Analyzing the Effect of International Sanctions and Exchange Rate Shocks on Selected Iranian Macroeconomic Variables Using the New Keynesian Dynamic Stochastic General Equilibrium Model

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Abstract

In this article, with the aim of investigating the impact of the international sanctions shock on the nominal exchange rate variable and other selected macroeconomic variables of Iran, and then the impact of the nominal exchange rate shock on selected macroeconomic variables, an appropriate model of the Iranian economy was designed within the framework of a dynamic stochastic general equilibrium model with a New Keynesian approach and solved using the calibration method.

In order to ensure the reliability of the model results, the second-order moments of the main variables based on real data were compared with the second-order moments of the simulated values of those variables, and the instantaneous response functions of the variables to the model impulses were examined.

The results of this study indicate that the increase in the intensity of international sanctions has significant effects on macroeconomic variables in the form of a decrease in foreign exchange earnings from oil exports, a decrease in the ratio of the central bank's foreign reserves to the monetary base, and an increase in the nominal exchange rate, leading to a decrease in the export of intermediate goods (non-oil exports). Also, an increase in the nominal exchange rate leads to an increase in the export of intermediate goods (non-oil exports), a decrease in the import of consumer goods, a decrease in the import of capital goods, a decrease in the import of intermediate inputs, and an increase in total production (GDP).

Keywords: Exchange rate, economic sanctions, dynamic stochastic general equilibrium model, New Keynesian school

1- Introduction

Economic sanctions have a significant impact on the exchange rate, affecting the amount of foreign exchange inflows and outflows through a direct impact on exports and imports. By intensifying sanctions and creating obstacles in the path of exports, imports, and foreign exchange transfers, the amount of foreign exchange supply and demand is affected, leading to currency fluctuations (Vortabian Kashani, 2013). Oil sanctions reduce oil exports and reduce government revenues from oil exports (Rahmati et al., 2016), which on the one hand, due to the dependence of the majority of government revenues on oil exports, including the sale of crude oil and petroleum products, causes a government budget deficit, and due to the stagnation of economic activities under sanctions and insufficient tax revenues, it leads the government to borrow from the banking network or withdraw from the reserves of the central bank, and can even cause the central bank's foreign exchange policies to deviate from maintaining the value of the national currency, towards a devaluation of the national currency or an increase in the exchange rate to compensate for the government budget deficit (Darakhshan, 2014). On the other hand, due to the reduction in the country's foreign exchange resources resulting from the reduction in oil exports and the reduction in the supply of foreign exchange in the market, the exchange rate increases (Nademi et al., 2017). International financial sanctions mainly focus on the banking network and the central bank to prevent international financial transactions and also to limit the use of international financial messengers to access services related to financial transactions (Taibi and Sadeghi, 2017). By increasing the risk of transactions between other countries and the banking and financial network of the target country, international financial sanctions have led to the expansion of financial activities in the informal sector, which in turn increases the risk of foreign exchange transfers due to the use of informal and insecure methods and increases the cost of trade transactions and international financing (Eyler, 2007). Due to the non-return of a significant percentage of foreign exchange resources from oil exports under central bank sanctions, there is a possibility of disruption in the central bank's foreign exchange policy because in these conditions, the central bank's ability to manage the foreign exchange market in a managed float from the foreign exchange supply side decreases, leading to an increase in the exchange rate (Darakhshan, 2014).

By imposing unfair sanctions as an external factor, the exchange rate increases significantly (Pourfathi and Kafaei, 2019). With an increase in the exchange rate, the price of the country's exported goods in foreign markets decreases, and as a result, the demand for these goods increases, leading to an increase in exports. Hence, domestic production is directed towards foreign markets and a smaller share is sold in the domestic market. As a result, domestic markets face a decrease in supply, and therefore, prices increase. In addition, with an increase in the exchange rate, the price of imported raw materials and intermediate inputs increases. This increases production costs and causes production to decrease, and in industries where production is largely dependent on imported intermediate inputs, with an increase in the price of imported intermediate inputs, there is an expectation of an increase in the cost price of goods, and this increase reduces the competitiveness of domestic production in foreign markets and reduces exports. On the one hand, an increase in the exchange rate increases the competitiveness of domestically produced goods in foreign markets, and on the other hand, an increase in the price of exported goods due to an increase in the price of imported intermediate inputs due to an increase in the exchange rate reduces the competitiveness of domestically produced goods in foreign markets. The result of market forces in the general equilibrium model of the Iranian economy determines the increase or decrease in the country's exports (Davoodi and Sezavar, 2022).

This study attempts to examine the impact of the international sanctions shock on the nominal exchange rate variable and other macroeconomic variables of Iran, and then analyze the impact of the nominal exchange rate shock on Iran's macroeconomic variables by using a dynamic stochastic general equilibrium model with a new Keynesian approach.

The practical advantage of the method used in the present study over other studies, especially domestic studies, is that this study is one of the few studies that uses the New Keynesian dynamic stochastic general equilibrium model to analyze the effect of international sanctions shocks and exchange rate shocks on selected Iranian macroeconomic variables.

2- Theoretical foundations

2-1- How economic sanctions affect the exchange rate

International trade and international finance are interconnected through the balance of payments channel. Trade sanctions indirectly affect the financial markets of the target country. Financial sanctions also

indirectly affect the commodity markets of the target country. When the sanctioning country restricts the target country's access to its financial resources, it actually reduces the supply of funds and increases the financing costs for the target country. Another form of financial sanctions involves reducing or cutting off income from assets of the target country held by the sanctioning countries, known as asset freezes. These types of sanctions can have a significant impact if the target country uses the financial markets of the sanctioning countries (Eyler, 2008).

The freezing of the assets of the Central Bank has been one of the first effects of the sanctions. As a result, the country's assets are frozen in all kinds of accounts in Iranian banks or with other banks, because any financial institution, since it ultimately belongs to the Central Bank, is affected by the sanctions. Another important consequence of the Central Bank sanctions is the disruption of monetary policies. Disruption of foreign exchange policy can be another result of the Central Bank sanctions, because in such circumstances, the Central Bank faces a shortage of foreign exchange reserves and loses the ability to effectively intervene in the market in order to maintain the value of the national currency. The freezing and freezing of revenues from oil exports is also one of the results of the Central Bank sanctions (Vesali and Torabi, 2010). The lack of full access to foreign exchange resources not only increases government costs, but also makes a significant part of government revenues practically unusable (Pahlavani et al., 2014). In addition, banking sanctions, especially the Central Bank sanctions, pose problems for the country's monetary transactions and cause widespread disruptions to the country's commercial activities, thus seriously disrupting revenues from non-oil exports (Nademi et al., 2017).

The transmission of negative oil shocks to the foreign exchange market, given the dominant share of foreign exchange earnings from oil exports in the country's foreign exchange reserves, has caused significant fluctuations in the exchange rate. Since the share of foreign exchange earnings from non-oil exports is very small and there are no alternative foreign exchange sources, the exchange rate is more susceptible to oil shocks. Given this, the Iranian economy is affected by events that affect oil exports, including economic sanctions (Taibi and Sadeghi, 2017).

Under the conditions of increasing sanctions pressure and the resulting uncertainty from the channel of limiting oil sales and foreign exchange earnings, the exchange rate is affected upwards, which in turn increases production costs due to the increase in the price of imported raw materials and capital goods, and restricts non-oil production and exports. Even sanctions on the supply of certain goods, as well as sanctions in the interbank and financial transactions sector, and the like, restrict access to capital goods, which in turn puts pressure on the market for export products, and in the subsequent stages, its negative effects are transferred to different sectors of the economy (Keshavarz Haddad et al., 2010).

Exports are considered one of the most important sources of foreign exchange supply in any country. If the export of goods and services is one of the areas of economic sanctions, then it is expected that foreign exchange resources, which are themselves import requirements, will be disrupted. Export sanctions can be extremely dangerous and damaging when export diversification in the target country is low (Gershasbi and Yousefi Dindarloo, 2016).

Financial and currency sanctions have significant effects on the country's monetary and foreign exchange system (Dreisner, 1999). Economic sanctions affect the country's foreign exchange market and foreign exchange reserves. They also directly affect other markets and speculative attacks, but economic sanctions indirectly affect the country's foreign exchange reserves, other markets, and speculative attacks through the foreign exchange market. Speculative attacks also affect the economy on the foreign exchange market, foreign exchange reserves, and other markets (Pourshahabi, 2014).

In fact, economic sanctions have three direct effects on the foreign exchange market, which are: an increase in the real exchange rate, an increase in the gap between the official exchange rate and the free market exchange rate, and an intensification of exchange rate fluctuations (Nademi et al., 2017). Foreign exchange sanctions increase the gap between the nominal and real sectors, because if foreign exchange transactions are not carried out on time, these transactions must be carried out through mechanisms other than SWIFT or using other currencies. This can lead to corruption, delays in transactions, and increased costs associated with them (Bastanifar, 2016). The exchange rate gap strengthens the rent-seeking process in the foreign exchange market, and this phenomenon can direct stray liquidity towards speculative transactions in the foreign exchange market and the use of multi-rate currency rents instead of being absorbed in productive activities. This phenomenon itself contributes to a sharp increase in the exchange rate and the formation of

inflationary expectations in this market. Another mechanism by which sanctions affect the foreign exchange market is an increase in the exchange rate due to a decrease in foreign exchange resources and the supply of foreign exchange in the market (Nademi et al., 2017).

2-2- How economic sanctions affect exports and imports

Depending on their type, sanctions can affect exports in different ways (Esmailpour et al., 2023):

A) Direct trade sanctions, due to the existence of legal barriers in the sanctioning countries, cause these countries to cut off or reduce their imports from the target countries. On the other hand, increasing the risk of importers from the sanctioned exporting country prevents countries from exporting non-oil products, which can be due to the fear of punishment and sanctions from large economic countries (countries such as the United States, which have large economies, meaning their export and import volumes are very significant and are important for most economic enterprises).

B) Financial sanctions, commercial banks, and the central bank make it very difficult and even eliminate the possibility of trade for exporters from sanctioned countries and importers from destination countries, as a result of which the country's exports decrease.

C) Sanctions on knowledge and technology can reduce the possibility of exports by reducing the production capacity and competitiveness of exporting companies in competition with other exporting companies. However, given the ability to circumvent these types of sanctions, their effectiveness is low.

The high dependence of production on imports of various raw materials, intermediate inputs, and capital is one of the ways in which sanctions expose a country's economy to potential threats. Even if sanctions do not lead to a cut in imports, the cost of domestic production will increase due to increased import costs, which will increase domestic price levels and reduce the competitiveness of manufactured goods in international markets. On the one hand, imposing sanctions on imports can lead to a decrease in the amount of imports and, on the other hand, increase import costs per specific volume.

2-3- How exchange rate changes affect exports and imports

The current balance model in terms of the domestic currency is introduced as follows (Vaez, 2019):

$$CA = PX - RP^{*}M \quad (1)$$

So that P is the price of exported goods in terms of domestic currency, X amount of export, R of the exchange rate, ie the number of units required by the national currency to exchange with a foreign currency, P^{*} is the price of each unit of imported goods in terms of foreign currency and M is the amount of imports from abroad. The level of foreign and domestic prices can be written in a normal way (ie, divided by the price of each unit of domestic goods), so the first sentence will be x and the second sentence will be rm.

$$CA = x - rm \quad (2)$$

If a complete differential is taken from Equation (2) to express the complete change, then:

$$dCA = dx - rdm - mdr \quad (3)$$

By dividing the parties, we will have a relationship (3) to dr:

$$\frac{dCA}{dr} = \frac{dx}{dr} - \frac{rdm}{dr} - \frac{mdr}{dr} \quad (4)$$

This relationship can be shown in terms of export and import tensions. To do this, two tensions are introduced: export tension and import traction.

The price elasticity of the export demand:

$$\eta_x = \frac{\frac{dx}{x}}{\frac{dr}{r}} \rightarrow dx = \eta_x \frac{dr}{r} x \quad (5)$$

As it is clear, this elasticity indicates the percentage change in exports to the percentage change in the exchange rate. As a result of export changes in terms of export elasticity (price elasticity of demand for exports) is obtained in the form of (5).

The price elasticity of imports:

$$\eta_m = \frac{\frac{dm}{m}}{\frac{dr}{r}} \rightarrow dm = -\eta_m \frac{dr}{r} m \quad (6)$$

The price elasticity of demand for imports is equal to the percentage change in the amount of import to the percentage change in the exchange rate, which ultimately achieves the amount of import change in terms of import elasticity.

Now the relations (5) and (6) are placed in the relationship (4):

$$\frac{dCA}{dr} = \eta_x \frac{x}{r} + (\eta_m m) - m \quad (7)$$

If we multiply the sides by $\frac{1}{m}$, we will have:

$$\frac{dCA}{dr}\frac{1}{m} = \eta_x \frac{x}{r}\frac{1}{m} + \eta_m - 1 \quad (8)$$

If we assume that we are in a trade balance situation:

$$x = rm \quad (9)$$

In other words, the value of imports in terms of the foreign currency multiplied by the exchange rate is equal to the value of exports in terms of the national currency. According to the above assumption:

$$\frac{dCA}{dr} = m(\eta_x + \eta_m - 1) \quad (10)$$

Given that m is always positive in terms of trade, the phrase in parentheses will be positive when the sum of the export and import tensions is greater than one.

$$\eta_x + \eta_m > 1 \quad (11)$$

The final result is known as Marshall-Lerner. In other words, the Marshall-Lerner condition indicates that the increase in the exchange rate or the devaluation of the national currency improves the current balance when the total price elasticity of foreigners for our export goods and the price elasticity of domestic demand for imported goods are greater than one. In other words, the condition for achieving the desired changes in the balance of payments by changing the exchange rate is to establish this condition.

In simple terms, if the current balance is in the deficit, if the Marshall-Lerner condition is met, the current balance deficit can be eliminated or reduced by increasing the exchange rate.

In short, following the increase in the exchange rate, events occur in three stages. The first stage is called the price effect, the second stage is called the value effect and the third stage is called the net effect.

Price effect: The price effect appears in such a way that when the exchange rate increases, this increase reduces the price of exported goods offered in foreign target markets and on the other hand increases the domestic price of imported goods and these two intensify the initial deficit in the current level. In other words, the effect of the policy of change in the exchange rate, in the event of a deficit in the current balance, intensifies it, because the monetary value of exports decreases and the monetary value of imports increases.

Quantitative effect: As a result of the increase in the exchange rate, the exchange rate of each unit of domestic export in foreign target markets decreases, and therefore the demand of foreigners for the import of domestic exports increases, ie the amount of exports increases from inside to outside. Likewise, as a result of the increase in the domestic price of imported goods, the amount of imports from abroad is reduced.

Net effect: The third net effect is two high effects. In fact, the net effect is expressed as the sum of the two tensions. In other words, if the sum of two elasticities is more than one, that is, the price elasticity of foreigners for our export goods and the price elasticity of domestic demand for imported goods, the effect of quantitative over the price effect prevails, and as a result, the increase in the exchange rate reduces or eliminates the initial deficit in the current level.

If we define the exchange rate as the value of a foreign currency compared to a country's domestic currency, then if the exchange rate increases, the price of imported goods in the country's domestic currency will increase. As a result, the demand for these goods will decrease. In addition, as the exchange rate increases, the price of the country's exported goods in foreign markets will become cheaper, and thus, the demand for these goods will increase. So, with a decrease in imports and an increase in exports, net exports and, consequently, GDP are expected to increase (Fouladi, 2012).

An increase in the exchange rate will increase the price level of imported goods in the domestic market, so it is expected that the demand for these goods will decrease and the demand for domestically produced goods will increase. In addition, with an increase in the exchange rate, the relative price of the country's exported goods in foreign markets will decrease, and as a result, the demand for these goods is expected to increase. As a result, domestic production may be directed to foreign markets and a smaller share will be

sold in the domestic market. Due to the increase in the price of imported goods and the decrease in domestic supply, domestic markets will face a decrease in supply and therefore prices will increase.

Therefore, it is generally expected that domestic production will increase, imports will decrease, exports will increase, and the domestic price level will increase. In addition, with the increase in the exchange rate, the price of imported intermediate inputs will also increase, and therefore, in sectors and industries where production is highly dependent on imported intermediate inputs, there is an expectation of an increase in the cost price of goods, and this increase may reduce the competitiveness of goods in foreign markets and intensify the increase in domestic prices.

3- Research background

Various domestic and foreign studies have been conducted on the impact of international sanctions on selected macroeconomic variables in Iran, of which only some of the most important are mentioned below:

Author	Title	Method and results
Kioumarsi et al. (2019)	Examining the effect of financial and energy sanctions on the output gap in the Iranian economy	This study examines the impact of financial and energy sanctions on the output gap in the Iranian economy. For this purpose, a New Keynesian stochastic dynamic general equilibrium model has been used. The results of this study show that the imposition of economic sanctions has, on the one hand, reduced investment spending, total consumption, and capital formation, and on the other hand, increased production costs, and as a result, the output gap in the economy has increased.
Ludati and Sons (2021)	Identifying the effects of sanctions on the Iranian economy using newspaper coverage	This study examines the impact of sanctions by using a new measure of sanctions severity based on newspaper coverage from 1979 to 2021, using the GVAR method. The findings of this study show that real household spending in most urban areas of Iran has decreased more than in rural areas. Sanctions have also had significant effects on exchange rates and inflation. In addition, sanctions have had significant negative consequences on employment, labor force participation, and secondary education in Iran.
Dizji and Farzanegan (2021)	Will sanctions limit Iran's military spending?	This study examines the role of sanctions on military spending in Iran using data from 1960 to 2017 and using the ARDL model. The results of this study show that increasing the severity of sanctions has had significant negative effects on Iran's military spending in both the short and long term.
Salehi Isfahani (2021)	Iran under sanctions, the impact of sanctions on household welfare and employment	This study examines the impact of sanctions imposed on Iran since 2010 on household consumption and employment. The findings of this study show that although household income and consumption have been hit hard, employment in Iran has shown greater resilience. The impact of sanctions on the Iranian economy has been twofold, both reducing government revenues from oil exports and reducing Iran’s trade with the world.
Zarei et al. (2024)	The impact of international sanctions on the Iranian economy with emphasis on	The present study examines the simultaneous effects of various types of economic sanctions along with the role of the National Development Fund on Iranian economic

	the role of the National Development Fund: Model Approach (DSGE)	variables. For this purpose, a dynamic stochastic general equilibrium model based on the New Keynesian approach has been used. The results show that the imposition of export sanctions on non-oil goods and imported intermediate goods has had the greatest impact on employment, wages, inflation, and total output. Also, the results indicate that the National Development Fund has not been able to play an effective role in reducing currency fluctuations caused by sanctions and has lost its effectiveness in the Iranian economy.

