

DISCUSSION PAPER SERIES

IZA DP No. 17062

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Emigration: A Case Study of Iran**

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**Afsaneh Zareei**

*Ferdowsi University of Mashhad and  
Stockholm University*

**Mohammad Ali Falahi**

*Ferdowsi University of Mashhad*

**Eskil Wadensjö**

*Stockholm University and IZA*

**Saeed Malek Sadati**

*Ferdowsi University of Mashhad*

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ISSN: 2365-9793

**IZA – Institute of Labor Economics**

Schaumburg-Lippe-Straße 5–9  
53113 Bonn, Germany

Phone: +49-228-3894-0  
Email: [publications@iza.org](mailto:publications@iza.org)

[www.iza.org](http://www.iza.org)

## ABSTRACT

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# International Sanctions and Labor Emigration: A Case Study of Iran

Sanctions have severe adverse effects on societies. Even though sanctions are used against governments, the population is punished for its government's behavior. Sanctions can create problems due to international migration. Iran is a unique case study because it faced the most and hardest sanctions in the world until February 2022. Many negative effects on the economy have been observed such as losing the Rial's value against the US Dollar by 80 percent, increasing poverty, and reducing exports and imports. At the same time, Iran had a very fast growth of emigration with an increase of 141 percent. Sanctions have been imposed on Iran's economy in different ways, but so far, it has not been determined how each type of sanctions will affect emigration. The aim of this study is to study the relationship between different kinds of economic sanctions and labor emigration using the Dynamic Stochastic General Equilibrium model. Different types of sanctions as oil and nonoil exports and three different import sanctions on consumer, capital, and intermediate goods are considered. The results show that sanctions on nonoil exports are most influencing emigration. Sanctions on the imports of intermediate and consumer goods, as well as sanctions on oil exports, are in the next steps, but not as much as the non-oil exports. It can be noticed that out of approximately 24 million people working in Iran, up to 4 percent of the working force have a desire to leave the country as migrant workers due to the sanctions.

**JEL Classification:** B22, C02, C11, C68, F22, P00

**Keywords:** international sanctions, labor emigration, DSGE Models, Iran

**Corresponding author:**

Eskil Wadensjö  
Swedish Institute for Social Research (SOFI)  
Stockholm University  
Universitetsvägen 10 F  
Frescati  
Stockholm  
Sweden

E-mail: [eskil.wadensjo@sofi.su.se](mailto:eskil.wadensjo@sofi.su.se)

## Introduction

Iran has been subjected to harsh sanctions for decades. They have been tightened since May 2012. The main goal of sanctions was to change the government's behavior, but the pressure was felt mainly by people through welfare. Iran's GDP, which stagnated during the first phase of sanctions under President Obama, has been shrinking ever since, partly because the COVID-19 pandemic has added to the damage caused by these sanctions (Salehi-Isfahani J, 2020). Rial depreciation, government debt, liquidity growth, and high inflation have been the result each time sanctions have been tightened (Mazarei, 2020). Sanctions raised international transaction costs and, in some cases, disrupted industrial production by cutting off the supply of imported inputs and reducing government revenues. People's financial behavior also changes as the sense of hopelessness in society increases and the atmosphere of uncertainty grows.

In addition to sanctions, emigration has become an important problem in Iran in terms of policymaking and analyzing the performance of policies and economic programs. The Iran Migration Observatory in 2022 underlines that emigration had been the most growing social phenomenon in Iran during the past two years. The downward trends of social hope and economic stability, the reduction of basic freedom, and the negative economic, social, and political situations have increased emigration among many different groups. Sanctions have played a significant role in worsening economic conditions. As sanctions increase emigration (Gutman et al., 2024), their effect on the economy and the labor market have become among the most important economic issues for researchers in recent years considering the influence of various economic factors on sanctions and the direct and indirect effects of sanctions on the labor market and migration. Gutmann et al. (2024) show that sanctions increase emigration by around 20 percent. The impact of UN sanctions on international migration is smaller and less persistent. Moreover, the effects are driven by target countries with fewer political rights and civil liberties, where emigration substitutes for the costly voicing of dissent.

The impact of migration from various factors has been studied by researchers. Some of the important factors influencing migration are differences in expected income at the origin and destination, unemployment, taxes, per capita income, development level, meritocracy, political instability, and corruption. However, it is not possible to define a clear border between economic and non-economic factors affecting migration (Ahadi et al., 2018). Therefore, the issue of migration, with a focus on the economic perspective as well as the various channels through which oil sanctions and nonoil are applied, is examined in this study considering the importance of sanctions and their widespread economic effects in Iran. Therefore, the main emphasis of the study is on the economic approach to labor emigration according to the framework and assumptions considered. However, this does not mean that other factors, including political and social factors, are unimportant.

In this regard, we would like to know how the sanctions of the West and the economic problems in Iran are affecting the emigration of the labor force. Focusing on the economic effects, we model the impact of different types of sanctions on labor emigration, including oil and nonoil exports and imports of capital, consumers, and intermediate goods. A dynamic stochastic general equilibrium (DSGE) model of a small open economy will be used to achieve the following objectives. This method allows for an integrated examination of the overall impact and composition of emigrants and can be used to explain appropriate policies to address the challenge of emigration.

In the case of sanctions, there are several studies on how international sanctions influence the economy (Laudati & Pesaran, 2023; Batmanghelidj 2022; Mazarei, 2020), household welfare, and women's employment (Demir & Tabrizy, 2022; Salehi-Isfahani, J, 2023), government expenditures and revenues (Harris, 2020), militarization (Farzanegan, 2022), trade (Erdóhádi-Kiss et al, 2023; Mahlstein et al; 2022 Shakib et al; 2023), finance (Alexakis et al, 2024; Clichic and Dragoi, 2023; Torbat, 2005 ), energy (Chen et al, 2023; Nakhli et al, 2021; Nephew, 2015), environment (Madani 2020), firms (Gaur et al, 2023; Andrei 2021; Cheratian et al, 2023) and migration (Gutmann et al, 2024). However, the case of the effectiveness of different types of sanctions with separation on oil and nonoil exports, and sanctions on imports for different goods, has not yet been investigated. Our study aims to fill this gap in the literature and contributes to a body of literature that has identified events of conflict as one of the main drivers of emigration and ignored the different effects of various types of sanctions as a shock for emigration decisions (Gutmann et al, 2024; Dreher et al. 2011).

The main contribution of this study is modeling the effect of sanctions on labor emigration with emphasis on the type of sanctions from the different five channels. The inclusion of both emigration

and sanctions in the model sets it apart from other studies in the field of emigration and the labor market. Our finding suggests that while shocks to nonoil exports, oil exports, imports of consumer goods, and imports of intermediate goods all increase the desire to migrate, the greatest effect is due to nonoil export. Nonoil sanctions have had much broader effects on Iran’s labor market, as they indirectly distort backward and forward economic activities in the targeted sectors. Moreover, the larger share of sanctions on intermediate goods imports in comparison to oil sanctions indicates that the former is relatively more endogenous than the latter, having greater and broader effects on labor demand.

The structure of the paper is as follows. The first part is an overview of Iran's long-term economic development and the characteristics of the Iranian economy as a context for recent developments and a discussion of the impact of Western and EU sanctions. Migration trends in Iran will also be on the agenda. Section two describes the research design, section three presents the results, and finally, section four provides the conclusion.

## Background and Literature Review

### Sanctions

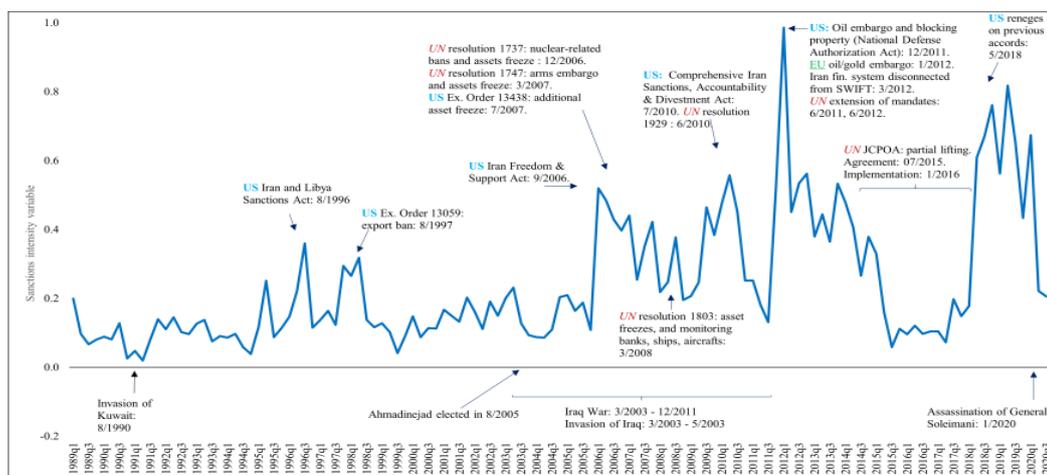
There are many different types of sanctions against Iran, which began in 1979. In 2006, the United Nations Security Council imposed various arms, technology, and trade sanctions in response to threatening trends in the development of Iran's nuclear capabilities. The US also expanded its sectoral sanctions in 2007–2008. President Obama's administration deepened these sanctions by imposing severe financial sanctions that effectively cut the country’s banks off from the global financial system and in turn halted the country's oil exports and deprived the economy of significant revenues. In 2013, these sanctions were re-imposed and expanded. In 2018, after a brief period of multilateral sanction relief related to the implementation of the 2015 Joint Comprehensive Plan of Action (Batmanghelidj, 2022), the President Trump administration moved unilaterally to put Iran's economy under "maximum pressure". Some of the most significant sanctions imposed on Iran since 2011 are listed in Table 1.

