oil production and exports are expected to increase to pre-sanctions levels, while the country's reconnection to international banking will increase its foreign exchange revenues. Indeed, a recent report by the Economist Intelligence Unit on "assessing opportunities and risks in postsanctions Iran" (EIU 2016) highlights Iran's significant potential for growth and attracting international investors. In particular, Iran's GDP (adjusted for inflation) is forecasted to grow at approximately 5 percent per year in the period 2016–2020.

The implementation of JCPOA will most likely give a significant boost to the Iranian economy. However, its full realization is uncertain at the time being. According to Secretary of State John Kerry, Iran has only received $3 billion of its $100 billion frozen assets to date (CNSNews.com, 19 April 2016). In April 2016, the Governor of Central Bank of Iran met with US Treasury Secretary Jacob Lew to warn that banking-access problems were jeopardizing JCPOA (The Wall Street Journal, 15 April 2016). Furthermore, with uncertainty looming over policies to be pursued by the winner of upcoming US presidential elections vis-à-vis Iran, the impact of sanctions is likely to remain relevant in the foreseeable future.

In this study, we deviate from existing empirical analyses of economic sanctions against Iran (see next section) by utilizing a computable general equilibrium (CGE) model based on Iran's social accounting matrix (SAM). We estimate the impact of oil sanctions on a set of key macroeconomic indicators and household welfare. We show that under the scenario of oil sanctions imposed by the EU and Japan (our scenario three, which is a more realistic scenario than the others), there would be a dampening effect on

Iran's GDP of 2.2 percent, reducing total imports and exports by 20 percent and 16.5 percent, respectively, and decreasing private consumption by 3.9 percent. Furthermore, such a sanctions regime would increase net indirect taxes in Iran by almost 23.6 percent, the real exchange rate by 13 percent, and labor income by 8.7 percent. Most importantly, based on our simulation results, we suggest that such sanctions may increase non-oil exports by 61 percent and decrease consumer price index (CPI) by about 0.8 percent. Finally, we contend that richer households would experience greater welfare loss than poorer households.

The rest of the chapter is organized in the following way. The next section discusses the available literature on economic sanctions with a particular attention given to the case of Iran. In the third section, we present and discuss our empirical strategy and the data. The fourth section provides the empirical evidence and some robustness analyses. The final section concludes the chapter.

A Brief Review of the Literature on Sanctions

Overall, the literature is inconclusive about the effectiveness of economic sanctions in changing the target country's political behavior. Some studies, such as Eaton and Engers (1992, 1999) and Hufbauer et al. (2007), suggest that sanctions can be effective tools. Others, including Clawson (1998), Askari et al. (2001), and Torbat (2005), hold the opposite view. Dashti-Gibso et al. (1997) empirically examine the success determinants of economic sanctions, while Naghavi and Pignataro (2013) highlight the role of religious ideology in the economic sanctions/politics nexus. The latter's theoretical modeling shows that "…sanctions increase the magnitude and persistence of religious ideology in the target country," and thus enhance the legitimacy of the ruling state among the religious population.

Farzanegan (2013) explains how the sanctions have increased the size of Iran's shadow economy. Furthermore, Farzanegan (2011) investigates the Iranian government's budget allocations to different functions (such as military and non-military) in relation to the negative oil revenue shocks. As a proxy for oil sanctions, he uses the negative shocks on Iran's oil revenues. Employing unrestricted vector autoregressive (VAR) models and annual data from 1959 to 2007, his impulse-response analyses indicate that military and domestic security spending demonstrate a statistically significant negative response to negative oil shocks. That is, Iranian government's budget-allocation behavior is likely to change as a result of oil sanctions. Military and security spending also react positively and significantly at the time of increasing oil revenue shocks, whereas other non-military spending (e.g., education, health, and culture) do not show such a positive and statistically significant response. In another study using VAR models and a Granger causality analysis, Farzanegan (2014) finds a significant interaction between economic growth and military spending in Iran. By reducing military spending, economic sanctions cause lower economic growth in Iran because of strong linkages between Iran's military and its economy.

What is to be made of the effects of sanctions on Iran's domestic politics? Dizaji and van Bergeijk (2013) examine this issue using democracy indicators (e.g., Polity and Vanhanen indicators) and their response to oil revenue shocks as a proxy for oil sanctions. Their findings show that sanctions do change Iran's political behavior in the short term. Thus, lifting the sanctions may have negative short-term consequences for political rights.

On the methodological front, Siddig (2011) emphasizes that "simulation of economic sanctions using the CGE [computable general equilibrium] approach is particularly rare." The few studies of economic sanctions using CGE models include McDonald and Roberts (1998), Hubbard and Philippidis (2001), Philippidis and Hubbard (2005), and Siddig (2010, 2011). In the case of Iran, CGE has been mostly used in the trade-policy context, but not sanctions (see Sadeghi and Hassanzadeh 2011; Daneshjafari and Barghi Oskuei 2009; Mehrara and Barkhordari 2007). Therefore, our two-step methodological approach to the case study of Iranian oil sanctions using standard CGE (SCGE) is new and can provide further insight into the impact of sanctions on Iran's economy.

Model and Data

This section explains how we model the effects of oil sanctions as well as the applied dataset and elasticities.

Model Overview

We employ SCGE as this chapter's basic model. The multisectorial characteristic of SCGE (see Lofgren et al. 2002), together with an entirely specified economic trade side, makes it a rich model and facilitates the analysis of economic policies. Our contributions include both parameterizing SCGE on Iranian data and adjusting it to show how oil sanctions work.