Various domestic and foreign studies have been conducted on the impact of exchange rate changes on selected Iranian macroeconomic variables, of which only some of the most important are mentioned below:

Author	Title	Method and results
Apollos et al. (2015)	Exchange rate fluctuations and economic growth in Nigeria	This study examines the relationship between GDP, exchange rate, exports, imports and inflation rate in Nigeria from 1986 to 2013. The results of the econometric model estimate show that there is a positive and significant relationship between GDP, exchange rate and exports. The results also show that exchange rate fluctuations have had an impact on Nigeria's economic growth.
Aziznejad and Komijani (2015)	Exchange rate changes and their effect on the fluctuations of selected macroeconomic variables in Iran	The present study has investigated the effects of exchange rate fluctuations on some macroeconomic variables using the vector autoregressive (VAR) method. The results of this study indicate that real exchange rate fluctuations in the Iranian economy have had the greatest impact on changes in short-term deposit interest rates. Also, after short-term deposit interest rates, the greatest changes in producer inflation rates have also been explained by changes in real exchange rates. Economic growth is positively affected by exchange rate changes in the short and long term and negatively affected by exchange rate changes in the medium term.
Habib et al. (2016)	Reexamining the relationship between real exchange rates and economic growth using external instruments	This study examines the impact of real exchange rate changes on economic growth using mixed data regression over the period 2010 to 2015 in 150 countries in the post-Bretton Woods monetary system. The results of this study show that an increase in real exchange rates significantly affects the annual economic growth of developing countries.
Aman, Ola, Khan and Khan (2017)	The relationship between exchange rate and economic growth in Pakistan (an econometric approach)	The present study examined the relationship between exchange rate and economic growth using the simultaneous equations method in Pakistan from 1976 to 2010. The findings of the present study show that an increase in the exchange rate has increased economic growth by strengthening export incentives, increasing investment volume, inflow of foreign direct investment, and strengthening import substitution.
Kohnsal and Mahmoudi (2019)	Investigating exchange rate fluctuations on exports and value added of Iranian food industries (using structural vector autoregression model)	The present study examined the effect of exchange rate fluctuations on Iranian food industry exports within the framework of a structural vector autoregression model during the years 1971 to 2014. The results of the present study show that exchange rate fluctuations increase export volume only in short-term periods and in

		subsequent periods cause a decrease in the activity of exporters compared to importers, which results in a decrease in the volume of food exports.

4- Specifying the pattern

The research model consists of the following sections: household, labor market, intermediate goods producing firm, trade including exports of intermediate goods and imports of consumer goods, capital goods and intermediate inputs, oil, government and central bank, and the goods market settlement condition. Each section is explained in detail below, and the equations related to each section are presented.

4-1- Household

A point that is assumed in the context of modeling the household sector is the similarity of household preferences, which is called the assumption of household homogeneity or symmetry. This assumption is important because by analyzing the behavior of a typical household, the results obtained can be generalized to other households. It is also assumed that the life of the household is unlimited. The household gains utility from consumption (C_t), holding real money balances $\left(\frac{M_t}{P_t}\right)$, and loses utility through labor supply (L_t). The household utility function is defined as follows (Tavakolian and Sarem, 2017):

$$U_t = E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t - H_t)^{1-\sigma_c}}{1-\sigma_c} + \frac{\chi_m}{1-\sigma_m} \left(\frac{M_t}{P_t}\right)^{1-\sigma_m} - \chi_l \frac{{L_t}^{1+\sigma_l}}{1+\sigma_l} \right] \quad (12)$$

Where, β is the subjective discount factor, C_t is the consumption index, M_t is the nominal money supply, P_t is the price index, and L_t is the household labor supply. σ_c is the inverse of the intertemporal substitution elasticity of consumption, σ_m is the interest elasticity of demand for real money balances, and σ_l is the inverse of the labor supply elasticity. H_t is the consumption habit variable and is defined as $H_t = hC_{t-1}$, where h is called the habit stability parameter.

The real household budget constraint is defined as follows:

$$C_t + I_t + m_t + b_t = w_t L_t + \frac{m_{t-1}}{\pi_t} + (1 + i_{t-1}) \frac{b_{t-1}}{\pi_t} + \left(r_t^k Z_t K_{t-1} - \Psi(Z_t) K_{t-1}\right) - ta_t \quad (13)$$

Where, $m_t = \frac{M_t}{P_t}$ is the real money balance, $b_t = \frac{B_t}{P_t}$ is the real amount of bonds, $w_t = \frac{W_t}{P_t}$ is the real wage rate, $\pi_t = \frac{P_t}{P_{t-1}}$ is the gross inflation rate, i_t is the nominal interest rate, r_t^k is the rate of return on capital, Z_t is the rate of capital utilization, K_{t-1} is the volume of capital, $\Psi(Z_t)$ is the cost of capital utilization, and ta_t is the tax paid by households.

The capital accumulation relationship is also defined as the second constraint of the household as follows:

$$K_t = (1-\delta) K_{t-1} + I_t \left[1 - S\left(\frac{\varepsilon_t^I I_t}{I_{t-1}}\right)\right] \quad (14)$$

Where, δ is the depreciation rate of private capital, ε_t^I is the investment impulse, and $S\left(\frac{I_t}{I_{t-1}}\right)$ is the investment adjustment cost function.

The household's goal is to find optimal paths for consumption, labor supply, real money balances, bonds, investment, capital utilization rate, and capital stock such that the household's utility function is maximized subject to the household's real budget constraints and the capital accumulation relationship. The Lagrange function of this problem is defined as:

$$\begin{aligned} \mathcal{L} = E_t \sum_{t=0}^{\infty} \beta^t \Bigg\{ & \left[\frac{(C_t - H_t)^{1-\sigma_c}}{1-\sigma_c} + \frac{\chi_m}{1-\sigma_m} \left(\frac{M_t}{P_t}\right)^{1-\sigma_m} - \chi_l \frac{{L_t}^{1+\sigma_l}}{1+\sigma_l} \right] \\ & + \lambda_t \left[w_t L_t + \frac{m_{t-1}}{\pi_t} + (1+i_{t-1}) \frac{b_{t-1}}{\pi_t} + \left(r_t^k Z_t K_{t-1} - \Psi(Z_t) K_{t-1}\right) - ta_t - C_t - I_t - m_t \right. \\ & \left. - b_t \right] + \mu_t \left[(1-\delta) K_{t-1} + I_t \left[1 - S\left(\frac{\varepsilon_t^I I_t}{I_{t-1}}\right)\right] - K_t \right] \Bigg\} \end{aligned} \quad (15)$$

Where, λ_t is the Lagrange coefficient associated with the real household budget constraint and μ_t is the Lagrange coefficient associated with the capital accumulation relationship.

The first-order optimal conditions for this problem are:

$$\frac{\partial \mathcal{L}}{\partial C_t} = 0 \rightarrow (C_t - H_t)^{-\sigma_c} - \lambda_t = 0 \quad (16)$$

$$\frac{\partial \mathcal{L}}{\partial L_t} = 0 \rightarrow -\chi_l {L_t}^{\sigma_l} + \lambda_t w_t = 0 \quad (17)$$

$$\frac{\partial \mathcal{L}}{\partial m_t} = 0 \rightarrow \chi_m (m_t)^{-\sigma_m} - \lambda_t + \beta E_t \frac{\lambda_{t+1}}{\pi_{t+1}} = 0 \quad (18)$$

$$\frac{\partial \mathcal{L}}{\partial b_t} = 0 \rightarrow -\lambda_t + \beta(1+i_t) E_t \frac{\lambda_{t+1}}{\pi_{t+1}} = 0 \quad (19)$$

$$\frac{\partial \mathcal{L}}{\partial I_t} = 0 \rightarrow -\lambda_t + \mu_t - \mu_t S\left(\frac{\varepsilon_t^I I_t}{I_{t-1}}\right) - \mu_t I_t \frac{\varepsilon_t^I}{I_{t-1}} S'\left(\frac{\varepsilon_t^I I_t}{I_{t-1}}\right) + \beta E_t \mu_{t+1} \varepsilon_{t+1}^I \left(\frac{I_{t+1}}{I_t}\right)^2 S'\left(\frac{\varepsilon_{t+1}^I I_{t+1}}{I_t}\right) = 0 \quad (20)$$

$$\frac{\partial \mathcal{L}}{\partial Z_t} = 0 \rightarrow r_t^k - \Psi'(Z_t) = 0 \quad (21)$$

$$\frac{\partial \mathcal{L}}{\partial K_t} = 0 \rightarrow E_t \beta^{t+1} \left[\lambda_{t+1}\left(r_{t+1}^k Z_{t+1} - \Psi(Z_{t+1})\right) + \mu_{t+1}(1-\delta)\right] - \beta^t \mu_t = 0 \quad (22)$$

By placing Equation (16) in Equation (17), the labor supply equation is obtained as follows:

$$w_t = \frac{\chi_l {L_t}^{\sigma_l}}{(C_t - H_t)^{-\sigma_c}} \quad (23)$$

By placing the equation (19) in relation (18), the money demand equation is obtained as follows:

$$\frac{\chi_m (m_t)^{-\sigma_m}}{(C_t - H_t)^{-\sigma_c}} = \frac{i_t}{1+i_t} \quad (24)$$

By placing Equation (16) in Equation (19), the Euler equation of consumption is obtained as follows:

$$\beta(1+i_t) E_t \frac{(C_{t+1} - H_{t+1})^{-\sigma_c}}{\pi_{t+1}} = (C_t - H_t)^{-\sigma_c} \quad (25)$$

By placing Equation (19) in Equation (20), the investment equation is obtained as follows, in which, q_t is the final rate of Tobin and equal to the ratio of Lagrange coefficient of capital accumulation to Lagrange coefficient of budget constraint.

$$q_t - q_t S\left(\frac{\varepsilon_t^I I_t}{I_{t-1}}\right) - q_t I_t \frac{\varepsilon_t^I}{I_{t-1}} S'\left(\frac{\varepsilon_t^I I_t}{I_{t-1}}\right) + \frac{1}{R_t} E_t q_{t+1} \varepsilon_{t+1}^I \left(\frac{I_{t+1}}{I_t}\right)^2 S'\left(\frac{\varepsilon_{t+1}^I I_{t+1}}{I_t}\right) = 1 \quad (26)$$

By substituting equation (19) into equation (22), the equation for capital price dynamics is obtained as follows, where $\zeta_t = 1 + r_t^k + \Pi_t - \delta$ (which is actually the gross nominal interest rate of capital) and in this relation $\Pi_t = \pi_t - 1$, which is the net inflation rate.

$$E_t \frac{\pi_{t+1}}{\zeta_t} \left[r_{t+1}^k Z_{t+1} - \Psi(Z_{t+1}) + q_{t+1}(1-\delta)\right] = q_t \quad (27)$$

According to research (Nakhli et al., 2020), household consumption is assumed to be a combination of domestic and imported goods, and accordingly, the household consumption index is expressed as follows:

$$C_t = \left[\alpha_c^{\frac{1}{\theta_c}} C_t^{d\,\frac{\theta_c - 1}{\theta_c}} + (1-\alpha_c)^{\frac{1}{\theta_c}} C_t^{m\,\frac{\theta_c - 1}{\theta_c}}\right]^{\frac{\theta_c}{\theta_c - 1}} \quad (28)$$

Where, C_t^d is the index of consumption of domestic goods, C_t^m is the index of consumption of imported goods, α_c is the share of domestic consumer goods in the household consumption index, and θ_c is the elasticity of substitution between domestic consumer goods and imported consumer goods. The household's goal is to find the optimal combination of consumption of domestic goods and imported goods, such that total expenditure is minimized. The mathematical form of this problem is as follows:

$$\min_{C_t^d, C_t^m} \quad P_t C_t - P_t^{cd} C_t^d - P_t^{cm} C_t^m \quad (29)$$

$$s.t. \quad C_t = \left[\alpha_c^{\frac{1}{\theta_c}} C_t^{d\,\frac{\theta_c - 1}{\theta_c}} + (1-\alpha_c)^{\frac{1}{\theta_c}} C_t^{m\,\frac{\theta_c - 1}{\theta_c}}\right]^{\frac{\theta_c}{\theta_c - 1}}$$

From solving this problem, the optimal demand functions for the consumption index of domestic and imported goods are obtained as follows:

$$C_t^d = \alpha_c \left(\frac{P_t^{cd}}{P_t}\right)^{-\theta_c} C_t \quad (30)$$

$$C_t^m = (1-\alpha_c) \left(\frac{P_t^{cm}}{P_t}\right)^{-\theta_c} C_t \quad (31)$$

Where, P_t^{cd} is the price index of domestic consumer goods, P_t^{cm} is the price index of imported consumer goods, and P_t is the price index of total consumer goods.

By substituting the optimal demand functions into equation (28), the total price index of consumer goods is obtained as follows:

$$P_t = \left[\alpha_c \left(P_t^{cd}\right)^{1-\theta_c} + (1-\alpha_c)(P_t^{cm})^{1-\theta_c}\right]^{\frac{1}{1-\theta_c}} \quad (32)$$

According to research (Nakhli et al., 2020), household investment is assumed to be a combination of domestic and imported goods, and accordingly, the household investment index is expressed as follows:

$$I_t = \left[\alpha_I^{\frac{1}{\theta_I}} I_t^{d\,\frac{\theta_I-1}{\theta_I}} + (1-\alpha_I)^{\frac{1}{\theta_I}} I_t^{m\,\frac{\theta_I-1}{\theta_I}}\right]^{\frac{\theta_I}{\theta_I-1}} \quad (33)$$

Where, I_t^d is the domestic investment index, I_t^m is the imported investment index, α_I is the share of domestic capital goods in the household investment index, and θ_I is the elasticity of substitution between domestic capital goods and imported capital goods. The household's goal is to find the optimal combination of domestic and imported capital goods investment, such that total expenditure is minimized. The mathematical form of this problem is as follows:

$$\min_{I_t^d, I_t^m} \quad P_t I_t - P_t^{Id} I_t^d - P_t^{Im} I_t^m \quad (34)$$

$$s.t. \quad I_t = \left[\alpha_I^{\frac{1}{\theta_I}} I_t^{d\,\frac{\theta_I-1}{\theta_I}} + (1-\alpha_I)^{\frac{1}{\theta_I}} I_t^{m\,\frac{\theta_I-1}{\theta_I}}\right]^{\frac{\theta_I}{\theta_I-1}}$$

From solving this problem, the optimal demand functions for the domestic and imported goods investment index are obtained as follows:

$$I_t^d = \alpha_I \left(\frac{P_t^{Id}}{P_t}\right)^{-\theta_I} I_t \quad (35)$$

$$I_t^m = (1-\alpha_I) \left(\frac{P_t^{Im}}{P_t}\right)^{-\theta_I} I_t \quad (36)$$

Where, P_t^{Id} is the domestic capital goods price index, P_t^{Im} is the imported capital goods price index, and P_t is the total capital goods price index.

By substituting the optimal demand functions into equation (33), the total price index of capital goods is obtained as follows:

$$P_t = \left[\alpha_I \left(P_t^{Id}\right)^{1-\theta_I} + (1-\alpha_I)(P_t^{Im})^{1-\theta_I}\right]^{\frac{1}{1-\theta_I}} \quad (37)$$

4-2- Labor market

Inspired by the research (Erseg et al., 2000), the labor market is a monopolistic competition market where households supply their differentiated labor to intermediary firms. Each household is a monopolistic supplier of labor who can determine its own wage and determine the amount of labor supplied in proportion to the determined wage. According to the method (Digit and Stiglitz, 1977), it is assumed that there is a labor aggregator who rents differentiated labor from households and transforms them into a homogeneous factor of production L_t using the following technology:

$$L_t = \left(\int_0^1 L_t(i)^{\frac{\theta_w-1}{\theta_w}} di\right)^{\frac{\theta_w}{\theta_w-1}} \quad (38)$$

where θ_w is the constant substitution elasticity between different labor forces. The goal of the labor aggregate is to choose the amount of labor force such that its profit is maximized.