**Table 1:** Major sanctioning events against Iran over the period 2011–2022

<b>Year of implementation</b>	<b>Forms of Sanctions (Sanctioning Entity)</b>
<b>Apr to Dec 2011</b>	<ul style="list-style-type: none"> <li>-Travel restrictions and assets freeze of people related to human rights violations (EU)</li> <li>-Assets freeze of persons and entities involved with abuses. (USA)</li> <li>-Enhanced sanctions from the Iran Sanctions Act. No credit, no FX, property block from U.S. financial institutions, imports ban (USA)</li> <li>-Extended mandate of the panel of experts that supports the Iran sanctions committee for one year. (UN)</li> <li>-Sanctions on entities and individuals helping Iran’s energy and petrochemical sectors maintenance and expansions (USA)</li> <li>-Sanctions against banks dealing with Iranian financial institutions, the Central bank of Iran included. Restricted export of Iranian Oil (USA)</li> </ul>
<b>Jan to Oct 2012</b>	<ul style="list-style-type: none"> <li>-Oil embargo, assets freeze of CBI, Embargo on gold, precious metals (EU)</li> <li>- Blocking property of the Government of Iran and Iranian financial institutions, the Central bank of Iran included (USA)</li> <li>-Decision 2010/413 expanded with new but marginal financial restrictions (EU)</li> <li>-Wide expansions of the Scope of import/export restrictions and banking financial sanctions (EU)</li> <li>-Assets freeze of companies providing technology for human rights abuses. Donations prohibited to blocked entities and persons (USA)</li> <li>-Extra sanctions for entities and persons found to evade previously issued sanctions against Iran (USA)</li> <li>-Renewed the mandate of the Committee’s panel of Exports to monitor Iran for 13 months (UN)</li> <li>-Sanctions on foreign institutions involved in deals with Iran’s energy and petrochemical sectors products (USA)</li> <li>-New multilateral sanctions on entities facilitating Iranian transactions (USA)</li> <li>-Expansions of assets freeze and financial restrictions (USA)</li> <li>-Ban on trade and financial assistance to buy natural gas, a range of manufacturing and software products for ballistic missiles, and ship-building (EU)</li> </ul>
<b>Jan to June 2013</b>	<ul style="list-style-type: none"> <li>-Broad range of economic and financial sanctions expanded (USA)</li> <li>-Financial restrictions and assets freeze on foreign institutions doing business in Rials or in the automotive industry (USA)</li> </ul>
<b>Jul to Oct 2015</b>	<ul style="list-style-type: none"> <li>-Agreement to schedule suspension and lift of U.N. sanctions (UN)</li> </ul>

	-EU intermediate steps toward the application of JCPOA (EU)
<b>Jan to Dec 2016</b>	-Implementation day: the EU, USA, and UN suspend or terminate nuclear sanctions. A process of recovery of Iran's assets for about \$100 billion begins (UN) -Iranian banks have access to the SWIFT system. U.S. banks remain prohibited from doing business with Iran directly or indirectly (World) -USA renew the sanctions going on since 1996 on Iran (USA)
<b>May to Nov 2018</b>	-USA announcements of withdrawal from JCPOA (USA) -Re-impose all sanctions lifted or waived by JCPOA (USA) -Largest ever single-day action targeting the Iranian regime (USA) -SWIFT restrictions (USA)
<b>May to June 2019</b>	-Sanctions on iron, steel, aluminum, and copper sectors of Iran (USA) -Further assets freeze, secondary sanctions on financial institutions (USA)
<b>Jan to Oct 2020</b>	-Assets freeze related to entities and individuals trading in the manufacturing sector, among others (USA) -Restrictions on immigration (USA) -Sanctions related to the trade and financial support arms trade (USA) -18 Iranian banks hit by further sanctions (USA) -Sanctions on companies supporting: metal, steel, petroleum, and petrochemical sectors (USA)
<b>Jan. 2021</b>	-Sanctions on companies supporting: metal, steel, petroleum, and petrochemical sectors (USA) -Sanctions on two organizations controlled by the Supreme Leader (USA)
<b>May to December 2022</b>	-Treasury Targets Oil (USA) -Targeting a Sanctions Evasion Network Supporting Iranian Petrochemical Sales (USA) -Targeting Iran's International Petroleum Trade (USA) -Treasury Targets Financial and Shipping Facilitators of Iranian Petrochemicals and Petroleum Sales (USA) -Designating a Network of Iranian Oil Sanctions Evaders (USA)

Source: Laudati and Pesaran, 2021, U.S. Department of State, 2023



**Figure 1: Sanction intensity variable over the period 1989q1–2020q3**

Source: Laudati and Pesaran, 2023

Severe sanctions led to a 5.8 percent decrease in GDP and a 40 percent increase in the Consumer Price Index (CPI) for 2012–2013 (Nakhli et al., 2020). Economic growth fell from 13 percent to -6 percent in the short period between the lifting of sanctions in 2016 and their reimposition in 2018 (Salehi Isfahani, J, 2020). These sanctions have reduced Iran's oil exports to their lowest level since 2011, dealing a major blow to Iran's economy and disrupting international trade. Since 2018, oil exports have fallen by \$80 billion, and the Rial has lost approximately 80% of its value against the US dollar (Fardoust, 2020). Analysis of oil and nonoil export statistics reveals that oil and natural gas account for the majority of Iran's exports, averaging approximately 80% of total exports from 1974–2022. Chemicals, plastics, fruits, ceramics, and metals are some of the other items exported (Trading Economics, 2023). A comparison of oil and nonoil export statistics reveals that nonoil exports have been increasing since 2010. The increase in economic sanctions, which led to a decline in oil exports

compared to the years before 2010, is one of the main reasons (EIA, 2022). The value of Iran's nonoil exports exceeded the value of its oil exports in December 2021 (Trading Economics, 2023).

In addition to increasing the supply of money, inflation also increased due to the devaluation of the Rial, which caused cost pressures on imports, including the inputs of manufactured goods in Iran. By targeting the central bank, U.S. and European Union officials have shown that they can significantly reduce Iran's free access to its abundant foreign exchange reserves. Targeting these reserves was a special concern of the Trump administration, which estimated that by 2020, Iran would be able to access only 10% of its reserves. Therefore, the Rial lost approximately one-fifth of its value in the free market between November 2018 and May 2019, a decrease in value similar in scale to the decrease in value that occurred after the imposition of financial sanctions against Iran in 2012 (Batmanqlich, 2022).

However, the impact of economic sanctions on employment has been much weaker than that on consumption. One of the reasons for this may be the high degree of inflexibility of employment in Iran. Employment does not react quickly to falling output. The government allowed prices to rise and the value of the national currency to fall rapidly to make local production more competitive in certain sectors. This policy did not prevent a decrease in real incomes, although it made employment more resilient to the shock of sanctions. Total employment grew by 2.1 percent per year, from approximately 20 million in 2011 to 27 million in 2019. The services sector grew by 2.7 percent, followed by industry and agriculture, both of which grew by 1.5 percent. However, despite the increase in employment, as the depreciation of the national currency led to a fall in real wages, the increase in employment did not compensate for the fall in real wages (Salehi Isfahani. J, 2020).

Based on gender bias and education, women's labor participation was much more affected by sanctions than men's labor participation was. Furthermore, sanctions appear to have hurt those who completed lower secondary and upper secondary education but not those who completed primary education. There has been a reduction in the ratio of female to male students as a result of sanctions (Laudati & Pesaran, 2021). Moreover, while the impact is greatest in the early stages of sanction approval, the long-term expectation of sanction imposition gradually declines. This means that sanctions have had more of a short-term effect than a lasting effect (Faraji Dizaji & Bergeijk, 2013).

Moreover, average spending per capita has fallen dramatically since the tightening of US sanctions in 2011. In 2019, per capita spending was 17.7 percent lower than that in 2010, a return to 2002 levels. The number of poor people almost doubled, from 6.4 to 12.1 percent, between 2012 and 2019 (Salehi Isfahani. J, 2020). Because of the unequal distribution of human capital and hence labor income inequality, Iran has generally had little success in reducing poverty. Income from wage employment is more common than income from self-employment in Iran, accounting for 63 percent of all income (Salehi-Isfahani. J, 2020). In this respect, any reduction in the number of jobs or in wages would have a major negative impact on the average income of households.

However, sanctions also have unintended positive effects on Iran's economy. U.S. sanctions were likely partly responsible for the rapid rise of high-tech companies and rapid growth in large web-based businesses in Iran, which are due to barriers to entry for foreign companies and a lack of a competitive market. Sanctions have also significantly advanced missiles and other military technologies (Laudati & Pesaran, 2023). However, some industries dependent on imported inputs and foreign technology were generally hard hit, while others based on domestic resources and regional export markets benefited from a shift in demand toward domestic products (Salehi-Isfahani H., 2020).

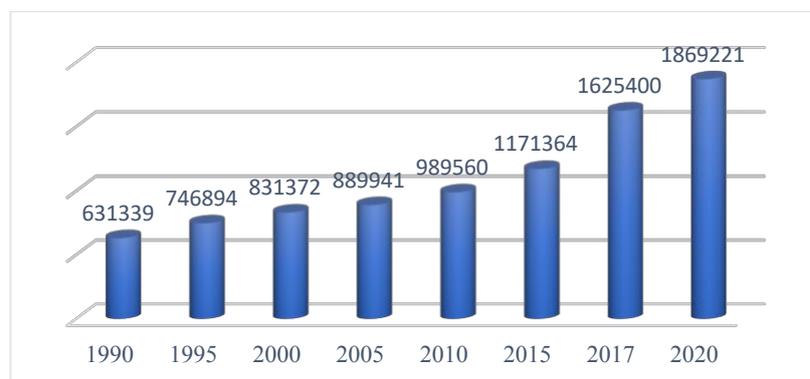
Several studies have been carried out in the field of international sanctions, but only a few of the most important are listed below. Laudati and Pesaran (2023) focus on the identification and quantitative estimation of sanctions on the Iranian economy over the period 1989–2019. It provides a new time series approach and proposes a novel measure of sanctions intensity based on daily newspaper coverage. Based on the result, sanctions significantly decrease oil export revenues and result in substantial depreciation of the Iranian rial, followed by subsequent increases in inflation and falls in output growth. Using a stochastic dynamic general equilibrium model with a new Keynesian approach, Nakhli et al. (2021) examine the impact of oil sanctions on the Iranian economy. The sanctions lowered the ratio of foreign exchange reserves to the monetary base, which pushed up the nominal exchange rate. In the public sector, falling government oil revenues increased the demand for money creation and led to stagflation. Household consumption has risen, while investment has fallen, reflecting rising expected inflation.

Fardoust (2020) investigated the role of the maximum pressure applied by the U.S. and other countries against the Iranian nuclear program at the beginning of 2018. It was found that Iran's GDP per capita fell by 12 percent (6.8 percent annually) in 2018-2019, significantly greater than the average decline of 3 percent to 4 percent annually under trade sanctions. Iran's inflation rate has also risen from 9.6 percent to more than 40 percent. Oil exports have fallen by \$80 billion a year, and the Rial has lost approximately 80 percent of its value against the US dollar. Iran's oil export revenues, financial position, and balance of payments have been severely weakened by the decline in oil revenues. Salehi Isfahani. J. (2020) examined the household and employment effects of sanctions since 2010. The results show that employment has been more resilient, while household income and consumption have been hit. In other words, employment has taken a different path because the devaluation of the Iranian national currency has increased the profitability of the nonoil-tradable sectors of the country, thereby encouraging the process of import substitution.

Farzanegan (2020) examines the impact of international banking and energy sanctions on Iran's military spending between 2012 and 2015. According to the findings, per capita military spending has fallen by approximately \$119 annually, or nearly 54 percent of 2012 baseline levels. According to the study by Dizaji and Farzanegan (2021), multilateral sanctions reduce Iran's military spending by approximately 77 percent in the long run, *ceteris paribus*. To explain the success of economic sanctions in the first two years of implementation, Faraji Dizaji and Bergeijk (2013) examined the economic and political effects of economic sanctions. Two key findings emerged from this research. First, the most significant impact occurs at the initial stage of sanction approval. Second, long-term expectations of sanctions gradually decline to a constant level. The results also show that economic sanctions significantly affect key economic variables (government consumption, imports, investment, and income) and two political indicators (democracy and political competition). These impacts are significant only for the first two years and then become negative, and structural adjustment reduces the economic and political impact of sanctions.