The model is static, nonmonetary, and written as a collection of linear and nonlinear equations. The nature of the model is neoclassical and it follows a Walrasian general equilibrium theory inside a small, open country. It reflects the interactions between different economic performers at the same time. These performers include activities (represented as producers), commodities, factors, households, government, enterprises, and the rest of the world.[5] The entire system of equations must also meet a set of constraints covering macroeconomic aggregates and markets.

Optimal decisions about the amount of production are driven by activities that maximize profits as the difference between revenues and expenses on factors and intermediate inputs. Activities are not restricted to the production of only one commodity; two or more commodities can be simultaneously produced by an activity. In addition, commodities can be sold for domestic uses or exported. The model assumes that commodity and factor markets are completely competitive. Factors are mobile and fully employed where the total supply amount of factors is fixed at the level at which they are observed.

Our institutions include households, enterprises, government, and the rest of the world. Maximizing their utility function subject to budget constraints, households derive their amount of consumption through optimization. After paying taxes directly, households pay for marketed and nonmarketed commodities, save, and transfer some amount to other institutions. Selling factors to activities is the main source of households' income. Other income sources include transfers from other institutions such as enterprises, which do not consume but instead save, pay direct taxes, and receive from and transfer to other institutions. The government receives transfers from other institutions and tax revenues to save, buy commodities, and make transfers to other institutions. The final institution is the rest of the world and is known as the counterparty, that is, the destination of Iranian exports and the origin of Iranian imports. Except for exports and imports, all other transfers from and to the rest of the world are fixed in foreign currency. The difference between total foreign spending and receipts is foreign savings.

Three macroeconomic balances that should be satisfied by the entire system are government, external, and saving-investment balances. Here, we follow the "Johansen closure" (Johansen 1960). With respect to the government balance, the real government expenditure is fixed, whereas government saving is flexible given that it is the difference between government earning and spending. For external balance, whereas foreign saving is fixed in foreign currency, the real exchange rate is flexible. The trade balance and all transfers between the rest of the world and other institutions are also fixed in foreign currency. Finally, the macroeconomic closure related to saving-investment assumes that the quantities of real investment are fixed; thus, domestic nongovernment institutions (households and enterprises) must adjust their saving rates to equalize the savings needed to finance investment costs.[6] Although many macroclosures can be implemented in SCGE models, the macroclosures used in our static analysis are "preferable for simulations that explore the equilibrium welfare changes of alternative policies" (Lofgren et al. 2002), because it "avoids misleading welfare effects."

Moreover, there is empirical evidence to support the closure that we use for the case of Iran. For example, Farzanegan and Markwardt (2009) show that the oil price shocks have only a "marginal" effect on Iranian real government expenditures. In addition, despite the fact that the official exchange rate in Iran is fixed by the Central Bank, there has always been a free-market exchange rate that is a reference for most businesses, especially those without access to the subsidized exchange rate.[7] Indeed, Bahmani-Oskooee (1996) claims that in Iran, instead of the official exchange rate, "it is the black market rate (for foreign currency) that is co-integrated with money, income, and inflation rate." Moreover, the recent oil sanctions forced the Central Bank of Iran to raise the exchange rate, a move that serves as further evidence of exchange rate flexibility.[8]

Modeling Oil Sanctions: A Simple Theoretical Exposition

To model oil sanctions, we use a two-step approach. The first step provides us with the initial equilibrium value of oil exports under the no-sanctions condition; therefore, the amount of oil exports in the model is determined endogenously. This entails no major change to the SCGE model. Step two considers some scenarios in which the amount of oil exports is exogenously decreased. It is necessary to modify SCGE in order to show how sanctions work. Thus, in step two we introduce an equation which enables us to treat oil exports as an exogenous variable.

Step One

The SCGE model employs a constant elasticity of transformation (CET) function, Eq. 1, for commodity C, which is both exported and sold domestically. A CET function is identical to a constant elasticity of substitution

(CES) function except for the negative elasticity of substitution. Equation 1 provides the possibility of addressing the allocation of marketed domestic output for commodity C (QX_c) to two alternative destinations: domestic sale for commodity C (QD_c) and export for commodity C (QE_c).

$$QX_c = \alpha_c.\left(\delta_c.QE_C^{\rho_c} + (1-\delta_c).QD_C^{\rho_c}\right)^{\frac{1}{\rho_c}} \qquad \text{(Eq.1)}$$

where

α_c = a CET function shift parameter for commodity C;

δ_c = a CET function share parameter for commodity C; and

ρ_c = a CET function exponent for commodity C.

$\Omega_C = \frac{1}{1+\rho_c}$, a transformation of ρ_c, is the elasticity of transformation between the two destinations. Because $-1 < \rho_c < \infty$, Ω_C varies from infinity to zero. In addition, for each domestically produced commodity, Eq. 2 shows the sum of the values of domestic sale and export, stating the marketed output value in producer price:

$$PX_c.QX_c = PDS_c.QD_c + PE_c.QE_c \qquad \text{(Eq.2)}$$

where

PX_c = aggregate producer price for commodity C;

PDS_c = supply price for commodity C produced and sold domestically; and

PE_c = export price for commodity C in local currency. Suppliers maximize the sale revenues defined in Eq. 2 for any given aggregate output level subject to the imperfect transformability between domestic sales and exports expressed in Eq. 1. Eq. 3 defines the first-order condition that is the optimal mix between domestic sales and exports given the two prices PDS_c and PE_c[9]:

$$\frac{PDS_c}{PE_c} = \left(\frac{QD_c}{QE_c^*}\right)^{\rho_c - 1} . \frac{1-\delta_c}{\delta_c} \qquad \text{(Eq.3)}$$

where

QE_c^* = the equilibrium amount of export for commodity C. It is useful to note that Eq. 3 assures that a decrease in the export-domestic price ratio generates a decrease in the export-domestic supply ratio, which represents a shift toward the destination that offers the higher return.