The above problem is expressed as follows:

$$\max_{L_t(i)} \quad W_t L_t - \int_0^1 W_t(i) L_t(i)\, di \tag{39}$$

$$s.t. \qquad L_t = \left(\int_0^1 L_t(i)^{\frac{\theta_w - 1}{\theta_w}} di \right)^{\frac{\theta_w}{\theta_w - 1}}$$

From solving this problem, the optimal aggregate demand function for labor from the labor force of the i household is obtained as follows:

$$L_t(i) = \left(\frac{W_t(i)}{W_t} \right)^{-\theta_w} L_t \tag{40}$$

By substituting the optimal demand function into equation (38), the total nominal wage index is obtained as follows:

$$W_t = \left(\int_0^1 W_t(i)^{1-\theta_w} di \right)^{\frac{1}{1-\theta_w}} \tag{41}$$

Households are assumed to be wage setters in the labor market because they supply their labor under monopolistic competition, but it is not possible for them to always adjust their wages optimally in each period. The probability that a representative household can adjust its wages optimally is $(1 - \upsilon_w)$, but households that do not have such an opportunity to adjust their wages are assumed to set their wages for the next period according to a rule of thumb, adjusted for inflation:

$$W_{t+1}(i) = (\pi_t)^{\tau_w} W_t(i) \tag{42}$$

where τ_w is the degree of wage indexation. The percentage of households that do not have the opportunity to adjust their wages optimally will index their wages according to equation (42) until an opportunity for optimal adjustment arises in future periods. To determine their optimal wage, households behave in a way that maximizes their utility from work, assuming that they will not be able to adjust their wages for several future periods with probability υ_w. The mathematical form of this problem is as follows:

$$\max_{W_t(i)} \quad E_t \sum_{s=0}^{\infty} (\beta \upsilon_w)^s \Delta_{s,t+s} \left[-\frac{\chi_l}{1+\sigma_l} L_{t+s}(i)^{1+\sigma_l} + \lambda_{t+s} W_{t+s}(i) L_{t+s}(i) \right] \tag{43}$$

$$s.t. \qquad L_{t+s}(i) = \left(\frac{W_{t+s}(i)}{W_{t+s}} \right)^{-\theta_w} L_{t+s}$$

Given that in each period, υ_w percent of households cannot adjust their wages and only $(1 - \upsilon_w)$ percent of them will be able to adjust their wages, the total nominal wage index is defined as follows:

$$W_t = \left[(1 - \upsilon_w)(W_t^*)^{1-\theta_w} + \upsilon_w ((\pi_{t-1})^{\tau_w} W_{t-1})^{1-\theta_w} \right]^{\frac{1}{1-\theta_w}} \tag{44}$$

Using the first-order optimal condition of problem (43) and equation (44), the wage Phillips curve is obtained as follows:

$$\hat{w}_t = \frac{\beta}{1+\beta} E_t \hat{w}_{t+1} + \frac{1}{1+\beta} \hat{w}_{t-1} + \frac{\beta}{1+\beta} E_t \hat{\pi}_{t+1} - \frac{1 + \beta \tau_w}{1+\beta} \hat{\pi}_t + \frac{\tau_w}{1+\beta} \hat{\pi}_{t-1}$$
$$- \frac{1}{1+\beta} \frac{(1 - \beta \upsilon_w)(1 - \upsilon_w)}{\upsilon_w} \left[\hat{w}_t - \sigma_l \hat{l}_t - \frac{\sigma_c}{1-h} (\hat{c}_t - h \hat{c}_{t-1}) \right] \tag{45}$$

4-3- Intermediate goods manufacturing firm

According to the research (Block and Brown, 2018), the intermediary firm produces the intermediate good $Y_t^{no}(j)$ using private capital input $K_{t-1}(j)$, labor input $L_t(j)$, government capital input KG_{t-1} and intermediate inputs $In_t(j)$. The production function of the intermediary firm is as follows:

$$Y_t^{no}(j) = A_t \left(Z_t K_{t-1}(j) \right)^{\varphi} L_t(j)^{\eta} {KG_{t-1}}^{\theta_g} In_t(j)^{1-\varphi-\eta} \tag{46}$$

Where, φ is the production elasticity of private capital input, η is the production elasticity of labor input, θ_g is the production elasticity of public capital input, $1 - \varphi - \eta$ is the production elasticity of intermediate inputs, and $Z_t K_{t-1}(j)$ is the effective capital stock.

The goal of the intermediary firm is to find optimal demand functions for factors of production by minimizing the cost of production for a given level of output. The mathematical form of this problem is as follows:

$$\min_{K_{t-1}(j),L_t(j),In_t(j)} \quad r_t^k Z_t\, K_{t-1}(j) + W_t L_t(j) + P_t^{In} In_t(j) \tag{47}$$

$$s.t. \qquad Y_t^{no}(j) = A_t\left(Z_t K_{t-1}(j)\right)^{\varphi} L_t(j)^{\eta} {KG_{t-1}}^{\theta_g} In_t(j)^{1-\varphi-\eta}$$

From solving this problem, the optimal demand functions for the factors of production (private capital, labor, and intermediate inputs) are obtained as follows:

$$K_{t-1}(j) = \varphi mc_t \frac{Y_t^{no}(j)}{r_t^k Z_t} \tag{48}$$

$$L_t(j) = \eta mc_t \frac{Y_t^{no}(j)}{W_t} \tag{49}$$

$$In_t(j) = (1-\varphi-\eta) mc_t Y_t^{no}(j) \frac{P_t}{P_t^{In}} \tag{50}$$

By substituting relations (48), (49), and (50) into relation (46), the final cost is obtained as follows:

$$mc_t = \frac{1}{A_t}\left(\frac{1}{\varphi}\right)^{\varphi}\left(\frac{1}{\eta}\right)^{\eta}\left(\frac{1}{1-\varphi-\eta}\right)^{1-\varphi-\eta} {r_t^k}^{\varphi} {W_t}^{\eta} {KG_{t-1}}^{-\theta_g}\left(\frac{P_t^{In}}{P_t}\right)^{1-\varphi-\eta} \tag{51}$$

According to research (Nakhli et al., 2020), it is assumed that a firm producing intermediate goods supplies its product to the domestic and foreign markets:

$$Y_t^{no} = \left[\alpha_y^{\frac{1}{\theta_y}} Y_t^{d\,\frac{\theta_y+1}{\theta_y}} + (1-\alpha_y)^{\frac{1}{\theta_y}} Y_t^{x\,\frac{\theta_y+1}{\theta_y}}\right]^{\frac{\theta_y}{\theta_y+1}} \tag{52}$$

Where, Y_t^d is the index of intermediate goods supplied to the domestic market, Y_t^x is the index of intermediate goods supplied to foreign markets, α_y is the share of intermediate goods supplied to the domestic market in the intermediate goods index of the intermediary firm, and θ_y is the elasticity of substitution between intermediate goods supplied to the domestic market and intermediate goods supplied to foreign markets. The objective of the intermediary firm is to find the optimal combination of supplies of intermediate goods to the domestic market and foreign markets, such that total costs are minimized. The mathematical form of this problem is as follows:

$$\min_{Y_t^d, Y_t^x} \quad P_t^y Y_t^{no} - P_t^d Y_t^d - P_t^x Y_t^x \tag{53}$$

$$s.t. \qquad Y_t^{no} = \left[\alpha_y^{\frac{1}{\theta_y}} Y_t^{d\,\frac{\theta_y+1}{\theta_y}} + (1-\alpha_y)^{\frac{1}{\theta_y}} Y_t^{x\,\frac{\theta_y+1}{\theta_y}}\right]^{\frac{\theta_y}{\theta_y+1}}$$

From solving this problem, the optimal supply functions for the index of intermediate goods supplied to the domestic market and supplied to foreign markets are obtained as follows:

$$Y_t^d = \alpha_y \left(\frac{P_t^d}{P_t^y}\right)^{\theta_y} Y_t^{no} \tag{54}$$

$$Y_t^x = (1-\alpha_y)\left(\frac{e_t P_t^x}{P_t^y}\right)^{\theta_y} Y_t^{no} \tag{55}$$

Where, P_t^d is the price index of intermediate goods supplied to the domestic market, P_t^x is the price index of intermediate goods supplied to foreign markets, and P_t^y is the price index of total intermediate goods.

By substituting the optimal supply functions into equation (52), the total price index of intermediate goods is obtained as follows:

$$P_t^y = \left[\alpha_y \left(P_t^d\right)^{1+\theta_y} + (1-\alpha_y)(e_t P_t^x)^{1+\theta_y}\right]^{\frac{1}{1+\theta_y}} \tag{56}$$

The market for the sale of products produced by intermediary firms in the domestic and foreign markets is of a monopolistic competition type, and these firms set the price of their products above the marginal cost. According to the method (Dixit and Stiglitz, 1977), it is assumed that there is an aggregator of intermediate

goods supplied to the domestic market, which aggregates the supply of all intermediary firms to the domestic market according to the following technological relationship and supplies it to the market at a single price:

$$Y_t^d = \left(\int_0^1 Y_t^d(j)^{\frac{\theta_d - 1}{\theta_d}} dj \right)^{\frac{\theta_d}{\theta_d - 1}} \quad (57)$$

Where, θ_d is the elasticity of substitution of the products of intermediate firms supplying to the domestic market. The objective of the aggregator of intermediate goods supplied to the domestic market is to choose the quantity of intermediate goods supplied to the domestic market in such a way that its profit is maximized. The above problem is expressed as follows:

$$\max_{Y_t^d(j)} \quad P_t^d Y_t^d - \int_0^1 P_t^d(j) Y_t^d(j) dj$$
$$s.t. \quad Y_t^d = \left(\int_0^1 Y_t^d(j)^{\frac{\theta_d - 1}{\theta_d}} dj \right)^{\frac{\theta_d}{\theta_d - 1}} \quad (58)$$

From solving this problem, the optimal demand function of the aggregate of intermediate goods supplied to the domestic market from the intermediate goods supplied to the domestic market of the j intermediary firm is obtained as follows:

$$Y_t^d(j) = \left(\frac{P_t^d(j)}{P_t^d} \right)^{-\theta_d} Y_t^d \quad (59)$$

By substituting the optimal demand function into equation (57), the price index of intermediate goods supplied to the domestic market is obtained as follows:

$$P_t^d = \left(\int_0^1 P_t^d(j)^{1-\theta_d} dj \right)^{\frac{1}{1-\theta_d}} \quad (60)$$

According to the method (Calvo, 1983) and due to the costs of price adjustment, intermediary firms supplying products to the domestic market cannot always set the price of their products optimally in a monopolistic competitive market. Intermediary firms supplying products to the domestic market are divided into two categories. The first category includes $(1 - \upsilon_d)$ percent of firms that are able to set the optimal price in each period, which is also determined based on profit maximization in a time period. The second category includes υ_d percent of firms that are unable to set their optimal price and, therefore, their price is not obtained from maximizing the profit function. When an intermediary firm supplying products to the domestic market fails to set the price of its product at the optimal level, it sets the price of its products for the next period according to the rules of thumb and based on the adjusted inflation rate:

$$P_{t+1}^d(j) = \left(\pi_t^d\right)^{\tau_d} P_t^d(j) \quad (61)$$

Where, τ_d is the price indexation degree of the intermediary firm supplying the product to the domestic market. The intermediary firm supplying the product to the domestic market sets the price of its products in a monopolistic competition market, in accordance with the optimization behavior with the profit maximization approach, at a level higher than the marginal cost. This problem is expressed as follows:

$$\max_{P_t^d(j)} \quad E_t \sum_{s=0}^{\infty} (\beta \upsilon_d)^s \Delta_{s,t+s} \left[\frac{P_{t+s}^d(j)}{P_{t+s}^d} Y_{t+s}^d(j) - mc_{t+s} Y_{t+s}^d(j) \right]$$
$$s.t. \quad Y_{t+s}^d(j) = \left(\frac{P_{t+s}^d(j)}{P_{t+s}^d} \right)^{-\theta_d} Y_{t+s}^d \quad (62)$$

$$P_{t+1}^d(j) = \left(\pi_t^d\right)^{\tau_d} P_t^d(j)$$
$$P_{t+2}^d(j) = \left(\pi_{t+1}^d\right)^{\tau_d} P_{t+1}^d(j) = \left(\pi_{t+1}^d\right)^{\tau_d} \left(\pi_t^d\right)^{\tau_d} P_t^d(j)$$
$$P_{t+3}^d(j) = \left(\pi_{t+2}^d\right)^{\tau_d} P_{t+2}^d(j) = \left(\pi_{t+2}^d\right)^{\tau_d} \left(\pi_{t+1}^d\right)^{\tau_d} \left(\pi_t^d\right)^{\tau_d} P_t^d(j)$$

$$\vdots \tag{63}$$

$$P_{t+s}^{d}(j)=\left(\pi_{t+s-1}^{d}\right)^{\tau_d}P_{t+s-1}^{d}(j)=\left(\pi_{t+s-1}^{d}\right)^{\tau_d}\left(\pi_{t+s-2}^{d}\right)^{\tau_d}\times\ldots\times\left(\pi_{t+2}^{d}\right)^{\tau_d}\left(\pi_{t+1}^{d}\right)^{\tau_d}\left(\pi_{t}^{d}\right)^{\tau_d}P_{t}^{d}(j)$$

Given this trend, the relationship between the current price and the price in the next period s can be written as follows:

$$P_{t+s}^{d}(j)=\prod_{k=1}^{s}\left(\pi_{t+k-1}^{d}\right)^{\tau_d}P_{t}^{d}(j) \tag{64}$$

By substituting equation (64) into equation (62), the unconstrained form of this optimization problem will be as follows:

$$\max_{P_t^d(j)}\left\{E_t\sum_{s=0}^{\infty}(\beta\upsilon_d)^s\Delta_{s,t+s}\left[\frac{\prod_{k=1}^{s}\left(\pi_{t+k-1}^{d}\right)^{\tau_d}P_{t}^{d}(j)}{P_{t+s}^{d}}\left(\frac{\prod_{k=1}^{s}\left(\pi_{t+k-1}^{d}\right)^{\tau_d}P_{t}^{d}(j)}{P_{t+s}^{d}}\right)^{-\theta_d}Y_{t+s}^{d}-mc_{t+s}\left(\frac{\prod_{k=1}^{s}\left(\pi_{t+k-1}^{d}\right)^{\tau_d}P_{t}^{d}(j)}{P_{t+s}^{d}}\right)^{-\theta_d}Y_{t+s}^{d}\right]\right\} \tag{65}$$

By setting the optimal price as $P_t^d(j)=P_t^{d*}$, the first-order optimal condition of the above problem after simplification is as follows:

$$\frac{P_t^{d*}}{P_t^d}=\frac{\theta_d}{\theta_d-1}\frac{E_t\sum_{s=0}^{\infty}(\beta\upsilon_d)^s\Delta_{s,t+s}mc_{t+s}\left(\frac{P_{t+s}^d}{P_t^d}\right)^{\theta_d}\left(\frac{P_{t-1}^d}{P_{t+s-1}^d}\right)^{\tau_d\theta_d}Y_{t+s}^d}{E_t\sum_{s=0}^{\infty}(\beta\upsilon_d)^s\Delta_{s,t+s}\left(\frac{P_{t+s}^d}{P_t^d}\right)^{\theta_d-1}\left(\frac{P_{t-1}^d}{P_{t+s-1}^d}\right)^{\tau_d(\theta_d-1)}Y_{t+s}^d} \tag{66}$$

Given that $(1-\upsilon_d)$ percent of intermediary firms supplying products to the domestic market are able to determine the optimal price in each period and υ_d percent of intermediary firms supplying products to the domestic market are unable to determine their optimal price, the price index of intermediary goods supplied to the domestic market is defined as follows:

$$P_t^d=\left[(1-\upsilon_d)\left(P_t^{d*}\right)^{1-\theta_d}+\upsilon_d\left(\left(\pi_{t-1}^{d}\right)^{\tau_d}P_{t-1}^{d}\right)^{1-\theta_d}\right]^{\frac{1}{1-\theta_d}} \tag{67}$$

The linearization of equation (67) is as follows:

$$\hat{P}_t^d=(1-\upsilon_d)\hat{P}_t^{d*}+\upsilon_d\tau_d\hat{\pi}_{t-1}^{d}+\upsilon_d\hat{P}_{t-1}^{d} \tag{68}$$

By subtracting the expression $\upsilon_d\hat{P}_t^d$ from both sides of equation (68), we have:

$$(1-\upsilon_d)\hat{P}_t^d=(1-\upsilon_d)\hat{P}_t^{d*}+\upsilon_d\tau_d\hat{\pi}_{t-1}^{d}-\upsilon_d\hat{\pi}_t^{d} \tag{69}$$

Therefore, from equation (69) we can conclude:

$$\hat{P}_t^{d*}-\hat{P}_t^d=\frac{\upsilon_d}{1-\upsilon_d}\left(\hat{\pi}_t^d-\tau_d\hat{\pi}_{t-1}^{d}\right) \tag{70}$$

By defining $\mu=\frac{\theta_d}{\theta_d-1}$ and $Q_t=\frac{P_t^{d*}}{P_t^d}$, the linearization of equation (66) can be written as follows:

$$\hat{P}_t^{d*}-\hat{P}_t^d=(1-\beta\upsilon_d)E_t\sum_{s=0}^{\infty}(\beta\upsilon_d)^s\left[\widehat{mc}_{t+s}+\left(\hat{P}_{t+s}^d-\hat{P}_t^d\right)+\tau_d\left(\hat{P}_{t-1}^d-\hat{P}_{t+s-1}^d\right)\right] \tag{71}$$

If the expression on the right side of equation (71) is expanded to the first two terms, we will have:

$$\hat{P}_t^{d*}-\hat{P}_t^d=(1-\beta\upsilon_d)\widehat{mc}_t+(1-\beta\upsilon_d)(\beta\upsilon_d)E_t\left[\widehat{mc}_{t+1}+\left(\hat{P}_{t+1}^d-\hat{P}_t^d\right)+\tau_d\left(\hat{P}_{t-1}^d-\hat{P}_t^d\right)\right] \tag{72}$$

As a result:

$$\begin{aligned}\hat{P}_t^{d*}-\hat{P}_t^d=&(1-\beta\upsilon_d)\widehat{mc}_t+\beta\upsilon_dE_t\left[\widehat{mc}_{t+1}+\left(\hat{P}_{t+1}^d-\hat{P}_t^d\right)+\tau_d\left(\hat{P}_{t-1}^d-\hat{P}_t^d\right)\right]\\&-(\beta\upsilon_d)^2E_t\left[\widehat{mc}_{t+1}+\left(\hat{P}_{t+1}^d-\hat{P}_t^d\right)+\tau_d\left(\hat{P}_{t-1}^d-\hat{P}_t^d\right)\right]\end{aligned} \tag{73}$$

Assuming that $(\beta\upsilon_d)^2\cong 0$, then equation (73) can be written as follows:

$$\hat{P}_t^{d*}-\hat{P}_t^d=(1-\beta\upsilon_d)\widehat{mc}_t+\beta\upsilon_dE_t\left[\widehat{mc}_{t+1}+\left(\hat{P}_{t+1}^d-\hat{P}_t^d\right)+\tau_d\left(\hat{P}_{t-1}^d-\hat{P}_t^d\right)\right] \tag{74}$$