## Migration

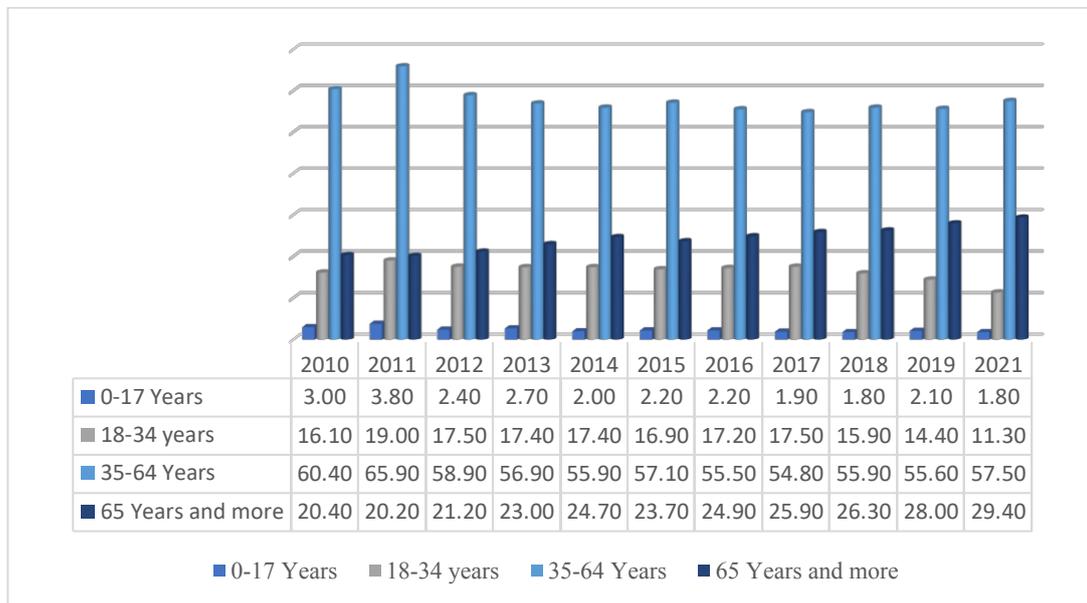
Iran is one of the countries that has faced an increase in emigration in recent years. The development of the total number of Iranian emigrants (including those who are not permanent residents) increased from approximately 13,000 in 1970 to 3.1 million in 2019 (Azadi et al., 2020). The number of Iranian migrants increased at an annual rate of 3.8 percent from 1990 to 2020. The most popular destinations for Iranian immigrants are the United States, Canada, Germany, the United Kingdom, and Sweden (Azadi et al., 2020; Iranian Migration Outlook, 2021). Additionally, according to OECD statistics, the first occupational group among Iranians in these countries is specialists. In addition, professionals are the most common occupational group among Iranians in OECD countries, and their share among Iranian emigrants increased from 25.0 percent in 2000 to 29.6 percent in 2015 (Iranian Migration Outlook, 2020).



**Figure 2:** Stock of total Iranian migrants (persons) (UN, 2022)

More than 75 percent of Iranians in the U.S. are of working age, and this number decreased slightly between 2011 and 2019 as a result of US immigration restrictions (Iranian Migration Outlook, 2021). Conversely, the number of Iranians with work permits in EU countries has risen sharply (Iranian

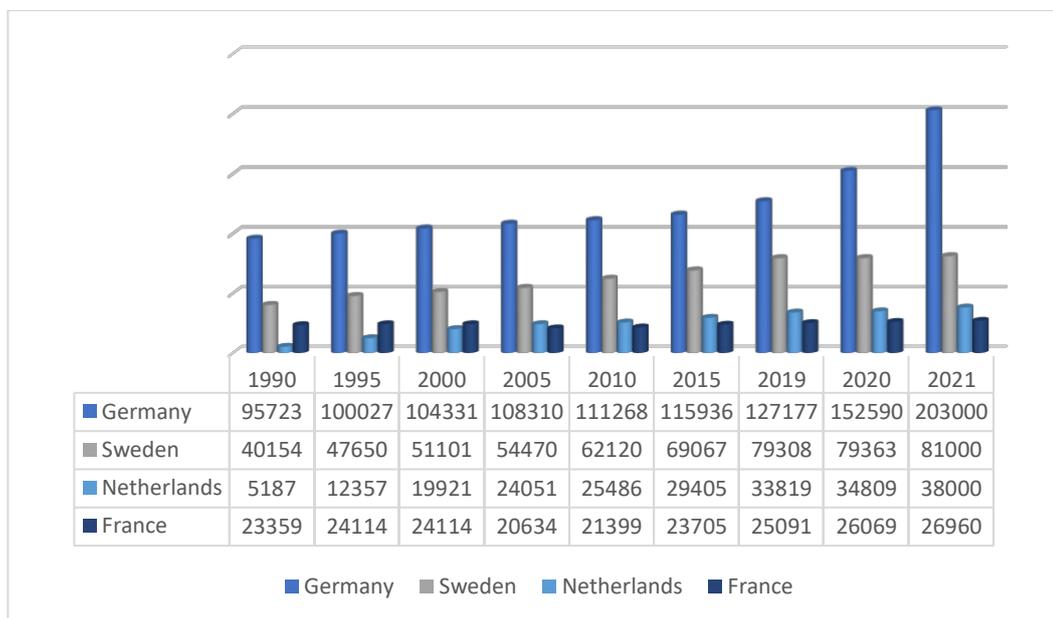
Migration Outlook, 2021). In 2021, Iranians participated in the U.S. labor market at a rate of 63.9 percent, with an unemployment rate of 8.5 percent. The employment rate of Iranians is higher than the average rate for immigrants but lower than the rate for native-born individuals (Iran Migration Outlook, 2022).



**Figure 3: Share of Iranians in the USA**

Source: Iran Migration Outlook, 2022

Note: The US Bureau of Statistics has not estimated the population or its characteristics in 2020



**Figure 4: The number of Iranian immigrants in the four countries with the most immigrants from Iran in the European Union**

One of the most important factors in the decision to emigrate from Iran is related to predisposing factors, which are structural forces that influence the decision to emigrate but are very slow to develop over time. The most important of these factors is the income gap between Iran and its destination countries. In recent decades, per capita income in advanced economies and popular destinations for Iranian emigrants has been three to ten times greater than that in Iran (Azadi et al., 2020).

According to the Iran Migration Outlook 2022, among the different social groups (entrepreneurs and executives, middle managers, employees, foreign students in Iran, and students and graduates), the desire to emigrate is high among most of the groups studied, except for physicians and nurses. Specifically, more than 60 percent of all groups surveyed expressed a desire to emigrate due to actions, currency fluctuations, inflation, and economic instability. The combined effects of multiple factors, including decades of poor governance, political repression, human rights abuses, dark economic prospects, corruption, and sociodemographic factors, have also contributed to Iran's ongoing brain drain crisis. In this regard, the imposition of major economic sanctions in 2012 and 2018 was a precipitating event that had an impact on emigration.

### **Analytical Framework**

To capture labor market mobility, we use a new Keynesian Stochastic Dynamic General Equilibrium model for an open economy. The destination country includes developed countries with more than 90 percent of Iranian labor immigrants. The model of the study was developed based on international sanctions and the realities of Iran's economy, as described by Nakhli et al. (2020 & 2021), Khosravi (2016), Tavakolian and Jalili Naini (2016), Igityan (2016) and Esfandiari (2013). Households, labor markets, final and intermediate goods-producing firms, the trade sector in terms of both exports and imports, the government, and clearing conditions were considered in the model study. The model considers a typical household in the home country to decide whether to work in Iran ( $N_t^{ir}$ ) or become an emigrant ( $N_t^{im}$ ) and work in one of the developed countries. They face budget constraints such that earn income from the use of labor at home at the wage  $w_t^{ir}$  and wages abroad  $w_t^f$ , from hiring capital  $K_t$ , and from intermediate goods producers at the rental rate of  $r_t$  transfer payments  $Tr_t$ . The costs associated with migration are included in the expenditure side of the budget constraint. There are two types of domestic firms in the current model: intermediate goods and final goods firms. Producing firms separate their products to supply domestic and foreign markets with nonoil exports. To examine the impact of international financial sanctions the external sector is divided into two parts: exporting and importing. Intermediate producers sell some of their products abroad. Exporters buy domestic intermediate goods at a price of  $P_t^d$  and sell them to foreign consumers at a price of  $P_t^x$ . Importers can operate in three areas: consumer, capital, and intermediate goods. The importer of three products buys them from foreign companies and sells them to consumers, including households and the government. International sanctions will increase the price of export and import goods. Since financial sanctions increase the final cost of oil sector exports, the model uses the oil sector export channel to determine the effect of financial sanctions. Finally, we have government revenues that the government provides consumption and investment goods from domestic and imported goods. The figure below shows the relationship chart of the model developed for the study<sup>1</sup>.

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<sup>1</sup> Due to the length of the relationships, some important equations are mentioned in the appendix. All questions are available to the readers upon request.

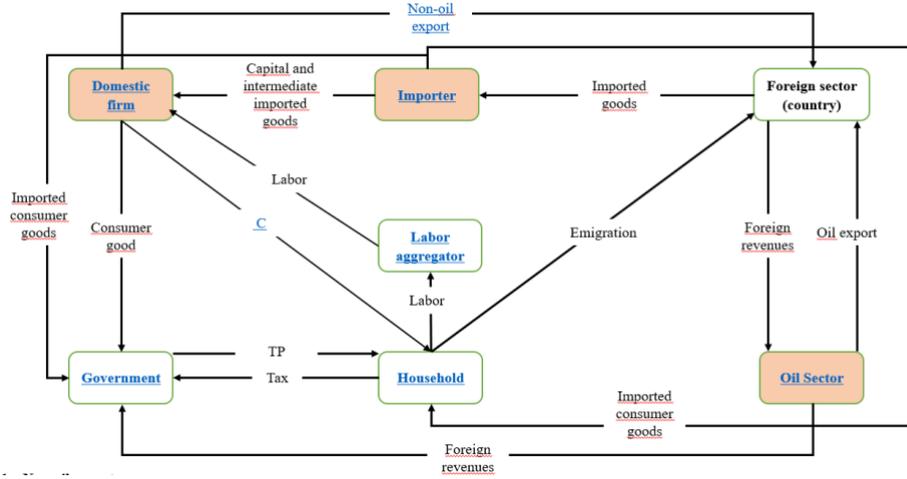


Figure 5: Relationships between different parts of the model

## Calibration and estimation of the model

The equilibrium model designed for Iran's economy is linear logarithmic with 73 variables and 73 equations, which provides the first-order conditions for optimizing the behavior of households with emphasis on emigration, random processes of shocks, oil revenues, government expenditure, and the market clearing condition. The main sources of our data are the CB (Central Bank of Iran) and the SCI (Statistical Centre of Iran). We also use adjusted seasonal quarterly data from 2004Q1- 2020Q4 (detrending) (Hodric–Prescott filter). This dataset consists of gross domestic product, capital stock, government consumption, and private consumption as observable data to perform Bayesian estimation. The values for the parameters for which insufficient data are available are based on the values of similar parameters in previous studies or based on the information and indicators of the Iranian economy (with the help of econometrics). The following table shows the values of the calibrations.