Step Two

Facing oil sanctions, the country is forced to reconsider finding the amount of QE^*_{oil} endogenously. Thus, it should consider the given quantity of oil exports after sanctions are imposed, $QE_{oil} = \overline{QE}^s_{oil} \leq QE^*_{oil}$, to be an exogenous variable. The maximization process then gives us Eq. 4 (see Appendix A):

$$\frac{PDS_{oil}}{PE_{oil}} = \left(\frac{QX^{\rho}_{oil}}{\delta.\alpha^{\rho}} - \frac{1-\delta}{\alpha}.QD^{\rho}_{oil}\right)^{\frac{1}{\rho}-1}.\frac{\delta}{1-\delta}\ QD^{\rho-1}_{oil} \qquad \text{(Eq.4)}$$

The model in step one should have the same number of single equations and variables. Because we are making QE_{oil} exogenous, we must omit one single equation in step two to maintain an identical number of single equations and variables. Thus, Eq. 1 for oil is excluded from the model in step two. We can test the correctness of the process in step two in the following manner: If the value of QE_{oil} is fixed at QE^*_{oil}, then the simulation results for both steps must be the same.

Data

Social Accounting Matrix (SAM)

We use the social accounting matrix (SAM) as the main dataset to provide an economy-wide, micro-consistent benchmark.[10] We employ a large disaggregated form of the SAM to best show the relationships between all of the players in the Iranian economy. To this end, we use the SAM modified by Mehrara and Barkhordari (2007) for the year 2001 and aggregate it.[11] The aggregated SAM has 151 accounts: 66 accounts representing commodities, 53 accounts representing activities, 20 accounts representing Iranian urban and rural households separated by income level, 2 accounts representing labor and capital, 3 accounts representing domestic, export and import transaction costs, and 3 accounts representing direct and indirect taxes and tariffs. In addition, there are four accounts representing enterprises, government, saving-investment, and the rest of the world. This SAM is balanced by using the iterative adjustment method provided in the SCGE.[12]

Elasticities

When dealing with the applied general equilibrium, it is typical to use components of integrated dataset as a benchmark to calibrate the parameters and exogenous variables for the base year. Although employing a calibration procedure provides us with most of the coefficients and exogenous variables in our analysis, the SCGE requires that we introduce Armington and CET elasticities,[13] the elasticity of substitution between factors (bottom of technology nest), the elasticity of substitution between aggregate factors and intermediate inputs (top of technology nest), the output aggregation elasticity for commodities, the Frisch parameter,[14] and the expenditure elasticity of goods. We invoke other studies, especially those that concern Iran, for these elasticities. Most studies that use CGE models have employed a number between 2 and 3 as the elasticity for the Armington function (e.g., McCalla and Nash 2007; Sadeghi and Hassanzadeh 2011). Likewise, we choose 3 for the Armington elasticity. For the CET function, 2 and 3 were used by Sadeghi and Hassanzadeh (2011) and Jensen and Tarr (2003), respectively. We use 2.5 for CET elasticity. Khodadadkashi and Jani (2011) and Akbarian and Rafiee (2006) show that substitution between factors as well as substitution between factors and intermediate inputs (such as energy) is nonelastic. Thus, we use 0.8 and 0.6 for the elasticity of substitution between factors and the elasticity of substitution between aggregate factors and intermediate inputs, respectively. AlShehabi (2013), De Melo and Tarr (1992), Jensen and Tarr (2003), and Rutherford et al. (1997) use 6 for the output aggregation elasticity, AlShehabi (2013) uses −1 for the Frisch parameter, and AlShehabi (2013) and Jensen and Tarr (2003) use 1 for the expenditure elasticity of most goods. Thus, we set the output aggregation elasticity at 6, the Frisch parameter at −1, and the expenditure elasticity of goods at 1.

Scenarios and Analysis

Scenarios

The geographic distribution of the destinations of Iranian oil exports from 1979 to 2009 is depicted in Fig. 8.1. During this period, Europe was the most important destination of Iranian oil exports, importing nearly 39 percent of Iran's oil. After Europe, the largest importing areas were Asia, except Japan (importing an average of 26 percent of Iran's oil exports), and Japan

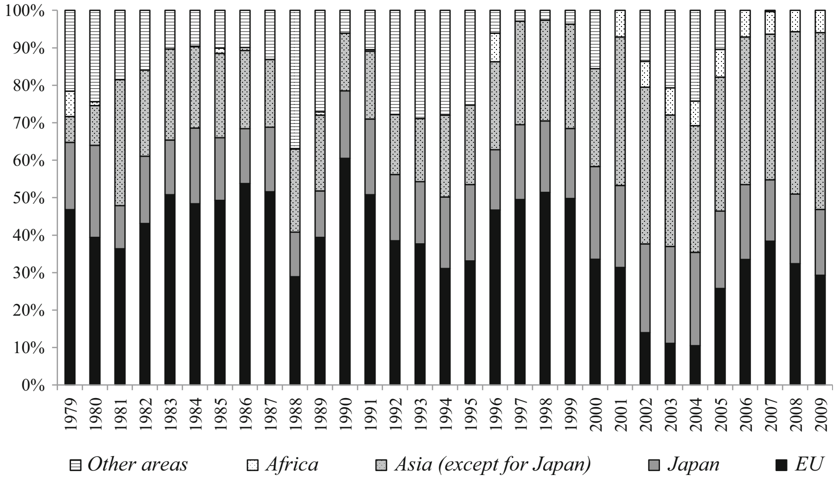

Fig. 8.1 Geographical distribution of Iranian oil exports (1979–2009). *Source*: CBI (2015)

(importing nearly 18 percent of Iran's oil exports). The remaining regions are categorized as Africa and other areas.