On the other hand, given that $Q_t=\frac{P_t^{d*}}{P_t^d}=\mu mc_t$, therefore $\widehat{mc}_{t+1}=\hat{P}_{t+1}^{d*}-\hat{P}_{t+1}^d$ and we can write equation (74) as follows:

$$\hat{P}_t^{d*}-\hat{P}_t^d=(1-\beta\upsilon_d)\widehat{mc}_t+\beta\upsilon_dE_t\left[\hat{P}_{t+1}^{d*}-\hat{P}_{t+1}^d+\left(\hat{P}_{t+1}^d-\hat{P}_t^d\right)+\tau_d\left(\hat{P}_{t-1}^d-\hat{P}_t^d\right)\right] \tag{75}$$

On the other hand, by substituting equation (70) into equation (75), we can arrive at the following expression:

$$\frac{\upsilon_d}{1-\upsilon_d}\left(\hat{\pi}_t^d-\tau_d\hat{\pi}_{t-1}^d\right)=(1-\beta\upsilon_d)\widehat{mc}_t+\beta\upsilon_d\frac{\upsilon_d}{1-\upsilon_d}E_t\left[\hat{\pi}_{t+1}^d-\tau_d\hat{\pi}_t^d\right]+\beta\upsilon_d E_t\hat{\pi}_{t+1}^d-\beta\upsilon_d\tau_d\hat{\pi}_t^d \quad (76)$$

By simplifying equation (76), the new Phillips Keynesian curve of the inflation index of the price of intermediate goods supplied to the domestic market is obtained as follows:

$$\hat{\pi}_t^d=\frac{\tau_d}{1+\beta\tau_d}\hat{\pi}_{t-1}^d+\frac{\beta}{1+\beta\tau_d}E_t\hat{\pi}_{t+1}^d+\frac{(1-\beta\upsilon_d)(1-\upsilon_d)}{\upsilon_d(1+\beta\tau_d)}\widehat{mc}_t \quad (77)$$

According to research (Nakhli et al., 2020), a firm producing intermediate goods demands its intermediate inputs from the domestic market and foreign markets:

$$In_t=\left[\alpha_{In}^{\frac{1}{\theta_{In}}}In_t^{d\,\frac{\theta_{In}-1}{\theta_{In}}}+(1-\alpha_{In})^{\frac{1}{\theta_{In}}}In_t^{m\,\frac{\theta_{In}-1}{\theta_{In}}}\right]^{\frac{\theta_{In}}{\theta_{In}-1}} \quad (78)$$

Where, In_t^d is the index of intermediate inputs demanded from the domestic market, In_t^m is the index of intermediate inputs demanded from foreign markets, α_{In} is the share of intermediate inputs demanded from the domestic market in the intermediate input index of the intermediary firm, and θ_{In} is the elasticity of substitution between intermediate inputs demanded from the domestic market and intermediate inputs demanded from foreign markets. The objective of the intermediary firm is to find the optimal combination of demand for intermediate inputs from the domestic market and foreign markets, such that total expenditure is minimized. The mathematical form of this problem is as follows:

$$\min_{In_t^d,In_t^m}\quad P_t^{In}\,In_t-P_t^{Ind}In_t^d-P_t^{Inm}In_t^m \quad (79)$$

$$s.t.\qquad In_t=\left[\alpha_{In}^{\frac{1}{\theta_{In}}}In_t^{d\,\frac{\theta_{In}-1}{\theta_{In}}}+(1-\alpha_{In})^{\frac{1}{\theta_{In}}}In_t^{m\,\frac{\theta_{In}-1}{\theta_{In}}}\right]^{\frac{\theta_{In}}{\theta_{In}-1}}$$

From solving this problem, the optimal demand functions for the index of intermediate inputs demanded from the domestic market and demanded from foreign markets are obtained as follows:

$$In_t^d=\alpha_{In}\left(\frac{P_t^{Ind}}{P_t^{In}}\right)^{-\theta_{In}}In_t \quad (80)$$

$$In_t^m=(1-\alpha_{In})\left(\frac{P_t^{Inm}}{P_t^{In}}\right)^{-\theta_{In}}In_t \quad (81)$$

Where, P_t^{Ind} is the price index of intermediate inputs demanded from the domestic market, P_t^{Inm} is the price index of intermediate inputs demanded from foreign markets, and P_t^{In} is the price index of total intermediate inputs.

By substituting the optimal demand functions into equation (78), the total price index of intermediate inputs is obtained as follows:

$$P_t^{In}=\left[\alpha_{In}\left(P_t^{Ind}\right)^{1-\theta_{In}}+(1-\alpha_{In})(P_t^{Inm})^{1-\theta_{In}}\right]^{\frac{1}{1-\theta_{In}}} \quad (82)$$

4-4- Trade

4-4-1- Export

Firms producing intermediate goods, despite supplying part of their products to the domestic market, export part of their products to foreign markets and, since foreign markets are monopolistically competitive, they set a price for their products higher than the marginal cost. According to the method (Dixit and Stiglitz, 1977), it is assumed that there is an aggregator of intermediate goods supplied to foreign markets that aggregates the supply of all intermediate firms to foreign markets according to the following technological relationship and supplies the market with a single price:

$$Y_t^x=\left(\int_0^1 Y_t^x(j)^{\frac{\theta_x-1}{\theta_x}}dj\right)^{\frac{\theta_x}{\theta_x-1}} \quad (83)$$

Where, θ_x is the elasticity of substitution of the products of intermediate firms supplying to foreign markets. The objective of the aggregate of intermediate goods supplied to foreign markets is to choose the quantity of intermediate goods supplied to foreign markets in such a way that its profit is maximized.
The above problem is expressed as follows:

$$\max_{Y_t^x(j)} \quad P_t^x Y_t^x - \int_0^1 P_t^x(j) Y_t^x(j) dj \tag{84}$$

$$s.t. \quad Y_t^x = \left(\int_0^1 Y_t^x(j)^{\frac{\theta_x - 1}{\theta_x}} dj \right)^{\frac{\theta_x}{\theta_x - 1}}$$

From solving this problem, the optimal aggregate demand function for intermediate goods supplied to foreign markets from intermediate goods supplied to foreign markets of the j exporting firm is obtained as follows:

$$Y_t^x(j) = \left(\frac{P_t^x(j)}{P_t^x} \right)^{-\theta_x} Y_t^x \tag{85}$$

By substituting the optimal demand function into equation (83), the price index of intermediate goods supplied to foreign markets is obtained as follows:

$$P_t^x = \left(\int_0^1 P_t^x(j)^{1-\theta_x} dj \right)^{\frac{1}{1-\theta_x}} \tag{86}$$

According to the method (Calvo, 1983) and due to the costs of price adjustment, intermediary firms supplying products to foreign markets cannot always set the price of their products optimally in a foreign monopolistic competitive market. Intermediary firms supplying products to foreign markets are divided into two categories. The first category includes $(1 - \upsilon_x)$ percent of firms that are able to set the optimal price in each period, which is also determined based on profit maximization in a time period. The second category includes υ_x percent of firms that are unable to set their optimal price and, therefore, their price is not obtained from maximizing the profit function. When an intermediary firm supplying products to foreign markets fails to set the price of its product at the optimal level, it sets the price of its products for the next period according to the rules of thumb and based on the adjusted inflation rate:

$$P_{t+1}^x(j) = (\pi_t^x)^{\tau_x} P_t^x(j) \tag{87}$$

Where, τ_x is the price indexation degree of the intermediary firm supplying the product to foreign markets. The intermediary firm supplying the product to foreign markets sets the price of its products in the foreign monopolistic competition market, in accordance with the optimization behavior with the profit maximization approach, at a level higher than the marginal cost. This problem is expressed as follows:

$$\max_{P_t^x(j)} \quad E_t \sum_{s=0}^{\infty} (\beta \upsilon_x)^s \Delta_{s,t+s} \left[\frac{P_{t+s}^x(j)}{P_{t+s}^x} Y_{t+s}^x(j) - mc_{t+s}^x Y_{t+s}^x(j) \right] \tag{88}$$

$$s.t. \quad Y_{t+s}^x(j) = \left(\frac{P_{t+s}^x(j)}{P_{t+s}^x} \right)^{-\theta_x} Y_{t+s}^x$$

By setting the optimal price as $P_t^x(j) = P_t^{x*}$, the first-order optimal condition of the above problem after simplification is as follows:

$$\frac{P_t^{x*}}{P_t^x} = \frac{\theta_x}{\theta_x - 1} \frac{E_t \sum_{s=0}^{\infty} (\beta \upsilon_x)^s \Delta_{s,t+s} mc_{t+s}^x \left(\frac{P_{t+s}^x}{P_t^x} \right)^{\theta_x} \left(\frac{P_{t-1}^x}{P_{t+s-1}^x} \right)^{\tau_x \theta_x} Y_{t+s}^x}{E_t \sum_{s=0}^{\infty} (\beta \upsilon_x)^s \Delta_{s,t+s} \left(\frac{P_{t+s}^x}{P_t^x} \right)^{\theta_x - 1} \left(\frac{P_{t-1}^x}{P_{t+s-1}^x} \right)^{\tau_x (\theta_x - 1)} Y_{t+s}^x} \tag{89}$$

Given that $(1 - \upsilon_x)$ percent of intermediary firms supplying products to foreign markets are able to determine the optimal price in each period and υ_x percent of intermediary firms supplying products to foreign markets are unable to determine their optimal price, the price index of intermediary goods supplied to foreign markets is defined as follows:

$$P_t^x = \left[(1 - \upsilon_x)(P_t^{x*})^{1-\theta_x} + \upsilon_x ((\pi_{t-1}^x)^{\tau_x} P_{t-1}^x)^{1-\theta_x} \right]^{\frac{1}{1-\theta_x}} \tag{90}$$

Using relations (89) and (90), the new Keynesian Phillips curve of the inflation index of the price of intermediate goods supplied to foreign markets is obtained as follows:

$$\hat{\pi}_t^x = \frac{\tau_x}{1 + \beta \tau_x} \hat{\pi}_{t-1}^x + \frac{\beta}{1 + \beta \tau_x} E_t \hat{\pi}_{t+1}^x + \frac{(1 - \beta \upsilon_x)(1 - \upsilon_x)}{\upsilon_x (1 + \beta \tau_x)} \widehat{mc}_t^x \tag{91}$$

The aggregator of intermediate goods supplied to foreign markets purchases the intermediate goods needed for export from the aggregator of intermediate goods supplied to the domestic market at the price P_t^d and sells them in foreign markets at the price P_t^x. International sanctions in the export sector of intermediate goods increase transaction costs (receiving and transferring foreign exchange from exports, transportation, insurance, etc.) in the process of exporting intermediate goods. Therefore, the real final cost of the aggregator of intermediate goods supplied to foreign markets is as follows:

$$mc_t^x = \frac{P_t^d}{e_t P_t^x} S_t^x \quad (92)$$

Where, S_t^x is the additional transaction costs resulting from the imposition of international sanctions that increase the real marginal cost of intermediate goods supplied to foreign markets and is assumed to follow a first-order autoregressive process. International sanctions $(sanc_t)$ increase transaction costs in the intermediate goods export sector through the parameter SSX.

$$S_t^x = \rho_x S_{t-1}^x + (1-\rho_x)\bar{S}^x + SSX sanc_t + \varepsilon_t^x \quad (93)$$

4-4-2- Import

Importing firms operate in three sectors: importing consumer goods, importing capital goods, and importing intermediate inputs.

Consumer goods importers purchase consumer goods needed for import into the country from world markets and sell them to domestic consumers. It is assumed that the market for imported consumer goods in the country is monopolistically competitive and that importing firms set the price of consumer goods above marginal cost and sell them. According to the method (Dixit and Stiglitz, 1977), it is assumed that there is an aggregator of imported consumer goods that purchases consumer goods from all importing firms and aggregates them according to the following technological relationship and supplies them to the domestic consumer goods market at a single price:

$$C_t^m = \left(\int_0^1 C_t^m(j)^{\frac{\theta_{cm}-1}{\theta_{cm}}} dj \right)^{\frac{\theta_{cm}}{\theta_{cm}-1}} \quad (94)$$

Where, θ_{cm} is the elasticity of substitution of imported consumer goods of different importing firms. The objective of the imported consumer goods aggregator is to choose the quantity of imported consumer goods such that its profit is maximized.

The above problem is expressed as follows:

$$\max_{C_t^m(j)} \quad P_t^{cm} C_t^m - \int_0^1 P_t^{cm}(j) C_t^m(j) dj \quad (95)$$

$$s.t. \quad C_t^m = \left(\int_0^1 C_t^m(j)^{\frac{\theta_{cm}-1}{\theta_{cm}}} dj \right)^{\frac{\theta_{cm}}{\theta_{cm}-1}}$$

From solving this problem, the optimal aggregate demand function for imported consumer goods from the consumer goods of the j importing firm is obtained as follows:

$$C_t^m(j) = \left(\frac{P_t^{cm}(j)}{P_t^{cm}} \right)^{-\theta_{cm}} C_t^m \quad (96)$$

By substituting the optimal demand function into equation (94), the price index of imported consumer goods is obtained as follows:

$$P_t^{cm} = \left(\int_0^1 P_t^{cm}(j)^{1-\theta_{cm}} dj \right)^{\frac{1}{1-\theta_{cm}}} \quad (97)$$

According to the method (Calvo, 1983) and due to the costs of price adjustment, firms importing consumer goods cannot always set the price of their products optimally in a monopolistic competitive market. Firms importing consumer goods are divided into two categories. The first category includes $(1-\upsilon_{cm})$ percent of firms that are able to set the optimal price, which is also determined based on profit maximization in a time period. The second category includes υ_{cm} percent of firms that are unable to set their optimal price and, therefore, their price is not obtained from maximizing the profit function. When a firm

importing consumer goods fails to set the price of its product at the optimal level, it sets the price of its products for the future period according to the rules of thumb and based on the adjusted inflation rate:

$$P_{t+1}^{cm}(j) = (\pi_t^{cm})^{\tau_{cm}} P_t^{cm}(j) \quad (98)$$

Where, τ_{cm} is the price indexation degree of the consumer goods importing firm. The consumer goods importing firm sets the price of its products in a monopolistically competitive market, in accordance with the optimization behavior with the profit maximization approach, at a level above the marginal cost. This problem is expressed as follows:

$$\max_{P_t^{cm}(j)} \quad E_t \sum_{s=0}^{\infty} (\beta \upsilon_{cm})^s \Delta_{s,t+s} \left[\frac{P_{t+s}^{cm}(j)}{P_{t+s}^{cm}} C_{t+s}^m(j) - mc_{t+s}^{cm} C_{t+s}^m(j) \right]$$
$$s.t. \quad C_{t+s}^m(j) = \left(\frac{P_{t+s}^{cm}(j)}{P_{t+s}^{cm}} \right)^{-\theta_{cm}} C_{t+s}^m \quad (99)$$

By setting the optimal price as $P_t^{cm}(j) = P_t^{cm*}$, the first-order optimal condition of the above problem after simplification is as follows:

$$\frac{P_t^{cm*}}{P_t^{cm}} = \frac{\theta_{cm}}{\theta_{cm}-1} \frac{E_t \sum_{s=0}^{\infty} (\beta \upsilon_{cm})^s \Delta_{s,t+s} mc_{t+s}^{cm} \left(\frac{P_{t+s}^{cm}}{P_t^{cm}} \right)^{\theta_{cm}} \left(\frac{P_{t-1}^{cm}}{P_{t+s-1}^{cm}} \right)^{\tau_{cm}\theta_{cm}} C_{t+s}^m}{E_t \sum_{s=0}^{\infty} (\beta \upsilon_{cm})^s \Delta_{s,t+s} \left(\frac{P_{t+s}^{cm}}{P_t^{cm}} \right)^{\theta_{cm}-1} \left(\frac{P_{t-1}^{cm}}{P_{t+s-1}^{cm}} \right)^{\tau_{cm}(\theta_{cm}-1)} C_{t+s}^m} \quad (100)$$

Given that $(1-\upsilon_{cm})$ percent of firms importing consumer goods in each period are able to determine the optimal price and υ_{cm} percent of firms importing consumer goods are unable to determine their optimal price, the price index of imported consumer goods is defined as follows:

$$P_t^{cm} = \left[(1-\upsilon_{cm})(P_t^{cm*})^{1-\theta_{cm}} + \upsilon_{cm} ((\pi_{t-1}^{cm})^{\tau_{cm}} P_{t-1}^{cm})^{1-\theta_{cm}} \right]^{\frac{1}{1-\theta_{cm}}} \quad (101)$$

Using relations (100) and (101), the new Phillips Keynesian curve for the inflation index of imported consumer goods is obtained as follows:

$$\hat{\pi}_t^{cm} = \frac{\tau_{cm}}{1+\beta\tau_{cm}} \hat{\pi}_{t-1}^{cm} + \frac{\beta}{1+\beta\tau_{cm}} E_t \hat{\pi}_{t+1}^{cm} + \frac{(1-\beta\upsilon_{cm})(1-\upsilon_{cm})}{\upsilon_{cm}(1+\beta\tau_{cm})} \widehat{mc}_t^{cm} \quad (102)$$

The aggregator of imported consumer goods purchases the consumer goods needed for import from the world markets at the price P_t^f and sells them in the domestic market at the price P_t^{cm}. International sanctions on the import of consumer goods increase transaction costs (payment and transfer of foreign exchange for the purchase of imported consumer goods, transportation, insurance, etc.) in the process of importing consumer goods. Therefore, the true final cost of the aggregator of imported consumer goods is as follows:

$$mc_t^{cm} = \frac{e_t P_t^f}{P_t^{cm}} S_t^{cm} \quad (103)$$

Where, S_t^{cm} is the additional transaction costs resulting from the imposition of international sanctions that increase the real marginal cost of importing consumer goods and is assumed to follow a first-order autoregressive process. International sanctions $(sanc_t)$ increase transaction costs in the consumer goods import sector through the parameter $SSCm$.

$$S_t^{cm} = \rho_{cm} S_{t-1}^{cm} + (1-\rho_{cm}) \bar{S}^{cm} + SSCm sanc_t + \varepsilon_t^{cm} \quad (104)$$