Table 2: Values of parameters

parameter	value	Parameter description	Initialization method
$\beta$	0.965	Intertemporal discount factor	Nakhli et al., 2020
$\sigma_c$	1.5	The elasticity of the intertemporal substitution of consumption	Khosravi, 2017
$\delta$	0.048	The depreciation rate of private capital	Esfandiari, 2014
$t^w$	0.24	The income tax rate	Nakhli et al., 2020
$t^{VA}$	0.27	The consumption (value-added) tax rate	Nakhli et al., 2020
$\sigma_{ir}$	2.9	Frisch labor elasticity	Nakhli et al., 2020
$\alpha$	0.4	The share of capital services in the production of domestic goods	Nakhli et al., 2020
$\alpha_{In}$	0.7	The share of domestic inputs in the production of domestic goods	Nakhli et al., 2020
$\alpha_I$	0.81	The share of domestic investment in household investment	Research calculations
$\alpha_c$	0.9	The share of domestically produced consumer goods in total consumption	Research calculations
$\omega$	0.34	The share of labor in the production of domestic goods	Research calculations
$\vartheta_w^{ir}$	0.68	The percentage of workers who are unable to adjust their wages	Research calculations
$\rho_{oil}$	0.35	AR (1) coefficient of crude oil export	Research calculations
$\rho_m$	0.29	The coefficient of the importance of the interruption of money growth	Research calculations
$\rho_{Gbd}$	0.73	The coefficient of the importance of the budget deficit in determining the growth of money volume	Research calculations

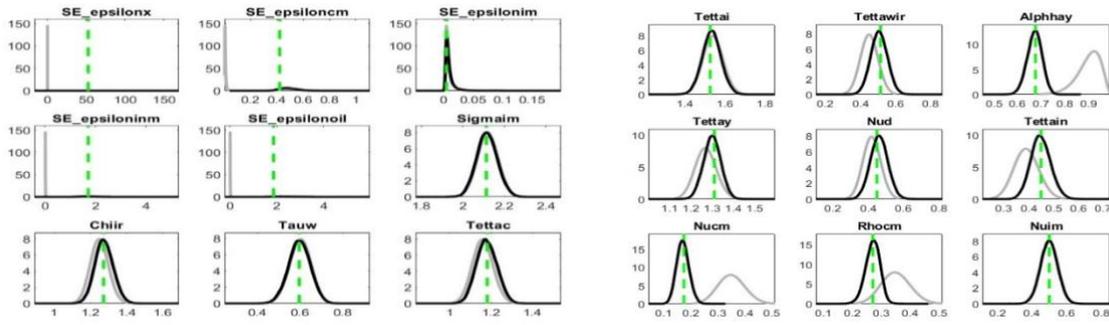
$\rho_{re}$	0.65	The coefficient of the importance of the real exchange rate in determining the growth of the money volume	Research calculations
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Several studies (Khosravi 2016; Esfandiari 2013; Nakhli, et al. 2021; Javan 2016; Tavakolian & Jalali Naini 2016; Igityan, 2016) have chosen to determine the prior distribution of parameters via the Bayesian method. Table 3 presents the information on the prior distribution of the structural parameters.

**Table 3:** Prior and posterior distributions of structural parameters of the estimated model

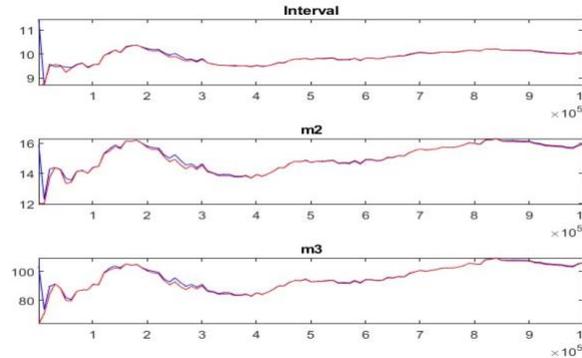
Parameter description	type of distribution	Prior mean	Post. mean	90percent HPD interval		pstd
$\sigma_{im}$	Gam	2.12	2.138	2.0560	2.2189	0.05
$\chi_{im}$	beta	0.5	0.503	0.4182	0.5887	0.05
$\chi_{ir}$	Gam	1.25	1.25	1.1697	1.3321	0.05
$\tau_w$	beta	0.6	0.59	0.5118	0.6813	0.05
$\theta_c$	Gam	1.16	1.18	1.1067	1.2635	0.05
$\theta_I$	Gam	1.54	1.53	1.4565	1.6098	0.05
$\theta_w^{ir}$	beta	0.45	0.50	0.4274	0.5841	0.05
$\alpha_y$	beta	0.9	0.67	0.6202	0.7225	0.05
$\theta_y$	Gam	1.27	1.29	1.2334	1.3664	0.05
$\vartheta_d$	beta	0.42	0.46	0.3781	0.5407	0.05
$\theta_{In}$	beta	0.39	0.44	0.3819	0.5134	0.05
$\vartheta_{cm}$	beta	0.35	0.16	0.1316	0.2064	0.05
$\rho_{cm}$	beta	0.35	0.27	0.2307	0.3109	0.05
$\vartheta_{im}$	beta	0.5	0.497	0.4160	0.5787	0.05
$\rho_{Im}$	beta	0.43	0.44	0.3889	0.5013	0.05
$\vartheta_{inm}$	beta	0.15	0.154	0.0700	0.2370	0.05
$\rho_{Inm}$	beta	0.36	0.35	0.2908	0.4206	0.05
$\alpha_{cG}$	beta	0.9	0.74	0.6933	0.7982	0.05
$\theta_{cG}$	beta	0.81	0.85	0.7943	0.9176	0.05
$\alpha_{IG}$	beta	0.83	0.838	0.7655	0.9169	0.05
$\theta_{IG}$	beta	0.108	0.177	0.1174	0.2382	0.05
$\vartheta_x$	beta	0.5	0.47	0.3937	0.5457	0.05
$\rho_x$	beta	0.4	0.39	0.3176	0.4724	0.05
$\varepsilon_x$	invg	0.1	3.065	2.0377	4.0645	Inf
$\varepsilon_{cm}$	invg	0.1	0.107	0.0545	0.1576	Inf
$\varepsilon_{im}$	invg	0.1	0.011	0.0024	0.0266	Inf
$\varepsilon_{inm}$	invg	0.1	0.435	0.3200	0.5495	Inf
$\varepsilon_{oil}$	invg	0.1	0.024	0.0044	0.0344	Inf

Figure 8 shows plots of the prior and posterior distributions of parameters. The results indicate that the parameters can be identified and that the information in the observable data has made a significant contribution to the determination of the parameters. However, for some parameters, the two plots overlap, indicating that the initial information about the previous density is the most important factor in determining the parameter values. Additionally, based on the results, the time series used in the model play an important role in determining the values of the structural parameters of the model, as shown by the examination of the prior and posterior functions of the estimated model.



**Figure 6:** Prior and posterior density of some estimated parameters

In addition, the univariate and multivariate diagnostic tests (Markov chain Monte Carlo) of Brooks and Gelman (1998) were used to check the accuracy of the estimates obtained by the MCMC method. The estimated parameters have shown sufficient strength, and these estimates are reliable because the within-sample and between-sample variances of all the parameters converge to a constant value. The multivariate test of the within-sample and between-sample variances also converges to a constant value.



**Figure 7:** Multivariate convergence diagnostic diagram<sup>2</sup>

### Variance decomposition

The variance decomposition results reveal that nonoil exports play the most dominant role in determining our variables of interest, i.e., labor emigration, labor supply, cost of emigration, real wage, and inflation. In addition, sanctions on imports of intermediate goods and oil exports come next. The main factor affected by fluctuations in labor emigration, both in the short and long run, is the impact of sanction shocks on nonoil exports in different periods. This share slightly decreased during the periods studied, but it could explain more than 86% of the changes in labor emigration. This problem can be explained by the increase in nonoil exports, especially after 2010 and 2011. Indeed, the nonoil export shock is the most important source of employment change. The nonoil sanctions targeted industries such as automobile, petrochemical, chemical, textile, and steel, which have strong linkages with other sectors. Thus, nonoil sanctions have had much broader effects on Iran’s labor market, as they indirectly distort backward and forward economic activities in the targeted sectors.

The larger share of sanctions on intermediate goods imports in comparison to oil sanctions indicates that the former is relatively more endogenous than the latter, having greater and broader effects on labor demand. The oil sector is relatively less labor intensive. While nonoil exports incorporate a wide range of economic sectors in Iran excluding oil, they have more economic linkages than the oil sector. Employment in the country is positively and significantly affected by employment in exporting

<sup>2</sup> Interval measure (the Bayesian approach allows straightforward facilities for the construction of confidence intervals for parameter estimates and impulse, forecasting and model comparison); m2 and m3: second and third-order multivariate moment measures

industries (Sabbagh Kermani et al., 2009). Despite the importance of oil and its revenues to Iran, this sector has not been able to contribute significantly to economic growth because the majority of Iranian oil exports are in the form of crude oil (EIA, 2022). This problem not only reduces the country's financial resources but also forces it to purchase and import petroleum products at exorbitant prices (Huseynli, 2022; Pourmand Bakhshayesh et al., 2020). Employment has not benefited significantly from oil exports, even though crude oil accounts for the majority of exports.

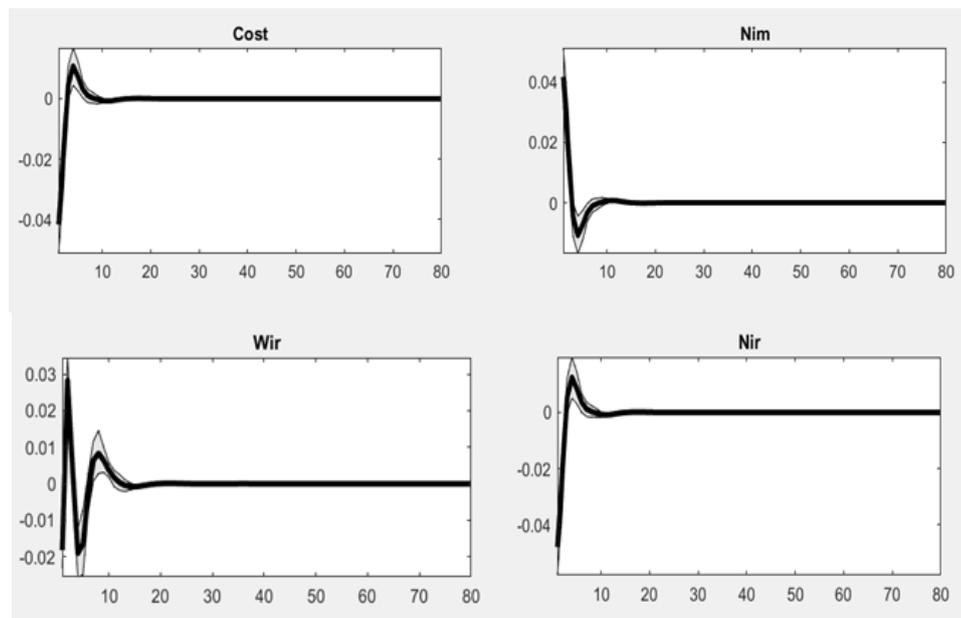
The oil sanctions are expected to have a stronger effect on inflation but still have a weaker effect than nonoil exports and intermediate goods imports. While oil sanctions will result in an increase in the exchange rate causing inflation, nonoil exports and intermediate goods imports will increase inflation by dampening the supply side of the economy. The oil industry in Iran's economy does not perform well in terms of employment development and cannot be considered a job creation sector in Iran's economy (Moalemi, 2012). Once again, this is due to selling crude oil and developing downstream industries, including petroleum products. The relationship between the oil industry and economic activity is not as strong as it should be, making it less stimulating to employment.