In this study, to show the effects of sanctions on the Iranian economy, *three scenarios* are built on the assumptions that the EU and Japan cut all of their imports of Iranian oil; given that the EU and Japan find another source of oil, we observe no major effect on world oil prices. Thus, the world price of oil in foreign currency is fixed.[15] The amount of Iranian oil exported to the EU and Japan fluctuates yearly, and thus, we use the average quantity of oil exported to these regions to model sanctions.

In the *first and second scenarios*, it is assumed that the amount of Iranian oil exports, QE_{oil}, decreases by 18 percent and 39 percent because of sanctions by Japan and the EU, respectively. The *third scenario* considers that both the EU and Japan implement sanctions at the same time, resulting in a 57 percent reduction in oil exports.

Simulation Results

Table 8.1 shows the impacts of the scenarios on macro-indicators in our general equilibrium model. Results are represented for *three conceptual scenarios*: sanctions by Japan, the EU, and both Japan and the EU. As

Table 8.1 Percent changes in macro-indicators due to oil sanctions

Indicators	*Oil sanctions by Japan*	*Oil sanctions by EU*	*Oil sanctions by Japan and EU*
Private consumption	−1.3	−2.8	−3.9
Total exports	−6.2	−12.3	−16.5
Total imports	−7.5	−14.8	−20.0
Non-oil export	16.5	39.0	61.1
Gross domestic production	−0.8	−1.6	−2.2
Net indirect tax	10.6	19.6	23.6
Real exchange rate	4.3	9.1	13.0
Consumer price index	−0.1	−0.4	−0.8
Labor income	2.5	5.7	8.7
Capital income	−1.1	−2.5	−3.8

Source: Authors' calculations

expected, our results indicate that the shock of oil sanctions in scenario three is bigger than the shock of sanctions by the EU, and these shocks are more significant than the shock of sanctions by Japan.

The shock of sanctions on oil starts with a decrease in total exports because oil exports constitute the major share of export revenues. In our SAM, the amount of oil exported is approximately 65 percent of total exports. Because oil exports are an important source of government revenues and are positively accounted for in GDP, a reduction in government oil income and a decrease in GDP are expected. Due to the dependence of imports on oil revenues, decreased oil earnings result in decreased imports. Foreign exchange rate appreciation aggravates the import situation. For example, the overall reduction in imports is 20 percent in scenario three.

The increase in exchange rate can have two different effects on activities' revenue. On the one hand, activities that demand imports as an intermediate input for their production line experience a higher import cost because of an increase in the exchange rate that forces them to produce less. On the other hand, for activities that involve selling products to the rest of the world, an increased exchange rate increases revenues and consequently provides the motivation to produce more.[16] The latter can be considered a blessing, as it mitigates the huge reduction in total exports; for instance, the total decrease in exports is 16.5 percent in scenario three with about 61 percent rise in non-oil export.

Regarding government, because of the assumption that its real expenditure is fixed at observed level, tax rates must grow to compensate for loss in oil revenues. Finally, as a result of sanctions, consumption by households—representing private sector consumption—decreases because import prices have increased and household incomes fall.

With respect to factor incomes, the results in Table 8.1 show that labor income rises by 8.7 percent, while capital income falls by 3.8 percent in scenario three. The reason is that as oil sanctions limit oil exports, oil production is logically reduced to prevent a huge loss to the oil industries. Therefore, producers do not need the same amount of the two factors anymore and those amounts are supplied in the factor market. The capital-intensive nature of oil production compared with Iran's other industries implies that the amount of capital supplied to the factor market exceeds the amount of capital demanded. In the SAM, the ratio of capital to the total factors employed by the oil industry is approximately 98 percent and this ratio for all other industries is 76 percent. Consequently, under the assumption of full employment, capital price drops because of an excess of supply in the capital factor market. This low-priced capital provides a good opportunity for other industries to increase the amount of their production. However, capital is not a complete substitution for labor in the technology nest and thus demand for labor rises. Finally, because the extra demand surpasses the extra supply of labor, labor wage increases and leads to increased labor income.

Regarding CPI, the simulation results show that oil sanctions not only do not raise the price index but also slightly decrease it. Under scenario three, for instance, CPI decreases by about 0.8 percent. On the one hand, reallocation of resources with lower price of capital compensates the loss to the supply side following the reduction of total import. On the other hand, due to decreases in household income, demand must fall. Therefore, the overall effect on the price index can be negative.

In Figs. 8.2a and b, we show the percentage changes in household welfare caused by oil sanctions. To capture welfare changes, SCGE employs the equivalent variation (EV) indicator that, at base prices, measures the changes in income needed to avert the simulated induced changes. All households experience welfare loss because of the sanctions as their earnings decrease. Although labor income rises as capital income drops, the overall result is a reduction in total factor income since the share of labor income is approximately 20 percent of Iran's total factor income in our SAM.