Importing capital goods firms purchase capital goods needed for import into the country from world markets and sell them to domestic investors. It is assumed that the market for imported capital goods in the country is monopolistically competitive and that importing firms set the price of capital goods above marginal cost and sell them. According to the method (Dixit and Stiglitz, 1977), it is assumed that there is an aggregator of imported capital goods that purchases the capital goods of all importing firms and aggregates them according to the following technological relationship and supplies them to the domestic capital goods market at a single price:

$$I_t^m = \left(\int_0^1 I_t^m(j)^{\frac{\theta_{Im}-1}{\theta_{Im}}} dj \right)^{\frac{\theta_{Im}}{\theta_{Im}-1}} \quad (105)$$

Where, θ_{Im} is the elasticity of substitution of imported capital goods of different importing firms. The objective of the imported capital goods aggregator is to choose the quantity of imported capital goods such that its profit is maximized.
The above problem is expressed as follows:

$$\max_{I_t^m(j)} \quad P_t^{Im} I_t^m - \int_0^1 P_t^{Im}(j)\, I_t^m(j) dj \tag{106}$$

$$s.t. \qquad I_t^m = \left(\int_0^1 I_t^m(j)^{\frac{\theta_{Im}-1}{\theta_{Im}}} dj \right)^{\frac{\theta_{Im}}{\theta_{Im}-1}}$$

From solving this problem, the optimal aggregate demand function for imported capital goods from the capital goods of the j importing firm is obtained as follows:

$$I_t^m(j) = \left(\frac{P_t^{Im}(j)}{P_t^{Im}} \right)^{-\theta_{Im}} I_t^m \tag{107}$$

By substituting the optimal demand function into equation (105), the price index of imported capital goods is obtained as follows:

$$P_t^{Im} = \left(\int_0^1 P_t^{Im}(j)^{1-\theta_{Im}} dj \right)^{\frac{1}{1-\theta_{Im}}} \tag{108}$$

According to the method (Calvo, 1983) and due to the costs of price adjustment, firms importing capital goods cannot always set the price of their products optimally in a monopolistic competitive market. Firms importing capital goods are divided into two categories. The first category includes $(1-\upsilon_{Im})$ percent of firms that are able to set the optimal price in each period, which is also determined based on profit maximization in a time period. The second category includes υ_{Im} percent of firms that are unable to set their optimal price and, therefore, their price is not obtained from maximizing the profit function. When a firm importing capital goods fails to set the price of its product at the optimal level, it sets the price of its products for the next period according to the rules of thumb and based on the adjusted inflation rate:

$$P_{t+1}^{Im}(j) = (\pi_t^{Im})^{\tau_{Im}} P_t^{Im}(j) \tag{109}$$

Where, τ_{Im} is the degree of price indexation of the capital goods importing firm. The capital goods importing firm sets the price of its products in a monopolistically competitive market, in accordance with the optimization behavior with the profit maximization approach, at a level above the marginal cost. This problem is expressed as follows:

$$\max_{P_t^{Im}(j)} \quad E_t \sum_{s=0}^{\infty} (\beta \upsilon_{Im})^s \Delta_{s,t+s} \left[\frac{P_{t+s}^{Im}(j)}{P_{t+s}^{Im}} I_{t+s}^m(j) - mc_{t+s}^{Im} I_{t+s}^m(j) \right] \tag{110}$$

$$s.t. \qquad I_{t+s}^m(j) = \left(\frac{P_{t+s}^{Im}(j)}{P_{t+s}^{Im}} \right)^{-\theta_{Im}} I_{t+s}^m$$

By setting the optimal price as $P_t^{Im}(j) = P_t^{Im*}$, the first-order optimal condition of the above problem after simplification is as follows:

$$\frac{P_t^{Im*}}{P_t^{Im}} = \frac{\theta_{Im}}{\theta_{Im}-1} \frac{E_t \sum_{s=0}^{\infty} (\beta \upsilon_{Im})^s \Delta_{s,t+s} mc_{t+s}^{Im} \left(\frac{P_{t+s}^{Im}}{P_t^{Im}} \right)^{\theta_{Im}} \left(\frac{P_{t-1}^{Im}}{P_{t+s-1}^{Im}} \right)^{\tau_{Im}\theta_{Im}} I_{t+s}^m}{E_t \sum_{s=0}^{\infty} (\beta \upsilon_{Im})^s \Delta_{s,t+s} \left(\frac{P_{t+s}^{Im}}{P_t^{Im}} \right)^{\theta_{Im}-1} \left(\frac{P_{t-1}^{Im}}{P_{t+s-1}^{Im}} \right)^{\tau_{Im}(\theta_{Im}-1)} I_{t+s}^m} \tag{111}$$

Given that $(1-\upsilon_{Im})$ percent of firms importing capital goods in each period are able to determine the optimal price and υ_{Im} percent of firms importing capital goods are unable to determine their optimal price, the price index of imported capital goods is defined as follows:

$$P_t^{Im} = \left[(1-\upsilon_{Im})(P_t^{Im*})^{1-\theta_{Im}} + \upsilon_{Im} ((\pi_{t-1}^{Im})^{\tau_{Im}} P_{t-1}^{Im})^{1-\theta_{Im}} \right]^{\frac{1}{1-\theta_{Im}}} \tag{112}$$

Using relations (111) and (112), the new Keynesian Phillips curve of the inflation index of imported capital goods is obtained as follows:

$$\hat{\pi}_t^{Im} = \frac{\tau_{Im}}{1+\beta\tau_{Im}}\hat{\pi}_{t-1}^{Im} + \frac{\beta}{1+\beta\tau_{Im}}E_t\hat{\pi}_{t+1}^{Im} + \frac{(1-\beta\upsilon_{Im})(1-\upsilon_{Im})}{\upsilon_{Im}(1+\beta\tau_{Im})}\widehat{mc}_t^{Im} \quad (113)$$

The aggregator of imported capital goods purchases the capital goods needed for import from the world markets at the price P_t^f and sells them at the price P_t^{Im} in the domestic market. International sanctions on the import of capital goods increase transaction costs (payment and transfer of foreign exchange for the purchase of imported capital goods, transportation, insurance, etc.) in the process of importing capital goods. Hence, the real marginal cost of the aggregator of imported capital goods is as follows:

$$mc_t^{Im} = \frac{e_t P_t^f}{P_t^{Im}} S_t^{Im} \quad (114)$$

Where, S_t^{Im} is the additional transaction costs resulting from the imposition of international sanctions that increase the real marginal cost of importing capital goods and is assumed to follow a first-order autoregressive process. International sanctions $(sanc_t)$ increase transaction costs in the capital goods import sector through the parameter $SSIm$.

$$S_t^{Im} = \rho_{Im}S_{t-1}^{Im} + (1-\rho_{Im})\bar{S}^{Im} + SSImsanc_t + \varepsilon_t^{Im} \quad (115)$$

Importing firms purchase the intermediate inputs needed for domestic imports from world markets and sell them to producers of intermediate goods. It is assumed that the market for imported intermediate inputs in the country is monopolistically competitive and that importing firms set the price of intermediate inputs above marginal cost and sell them. According to the method (Dixit and Stiglitz, 1977), it is assumed that there is an aggregator of imported intermediate inputs that purchases the intermediate inputs of all importing firms and aggregates them according to the following technology relationship and supplies them to the domestic intermediate input market at a single price:

$$In_t^m = \left(\int_0^1 In_t^m(j)^{\frac{\theta_{Inm}-1}{\theta_{Inm}}} dj\right)^{\frac{\theta_{Inm}}{\theta_{Inm}-1}} \quad (116)$$

Where, θ_{Inm} is the elasticity of substitution of imported intermediate inputs of different importing firms. The objective of the imported intermediate input aggregator is to choose the amount of imported intermediate inputs such that its profit is maximized.

The above problem is expressed as follows:

$$\max_{In_t^m(j)} \quad P_t^{Inm} In_t^m - \int_0^1 P_t^{Inm}(j) In_t^m(j)\, dj \quad (117)$$

$$s.t. \qquad In_t^m = \left(\int_0^1 In_t^m(j)^{\frac{\theta_{Inm}-1}{\theta_{Inm}}} dj\right)^{\frac{\theta_{Inm}}{\theta_{Inm}-1}}$$

From solving this problem, the optimal demand function aggregating imported intermediate inputs from the intermediate inputs of the j importing firm is obtained as follows:

$$In_t^m(j) = \left(\frac{P_t^{Inm}(j)}{P_t^{Inm}}\right)^{-\theta_{Inm}} In_t^m \quad (118)$$

By substituting the optimal demand function into equation (116), the price index of imported intermediate inputs is obtained as follows:

$$P_t^{Inm} = \left(\int_0^1 P_t^{Inm}(j)^{1-\theta_{Inm}} dj\right)^{\frac{1}{1-\theta_{Inm}}} \quad (119)$$

According to the method (Calvo, 1983) and due to the costs of price adjustment, firms importing intermediate inputs cannot always set the price of their products optimally in a monopolistic competitive market. Firms importing intermediate inputs are divided into two categories. The first category includes $(1-\upsilon_{Inm})$ the percentage of firms that are able to set the optimal price in each period, which is also determined based on profit maximization in a time period. The second category includes the percentage of firms that are unable to set their optimal price and, therefore, their price is not obtained from maximizing the profit function. When a firm importing intermediate inputs fails to set the price of its product at the optimal level, it sets the price of its products for the next period according to the rules of thumb and based on the adjusted inflation rate:

$$P_{t+1}^{Inm}(j) = (\pi_t^{Inm})^{\tau_{Inm}} P_t^{Inm}(j) \quad (120)$$

Where, τ_{Inm} is the price indexation degree of the intermediate input importing firm. The intermediate input importing firm sets the price of its products in a monopolistically competitive market, in accordance with the optimization behavior with the profit maximization approach, at a level higher than the marginal cost. This problem is expressed as follows:

$$\max_{P_t^{Inm}(j)} \quad E_t \sum_{s=0}^{\infty} (\beta \upsilon_{Inm})^s \Delta_{s,t+s} \left[\frac{P_{t+s}^{Inm}(j)}{P_{t+s}^{Inm}} In_{t+s}^m(j) - mc_{t+s}^{Inm} In_{t+s}^m(j) \right] \quad (121)$$

$$s.t. \qquad In_{t+s}^m(j) = \left(\frac{P_{t+s}^{Inm}(j)}{P_{t+s}^{Inm}} \right)^{-\theta_{Inm}} In_{t+s}^m$$

By setting the optimal price as $P_t^{Inm}(j) = P_t^{Inm*}$, the first-order optimal condition of the above problem after simplification is as follows:

$$\frac{P_t^{Inm*}}{P_t^{Inm}} = \frac{\theta_{Inm}}{\theta_{Inm} - 1} \frac{E_t \sum_{s=0}^{\infty} (\beta \upsilon_{Inm})^s \Delta_{s,t+s} mc_{t+s}^{Inm} \left(\frac{P_{t+s}^{Inm}}{P_t^{Inm}} \right)^{\theta_{Inm}} \left(\frac{P_{t-1}^{Inm}}{P_{t+s-1}^{Inm}} \right)^{\tau_{Inm}\theta_{Inm}} In_{t+s}^m}{E_t \sum_{s=0}^{\infty} (\beta \upsilon_{Inm})^s \Delta_{s,t+s} \left(\frac{P_{t+s}^{Inm}}{P_t^{Inm}} \right)^{\theta_{Inm}-1} \left(\frac{P_{t-1}^{Inm}}{P_{t+s-1}^{Inm}} \right)^{\tau_{Inm}(\theta_{Inm}-1)} In_{t+s}^m} \quad (122)$$

Given that $(1 - \upsilon_{Inm})$ percent of firms importing intermediate inputs in each period are able to determine the optimal price and υ_{Inm} percent of firms importing intermediate inputs are unable to determine their optimal price, the price index of imported intermediate inputs is defined as follows:

$$P_t^{Inm} = \left[(1 - \upsilon_{Inm})(P_t^{Inm*})^{1-\theta_{Inm}} + \upsilon_{Inm} ((\pi_{t-1}^{Inm})^{\tau_{Inm}} P_{t-1}^{Inm})^{1-\theta_{Inm}} \right]^{\frac{1}{1-\theta_{Inm}}} \quad (123)$$

Using relations (122) and (123), the new Keynesian Phillips curve of the price index inflation of imported intermediate inputs is obtained as follows:

$$\hat{\pi}_t^{Inm} = \frac{\tau_{Inm}}{1 + \beta\tau_{Inm}} \hat{\pi}_{t-1}^{Inm} + \frac{\beta}{1 + \beta\tau_{Inm}} E_t \hat{\pi}_{t+1}^{Inm} + \frac{(1 - \beta\upsilon_{Inm})(1 - \upsilon_{Inm})}{\upsilon_{Inm}(1 + \beta\tau_{Inm})} \widehat{mc}_t^{Inm} \quad (124)$$

The aggregator of imported intermediate inputs purchases the intermediate inputs needed for import from the world markets at the price P_t^f and sells them in the domestic market at the price P_t^{Inm}. International sanctions on the import of intermediate inputs increase transaction costs (payment and transfer of foreign exchange for the purchase of imported intermediate inputs, transportation, insurance, etc.) in the process of importing intermediate inputs. Hence, the true marginal cost of the aggregator of imported intermediate inputs is as follows:

$$mc_t^{Inm} = \frac{e_t P_t^f}{P_t^{Inm}} S_t^{Inm} \quad (125)$$

Where, S_t^{Inm} is the additional transaction costs resulting from the imposition of international sanctions that increase the real marginal cost of the aggregate of imported intermediate inputs and is assumed to follow a first-order autoregressive process. International sanctions $(sanc_t)$ increase transaction costs in the import sector of intermediate inputs through the parameter $SSInm$.

$$S_t^{Inm} = \rho_{Inm} S_{t-1}^{Inm} + (1 - \rho_{Inm}) \bar{S}^{Inm} + SSInmsanc_t + \varepsilon_t^{Inm} \quad (126)$$

4-5- Oil

There are various methods for including the oil sector in the model. Some studies consider the oil sector as similar to other firms, but others use an exogenous process to model the oil sector. In the present study, the oil shock is considered through the imposition of international sanctions on the country's oil exports. It is also assumed that all extracted crude oil is exported at world prices and the foreign exchange income is provided to the government. In the modeling performed, real revenues from oil exports follow a first-order autoregressive process. International sanctions $(sanc_t)$ reduce real revenues from oil exports through the $SSor$ parameter.

$$or_t = \rho_{or} or_{t-1} + (1 - \rho_{or}) \overline{or} + SSorsanc_t + \varepsilon_t^{or} \quad (127)$$

4-6- Government and Central Bank

Due to the lack of independence of the Central Bank in Iran, the government and the Central Bank cannot be included as two separate parts in the model, but rather the government and the Central Bank should be

considered as a single agency. The government's revenue sources include: creating new debt (issuing bonds), collecting a lump sum tax from households, and revenues from oil exports. If the government balances its expenses through the above revenue sources, money creation will not occur in the form of increasing government debts to the Central Bank. However, if the government faces a budget deficit despite the above revenue sources and finances this deficit by borrowing from the Central Bank or through its deposits with the Central Bank, money creation will occur.

In this regard, following (Ireland, 1997), (Deeb, 2001), (Peiris and Sakjard, 2007), and (Gali, 2008), the government budget and central bank balance sheet constraints will be as follows.

4-6-1- Government budget constraints

In the government budget constraint, dc_t^g is the government's net debt to the central bank and b_t is the bonds. Government revenues are: ta_t lump sum tax collection from households and or_t real revenues from oil exports (ω is the percentage of real revenues from oil exports that are spent by the government and the rest is deposited in the National Development Fund) and government expenditures are: G_t real government expenditures and $(1+i_{t-1})b_{t-1}$ principal and interest payments on bonds.

$$\Delta dc_t^g + \Delta b_t = G_t + (1+i_{t-1})b_{t-1} - ta_t - \omega re_t or_t \quad (128)$$

4-6-2- Central Bank Balance Sheet

The central bank's balance sheet in real terms can be considered as follows:

$$mb_t = re_t fr_t + dc_t^g \quad (129)$$

Where, mb_t is the real monetary base, re_t is the real exchange rate, and fr_t is the real net foreign assets of the central bank.

4-6-3- Government spending

Following (Leeper et al., 2009), real government spending is considered as the sum of current spending (G_t^c) and development spending (G_t^I):

$$G_t = G_t^c + G_t^I \quad (130)$$

In this regard, it is assumed that government investment (G_t^I) gradually and over time turns into government capital accumulation (KG), which indicates the delay between the start of investment projects and their fruition. To specify this delay, that is, the time interval between the approval of a government development project and the time when this investment is put into operation in the form of capital, we denote the start time of the project and the amount of investment at the time of approval by t and A_t^{GI}. The years required to complete and operate the investment project are also specified by L. Therefore, the relationship of government capital accumulation will be as follows:

$$KG_t = (1-\delta^G)KG_{t-1} + A_{t-L+1}^{GI} \quad (131)$$

Where, KG is the accumulation of government capital, δ^G is the depreciation rate of government capital, and A_t^{GI} is the amount of government investment approved in the budget, which follows a first-order autoregressive process as follows:

$$A_t^{GI} = \rho_{GI} A_{t-1}^{GI} + (1-\rho_{GI})\bar{A}^{GI} + \varepsilon_t^{GI} \quad (132)$$

As we know, the expenditures allocated to investment projects are made gradually and over time. Let us assume that the share of expenditures allocated in each year of the total investment made is defined as the sequence $\{b_0, b_1, b_2, \dots, b_{L-1}\}$. In this sequence, year zero is the time of project approval and year $L-1$ is the year before the project is completed. The project implementation at time t will be as follows:

$$G_t^I = \sum_{n=0}^{L-1} b_n A_{t-n}^{GI} \quad (133)$$

In this relation, $\sum_{n=0}^{L-1} b_n = 1$. As mentioned, b represents the investment rate in each period. If the project has no delay or in other words, if the project approval and completion time is only one year, then $(b=1, L=1)$ and as a result we have: $G_t^I = A_t^{GI}$.