**Table 4:** Variance decomposition of different sanction shocks on migration

Variable	Nonoil export	Import of consumer goods	Import of capital goods	Import of intermediate goods	Oil exports
$N_t^{im}$ (Labor emigration)	86.81	3.16	1.03	5.5	3.69
$N_t^{ir}$ (Labor supply in Iran)	86.81	3.16	1.03	5.5	3.69
$Cost_t$ (Cost of emigration)	86.61	3.16	1.03	5.5	3.69
$w_t^{ir}$ (Real wage in Iran)	57.05	11.86	2.91	14.18	14
$\pi_t$ (Inflation)	75.58	6.16	0.58	12.89	4.79

### The IRF Results

The IRF results show that the shock due to the sanctions on nonoil exports increases labor emigration by reducing employment, real wages, and migration costs (Figure 8). Sanctions on nonoil exports increase the desire for labor emigration by 4 percent, and workers return to a steady state after seven periods. In fact, due to the role of domestic and foreign wages and exchange rates in migration costs and due to decreases in real wages, migration costs will decrease. The employment and wages of the labor force will decrease by 5 and 2 percent, respectively. Demonstrating the massive impact of sanctions on nonoil exports, it is worth noting that the imposition of sanctions on nonoil exports increased the final cost and prices of exports.

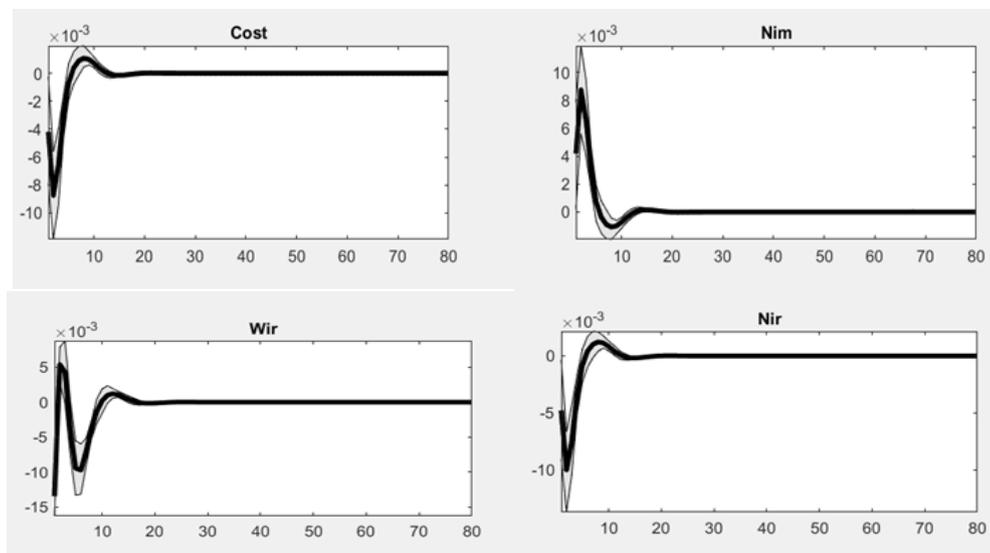


**Figure 8:** The IRF of sanctions on nonoil exports

Additionally, in the first period of sanction, the real exchange rate decreased by 2 percent, and production increased by 6 percent; however, the exchange rate experienced a large increase, production decreased, and both returned to steady states in 10 periods. This may be because sanctions have reduced the value of Rial, increasing the incentive to export. This tends to increase the demand for Iran’s Rial in other countries (especially for neighbors and a few other countries that have trade relations with Iran). Conversely, as the price of foreign goods in Iran has risen, the country's demand for foreign goods and foreign currency has increased. This mitigates the initial impact of sanctions on currency depreciation, prevents further depreciation, and may offset some of the initial depreciation (Tayebi and Sadeghi, 2016; Taghyani et al., 2012).

Despite the decrease in production in many industrial sectors in the country during 2012 and 2013 compared to that in 2008–2011 due to the decrease in the value of the Rial, production, and export of some sectors of the industry increased but decreased in the long term (Salehi Isfahani. H, 2020). In fact, bypassing sanctions and financial problems such as the return of foreign currency from exports and FATF increase the final costs of exports despite the relative increase in exports. As a result, it has effects on the real wage, and therefore, due to the increase in inflation, the real wage decreases, the cost of migration decreases, and the decision to emigrate increases.

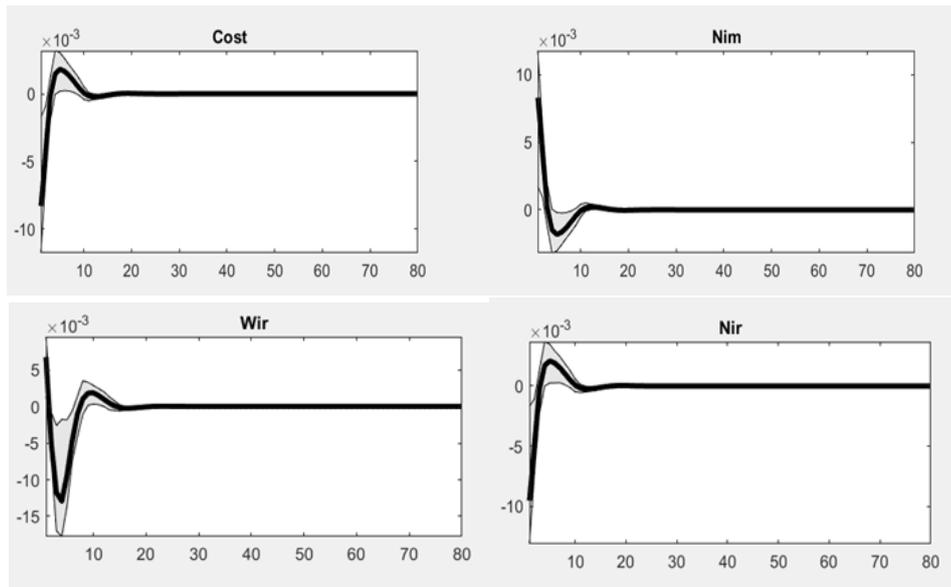
The impulse of sanctions on imports of intermediate goods indicates an increase in emigration of 0.4 percent (Fig. 9). This amount has increased to 0.9 percent, and the decision to migrate is positive until the sixth period and finally returns to its stable level after the 13th period. The reasons for this are related to the dependence of production in Iran on the imports of intermediate goods, as well as the increase in the final costs of importing because of sanctions, along with the increase in inflation caused by the imports of intermediate goods, which decrease in production. This problem has decreased the amount of employment, and the real wage has decreased due to pressure on the labor market. As a result, the migration costs have decreased due to the effect of changes of real wages in Iran. Considering the high share of people with higher education in Iran who work in the nonoil production sector and need imported intermediate goods, the impact of the embargo can be considered a repulsive factor for emigration from the country, especially the immigration of people with higher education.



**Figure 9:** The IRF of sanctions on imports of intermediate goods

Due to oil sanctions, there has been a decline in employment in the country due to a decrease in production and an increase in final production costs. The cost of emigrating has fallen again, despite an increase in real wages at the start of the shock (partly due to a fall in inflation caused by a reduction in government spending). After an increase in the impact of sanctions on oil exports, there is a decrease, which has long-term impact on the economy and will reach its stable level after eleven periods. Given that oil revenues are the main source of government revenue, this reduction has an impact on

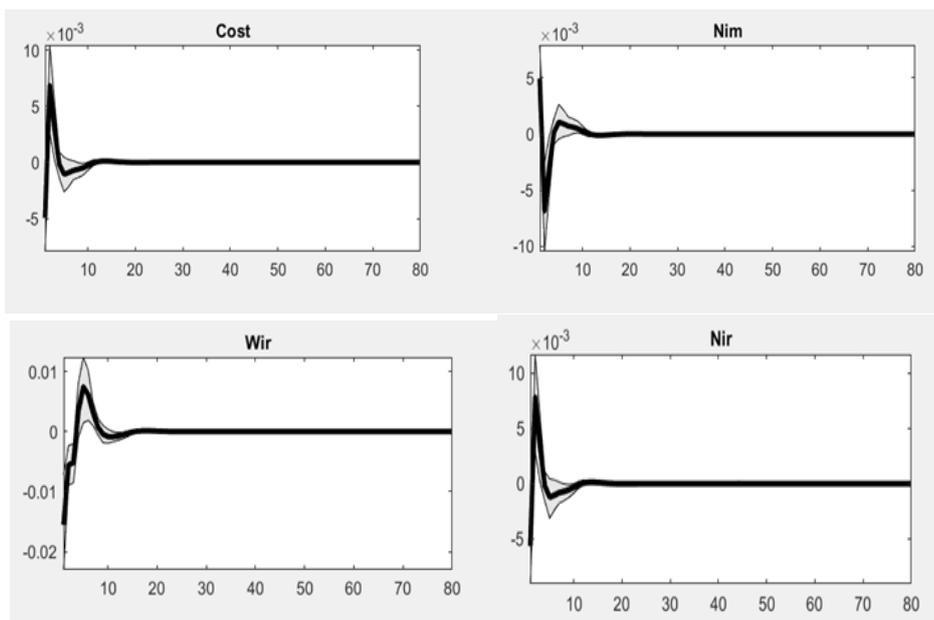
government consumption and investment spending. The result is a decrease in the cost of emigration and a 0.8 percent increase in the cost of emigration (Figure 10).



**Figure 10:** The IRF of sanctions on Oil Exports

Oil embargoes have led to a significant decrease in Iran's foreign exchange earnings, and through a sharp and sudden decrease in the supply of currency, inflation and unemployment in the country have increased (Nadmi et al., 2016). Most of the effects of oil embargoes have been caused by inflationary effects. Despite Iran's benefit from oil resources, this issue shows the lack of proper management of oil resources in Iran and the lack of proper influence of oil revenues on growth and development in the country.

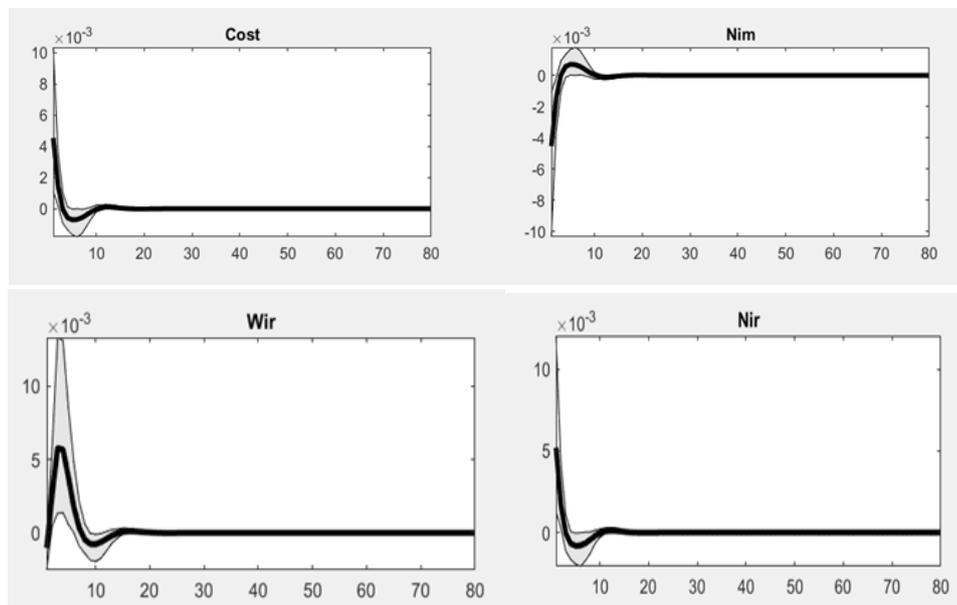
Sanctions on the imports of consumer goods increased the desire to emigrate by 0.5 percent and then decreased, with a return to equilibrium after eleven periods. This shock also reduced the cost of emigrating by 0.4 percent in the first period. Employment and labor wages also have an impact on these shocks. These sanctions have increased the final costs of importing consumer goods, as well as inflation of imported consumer goods. The IRF indicates the negative impact of sanctions on the consumption of consumer goods and its positive impact on the inflation rate (Figure 11).