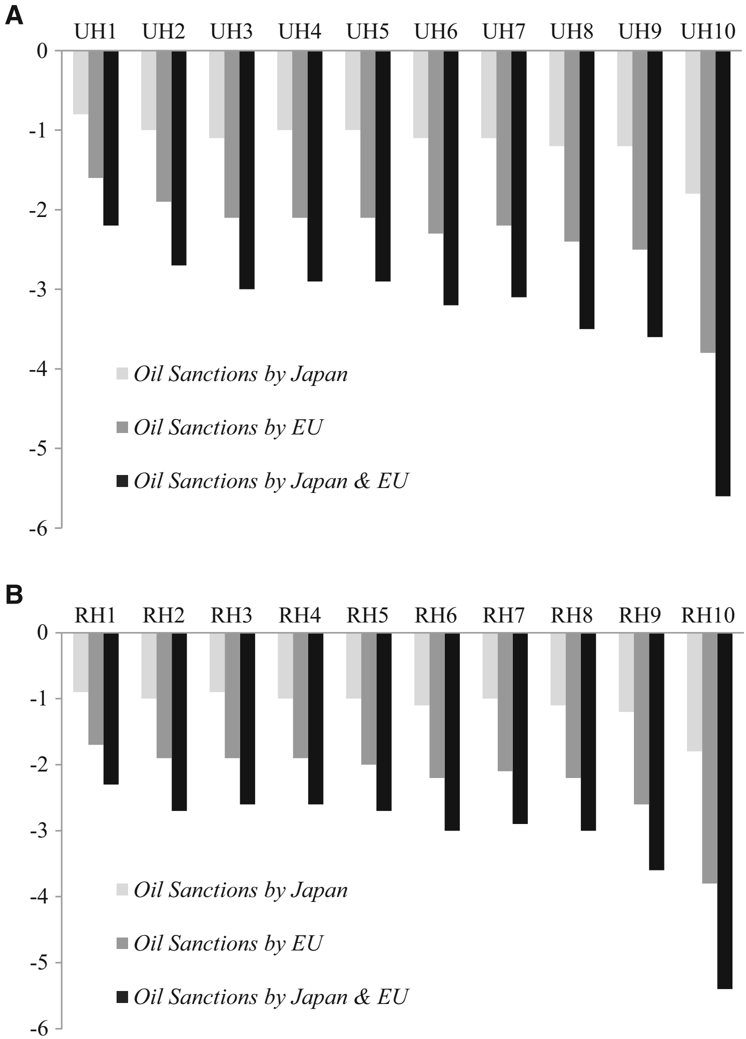

Fig. 8.2 (**a**) Percent changes in urban households' (UHs') welfare due to oil sanctions. Source: Author's calculations. (**b**) Percent changes in rural households' (RHs') welfare due to oil sanctions. *Source*: Author's calculations

Because a major source of household income is based on factor income, reduced factor income reduces income. Given that for each household the share of revenue from the factor income is fixed at the base simulation, the percentage decrease in household income is the same for all households. However, this means that the absolute decrease in income for richer households is greater than for poorer ones; in general, then, richer households suffer more from sanctions.

The SCGE assumes that utility functions are "Stone-Geary."[17] Therefore, in the SCGE, first-order conditions that show optimal household consumption are linear functions with respect to total consumption expenditure—known as the linear expenditure system (LES). One differentiable characteristic among households is their subsistence use of commodities. It is rational to suppose that, in general, this amount of consumption is larger for upper-income households. In addition, richer households may use greater share of imported commodities and services (e.g., international vacations) than do poorer ones. Under the aforementioned circumstances, oil sanctions result in decreased welfare for all households, with larger negative effects on upper-income households.

Sensitivity Analysis

Hitherto, we have presented our central results for the basic dataset included in the SAM. However, these results may be sensitive to the choice of key parameter levels or treatment of closures. How and to what extent do changing previous assumptions affect the results? We present our sensitivity tests in the following subsections. To investigate the sensitivity of our simulation, we consider the two following questions: Will the sign of the results of altering earlier assumptions differ from the central case? In addition, will the order of magnitudes for results change as a result of changing these assumptions?

Results of Altering Key Elasticities

The key elasticities that are the most strongly expected to affect the simulation results are the elasticity of substitution between factors in the bottom of the technology nest and the Armington and CET elasticities of substitution. As mentioned above, these parameters in our core analysis are 0.8, 3, and 2.5, respectively. The second column in Table 8.2 provides the central results for the scenario of oil sanctions by the EU and Japan (scenario three); it exactly duplicates the relevant results in Table 8.1, Figs. 8.2a