It is also assumed that current government spending follows a Cobb-Douglas function of the variables of current government spending in the previous period, lump sum tax, and revenues from oil exports.

$$G_t^c = (G_{t-1}^c)^{\rho_g} (ta_t)^{g_1} e^{\omega \varepsilon_t^{or}} e^{\varepsilon_t^g} \quad (134)$$

4-6-4- Government tax revenue

The real lump-sum tax is assumed to be a proportion of GDP and is defined as follows:

$$ta_t = t_t^r Y_t \quad (135)$$

Where, t_t^r is the tax rate and follows a first-order autoregressive process as follows:

$$t_t^r = \rho_r t_{t-1}^r + (1-\rho_r)\bar{t}^r + \varepsilon_t^r \quad (136)$$

4-6-5- National Development Fund

The National Development Fund was established under the Third Development Plan Law (1990) with the objectives of reducing the vulnerability of the economy, mitigating the damage caused by the decline in oil prices, and supporting private sector infrastructure projects. The resources of the National Development Fund are mainly derived from oil export revenues, such that $(1-\omega)$ percent of oil export revenues are deposited into the fund in each period. It is also assumed that the accumulation of the National Development Fund reserves in each period follows the following process:

$$DF_t = DF_{t-1} + (1-\omega)or_t \quad (137)$$

Where, DF_{t-1} is the balance of National Development Fund reserves from the previous period that is carried over to the current period.

4-6-6- Monetary policy

The Central Bank uses various tools for monetary policy, the choice of which depends on economic conditions and its goals. Among these tools, the interest rate and the monetary base growth rate are among the important tools in money market management and policymaking, which due to the inefficiency of the interest rate tool, the monetary base growth rate is considered as a monetary policy tool at the disposal of the Central Bank of Iran. Accordingly, the monetary policy response function is such that the Central Bank will determine the monetary base growth rate in a completely discretionary manner in such a way that its two desired goals, namely reducing the gap between current output and potential output and reducing the gap between the inflation rate and the target inflation, are achieved. The target inflation is an unobservable variable and is only available to the monetary authorities. Therefore, the monetary policy response function is defined as follows, following (Goli, 2008) and (Skode, 2013):

$$\frac{h_t}{\bar{h}} = \left(\frac{h_{t-1}}{\bar{h}}\right)^{\rho_h} \left(\frac{\pi_t}{\pi_t^T}\right)^{\lambda_\pi} \left(\frac{Y_t}{\bar{Y}}\right)^{\lambda_y} \varepsilon_t^{mb} \quad (138)$$

Where, h_t is the growth rate of the monetary base in period t, which is defined as follows:

$$h_t = \frac{mb_t}{mb_{t-1}}\pi_t \quad (139)$$

The target inflation (π_t^T) is assumed to follow a first-order autoregressive process as follows:

$$\pi_t^T = \rho_T \pi_{t-1}^T + (1-\rho_T)\bar{\pi}^T + \varepsilon_t^T \quad (140)$$

The change in the central bank's net foreign assets in real terms can be considered as follows:

$$re_t fr_t - re_t \frac{fr_{t-1}}{\pi_t^f} = \omega re_t or_t + \frac{P_t^x}{P_t^f} Y_t^x - \frac{P_t^{cm}}{P_t} C_t^m - \frac{P_t^{Im}}{P_t} I_t^m - \frac{P_t^{Inm}}{P_t} In_t^m \quad (141)$$

Where, π_t^f is the external inflation rate and follows a first-order autoregressive process as follows:

$$\pi_t^f = \rho_f \pi_{t-1}^f + (1-\rho_f)\bar{\pi}^f + \varepsilon_t^f \quad (142)$$

4-6-7 Exchange rate policymaking

There are three types of currency systems in the world: fixed exchange rate system, floating exchange rate system, and managed floating exchange rate system. The two fixed and floating exchange rate systems are less concerned by the monetary authorities of the countries, and the managed floating exchange rate system is used more to achieve the goals. Considering the managed floating exchange rate system for the exchange rate in Iran, the Central Bank uses the growth of the nominal exchange rate to set currency policy. In this regard, the Central Bank, on the one hand, reacts to the gap between the domestic inflation rate and the foreign inflation rate and, in proportion to the aforementioned gap, allows the exchange rate to increase in the foreign exchange market, and on the other hand, considers a precautionary limit for its foreign reserves and considers this precautionary limit as the share of foreign reserves in the monetary base to control the foreign exchange market. Therefore, in a situation where the share of the Central Bank's foreign reserves in the monetary base falls below the precautionary limit considered by the Central Bank, the Central Bank will allow the exchange rate to increase. Therefore, the reaction function of exchange rate policy, following (Essonson and Woodford, 2003) and (Eskud, 2013), is defined as follows:

$$\frac{\gamma_t}{\bar{\gamma}} = \left(\frac{\gamma_{t-1}}{\bar{\gamma}}\right)^{\rho_\gamma} \left(\frac{\pi_t}{\pi_t^f}\right)^{e_1} \left(\frac{\frac{re_t fr_t}{mb_t}}{\frac{\overline{re}\,\overline{fr}}{\overline{mb}}}\right)^{e_2} \varepsilon_t^e \quad (143)$$

where γ_t is the nominal exchange rate growth. The nominal exchange rate impulse (ε_t^e) follows a first-order autoregressive process as follows:

$$\varepsilon_t^e = \rho_e \varepsilon_{t-1}^e + \varepsilon_t^{ue} \quad (144)$$

The real exchange rate (re_t) defined as follows:

$$re_t = \frac{e_t P_t^f}{P_t} \quad (145)$$

Where, e_t is the nominal exchange rate, P_t^f is the price index of foreign goods, and P_t is the price index of total consumer goods.

4-7- Commodity market settlement condition

One of the most important equations is the goods market settlement, where real GDP equals household consumption, household investment, government current expenditure, government development expenditure, and net exports (total exports minus total imports). Total exports equal the sum of revenues from oil exports and exports of intermediate goods (non-oil exports), and total imports equal the imports of consumer goods, imports of capital goods, and imports of intermediate inputs. Therefore, the goods market settlement condition is defined as follows:

$$Y_t = C_t + I_t + G_t^c + G_t^I + re_t or_t + \frac{P_t^x}{P_t^f} Y_t^x - \frac{P_t^{cm}}{P_t} C_t^m - \frac{P_t^{Im}}{P_t} I_t^m - \frac{P_t^{Imm}}{P_t} In_t^m \quad (146)$$

Real GDP (total output) is equal to the sum of non-oil production and revenues from oil exports, which is defined as follows:

$$Y_t = Y_t^{no} + re_t or_t \quad (147)$$

Given that all price variables in the research model need to be presented uniformly, the domestic consumer goods price index, imported consumer goods price index, domestic capital goods price index, imported capital goods price index, total intermediate input price index, price index of intermediate goods supplied to the domestic market, price index of intermediate inputs demanded from the domestic market, and price index of intermediate inputs demanded from foreign markets are considered in relation to the total consumer goods price index and the price index of intermediate goods supplied to foreign markets in relation to the price index of foreign goods.

Also, given that the domestic consumer goods price index, the imported consumer goods price index, the domestic capital goods price index, the imported capital goods price index, the total intermediate input price index, the price index of intermediate goods supplied to the domestic market, the price index of intermediate goods supplied to foreign markets, the price index of intermediate inputs demanded from the domestic market, the price index of intermediate inputs demanded from foreign markets, the total consumer goods price index, and the price index of foreign goods are in the form of inflation rates, all of the aforementioned ratios are defined as follows:

Ratio of the domestic consumer price index to the total consumer price index:

$$\gamma_t^{cd} = \frac{P_t^{cd}}{P_t} \qquad \gamma_t^{cd} = \frac{\pi_t^{cd}}{\pi_t} \gamma_{t-1}^{cd} \quad (148)$$

Ratio of the price index of imported consumer goods to the price index of total consumer goods:

$$\gamma_t^{cm} = \frac{P_t^{cm}}{P_t} \qquad \gamma_t^{cm} = \frac{\pi_t^{cm}}{\pi_t} \gamma_{t-1}^{cm} \quad (149)$$

Ratio of the domestic capital goods price index to the total consumer goods price index:

$$\gamma_t^{Id} = \frac{P_t^{Id}}{P_t} \qquad \gamma_t^{Id} = \frac{\pi_t^{Id}}{\pi_t} \gamma_{t-1}^{Id} \quad (150)$$

Ratio of the price index of imported capital goods to the price index of total consumer goods:

$$\gamma_t^{Im} = \frac{P_t^{Im}}{P_t} \qquad \gamma_t^{Im} = \frac{\pi_t^{Im}}{\pi_t} \gamma_{t-1}^{Im} \quad (151)$$

Ratio of the total price index of intermediate inputs to the total price index of consumer goods:

$$\gamma_t^{In} = \frac{P_t^{In}}{P_t} \qquad \gamma_t^{In} = \frac{\pi_t^{In}}{\pi_t}\gamma_{t-1}^{In} \qquad (152)$$

Ratio of the price index of intermediate goods supplied to the domestic market to the price index of total consumer goods:

$$\gamma_t^{d} = \frac{P_t^{d}}{P_t} \qquad \gamma_t^{d} = \frac{\pi_t^{d}}{\pi_t}\gamma_{t-1}^{d} \qquad (153)$$

Ratio of the price index of intermediate goods supplied to foreign markets to the price index of foreign goods:

$$\gamma_t^{x} = \frac{P_t^{x}}{P_t^{f}} \qquad \gamma_t^{x} = \frac{\pi_t^{x}}{\pi_t^{f}}\gamma_{t-1}^{x} \qquad (154)$$

Ratio of the price index of intermediate inputs demanded from the domestic market to the price index of total consumer goods:

$$\gamma_t^{Ind} = \frac{P_t^{Ind}}{P_t} \qquad \gamma_t^{Ind} = \frac{\pi_t^{Ind}}{\pi_t}\gamma_{t-1}^{Ind} \qquad (155)$$

Ratio of the price index of intermediate inputs demanded from foreign markets to the price index of total consumer goods:

$$\gamma_t^{Inm} = \frac{P_t^{Inm}}{P_t} \qquad \gamma_t^{Inm} = \frac{\pi_t^{Inm}}{\pi_t}\gamma_{t-1}^{Inm} \qquad (156)$$

5- Initializing template parameters

In this paper, due to the lack of access to high-quality data for a number of variables and also due to the complexity of simultaneous estimation, calibration is preferred over Bayesian estimation and the calibration method is used to estimate the model parameters.

Before simulating the model and obtaining the instantaneous response functions (IRF), it is necessary to estimate the model parameters, which is done in this study using the calibration method. In this study, a number of parameters are quantified using the estimation method and other parameters are quantified using the long-run ratio of macroeconomic variables. For this purpose, parameters such as the habit stability parameter, the elasticity of the investment adjustment cost function, the coefficient of the first-order autoregressive process of the investment impulse, the production elasticity of private capital input, the production elasticity of public capital input, the coefficient of the first-order autoregressive process of productivity, First-order autoregressive coefficient of transaction costs in the intermediate goods export sector, first-order autoregressive coefficient of transaction costs in the consumer goods import sector, first-order autoregressive coefficient of transaction costs in the capital goods import sector, first-order autoregressive coefficient of transaction costs in the intermediate inputs import sector, first-order autoregressive coefficient of oil export revenues, first-order autoregressive coefficient of government development expenditures, first-order autoregressive coefficient of government current expenditures, elasticity of government current expenditures relative to a lump sum tax, percentage of oil export revenues spent by the government, The coefficient of the first-order autoregressive process of the tax rate, the coefficient of the autoregressive process of the monetary policy response function, the coefficient of the importance of the gap between the inflation rate and the target inflation in the monetary policy response function, the coefficient of the importance of the gap between current output and potential output in the monetary policy response function, the coefficient of the first-order autoregressive process of the target inflation, the coefficient of the first-order autoregressive process of the inflation of the foreign goods price index, the coefficient of the autoregressive process of the exchange rate response function, the coefficient of the importance of the gap between the domestic inflation rate and the foreign inflation rate in the exchange rate response function, The coefficient of the ratio of the central bank's foreign reserves to the monetary base in the exchange rate policy reaction function and the coefficient of the first-order autoregressive process of the nominal exchange rate shock were obtained using the estimation method from previous studies.

Other research parameters are estimated using the long-term ratio of macroeconomic variables. According to this method, in the first stage, the geometric mean of the ratio of non-price macro variables to GDP and the ratio of price macro variables, including the ratio of the domestic consumer goods price index, the ratio of the imported consumer goods price index, the ratio of the domestic capital goods price index, the ratio of the imported capital goods price index, the ratio of the total intermediate inputs price index, the ratio of the price index of intermediate goods supplied to the domestic market, the ratio of the price index of

intermediate inputs demanded from the domestic market, and the ratio of the price index of intermediate inputs demanded from foreign markets to the total consumer goods price index And the ratio of the price index of intermediate goods supplied to foreign markets to the price index of foreign goods has been calculated using the time series of macroeconomic variables.

In the second stage, the equations of the research model were entered nonlinearly into the Maple computing software and the geometric mean of the ratio of non-price macro variables to GDP and the ratio of price macro variables, including the ratio of the domestic consumer goods price index, the ratio of the imported consumer goods price index, the ratio of the domestic capital goods price index, the ratio of the imported capital goods price index, the ratio of the total intermediate inputs price index, the ratio of the price index of intermediate goods supplied to the domestic market, the ratio of the price index of intermediate inputs demanded from the domestic market, and the ratio of the price index of intermediate inputs demanded from foreign markets to the total consumer goods price index, and The ratio of the price index of intermediate goods supplied to foreign markets to the price index of foreign goods is entered as the long-term ratio of macroeconomic variables in the nonlinear equations of the model, and the Maple software, by solving simultaneous equations, determines the model parameters using the long-term ratio of macroeconomic variables calculated from the geometric mean of the ratio of non-price macroeconomic variables to GDP and It calculates the ratio of macro-price variables, including the ratio of the domestic consumer goods price index, the ratio of the imported consumer goods price index, the ratio of the domestic capital goods price index, the ratio of the imported capital goods price index, the ratio of the total intermediate inputs price index, the ratio of the price index of intermediate goods supplied to the domestic market, the ratio of the price index of intermediate inputs demanded from the domestic market, and the ratio of the price index of intermediate inputs demanded from foreign markets to the total consumer goods price index, and the ratio of the price index of intermediate goods supplied to foreign markets to the price index of foreign goods.

The long-term ratio of non-price macro variables to GDP and the long-term ratio of price macro variables, including the ratio of the domestic consumer goods price index, the ratio of the imported consumer goods price index, the ratio of the domestic capital goods price index, the ratio of the imported capital goods price index, the ratio of the total intermediate inputs price index, the ratio of the price index of intermediate goods supplied to the domestic market, the ratio of the price index of intermediate inputs demanded from the domestic market, and the ratio of the price index of intermediate inputs demanded from foreign markets to the total consumer goods price index, and the ratio of the price index of intermediate goods supplied to foreign markets to the price index of foreign goods, are as follows in Table 1:

Table 1- Long-run ratio of macroeconomic variables

Explanation	Proportion symbol	Amount
Gross Domestic Product	Y	1
household consumption	C	0.446
Household consumption of domestic consumer goods	C^d	0.422
Household consumption of imported consumer goods	C^m	0.026
Household investment	I	0.23
Household investment in domestic capital goods	I^d	0.0221
Household investment in imported capital goods	I^m	0.016
Intermediate goods, intermediary firm	Y^{no}	1.2
Intermediate goods An intermediary firm's supply of intermediate goods to the domestic market	Y^d	1.1089
Intermediate goods An intermediary firm of intermediate goods supplied to foreign markets	Y^x	0.0859
Intermediate inputs of the intermediary firm	In	0.367
Intermediate inputs of an intermediary firm from the intermediate inputs demanded from the domestic market	In^d	0.3065
Intermediate inputs of an intermediary firm from intermediate inputs demanded from foreign markets	In^m	0.0701
Bonds	b	0.026
Wage	w	0.2987
Rate of return on capital	r^k	0.0527

Monetary base	mb	0.12
Real exchange rate	re	1
Central Bank Net Foreign Assets	fr	0.084
Net government debt to the central bank	dc^g	0.036
Government current expenditure	G^c	0.116
Government development spending	G^I	0.09
Ratio of the domestic consumer price index to the total consumer price index	γ^{cd}	1.01057
Ratio of the price index of imported consumer goods to the price index of total consumer goods	γ^{cm}	0.76
Ratio of the domestic capital goods price index to the total consumer goods price index	γ^{Id}	1.0367
Ratio of the price index of imported capital goods to the price index of total consumer goods	γ^{Im}	1.94
Ratio of the total price index of intermediate inputs to the total price index of consumer goods	γ^{In}	1.159
Ratio of the price index of intermediate goods supplied to the domestic market to the price index of total consumer goods	γ^{d}	0.9991
Ratio of the price index of intermediate goods supplied to foreign markets to the price index of foreign goods	γ^{x}	1.25
Ratio of the price index of intermediate inputs demanded from the domestic market to the price index of total consumer goods	γ^{Ind}	1.022
The ratio of the price index of intermediate inputs demanded from foreign markets to the price index of total consumer goods	γ^{Inm}	1.6

Source: Nakhli et al. (2020)

Using the above methods, the model parameters are estimated according to Tables 2, 3, 4, and 5:

Table 2- Estimated parameters of the household sector and the labor market

Explanation	Parameter symbol	Amount	Source
Inverse elasticity of labor supply	σ_l	2.9	Nakhli et al. (2020)
Inverse elasticity of substitution between consumption periods	σ_c	1.2	Nakhli et al. (2020)
Habit stability parameter	h	0.3096	Taghipour (2014)
Inverse interest elasticity of demand for real money balances	σ_m	1.25	Nakhli et al. (2020)
Elasticity of the investment adjustment cost function	$\emptyset$	3.9374	Taghipour (2014)
Discount factor	β	0.965	Nakhli et al. (2020)
Private capital depreciation rate	δ	0.0103	Nakhli et al. (2020)
Coefficient of the first-order autoregressive process of investment impulse	ρ_I	0.446	Vali Beigi et al. (2018)
Elasticity of substitution between domestic consumer goods and imported consumer goods	θ_c	2.46	Nakhli et al. (2020)
Share of domestic consumer goods in the household consumption index	α_c	0.9	Nakhli et al. (2020)
Elasticity of substitution between domestic capital goods and imported capital goods	θ_I	1.54	Nakhli et al. (2020)
Share of domestic capital goods in the household investment index	α_I	0.84	Nakhli et al. (2020)
Wage indexation level	τ_w	0.6	Nakhli et al. (2020)