**Figure 11:** The IRF of sanctions on imports of consumer goods

Sanctions have a significant impact on emigration by affecting consumption by devaluing the national currency, which can cause a decrease in the entry of unskilled labor and the exit of more skilled labor from the labor market (Haghiqi and Bahalu, 2014). As a result, due to the decrease in people's utility and the cost of migration, the decision to migrate will increase when real wages in domestic and foreign countries are compared. This result is in line with the findings of different studies confirming that unemployment has the greatest short-term and long-term effects on emigration from Iran (Motaghi, 2014; Arab Mazar et al., 2016). With the increasing trend of sanctions and their negative consequences on unemployment and the utility of people in society, especially the unemployment of educated youth and the lack of proportional growth of knowledge and technology, we can witness more negative effects on emigration soon.

Figure 12 shows that sanctions on imported capital goods initially reduce the desire for emigration by 0.4 percent and then increase for three periods before returning to a steady state at the ninth. An increase of 0.4 percent in the cost of emigration is the main cause of this problem. Employment will increase by 0.5 percent. This could be due to the labor-intensive structure of the economy. Moreover, sanctions reduce real wages and increase inflation. The point, however, is that an increase in the cost of migration, which is affected by the exchange rate and real wages inside and outside the country, has outstripped the level of employment and the decline in emigration at the start of the sanctions.



**Figure 12:** The IRF of sanctions on capital goods importing

## Conclusions

The results show that economic sanctions increase the desire to emigrate by worsening economic conditions in Iran. While shocks to nonoil exports, oil exports, imports of consumer goods, and imports of intermediate goods all raise the decision to migrate, their impacts are not equal. In fact, the greatest effect is due to nonoil export shocks, which are 4 percent. In other words, out of approximately 24 million people working in Iran, up to 4 percent of the workforce have a potential desire to leave the country and become migrant workers.

Although the short-term effects are more visible, the long-term consequences may be just as important. The economic hardship and social unrest caused by such sanctions may have lasting impacts on the country and its people. The level of employment also plays a very important role in emigration during sanctions, as do emigration costs and real wages in Iran, especially the difference between wages in Iran and wages in other countries. It can also be concluded that the labor force in the nonoil sector is more affected than that in the oil sector, given the greater share of nonoil employment. This fact is in line with research findings that the biggest shock from sanctions is on nonoil exports. In addition, sanctions have reduced the real wages of the Iranian workforce as the value of the national currency has fallen.

In addition, the sanctions may act as a motive for emigration, especially for people with higher education, given that a high proportion of people in Iranian society have a higher education. According to the results of Iran Migration Outlook (2022) survey on migration aspirations and decisions, 63 percent of physicians and nurses and 51 percent of students overestimated the impact of sanctions on their desire to migrate.

Sanctions have disrupted the country's currency exchange and negatively impacted commercial activities, significantly disrupting nonoil export revenues. Indeed, these sanctions can affect Iran's economic openness by increasing the marginal cost of exports and imports, and studies show that the degree of economic openness is associated with brain drain from Iran (Ahadi et al., 2018). The openness of the commercial space expands the opportunities for profit in the domestic economy, and elites are able to carry out their entrepreneurial activities successfully in such an environment. Moreover, the openness of the economy has reduced the wage gap between workers in these countries and reduced their motivation to migrate, especially among elite and highly skilled workers.

On the other hand, sanctioning has a significant impact on the labor market and thus on emigration by affecting the value of the national currency. Depreciating national currencies can discourage unskilled workers from entering the labor market and encourage skilled workers to leave. In fact, the impact of sanctions on wages and unemployment is one of the most important factors in the emigration process. Unemployment is also seen as having the greatest impact on emigrating from Iran, both in the short and long term. Soon, we may see a greater impact on emigration due to the growing trend of sanctions and their negative impact on unemployment in society, especially among educated youth, as well as the country's lack of proportional growth in knowledge and technology.

It should be noted that the existence of an educated workforce in Iran, where real wages have fallen significantly and unemployment has risen due to various factors, particularly sanctions, is somewhat consistent with the human capital model. According to this model, the main goal of migrants is to increase their utility by choosing a location with the highest rate of return on investment and a market that offers the highest rate in exchange for the skills of the workforce, and this issue increases lifetime earnings (Sjaastad, 1962). In particular, when the share of educated laborers who decide to migrate is high, their greater skills make emigration less costly (Chiquiar & Hanson, 2005). This problem could arise if the motivation to emigrate increases significantly and the level of real wages in the country falls. Moreover, better-educated people tend to have larger social networks, which reduces the costs of moving (McKenzie & Rapoport, 2010).

Additionally, oil sanctions have led to a significant reduction in Iran's foreign exchange earnings. This has led to an increase in inflation and unemployment in the country as a result of a sharp and sudden reduction in the supply of foreign exchange in the market. This will also have an indirect impact on the labor market. In other words, most of the impact of oil sanctions has been through the inflationary effects of sanctions. However, compared to the nonoil exporting and importing sectors, the oil sector has had little impact on Iran's labor market and thus on labor emigration. The lack of good governance and high levels of corruption have prevented oil revenues from creating domestic production and jobs. The low quality of institutions and the decline in Iran's good governance index are deterrents to labor migration from Iran, so this issue is important for increasing the desire to emigrate (Mustafazadeh & Arab Mazar, 2017; Motaghi, 2014).

Consequently, the tightening of economic sanctions against countries such as Iran may lead to a deterioration in the labor market and employment conditions, thus increasing emigration (despite problems such as integration into the labor market of the destination country, language, and the costs of being away from family), in contrast to the attractive employment conditions in developed countries. This is particularly true given the large number of unemployed educated people, the large gap in real wages for skilled workers and specialists in various fields compared to those in developed countries, and the uncertainty about the future of the country for a variety of reasons (especially the very high uncertainty about the economic and political situation in the country). If this trend continues in the coming years, we will face massive emigration of students and highly skilled workers (as has already happened). This finding is consistent with that income differences are the main driver of migration, as migration goes from low- to high-income areas.

According to the results, one of the main actions in Iran should be the removal of sanctions through the resolution of international disputes. This issue, with the boom in production and therefore the reduction in the negative effects of sanctions, will lead to the return of foreign investment, the reduction

of barriers to international financial exchanges, the prosperity of foreign trade in the country, and therefore the reduction of emigration. An increase in domestic production through the removal of nonoil export barriers and the import of intermediate goods can also reduce emigration. The level of access to different markets harms the flow of labor emigration to other countries. As the access to the markets of the target countries increases, the flow of migrants to other countries decreases. This issue highlights the role of appropriate policies in reducing sanctions for the export of goods between countries and reducing emigration. The development of trade flows and domestic production and quick access to foreign markets will reduce the cost of final goods, increase employment by domestic producers, and moderate emigration. In this regard, considering the greater effectiveness of some economic sectors, such as industry and services, as a result of the departure of labor can play an important role in creating new technologies and spreading them to other sectors. Identifying and strengthening these sectors and creating job fields to attract labor by economic planners can have more positive consequences for the economy.

Reducing dependence on oil revenues and rents can be another important factor in reducing emigration, to bring more oil revenues into the production and employment sector. Policymakers should pay more attention to strengthening production infrastructure and supporting the projects of elites and entrepreneurs to create a platform for growth and progress in the country through the application of policies and the allocation of oil resources to the budget. Some activities can play a significant role in importing money from oil into production and employment, such as reducing the government's role in the economy and legislation, adopting stable and anticorruption policies, implementing policies that lead to stable and low inflation, and reducing restrictive conditions for accessing foreign money, such as lifting sanctions.

Finally, raising the value of the Rial, increasing real wages and bringing wages closer to those of developed countries can play a significant role in reducing emigration from Iran. Carrying out economic reforms along with the externalization strategy will lead to the possibility of reducing the difference in real wages between Iran and other countries, and it will be a deterrent to emigration.

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## Appendix:

### Households

In this study, the economy consists of similar households that have an infinite horizon. They use a basket with constant elasticity of substitution (CES) of domestic and imported consumption and capital goods and hold financial assets. Households derive utility from consumption  $C_t$  and the real value of money balances  $m_t = \frac{M_t}{P_t}$ , and they gain disutility from labor  $N_t$  (Felices and Tuesta 2010; Tavakolian and Jalali Naini 2016). A typical household in the home country decides whether to work in Iran ( $N_t^{lr}$ ) or become an emigrant ( $N_t^{lm}$ ) and work in one of the developed countries. Therefore, the maximization problem for a typical household over its lifetime is as follows:

$$\text{Max } E_0 \sum_{t=0}^{\infty} \beta^t U_i(C_t, \frac{M_t}{P_t}, N_t) \quad (1)$$

$$U_t = \frac{C_t^{1-\sigma_c}}{1-\sigma_c} + \frac{\chi_m}{1-\sigma_m} (\frac{M_t}{P_t})^{1-\sigma_m} - \chi_{ir} \frac{N_t^{ir}}{1+\sigma_{ir}} - \chi_{im} \frac{N_t^{im}}{1+\sigma_{im}} \quad (2)$$

where  $\sigma_c$ ,  $\sigma_m$ ,  $\sigma_{ir}$  and  $\sigma_{im}$  are the intertemporal elasticity of substitution for consumption, the inverse elasticity of real money balance, and the inverse of the Frisch elasticity of labor supply for employed in Iran and an emigrant, respectively.