Table 8.2 Sensitivity analysis on key elasticities

Indicator	*Scenario 3*	*ESB (low)*	*ESB (high)*	*Arm (low)*	*Arm (high)*	*CET (low)*	*CET (high)*
Private consumption	−3.9	−4.0	−3.9	−4.2	−3.7	−4.5	−3.5
Total exports	−16.5	−16.6	−16.5	−14.7	−18.0	−18.4	−14.9
Total imports	−20.0	−20.0	−20.0	−17.8	−21.8	−22.3	−18.0
Non-oil export	61.1	61.0	61.1	66.5	56.7	55.5	65.9
Gross domestic production	−2.2	−2.3	−2.2	−2.4	−2.1	−2.6	−2.0
Net indirect tax	23.6	24.6	22.8	27.4	21.5	20.5	25.0
Real exchange rate	13.0	13.0	13.0	14.4	11.9	14.8	11.7
Consumer price index	−0.8	−1.0	−0.7	−0.8	−0.9	−0.8	−0.9
Labor income	8.7	11.2	7.0	8.7	8.7	8.6	8.9
Capital income	−3.8	−4.4	−3.4	−3.8	−3.8	−3.9	−3.7
Urban household 1	−2.2	−2.1	−2.3	−2.4	−2.1	−2.7	−1.9
Urban household 2	−2.7	−2.6	−2.7	−2.9	−2.5	−3.2	−2.3
Urban household 3	−3.0	−2.9	−3.0	−3.2	−2.8	−3.5	−2.6
Urban household 4	−2.9	−2.9	−3.0	−3.1	−2.7	−3.5	−2.5
Urban household 5	−2.9	−2.9	−3.0	−3.2	−2.8	−3.5	−2.6
Urban household 6	−3.2	−3.2	−3.2	−3.4	−3.0	−3.8	−2.8
Urban household 7	−3.1	−3.0	−3.1	−3.3	−2.9	−3.6	−2.7
Urban household 8	−3.5	−3.5	−3.5	−3.7	−3.3	−4.0	−3.1
Urban household 9	−3.6	−3.6	−3.6	−3.8	−3.4	−4.2	−3.2
Urban household 10	−5.6	−5.8	−5.4	−5.9	−5.3	−6.3	−5.1
Rural household 1	−2.3	−2.3	−2.3	−2.4	−2.2	−2.8	−1.9
Rural household 2	−2.7	−2.7	−2.7	−2.8	−2.5	−3.2	−2.3
Rural household 3	−2.6	−2.6	−2.6	−2.7	−2.4	−3.1	−2.2
Rural household 4	−2.6	−2.6	−2.6	−2.8	−2.5	−3.1	−2.3
Rural household 5	−2.7	−2.7	−2.7	−2.8	−2.6	−3.2	−2.3
Rural household 6	−3.0	−3.1	−3.0	−3.2	−2.9	−3.5	−2.7
Rural household 7	−2.9	−2.9	−2.9	−3.0	−2.7	−3.3	−2.5
Rural household 8	−3.0	−3.1	−3.0	−3.2	−2.9	−3.5	−2.7
Rural household 9	−3.6	−3.7	−3.5	−3.8	−3.4	−4.1	−3.2
Rural household 10	−5.4	−5.7	−5.2	−5.7	−5.2	−6.1	−4.9

Source: Authors' calculations

and b under the third scenario. We use the central results in scenario three as a comparative point to determine how the results of altering key elasticities will vary. The next columns show the results when each elasticity deviates from its fixed initial level by 20 percent (either lower or higher).[18]

The third and fourth columns in the table show that the results are not sensitive to altering the elasticity of substitution between factors at the bottom of the technology nest elasticity of substitution (ESB). However, as expected, there are some minor changes in the results; the greatest change is found in labor and capital income. Because the elasticity of substitution between factors at the bottom of the technology nest is at the lower level, changes in labor and capital income are 11.2 percent and −4.4 percent, respectively. Conversely, with a higher elasticity of substitution between factors at the bottom of the technology nest, labor income increases by 7 percent while capital income decreases by 3.4 percent. The reason is that when this elasticity is higher, factors at the bottom of the technology nest can be substituted more easily, thus mitigating the effects of oil sanctions.

The Armington (CET) elasticity reflects substitutability between commodities that are produced domestically and commodities that are imported (exported). The sign and order of magnitude for none of the results vary from our central results. Thus, our results are considered insensitive to varying Armington and CET elasticities.

Furthermore, higher elasticities decrease the effect of oil sanctions on macro-indicators and household welfare (although this effect is rather small) and vice versa for the case of lower elasticities. Meanwhile, there are two exceptional cases for each of the Armington and CET elasticities. The lower Armington elasticity decreases the effect of oil sanctions on total exports and imports, whereas the higher elasticity increases that effect. In addition, lower CET elasticity decreases net indirect tax and labor income, whereas higher elasticity has an increasing effect on them. In sum, our results are robust when we change the initial elasticities by +/−20 percent.

Results of Enforcing Other Closures

The treatment of the government sector, the exchange rate, and the saving-investment ratio are the other important features of our core simulation. The current results are based on a closure involving the government in which the tax rates and government expenditure are fixed, while government saving is flexible. In the SCGE, there are two alternative closures with respect to government: Gov. 2 and Gov. 3. In both Gov. 2 and Gov. 3, government saving and expenditure are fixed and direct tax rates of domestic institutions are adjusted endogenously to generate that fixed level of government saving. The difference between these two closures is that for Gov. 2, the same numbers of percentage points are used to

Table 8.3 Sensitivity analysis on other closures

Indicator	*Scenario 1*	*Government*		*External balance*	*S-I*
		Gov. 2	*Gov. 3*		
Private consumption	−1.33	−1.33	−1.33	3.97	−0.05
Fixed investment	–	–	–	–	−2.93
Total exports	−6.17	−6.17	−6.17	−10.53	−6.23
Total imports	−7.46	−7.46	−7.46	2.23	−7.54
Non-oil export	16.5	16.5	16.5	3.8	16.3
Foreign saving	–	–	–	67.71	–
Gross domestic production	−0.75	−0.75	−0.75	−0.41	−0.81
Net indirect tax	10.60	10.61	10.60	−16.84	−0.69
Real exchange rate	4.30	4.30	4.30	–	4.10
Consumer price index	−0.1	−0.1	−0.1	0.0	−0.1
Labor income	2.51	2.51	2.51	2.09	1.98
Capital income	−1.11	−1.11	−1.11	−0.99	−0.99
Urban household 1	−0.80	−0.90	−0.90	3.90	0.30
Urban household 2	−1.00	−1.00	−1.00	4.00	0.20
Urban household 3	−1.10	−1.10	−1.10	4.20	0.20
Urban household 4	−1.00	−1.00	−1.10	4.00	0.20
Urban household 5	−1.00	−1.10	−1.10	3.90	0.20
Urban household 6	−1.10	−1.10	−1.10	3.90	0.10
Urban household 7	−1.10	−1.10	−1.10	3.70	0.10
Urban household 8	−1.20	−1.20	−1.20	3.90	0.0
Urban household 9	−1.20	−1.20	−1.20	3.70	0.0
Urban household 10	−1.80	−1.80	−1.80	4.50	−0.30
Rural household 1	−0.90	−0.90	−0.90	3.40	0.20
Rural household 2	−1.00	−1.00	−1.00	3.50	0.10
Rural household 3	−0.90	−1.00	−0.90	3.30	0.10
Rural household 4	−1.00	−1.00	−1.00	3.30	0.10
Rural household 5	−1.00	−1.00	−1.00	3.30	0.0
Rural household 6	−1.10	−1.10	−1.10	3.40	0.0
Rural household 7	−1.00	−1.10	−1.00	3.20	0.0
Rural household 8	−1.10	−1.10	−1.10	3.20	0.0
Rural household 9	−1.20	−1.30	−1.20	3.50	−0.10
Rural household 10	−1.80	−1.70	−1.70	4.60	−0.20