Percentage of households unable to determine their optimal wage	υ_w	0.68	Heydarian et al. (2024)

Table 3- Estimated parameters of the intermediate goods manufacturing firm sector

Explanation	Parameter symbol	Amount	Source
Production elasticity of private capital input	φ	0.423	Farzin Vash et al. (2014)
Labor input production elasticity	η	0.3	Nakhli et al. (2020)
Production elasticity of government capital input	θ_g	0.082	Taghipour (2014)
Coefficient of the first-order autoregressive process of productivity	ρ_a	0.8	Tavakolian and Qayai (2019)
The elasticity of substitution between intermediate goods supplied to the domestic market and intermediate goods supplied to foreign markets	θ_y	2.77	Nakhli et al. (2020)
The share of intermediate goods supplied to the domestic market in the intermediate goods index of the intermediary firm	α_y	0.9	Nakhli et al. (2020)
The degree of price indexation of the intermediary firm supplying the product to the domestic market	τ_d	0.4984	Tavakolian (2012)
Percentage of intermediary firms supplying products to the domestic market that are unable to determine their optimal price	υ_d	0.5	Nakhli et al. (2020)
Elasticity of substitution between intermediate inputs demanded from the domestic market and intermediate inputs demanded from foreign markets	θ_{In}	1.39	Nakhli et al. (2020)
The share of intermediate inputs demanded from the domestic market in the intermediate input index of the intermediary firm	α_{In}	0.7	Nakhli et al. (2020)

Table 4- Estimated parameters of the trade sector

Explanation	Parameter symbol	Amount	Source
The degree of price indexation of the intermediary firm supplying the product to foreign markets	τ_x	0.499	Vali Beigi et al. (2018)
Percentage of intermediary firms supplying products to foreign markets that are unable to determine their optimal price	υ_x	0.66	Heydarian et al. (2024)
Coefficient of the first-order autoregressive process of transaction costs in the intermediate goods export sector	ρ_x	0.4	Nakhli et al. (2020)
Elasticity of transaction costs in the intermediate goods export sector to the increasing severity of international sanctions	SSX	0.2	Nakhli et al. (2020)
The degree of price indexation of the consumer goods importing firm	τ_{cm}	0.499	Vali Beigi et al. (2018)
Percentage of firms importing consumer goods that are unable to determine their optimal price	υ_{cm}	0.42	Heydarian et al. (2024)
Coefficient of the first-order autoregressive process of transaction costs in the consumer goods import sector	ρ_{cm}	0.4	Nakhli et al. (2020)
Elasticity of transaction costs in the consumer goods import sector to the increasing severity of international sanctions	$SSCm$	0.2	Nakhli et al. (2020)
The degree of price indexation of the capital goods importing firm	τ_{Im}	0.499	Vali Beigi et al. (2018)

Percentage of firms importing capital goods that are unable to determine their optimal price	υ_{Im}	0.11	Heydarian et al. (2024)
Coefficient of the first-order autoregressive process of transaction costs in the capital goods import sector	ρ_{Im}	0.4	Nakhli et al. (2020)
Elasticity of transaction costs in the capital goods import sector to the increasing severity of international sanctions	$SSIm$	0.2	Nakhli et al. (2020)
The degree of price indexation of the firm importing intermediate inputs	τ_{Inm}	0.499	Vali Beigi et al. (2018)
Percentage of firms importing intermediate inputs that are unable to determine their optimal price	υ_{Inm}	0.11	Heydarian et al. (2024)
Coefficient of the first-order autoregressive process of transaction costs in the intermediate input import sector	ρ_{Inm}	0.4	Nakhli et al. (2020)
Elasticity of transaction costs of intermediate input imports to the increasing severity of international sanctions	$SSInm$	0.2	Nakhli et al. (2020)
Coefficient of the first-order autoregressive process of oil export revenues	ρ_{or}	0.33	Nakhli et al. (2020)
The elasticity of oil export revenues to the increasing severity of international sanctions	$SSor$	-0.5	Nakhli et al. (2020)

Table 5- Estimated parameters of the government sector and the central bank

Explanation	Parameter symbol	Amount	Source
Government capital depreciation rate	δ^G	0.0233	Nakhli et al. (2020)
Coefficient of the first-order autoregressive process of government development spending	ρ_{GI}	0.575	Vali Beigi et al. (2018)
Coefficient of the first-order autoregressive process of current government expenditure	ρ_g	0.4206	Vali Beigi et al. (2018)
Elasticity of current government spending relative to lump sum tax	g_1	0.3399	Taghipour (2014)
Percentage of oil export revenues spent by the government	ω	0.78	Tavakolian (2012)
Coefficient of the first-order autoregressive process of the tax rate	ρ_r	0.789	Vali Beigi et al. (2018)
The coefficient of the autoregressive process of the monetary policy response function	ρ_h	0.4	Tavakolian and Qayai (2019)
The importance coefficient of the gap between the inflation rate and the target inflation in the monetary policy reaction function	λ_π	-1.54	Taghipour and Manzoor (2014)
The importance coefficient of the gap between current output and potential output in the monetary policy response function	λ_y	-1.7	Taghipour and Manzoor (2014)
Coefficient of the first-order autoregressive process of target inflation	ρ_T	0.6	Permeh et al. (2016)
Coefficient of the first-order autoregressive process of inflation of the foreign goods price index	ρ_f	0.902	Vali Beigi et al. (2018)
Autoregressive process coefficient of the foreign exchange policy reaction function	ρ_γ	0.7	Tavakolian and Qayai (2019)
The importance coefficient of the gap between the domestic inflation rate and the external inflation rate in the exchange rate policy reaction function	e_1	-1.9	Tavakolian and Jalali (2017)
The coefficient of the ratio of central bank foreign reserves to the monetary base in the exchange rate policy reaction function	e_2	-1.55	Tavakolian and Jalali (2017)
Coefficient of the first-order autoregressive process of nominal exchange rate impulse	ρ_e	0.887	Vali Beigi et al. (2018)

6- Evaluating model fit and performance

To assess the fit and accuracy of the model simulation, the comparison of second-order moments in the form of variance and correlation of variables with the benchmark variable (here GDP) between real-world data and simulated values of variables is used. Since the basis of DSGE models is the changes in the random component of variables in a general equilibrium framework and the model of the present study is also linearly coded and the equations are linearized in logarithms and all variables are considered as logarithmic differences of their long-term values, it is necessary to extract the moments of the real data of the variables, first the time series of all selected variables are considered logarithmically and then using the Hodrick-Prescott filter, the long-term logarithm value of the variable is separated as a trend component from the value of fluctuations. Then the value of the fluctuations of the variables is used as the basis for calculating the moments of the variables (variance or correlation). Considering the torque values obtained from the model simulation as well as the calculated torque values of the real data in Table 6, the model is acceptable for simulation.

A comparison of the second-order moments of the variables of GDP, household consumption, household investment, current government spending, and non-oil exports with the simulated moments of these variables is presented in Table 6. The closer the simulated moments are to the actual moments, the more appropriately the model has been able to explain the realities of the Iranian economy.

Table 6 - Comparison of actual and simulated torques of selected variables

Variable	Variable symbol	Variance		Correlation with GDP	
		Real data	Simulation data	Real data	Simulation data
Gross Domestic Product	Y	0.0056	0.0021	1	1
Household consumption	C	0.0044	0.0032	0.924	0.911
Household investment	I	0.0136	0.0131	0.721	0.518
Current government spending	G^c	0.0042	0.0061	0.362	0.648
Non-oil exports	Y^x	0.0752	0.0516	0.432	0.583

Source: Research findings

As is clear from the above table, the second-order moments of the variables of GDP, household consumption, household investment, current government expenditure and non-oil exports of the model are almost consistent with the second-order moments of the actual data of these variables. This situation indicates that the designed model can be used for studying the Iranian economy.

7- Analysis of instantaneous response functions of macroeconomic variables

In this section, the impact of international sanctions shocks on macroeconomic variables and the impact of nominal exchange rate shocks on macroeconomic variables are analyzed using the instantaneous response functions of the variables.

After exporting oil and selling it to foreign buyers, the government's foreign exchange resources from oil exports are sold to the Central Bank, and the Central Bank increases the government's treasury account with rial resources in exchange for the dollars it has purchased. This action by the Central Bank increases the Central Bank's foreign reserves on the bank's balance sheet, which, given the role of the Central Bank's foreign reserves in the monetary base, increases the monetary base. If the share of the Central Bank's foreign reserves in the monetary base increases (against the share of the government's debt to the Central Bank in the monetary base), the Central Bank tries to increase the value of the rial against foreign currencies by increasing the supply of foreign currency to the market (decreasing the nominal exchange rate), and if the share of the Central Bank's foreign reserves in the monetary base decreases (against the share of the government's debt to the Central Bank in the monetary base), the Central Bank tries to reduce the value of the rial against foreign currencies by decreasing the supply of foreign currency to the market (increasing the nominal exchange rate). The first action of the central bank in the foreign exchange market leads to a decrease in the nominal exchange rate, and the second action of the central bank in the foreign exchange market leads to an increase in the nominal exchange rate.

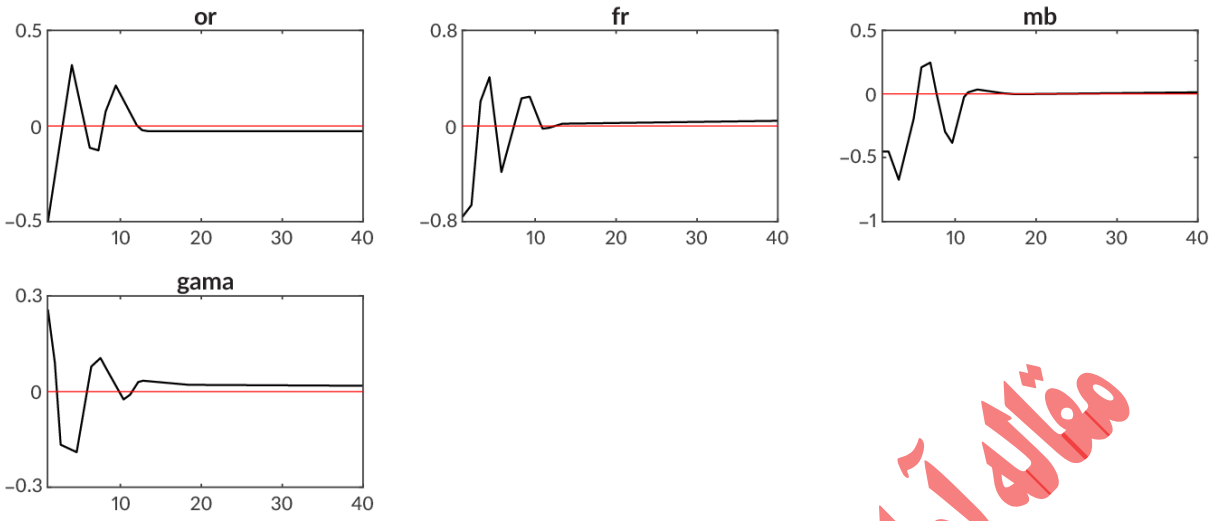

Figure 1- The impact of the international sanctions shock on the variables of oil export revenues, central bank foreign reserves, monetary base, and nominal exchange rate growth
Source: Research findings

According to Figure 1, as international sanctions become more severe, foreign exchange earnings from oil exports decrease. The decrease in foreign exchange earnings from oil exports leads to a decrease in the central bank's foreign reserves, and given the role of the central bank's foreign reserves in the monetary base, the monetary base decreases. Given the sharper decrease in the central bank's foreign reserves compared to the decrease in the monetary base, the ratio of the central bank's foreign reserves to the monetary base decreases, and by reducing the ratio of the central bank's foreign reserves to the monetary base, the central bank tries to reduce the value of the rial against foreign currencies by reducing the supply of foreign exchange to the market. This action by the central bank in the foreign exchange market leads to an increase in the growth of the nominal exchange rate.

International sanctions, by limiting and increasing the risk of international financial transactions and also increasing various types of financial frictions such as fines or even collecting the global exchange networks of the sanctioned country, sanctioning the banking network of the sanctioned country, preventing the formation of bilateral monetary agreements, preventing the physical transfer of currency notes or official banknotes of the sanctioned country, preventing the transfer of precious metals and non-financial frictions such as fines or even threats to international companies to insure commercial shipments of the sanctioned country, fines or even threats to international shipping companies to transport commercial shipments of the sanctioned country, threatening other countries to provide port services to ships carrying commercial shipments of the sanctioned country, numerous inspections of commercial shipments of the sanctioned country, increase the costs of trade exchange, including the export of intermediate goods and the import of consumer goods, the import of capital goods and the import of intermediate inputs for the sanctioned country, and by increasing the costs of Trade exchange, the marginal cost of commercial goods, including intermediate goods supplied to foreign markets (export intermediate goods) and imported consumer goods, imported capital goods and imported intermediate inputs, increases, and the increase in the marginal cost of commercial goods leads to an increase in the inflation of the price index of commercial goods, including intermediate goods supplied to foreign markets (export intermediate goods) and imported consumer goods, imported capital goods and imported intermediate inputs. The increase in the inflation of the price index of intermediate goods supplied to foreign markets (export intermediate goods) causes the competitiveness of domestic products to decrease against foreign products and causes a decrease in foreign demand for domestic products. The increase in the inflation of the price index of imported consumer goods, imported capital goods and imported intermediate inputs causes a decrease in domestic demand for foreign products.

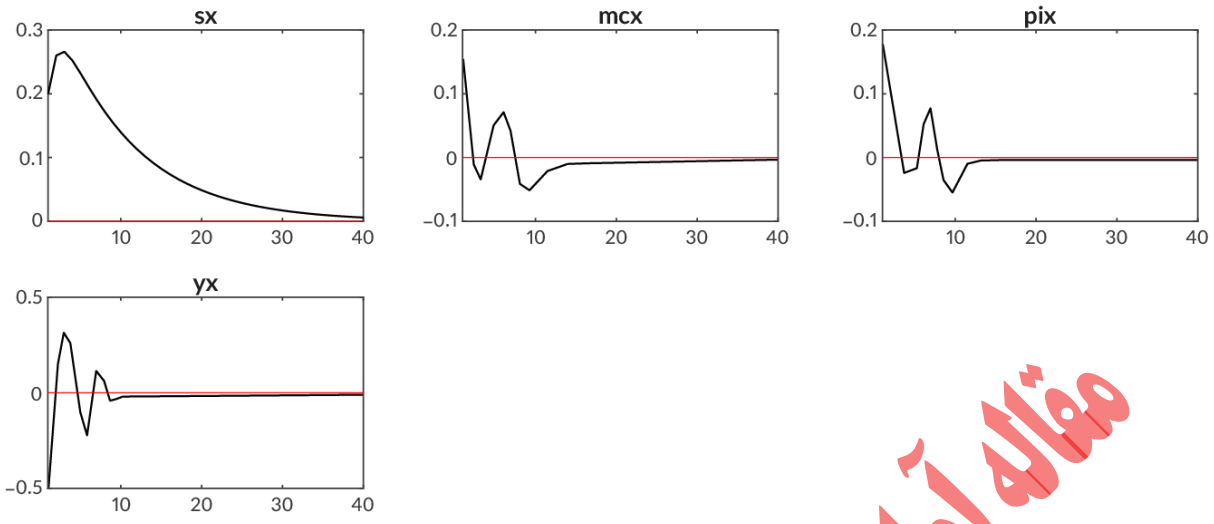

Figure 2- The impact of the international sanctions shock on the variables of transaction costs of exports of intermediate goods, the marginal cost of intermediate goods supplied to foreign markets (exported intermediate goods), the inflation index of the price of intermediate goods supplied to foreign markets, and the amount of exports of intermediate goods

Source: Research findings

According to Figure 2, as the intensity of international sanctions increases, the transaction costs of exporting intermediate goods increase. The increase in the transaction costs of exporting intermediate goods increases the final cost of intermediate goods supplied to foreign markets (exported intermediate goods), and the increase in the final cost of intermediate goods supplied to foreign markets leads to an increase in the inflation of the price index of intermediate goods supplied to foreign markets. The increase in the inflation of the price index of intermediate goods supplied to foreign markets causes the competitiveness of domestic products to decrease against foreign products, which reduces foreign demand for domestic products, and ultimately reduces the amount of exports of intermediate goods.

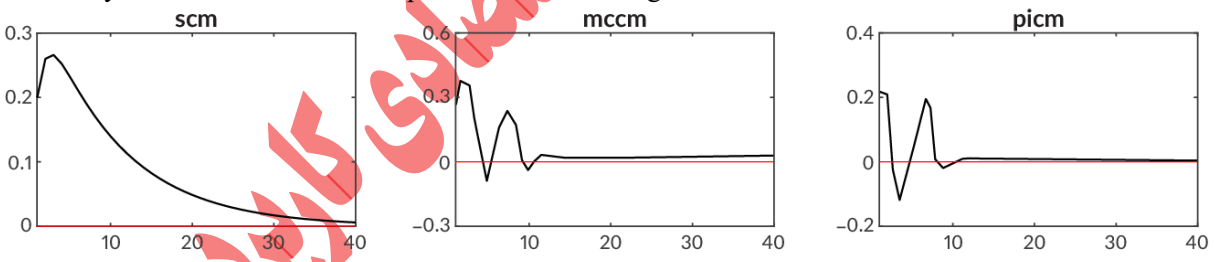

Figure 3- The impact of the international sanctions shock on the variables of transaction costs of imported consumer goods, the marginal cost of imported consumer goods, and the inflation index of imported consumer goods

Source: Research findings

According to Figure 3, as the intensity of international sanctions increases, the transaction costs of importing consumer goods increase. The increase in the transaction costs of importing consumer goods increases the final cost of imported consumer goods, and the increase in the final cost of imported consumer goods leads to an increase in the inflation of the price index of imported consumer goods.