On the one hand, the household faces budget constraints such that it earns income from the use of labor at home at the wage  $w_t^{ir}$  and wages abroad  $w_t^f$ , from hiring capital  $K_t$ , and from intermediate goods producers at the rental rate of  $r_t$  transfer payments  $Tr_t$ . Also, they spend on consumption  $C_t$ , investment  $I_t$ , holding real money  $m_t$ , and income and consumption taxes at rates of  $t^w$  and  $t^{VA}$ , and  $\tau_{im}$  is the share of income spent by migrants in the destination country. In addition, they face migration costs ( $Cost_t$ ), which they pay according to the number of emigrants.

$$C_t(1+t^{VA}) + m_t + I_t + Cost_t \cdot N_t^{im} = w_t^{ir} N_t^{ir} (1-t^w) + (1-\tau_{im}) r_e w_t^f N_t^{im} + \frac{m_{t-1}}{\pi_t} + Tr_t + r_t K_t \quad (3)$$

where  $r_e$  and  $\pi_t$  are the real exchange rate and domestic inflation rate, respectively. On the other hand, private capital motion is the second household constraint.

$$K_{t+1} = (1-\delta)K_t + I_t \quad (4)$$

In addition, the cost of migrating is expected to be as follows. The costs associated with migration are included in the expenditure side of the budget constraint. The wage ratio is a constraint on household migration decisions. Household members prefer to stay and work in Iran when the relative wage in the home country increases. If relative wages in Iran fall due to falling Iranian wages, rising wages in other countries, or the depreciation of the Iranian rial against other currencies, the household member's incentives to migrate increase. The level of the migration costs is the coefficient  $\sigma_{cost}$  times the relative wages in steady states.

$$Cost_t = \sigma_{cost} \frac{w_t^{ir}}{E x_t w_t^f} \quad (5)$$

According to the maximization of the utility function according to the introduced restrictions, the following relationships are obtained.

$$N_t^{ir \sigma_{ir}} = \frac{\lambda_t w_t^{ir} (1-t^w)}{\chi_{ir}} \quad (6)$$

$$N_t^{im \sigma_{im}} = \frac{1}{\chi_{im}} \lambda_t ((1-\tau_{im}) r_e w_t^f - Cost_t) \quad (7)$$

$$\lambda_t = m_t^{-\sigma_m} + \beta E_t \frac{\lambda_{t+1}}{\pi_{t+1}} \quad (8)$$

$$\frac{C_t^{-\sigma_c}}{1-t^{VA}} = \beta E_t [\frac{C_{t+1}^{-\sigma_c}}{1-t^{VA}} (r_{t+1} + (1-\delta))] \quad (9)$$

Finally, according to the Igityan (2016) study and F.O.C. results combinations, the linearized form of the migration relationship is as follows. The migration decision equation has the following form, in which small letters represent deviations of variables from their steady states and coefficients with 'SS' subscripts denote values of those variables in the steady state.

$$n_t^{im} = -\frac{1}{\chi_{im} \sigma_{im}} \left(1 + \frac{Cost^{ss}}{C^{ss}}\right) Cost_t - \frac{\sigma_{ir}}{\sigma_{im}} n_t^{ir} \quad (10)$$

Additionally, a constant elasticity of substitution (CES) function of domestically produced consumption  $C_t^d$  and imported consumption  $C_t^{pm}$  forms the aggregate consumption with the elasticity of  $\theta_c$ . The share of domestically produced goods consumed was  $\alpha_c$ .

$$C_t = [\alpha_c^{\frac{1}{\theta_c}} C_t^d]^{\frac{\theta_c-1}{\theta_c}} + (1-\alpha_c) C_t^{pm} \frac{\theta_c-1}{\theta_c} \frac{\theta_c}{\theta_c-1} \quad (11)$$

In addition, similar to consumer goods, it is assumed that households gain their total investment from domestic  $I_t^d$  and imported investment goods  $I_t^{pm}$  in the form of a CES function, in which  $\theta_I$  and  $\alpha_I$  are the elasticity of substitution and the share of each one in the total investment, respectively:

$$I_t = [\alpha_I^{\frac{1}{\theta_I}} I_t^d]^{\frac{\theta_I-1}{\theta_I}} + (1-\alpha_I) I_t^{pm} \frac{\theta_I-1}{\theta_I} \frac{\theta_I}{\theta_I-1} \quad (12)$$

## The Labor Market

Each household is a monopolistically competitive supplier of various labor services that are in demand by producers of intermediate goods. They supply differentiated labor  $N(i)_t^{ir}$  to labor organizations that combine homogeneous labor and supply firms according to the following Dixit–Stiglitz constant elasticity of substitution function:

$$N_t^{ir} = [\int_0^1 N(i)_t^{ir} \frac{\theta_I-1}{\theta_I} di]^{\frac{\theta_I-1}{\theta_I}} \frac{\theta_I}{\theta_I-1} \quad (13)$$

Because labor is differentiated, the wage for the  $i$ -th type of labor is  $w(i)_t^{ir}$ , and households or labor organizations representing them have the power to set wages, which is given for firms. From the labor organization optimization problem, the demand for the  $i$ -th type of labor is represented by the following equation:

$$N(i)_t = \left(\frac{w(i)_t^{ir}}{W_t^{ir}}\right)^{-\theta_w^{ir}} N_t \quad (14)$$

According to Calvo (1983), it is assumed that only  $(1 - \vartheta_w^{ir})$  the fraction of households in every period can negotiate wages. Therefore,  $\vartheta_w^{ir}$  is called the wage stickiness coefficient. Households set  $w_t^{*ir}$  optimal wages in such a way that they cannot change wages in the future. By defining wage inflation by  $\pi_{w,t}^{ir}$  and replacing  $W_t^{*ir}$  with the last equations, the New Keynesian Philips curve for wage inflation becomes the following form:

$$\pi_{w,t} = \beta \pi_{w,t+1} + \lambda_w^{ir} [mrs_t^{ir} - (W_t - P_t^{ir})] \quad (15)$$

where  $\lambda_w^{ir} = \frac{(1-\vartheta_w^{ir})(1-\beta\vartheta_w^{ir})}{\vartheta_w^{ir}(1+\theta_w^{ir}\sigma_{ir})}$  and  $mrs_t^{ir} = \frac{\chi_{ir} N_t^{ir\sigma_{ir}}}{c_t^{1-\sigma_c}}$ . This equation shows that when the real wage is below the desired level, households increase wages by pressing wage inflation to increase. Therefore, the real wage is defined by the following equation:

$$w_t = w_{t-1} + \pi_{w,t} - \pi_t \quad (16)$$

### Firms

There are two types of domestic firms in the current model: intermediate goods and final goods firms. The final good uses the following aggregate CES technique, where intermediate goods  $y_t^d(i)$  are indexed by  $i \in [0, 1]$ . The final good producer combines intermediate goods that are distinct and imperfectly substitutable according to a Dixit-Stiglitz defined as follows:

$$y_t^d = \left[ \int_0^1 y_t^d(i)^{\frac{\theta_d-1}{\theta_d}} di \right]^{\frac{\theta_d}{\theta_d-1}} \quad (17)$$

The final producer, operating under conditions of perfect competition, tries to determine the amount of these goods purchased to maximize its profit or minimize its costs according to the prices of intermediate goods. The first-order profit-maximizing condition can be written in the form of a demand function for the intermediate good:

$$y_t^d(i) = \left[ \frac{P_t^d(i)}{P_t^d} \right]^{-\theta_d} y_t^d \quad (18)$$

where  $P_t^d(i)$  is the price of the  $i$ -th intermediate good and  $P_t^d$  is the price index of domestically produced goods. By substituting and simplifying the result, the domestic goods price index can be obtained:

$$P_t^d = \left[ \int_0^1 P_t^d(i)^{1-\theta_d} di \right]^{\frac{1}{1-\theta_d}} \quad (19)$$

Intermediate goods firms operate in a monopolistically competitive market. They hire labor and capital from households and pay wages and a return on capital. Each firm, indexed by  $i \in [0, 1]$ , produces  $y_t(i)$  units of differentiated output using the following Cobb–Douglas production technology:

$$y_t(i) = A_t K(i)_t^\alpha N_t^{ir}(i)^\omega In_t^{1-\alpha-\omega}(i) \quad (20)$$

The firm's demand for labor, capital  $K_t$  and intermediate goods  $In_t$  as well as the final cost can be obtained through cost minimization. In these relationships,  $i$  is omitted from the mc index because it is assumed that all the firms have the same marginal cost.

$$N_t^{ir}(i) = \omega \frac{y_t(i)}{w_t^{ir}} mc_t \quad (21)$$

$$K_t(i) = \frac{\alpha y_t(i)}{r_t} mc_t \quad (22)$$

$$In_t(i) = (1 - \alpha - \omega) \frac{y_t(i)}{P_t^n} mc_t \quad (23)$$

$$mc_t = \left(\frac{1}{\omega}\right)^\omega \left(\frac{1}{\alpha}\right)^\alpha \left(\frac{1}{1-\alpha-\omega}\right)^{1-\alpha-\omega} w_t^{ir\omega} r_t^\alpha P_t^n^{1-\alpha-\omega} \quad (24)$$

Producing firms separate their products to supply domestic and foreign markets with nonoil exports, where  $y_t^d(i)$  the supply of manufactured goods to the domestic market is  $P_t^d$  is the price of the goods supplied to the domestic market. Additionally,  $y_t^x(i)$  is the supply of manufactured goods to the foreign market at price  $Ex_t P_t^x$ , where  $Ex_t$  represents the nominal exchange rate. The function with constant elasticity is as follows:

$$y_t(i) = \left[ \alpha_y \frac{1}{\theta_y} y_t^{\frac{\theta_y+1}{\theta_y}}(i) + (1 - \alpha_y) \frac{1}{\theta_y} y_t^x \frac{\theta_y+1}{\theta_y} \right]^{\frac{\theta_y}{\theta_y+1}} \quad (25)$$

Producing firms maximize their profits to determine supply to the foreign and domestic markets:

$$y_t^x = (1 - \alpha_y) \left( \frac{Ex_t P_t^x}{P_t^y} \right)^{\theta_y} y_t(i) \quad (26)$$

$$y_t^d = \alpha_y \left( \frac{P_t^d}{P_t^y} \right)^{\theta_y} y_t(i) \quad (27)$$

By placing relations 39 and 40 in relation to 38, the price of goods supplied to the domestic market is obtained as follows:

$$P_t^y(i)^{1+\theta_y} = \alpha_c P_t^d(i)^{1+\theta_y} + (1 - \alpha_y)[Ex_t P_t^x(i)]^{1+\theta_y} \quad (28)$$

Price adjustment is another problem faced by intermediate goods producers. As in the labor market sector, this study uses the Calvo (1983) method to adjust prices. Therefore, only  $(1 - \vartheta_d)$  of the firms can determine their optimal prices in the price  $P_t^d$ . For the remaining firms,  $\vartheta_d$ , the prices are determined according to the inflation of the previous periods adjusted by the degree of domestic price indexation:

$$P_{t+1}^d(i) = (\pi_t^d)^{\tau_d} P_t^d(i) \quad (29)$$

where  $\pi_t^d = \frac{P_t^d}{P_{t-1}^d}$  represents the inflation rate of domestic products and  $\tau_d$  is a parameter that shows the degree of price indexation. Now, according to the relationship  $P_t^d$ , the price index of domestic goods will be as follows:

$$P_t^{d^{1-\theta_d}} = \vartheta_d [(\pi_{t-1}^d)^{\tau_d} P_{t-1}^d]^{1-\theta_d} + (1 - \vartheta_d) P_t^{d^{1-\theta_d}} \quad (30)$$

If the first conditions are followed and combined with the rule for changes in the price index for domestic goods, it is possible to express the relationship between the dynamics of the inflation rate for domestic goods (the new Phillips–Keuls curve) in a linear-logarithmic form:

$$\hat{\pi}_t^d = \frac{\vartheta_d}{1+\beta\vartheta_d} \hat{\pi}_{t-1}^d + \frac{\beta}{1+\beta\vartheta_d} \hat{\pi}_{t+1}^d + \frac{(1-\vartheta_d)(1-\beta\vartheta_d)}{\beta\vartheta_d(1+\beta\vartheta_d)} \widehat{mc}_t^x \quad (31)$$

Additionally, the production demand for intermediate goods can be divided into two parts: domestic and imported intermediate goods. Therefore, the demand form for intermediary goods will be a CES form as follows:

$$In_t = [\alpha_{In}^{\frac{1}{\theta_{In}}} In_t^{\frac{\theta_{In}-1}{\theta_{In}}} + (1 - \alpha_{In})^{\frac{1}{\theta_{In}}} In_t^m]^{\frac{\theta_{In}-1}{\theta_{In}}} \frac{\theta_{In}}{\theta_{In}-1} \quad (32)$$

On the basis of the optimization behavior, the demand for each of the domestic goods by the price of  $P_t^{In}$  and imported intermediate goods by the price of  $P_t^{Inm}$  can be obtained as follows:

$$In_t^m = (1 - \alpha_{In}) \left( \frac{P_t^{Inm}}{P_t^{In}} \right)^{-\theta_{In}} In_t \quad (33)$$

$$In_t^d = \alpha_y \left( \frac{P_t^{Ind}}{P_t^{In}} \right)^{-\theta_{In}} In_t \quad (34)$$

The input price index can be calculated as follows:

$$P_t^{In^{1-\theta_{In}}} = \alpha_{In} P_t^{Ind^{1-\theta_{In}}} + (1 - \alpha_{In}) P_t^{Inm^{1-\theta_{Inm}}} \quad (35)$$

## Trade Sector

To examine the impact of international financial sanctions, which are one of the two types of sanctions considered, this study divides the external sector into two parts: exporting and importing.