Source: Authors' calculations

endogenously adjust the base-year direct tax rate of selected domestic nongovernment institutions, whereas for Gov. 3, the tax rates are adjusted through multiplying by a flexible scalar.[19] In Table 8.3, under columns Gov. 2 and Gov. 3, these closures are used to simulate the effects of sanctions for scenario one. A comparison shows that, in general, our results are not significantly affected; therefore, the simulation is not sensitive to altering the government closure.[20]

For external balance, our core simulation employs a *flexible* real exchange rate together with fixed foreign saving. In Table 8.3, under the column External Balance, another way of addressing external balance is employed; that is, the exchange rate is *fixed*, whereas foreign saving is left flexible.

The results are sensitive to the assumption about the *external balance*. Under this condition, households do *not* suffer from oil sanctions but instead *benefit* from a much higher welfare level compared with the pre-sanction situation. The results show that the changes in private consumption, import, and household welfare are positive. The reason behind these findings is that the huge reductions in total exports caused by oil sanctions are mostly compensated with an enormous increase in foreign saving, 67.71 percent, instead of an increase in the real exchange rate, 4.3 percent. Hence, the investment-driven characteristic of saving-investment balance implies that household saving decreases. Consequently, factors that are not needed in the oil industry are employed by other activities, and the increased production and consumption of other commodities increase households' welfare.

Another alternative closure that significantly affects the results is the *saving-investment balance*. In the core model, an investment-driven closure is used. This closure assumes that real investment quantities are fixed. To equalize savings with investments, the base-year saving rates for households and enterprises are modified by the same number of percentage points. In Table 8.3, under the column S-I (Saving-Investment), a saving-driven closure is employed. By using a saving-driven closure, the saving rates for nongovernment institutions are fixed; to equalize between the investment cost and the savings value, a flexible scalar is multiplied by the quantity of each commodity in the investment bundle. Although real exchange rate, export, and import are not much different from those of the core simulation, the results regarding welfare level show deviations. In this case, after the shock of oil sanctions affects the Iranian economy's trading sector, the other parts of the system primarily react to it by reducing the amount of fixed investment instead of the amount of private consumption.

With respect to welfare levels, all households are at least as well-off as they were before the sanctions except for the highest income group of urban households and the two highest income groups of rural households. The overall consequence for private consumption is a minor reduction.

It should be repeated that the results for the circumstances under which the exchange rate is fixed and/or the saving-investment balance is saving-driven are *misleading*, especially when a single-period model is used. As argued in relation to the empirical strategy and data section, the macroclosures used here are more in line with macroconditions in Iran. In addition, as oil sanctions are imposed, the use of a fixed exchange rate forces the model to raise foreign savings to reach an equilibrial solution regardless of what will happen subsequently. The welfare gained under this condition is misleading because, eventually, foreign investment is increased as foreign debts have to be repaid, and households will incur welfare losses. The use of a savings-driven closure in a single-period model also reduces investments since oil sanctions prevent the model from correctly capturing welfare changes. Indeed, reductions in investments will reduce production capacities in the future, eventually leading to welfare losses.

Conclusion

This chapter has focused on analyzing the economic effects of oil sanctions on the Iranian economy, including changes in household welfare and macro-indicators. The framework of our analysis is the CGE model, based on Lofgren et al. (2002), and we have used the Iranian social accounting matrix (SAM) in 2001 as an economy-wide database. We have modified Lofgren et al. (2002) in a manner that allows for the inclusion of oil sanctions in the model. The model is closed under the Johansen closure rule. Three scenarios in which the exportation of crude oil from Iran to the rest of the world is banned have been developed. In addition, sensitivity analysis of results to key elasticities and other macroclosures has been carried out.

Our results show that the Iranian economy and households are affected enormously by sanctions. The third scenario (i.e., sanctions by the EU and Japan) bans 57 percent of Iranian oil exports. Macro-indicators that are *negatively* affected are (in order) total imports by 20 percent, total exports by 16.5 percent, private consumption by 3.9 percent, capital income by 3.8 percent, GDP by 2.2 percent, and CPI by 0.8 percent. Other macro-indicators that *positively* change (i.e., increase) are (in order) non-oil export by 61 percent, net indirect tax by 23.6 percent, the real exchange rate by 13 percent, and labor income by 8.7 percent. The rise in non-oil exports can be considered an adjustment process to sanctions, as it mitigates the huge reduction in total exports.