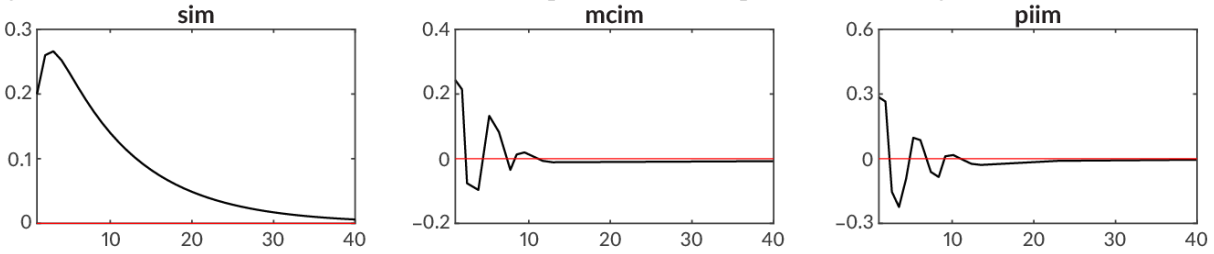

Figure 4- The impact of the international sanctions shock on the variables of transaction costs of imported capital goods, the marginal cost of imported capital goods, and the inflation of the price index of imported capital goods

Source: Research findings

According to Figure 4, as the intensity of international sanctions increases, the transaction costs of importing capital goods increase. The increase in the transaction costs of importing capital goods increases the final cost of imported capital goods, and the increase in the final cost of imported capital goods leads to an increase in the inflation of the price index of imported capital goods.

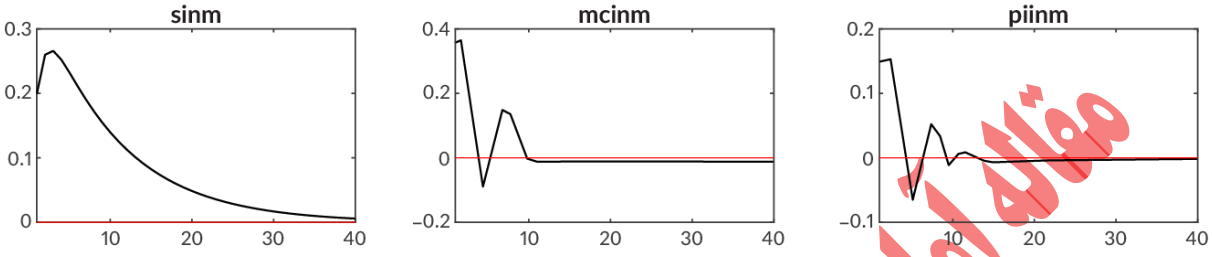

Figure 5- The impact of the international sanctions shock on the variables of transaction costs of imported intermediate inputs, the final cost of imported intermediate inputs, and the inflation of the price index of imported intermediate inputs

Source: Research findings

According to Figure 5, as the intensity of international sanctions increases, the transaction costs of importing intermediate inputs increase. An increase in the transaction costs of importing intermediate inputs increases the final cost of imported intermediate inputs, and an increase in the final cost of imported intermediate inputs leads to an increase in the inflation of the price index of imported intermediate inputs.

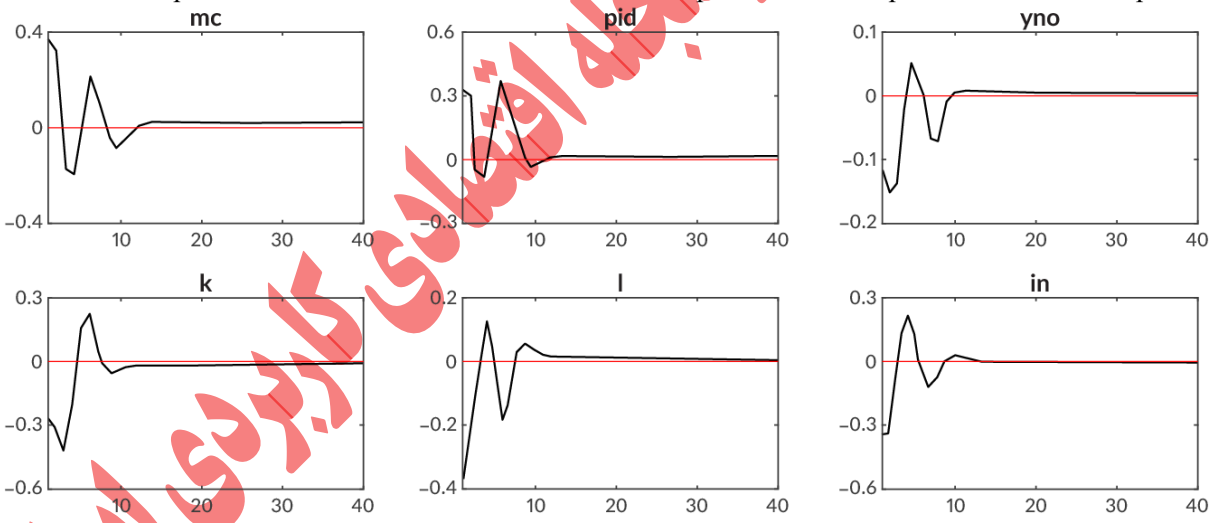

Figure 6 - The impact of the shock of international sanctions on the variables of the final cost of products produced by intermediary firms, the inflation index of the price of intermediate goods supplied to the domestic market, the production volume of intermediary firms, and the demand of producers of intermediate goods for private capital inputs, labor, and intermediate inputs

Source: Research findings

According to Figure 6, intermediate goods manufacturing firms that supply part of their products to the domestic market, due to the fact that they use imported intermediate inputs in the process of producing intermediate goods, face cost pressure with an increase in the inflation index of the price of imported intermediate inputs, which is manifested in the form of an increase in the final cost of the products produced by intermediate firms. With an increase in the final cost of the products produced by intermediate firms, the inflation index of the price of intermediate goods supplied to the domestic market increases. With an increase in the final cost of the products produced by intermediate firms, the production of intermediate firms

decreases and subsequently the demand of intermediate goods manufacturers for private capital inputs, labor, and intermediate inputs decreases.

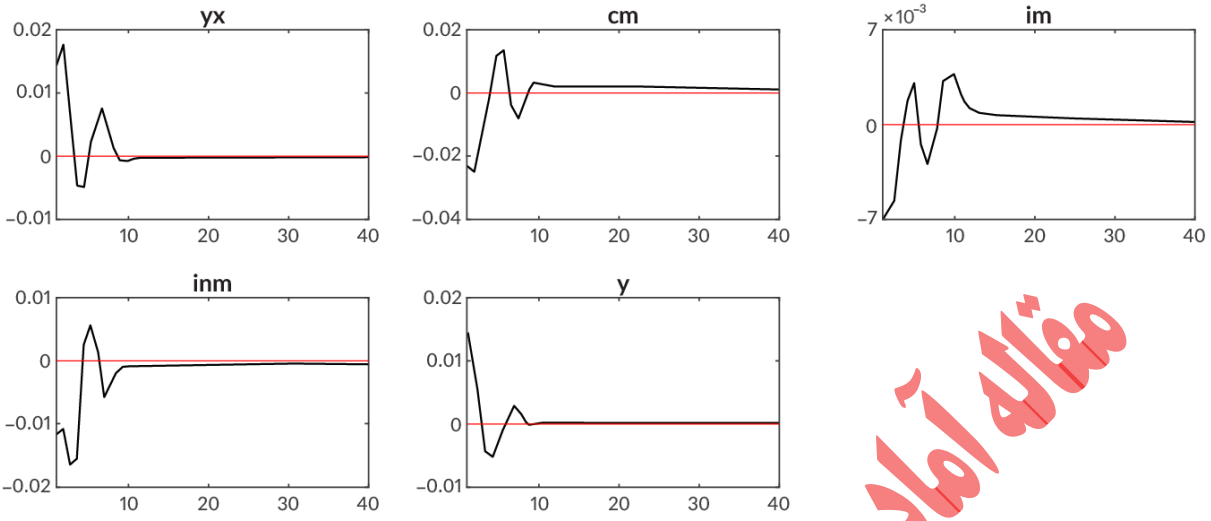

Figure 7 - The impact of a nominal exchange rate shock on the variables of intermediate goods exports, consumer goods imports, capital goods imports, intermediate input imports, and total output (GDP)

Source: Research findings

According to Figure 7, with an increase in the nominal exchange rate, the marginal cost of intermediate goods supplied to foreign markets (exported intermediate goods) decreases, and the decrease in the marginal cost of intermediate goods supplied to foreign markets leads to a decrease in the inflation of the price index of intermediate goods supplied to foreign markets. The decrease in the inflation of the price index of intermediate goods supplied to foreign markets increases the competitiveness of domestic products against foreign products, increases foreign demand for domestic products, and ultimately increases the amount of exports of intermediate goods.

According to Figure 7, with an increase in the nominal exchange rate, the marginal cost of imported consumer goods increases, and the increase in the marginal cost of imported consumer goods leads to an increase in the inflation of the price index of imported consumer goods. The increase in the inflation of the price index of imported consumer goods causes the competitiveness of foreign products to decrease against domestic products, which leads to a decrease in domestic demand for foreign products, and ultimately the amount of imported consumer goods decreases.

According to Figure 7, with an increase in the nominal exchange rate, the marginal cost of imported capital goods increases, and the increase in the marginal cost of imported capital goods leads to an increase in the inflation of the price index of imported capital goods. The increase in the inflation of the price index of imported capital goods causes the competitiveness of foreign products to decrease against domestic products, which leads to a decrease in domestic demand for foreign products, and ultimately the amount of capital goods imported decreases.

According to Figure 7, with an increase in the nominal exchange rate, the marginal cost of imported intermediate inputs increases, and the increase in the marginal cost of imported intermediate inputs leads to an increase in the inflation of the price index of imported intermediate inputs. The increase in the inflation of the price index of imported intermediate inputs causes the competitiveness of foreign products to decrease against domestic products, which leads to a decrease in domestic demand for foreign products, and ultimately the amount of imported intermediate inputs decreases.

According to Figure 7, total output (GDP) increases in response to an increase in the nominal exchange rate due to an increase in exports of intermediate goods and a decrease in imports of consumer goods, capital goods, and intermediate inputs.

8- Sensitivity analysis of model parameters

In this section, we examine the sensitivity analysis of the impact of international sanctions shocks on the inflation variable of the price index of intermediate goods supplied to the domestic market with respect to

changes in the parameter of the degree of stickiness of the price of the intermediary firm supplying the product to the domestic market (τ_d) and the sensitivity analysis of the impact of the nominal exchange rate shock on the inflation variable of the price index of intermediate goods supplied to foreign markets with respect to changes in the parameter of the degree of stickiness of the price of the intermediary firm supplying the product to foreign markets (τ_x).

The parameter of the degree of price stickiness of the intermediary firm supplying the product to the domestic market (τ_d) and the parameter of the degree of price stickiness of the intermediary firm supplying the product to foreign markets (τ_x) can range between zero (perfect price flexibility) and one (perfect price stickiness).

The results of the sensitivity analysis of the impact of the international sanctions shock on the inflation variable of the price index of intermediate goods supplied to the domestic market to changes in the price stickiness parameter of the intermediary firm supplying the product to the domestic market (τ_d) are given in Table 7. As explained in Figure 6, the impact of the international sanctions shock on the inflation variable of the price index of intermediate goods supplied to the domestic market is positive.

Table 7- Sensitivity analysis of the impact of international sanctions on the inflation variable of the price index of intermediate goods supplied to the domestic market with respect to changes in the parameter of the degree of stickiness of the price of the intermediate firm supplying the product to the domestic market (τ_d)

The parameter of the degree of price stickiness of the intermediary firm supplying the product to the domestic market (τ_d)	0	0.1	0.2	0.3	0.4
Average ($\times 10^{-6}$)	6.032	6.008	5.982	5.946	5.824
The parameter of the degree of price stickiness of the intermediary firm supplying the product to the domestic market (τ_d)	0.5	0.6	0.7	0.8	0.9
Average ($\times 10^{-6}$)	5.653	5.378	4.759	3.127	3.068

Source: Research findings

In Table 7, the average refers to the average impact of the international sanctions shock on the inflation variable of the price index of intermediate goods supplied to the domestic market over the 40 periods under study. As can be seen in Table 7, the average impact of the international sanctions shock on the inflation variable of the price index of intermediate goods supplied to the domestic market is close to each other at different values of the parameter of the degree of stickiness of the price of the intermediary firm supplying the product to the domestic market (τ_d), and the closeness of the average impact of the international sanctions shock on the inflation variable of the price index of intermediate goods supplied to the domestic market at different values of the parameter of the degree of stickiness of the price of the intermediary firm supplying the product to the domestic market (τ_d) shows that the results are not dependent on the calibrated values.

The results of the sensitivity analysis of the effect of the nominal exchange rate shock on the inflation variable of the price index of intermediate goods supplied to foreign markets with respect to changes in the parameter of the degree of stickiness of the price of the intermediary firm supplying the product to foreign markets (τ_x) are given in Table 8. As explained in Figure 7, the effect of the nominal exchange rate shock on the inflation variable of the price index of intermediate goods supplied to foreign markets is negative.

Table 8- Sensitivity analysis of the effect of a nominal exchange rate shock on the inflation variable of the price index of intermediate goods supplied to foreign markets with respect to changes in the parameter of the degree of stickiness of the price of the intermediate firm supplying the product to foreign markets (τ_x)

The parameter of the price stickiness of the intermediary firm supplying the product to foreign markets (τ_x)	0	0.1	0.2	0.3	0.4
Average ($\times 10^{-4}$)	-8.9304	-8.9257	-8.9241	-8.9185	-8.9062
The parameter of the price stickiness of the intermediary firm supplying the product to foreign markets (τ_x)	0.5	0.6	0.7	0.8	0.9
Average ($\times 10^{-4}$)	-8.8529	-8.8244	-8.7635	-8.4169	-8.2873

Source: Research findings

In Table 8, the mean means the average effect of the nominal exchange rate shock on the inflation variable of the price index of intermediate goods supplied to foreign markets over the 40 periods under study. As can be seen in Table 8, the average effect of the nominal exchange rate shock on the inflation variable of the price index of intermediate goods supplied to foreign markets is close to each other at different values of the parameter of the degree of stickiness of the price of the intermediary firm supplying the product to foreign markets (τ_x), and the closeness of the average effect of the nominal exchange rate shock on the inflation variable of the price index of intermediate goods supplied to foreign markets at different values of the parameter of the degree of stickiness of the price of the intermediary firm supplying the product to foreign markets (τ_x) shows that the results are not dependent on the calibrated values.

9- Policy proposals

1- Sanctioning countries do not impose sanctions on the strengths of the target country. The issue of reducing the value of the national currency (increasing the exchange rate) is one of the main weaknesses of the country. Surgery, reforms and structural changes, eliminating structural problems and strengthening the country's economic infrastructure (such as problems with the business environment, problems with the tax system, problems with the money, currency, capital markets, etc.) must be carried out in such a way that the Iranian economy can resist sanctions and neutralize their effects. This is the same as turning sanctions into a favorable opportunity to strengthen economic structures. The Iranian economy needs a resilient and resilient monetary and exchange system. It is obvious that by strengthening each area, the sanctions in that area will be lifted or rendered ineffective.

2- Given that economic sanctions have had a significant impact on the exchange rate, it is recommended that the country's diplomatic apparatus, through an active foreign policy and the use of economic diplomacy, make every effort to lift sanctions or at least reduce them to a weak level, and prevent global consensus building, especially by the United States of America, against Iran and Iran's exit from economic isolation (in the context of tension-free relations with other countries). By lifting sanctions, the rate of utilization of production capacities will increase and the entry of capital goods will also be facilitated.

3- In the context of economic sanctions, where the amount of income from oil exports has been severely limited and the amount of non-oil exports of the country and the foreign exchange earned from it have also decreased, and the country's import needs, mainly consumer goods, capital goods, and essential intermediate inputs, remain strong, the country's foreign exchange resources are limited. Therefore, in the first step, it is necessary for the government and the Central Bank to prevent the negative and destructive impact of economic sanctions on the country's trade, firstly, to prevent the wastage of the country's foreign exchange resources and refrain from allocating foreign exchange to unnecessary imported goods, and secondly, to make the foreign exchange available in the country available to meet the country's essential imported needs and goods that do not have domestic equivalents. Announcing a list of essential imported items and goods that do not have domestic equivalents and establishing supervisory systems in the country's customs are among the prerequisites for this policy proposal.

4- Since Iran is forced to import a number of raw materials, goods and services, and under economic sanctions, the import of these goods that are in the process of production is reduced, therefore, through necessary policies such as incentive policies, maximum use of domestic tricks, foreign joint investments, etc., measures should be devised so that a part of the capital goods and intermediate inputs required are

produced domestically, considering the existing capabilities, so that the country's production capacity does not face problems. Therefore, the first step is long-term planning in the field of self-sufficiency in the production of those goods and cutting off imports. Entering this path requires prerequisites such as a calculated roadmap, estimating the ability and capacity to achieve the required technical knowledge, using all available capacities (even foreign capacity), and finally, real support for those working in that field. The second step is to continue on the path of self-sufficiency, and even if sanctions are lifted or it is possible to import those goods cheaper than the domestic cost, the prepared roadmap should still proceed without interruption. Even if it is not economically viable for those products to be produced in the country, the potential possibility of producing them in the country should be institutionalized and, with the advancement of science, the quality and technology of their production should also be updated.

5- The results show that the policy of devaluation of the national currency (policy of increasing the exchange rate) cannot create serious momentum in non-oil exports. If policymakers are seeking to stimulate non-oil exports, non-price policies should also be considered in addition to this policy. These policies include: improving the country's business environment, improving trade infrastructure, developing credit lines with target export markets, granting facilities at preferential and targeted rates, strong economic and trade diplomacy in export markets, and ...

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