### A) Exports

Intermediate producers sell some of their products abroad. Here, as before, there is an aggregator that aggregates the goods produced in the domestic market and sells them to the foreign market. The goods exported by each supplier depend on the total price of the export goods and the price of each export goods by each firm  $P_t^x(i)$ :

$$y_t^x = \left[ \int_0^1 y_t^x(i)^{\frac{\theta_x-1}{\theta_x}} di \right]^{\frac{\theta_x}{\theta_x-1}} \quad (36)$$

Only  $(1 - \vartheta_x)$  percent of exporters have the chance to set their prices optimally, according to the Calvo (1983) model. Now, the problem is that each exporter considers the price  $P_t^{x*}$  to maximize his expected profit, and according to the relationship  $y_t^x(i)$  and the export price index, his or her profit is maximized until period  $s$ :

$$Max E_0 \sum_{s=0}^{\infty} (\beta v_x)^s \left( \frac{\lambda_{t+s}}{\lambda_t} \right) \left( \frac{P_{t+s}^{x*}(i)}{P_{t+s}^x} - mc_{t+s}^x \right) y_{t+s}^x(i) \quad (37)$$

where the ultimately log-linearized New Keynesian Philips curve of the export price is:

$$\hat{\pi}_t^x = \frac{v_x}{1+\beta v_x} \hat{\pi}_{t-1}^x + \frac{\beta}{1+\beta v_x} \hat{\pi}_{t+1}^x + \frac{(1-v_x)(1-\beta v_x)}{\beta v_x(1+\beta v_x)} \widehat{mc}_t^x \quad (38)$$

In fact, exporters buy domestic intermediate goods at a price of  $P_t^d$  and sell them to foreign consumers at a price of  $P_t^x$ . In fact, international sanctions will increase the price of export goods by  $S_t^x$ . Therefore, the final cost for each exporter will be as follows:

$$mc_t^x = \frac{P_t^d}{Ex_t P_t^x} S_t^x \quad (39)$$

Export financial costs follow an autoregressive process degree 1 (AR (1)), and sanctions increase costs through the  $ss_x$  parameter, where  $\overline{S^x}$  is the value of the steady-state of the export financial cost.

$$\ln S_t^x = (1 - \rho_x) \ln \overline{S^x} + \rho_x \ln S_{t-1}^x + s_{sx} \cdot sanc_t + \varepsilon_t^x \quad \varepsilon_t^x \sim i. d. N(0, \sigma_{sx}^2) \quad (40)$$

### B) Imports

According to Nakhli et al. (2020), importers can operate in three areas: consumer, capital and intermediate goods. The importer of three products buys them from foreign companies and sells them to consumers, including

households and the government<sup>3</sup>. An aggregator buys imported consumer goods from importers and sells them domestically.  $C_t^M$  is the supply of the imported good as a function of the consumer goods purchased from each importer (i).

$$C_t^M = \left[ \int_0^1 C_t^X(i)^{\frac{\theta_{cm}-1}{\theta_{cm}}} di \right]^{\frac{\theta_{cm}}{\theta_{cm}-1}} \quad (41)$$

The aggregator determines both the demand of each consumer goods importer and the price of imported consumer goods to maximize its profit. Only the  $(1 - \vartheta_{cm})$  percentage of importers of consumption goods can determine their optimal prices at the price  $P_t^{cm*}$ . The rest of the companies adjust the price of their imported goods. Each importer of consumption goods decides to choose  $P_t^{cm*}$  to maximize the sum of its expected profits; now, companies that have the opportunity to adjust their price should maximize the present value of their expected future profit flow to determine the optimal price.

$$Max E_0 \sum_{s=0}^{\infty} (\beta v_{cm})^s \left( \frac{\lambda_{t+s}}{\lambda_t} \right) \left( \frac{P_{t+s}^{cm*}(i)}{P_{t+s}^{cm}} - mc_{t+s}^{cm} \right) C_{t+s}^M(i) \quad (42)$$

Finally, the log-linearized New Keynesian Philips curve of imported consumer goods prices can be shown as follows:

$$\hat{\pi}_t^{cm} = \frac{v_{cm}}{1+\beta v_{cm}} \hat{\pi}_{t-1}^{cm} + \frac{\beta}{1+\beta v_{cm}} \hat{\pi}_{t+1}^{cm} + \frac{(1-v_{cm})(1-\beta v_{cm})}{\beta v_{cm} + \beta v_{cm}} \hat{m}c_t^{cm} \quad (43)$$

Importers buy the consumption goods needed from foreign markets at the price of  $P_t^f$  and sell them to domestic customers at the price of  $P_t^{cm}$ . In this regard, international financial sanctions increase the cost of consumer goods by  $S_t^{cm}$  through increased costs of shipping, insurance and the like. Therefore, the final costs for importers of consumer goods can be measured based on the following relationship:

$$mc_t^{cm} = \frac{Ex_t P_t^f}{P_t^{cm}} S_t^{cm} \quad (44)$$

The import financial costs follow an AR (1). Sanctions increase these costs through parameter  $cm$ .

$$\ln S_t^{cm} = (1 - \rho_{cm}) \ln \overline{S}^{cm} + \rho_{cm} \ln S_{t-1}^{cm} + sscm.sanc_t + \varepsilon_t^{cm} \quad \varepsilon_t^{cm} \sim i. i. d. N(0, \sigma_{scm}^2) \quad (45)$$

## Oil Sector

Given the characteristics of the Iranian economy, it is highly important to pay attention to the oil sector, which includes export revenues from crude oil production and oil sanctions. Moreover, oil production is dependent mainly on a country's oil reserves and cannot be changed by an increase in capital and labor; because of its exogenous nature, crude oil production is determined on the basis of available oil reserves and the quota set by the OPEC. Since financial sanctions increase the final cost of oil sector exports, the model uses the oil sector export channel to determine the effect of financial sanctions. The oil production process is considered a first-order AR(1) autoregressive process, which affects production through the *ss.oil* parameter.

$$\ln Oil_t = (1 - \rho_{oil}) \ln \overline{Oil} + \rho_{oil} \ln Oil_{t-1} + ssoil.sanc_t + \varepsilon_t^{oil} \quad \varepsilon_t^{oil} \sim i. i. d. N(0, \sigma_{soil}^2) \quad (46)$$

It is also assumed that all the crude oil produced in the economy is exported at the world price. The equivalent value of these nonoil goods is imported into the economy and purchased by households and firms producing intermediate goods.

## Government

The government is responsible for monetary and fiscal policy, and its spending is financed by printing and delivering partnership bonds, borrowing from the central bank, collecting taxes, and selling and exporting oil. Total government revenue comes from taxes on consumption and income and from foreign exchange earned from exporting oil. Additionally, government spending included transfer payments  $Tr_t$ , consumption  $C_t^G$  at the price of  $P_t^{CG}$ , investment  $I_t^G$  at the price of  $P_t^{IG}$  and the resources necessary for clearing previous bonds. The government budget deficit  $GBD_t$  at real prices can be expressed through the following relationship:

$$GBD_t = \frac{P_t^{CG}}{P_t} C_t^G + \frac{P_t^{IG}}{P_t} I_t^G + TR_t - \left[ \frac{Ex_t Oil_t}{P_t} + t^w w_t^{ir} N_t^{ir} + t^{VA} \left( C_t + \frac{P_t^{CG}}{P_t} C_t^G \right) \right] \quad (47)$$

Additionally, the government provides consumption and investment goods from domestic ( $C_t^{Gd}$  and  $I_t^{Gd}$ ) and imported goods ( $C_t^{Gm}$  and  $I_t^{Gm}$ ) combined in a CES function by the elasticity of substituting  $\theta_{cG}$  and  $\theta_{IG}$ :

$$C_t^G = \left[ \alpha_{cG}^{\frac{1}{\theta_{cG}}} C_t^{Gd \frac{\theta_{cG}+1}{\theta_{cG}}} + (1 - \alpha_{cG})^{\frac{1}{\theta_{cG}}} C_t^{Gm \frac{\theta_{cG}+1}{\theta_{cG}}} \right]^{\frac{\theta_{cG}}{\theta_{cG}-1}} \quad (48)$$

$$I_t^G = \left[ \alpha_{IG}^{\frac{1}{\theta_{IG}}} I_t^{Gd \frac{\theta_{IG}+1}{\theta_{IG}}} + (1 - \alpha_{IG})^{\frac{1}{\theta_{IG}}} I_t^{Gm \frac{\theta_{IG}+1}{\theta_{IG}}} \right]^{\frac{\theta_{IG}}{\theta_{IG}-1}} \quad (49)$$

Finally, according to Khosravi (2016), the reaction function of monetary policy for the Iranian economy can be expressed by determining the growth rate of the monetary base on the basis of the deviation of the government

<sup>3</sup> . Due to the length of the relationships, only the import of consumer goods is mentioned here, and the other two sections have the same relationships, which are available to the readers upon request.

budget deficit and the real exchange rate from the stability value. Therefore, the growth rate of the money volume is as follows:

$$\dot{m}_t = \rho_p m_{t-1} + \rho_{Gbd} GBD_t + \rho_{re} Re_t + \rho_{oil} Oil_t \quad (50)$$

where  $\dot{m}_t = \frac{m_t}{m_{t-1}} \pi_t$ .

#### Clear Conditions

Finally, under market settlement conditions, several equations are added to the model to establish the Walras condition. Additionally, in this model, the added value of the economy, in addition to the consumption of domestic goods, should be considered. Equations (52) and (53) represent all exports and imports, respectively, in the economy (the sum of exports and imports for different goods in the economy). Indeed, we have the sum of consumption and investment for the private and government sectors in the economy (Equations 54 and 55) and the market for domestic goods (Equation 56). Therefore, we have the following relationship under equilibrium conditions. These relationships are as follows:

$$y_t = C_t + Cost_t N_t^{im} + \frac{P_t^{CG} C_t^G}{P_t} + \frac{P_t^I I_t + P_t^{IG} I_t^G}{P_t} + \frac{X_t}{P_t} - \frac{M_t}{P_t} \quad (51)$$

$$X_t = P_t^x y_t^x + Ex_t Oil_t \quad (52)$$

$$M_t = P_t^{cm} C_t^M + P_t^{Im} I_t^M + P_t^{Inm} In_t^m \quad (53)$$

$$C_t^M = C_t^{pm} + C_t^{Gm} \quad (54)$$

$$I_t^M = I_t^{pm} + I_t^{Gm} \quad (55)$$

$$y_t^d = C_t^d + C_t^{gd} + I_t^d + I_t^{gd} + In_t^d \quad (56)$$