In addition, all household income groups in urban and rural areas suffer from oil sanctions and welfare declines. An interesting finding is that, in general, richer households lose more than poorer households. Furthermore, sensitivity analysis indicates that our model is robust and insensitive to the Armington and CET elasticities, along with the elasticity of substitution between factors at the bottom of the technology nest. However, although other government closures do not have a major effect on the findings, the use of other closures regarding *exchange rate* and *saving-investment* has misleading effects in simulations and can destabilize the model.

Our model may also be used to investigate the effects of lifting sanctions on the Iranian economy. In addition, small changes in the model structure may allow for the inclusion of sanctions on exports or imports of other commodities. Finally, the model can be applied to other sanctioned economies.

Appendix A

Proof of Eq. 4.
Allocation of domestic output of oil (QX_{oil}) follows a CET function (Eq. B) addressing oil production between two destinations, export (QE_{oil}) and domestic use (QD_{oil}). Oil producers experience sanctions and must consider the amount of oil export as a given. Therefore, an oil producer must maximize his revenues (Eq. A) given prices (PDS_{oil}, PE_{oil}, and PX_{oil}) and subject to the CET function and a fixed quantity of domestic output (QX_{oil}) and export (QE_{oil}):

$$\text{Max}: \quad PX_{oil}.QX_{oil} = PDS_{oil}.QD_{oil} + PE_{oil}.QE_{oil} \qquad \text{(Eq.A)}$$

$$\text{S.T.}: \quad QX_{oil} = \alpha.\left(\delta.\ QE_{oil}^{\rho} + (1-\delta).\ QD_{oil}^{\rho}\right)^{\frac{1}{\rho}} \qquad \text{(Eq.B)}$$

Since Eq. B can be written as the following equation:

$$QE_{oil} = \left(\frac{QX_{oil}{}^{\rho}}{\delta\alpha^{\rho}} - \frac{1-\delta}{\delta}\ QD_{oil}^{\rho}\right)^{\frac{1}{\rho}} \qquad \text{(Eq.b)}$$

Then, to maximize Eq. A subject to Eq. B, we have to solve the following equation:

$$\frac{d\left[PDS_{oil}.QD_{oil} + PE_{oil}.\left(\frac{QX_{oil}{}^{\rho}}{\delta\alpha^{\rho}} - \frac{1-\delta}{\delta}\, QD_{oil}^{\rho}\right)^{\frac{1}{\rho}}\right]}{dQD_{oil}} = 0$$

The result is Eq. 4 (mentioned in this chapter):

$$\frac{PDS_{oil}}{PE_{oil}} = \left(\frac{QX_{oil}^{\rho}}{\delta.\alpha^{\rho}} - \frac{1-\delta}{\alpha}.\ QD_{oil}^{\rho}\right)^{\frac{1}{\rho}-1} \cdot \frac{\delta}{1-\delta}\, QD_{oil}^{\rho-1}$$

Notes

1. This chapter is the extension of an earlier working paper (Farzanegan et al., 2015).
2. We follow Askari et al. (2003: 14) in defining sanctions as "coercive measures imposed by one country or coalition of countries, against another country, its government or individual entities therein to bring about a change in behavior or policies."
3. For a historical review of economic sanctions, see Daoudi and Dajani (1983) and Hufbauer et al. (2007).
4. We have not found any reliable data about non-oil exports after 2013.
5. For a complete description of SCGE, see Lofgren et al. (2002).
6. According to Lofgren et al. (2002), the implicit assumption is that "the government is able to implement policies that generate the necessary private savings to finance the fixed real investment quantities."
7. The gap between formal and informal (free) exchange rates is known as the black market premium, or BMP. See Farzanegan (2009, 2013).
8. See Farzanegan (2013) for an economic examination of recent sanctions in Iran.
9. This equation is the same as that of Lofgren et al. (2002).
10. For general discussions of SAMs, see Pyatt and Round (1985) and Reinert and Roland-Holst (1997); for perspectives on SAM-based modeling, see Pyatt (1988) and Robinson and Roland-Holst (1988).

11. The source of the SAM modified by Mehrara and Barkhordari (2007) is the SAM for 2001 which is published by the former Iranian Organization of Management and Planning.
12. The SAM is available upon request from authors.
13. In SCGE, a CES aggregation function that shows domestic market demand captures imperfect substitutability between imports and domestic output. This function is often called the Armington function after Paul Armington, who first introduced the use of the CES function for this purpose (Armington 1969).
14. The Frisch parameter measures the elasticity of the marginal utility of income with respect to income.
15. For a recent study on the response of international oil prices to negative shocks in Iranian oil exports, see Farzanegan and Raeisian Parvari (2014). In summary, Farzanegan and Raeisian Parvari (2014) show that oil sanctions do not increase international oil prices; instead, the supply of non-Iranian oil increases.
16. Financial and banking sanctions that can offset the increase in exports as an outcome of an increased exchange rate are not included among the goals of this study and therefore are not simulated.
17. For details, see Blonigen et al. (1997: 223–225) and Dervis et al. (1982: 482–485).
18. The Armington and CET elasticities of substitution are 2.4 and 2 at their low level and 3.6 and 3 at their high level, respectively. For the elasticity of substitution between factors in the bottom of the technology nest, the lower level is 0.64 and the higher level is 0.96.
19. For more explanation on the difference between the two alternative closures, see Lofgren et al. (2002: 14).
20. Unlike our sensitivity analysis on key elasticities, we have chosen scenario one as the central case to compare between closures. The reason is that making the exchange rate fixed in our model has a large effect on the results and in scenario three, we have not reached an equilibrium situation.

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