POLITECNICO DI TORINO

Department of Management and Production Engineering

Master of Science Degree in Engineering and Management

THE STUDY OF RIAL-DOLLAR EXCHANGE RATE BEHAVIOUR IN THE SHADOW OF SANCTIONS

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ABSTRACT

The exchange rate refers to the value of one country's currency relative to another country's currency [1]. Exchange rates are determined by a variety of factors, including economic and political conditions, interest rates, and trade balances. Exchange rates have a significant impact on international trade, as they affect the cost of importing and exporting goods and services. They also affect the value of international investments and the purchasing power of individuals who travel or make purchases in foreign countries [2].

Iran's exchange rate is a topic that can be quite complicated due to the country's complex economic and political situation. In recent years, Iran has experienced significant fluctuations in its exchange rate, with the value of its currency, the Iranian rial, declining significantly against major currencies like the US dollar and euro. One major factor affecting Iran's exchange rate is economic sanctions imposed by the United States and other countries, which have limited the country's ability to export its oil and conduct international financial transactions. Additionally, inflation and other economic factors have also played a role in the devaluation of the rial [3].

Exchange rate modeling is a crucial tool for businesses, investors, and policymakers who want to understand the factors affecting exchange rates and make informed decisions about currency transactions, international trade, and monetary policy. Some common exchange rate modeling techniques include time series analysis, which looks at past exchange rate data to identify trends and patterns that can be used to forecast future rates. Other techniques include econometric modeling, which uses mathematical models to analyze the relationships between exchange rates and various economic variables like interest rates, inflation, and GDP [3].

This article examines the behavior of the exchange rate between the Iranian Rial and the US dollar in the context of economic sanctions imposed on Iran by the United States and other countries. Using a combination of quantitative and qualitative analysis, the study investigates the impact of sanctions on the exchange rate, as well as the underlying economic and political factors driving currency fluctuations in Iran. Moreover, the study utilizes time series analysis to explore the trends and patterns of the exchange rate over 2015-2023. The findings of the study suggest that economic sanctions have had a significant impact on the Rial behavior, leading to a decline in its value against the US dollar. Additionally, the study identifies a range of other economic and political factors that contribute to the volatility of the exchange rate, including inflation, political instability, and fluctuations in oil prices.

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CHAPTER 1

IRAN'S OUTLOOK BY 2015

1. Global Economy

Economic globalization is one of the three main dimensions of globalization commonly found in academic literature, with the two others being political globalization and cultural globalization, as well as the general term of globalization [4]. Economically, globalization involves goods, services, data, technology, and the economic resources of capital. The expansion of global markets liberalizes the economic activities of the exchange of goods and funds. The removal of cross-border trade barriers has made the formation of global markets more feasible [5]. In a globalized economy, countries specialize in the products and services they have a competitive advantage. This generally means what they can produce and provide most efficiently, with the least amount of resources, at a lower cost than competing nations. If all countries are specializing in what they do best, production should be more efficient worldwide, prices should be lower, economic growth widespread, and all countries should benefit, in theory [6].

2. International Trade

The most notable manifestation of the global economy is the rise in international trade and capital flows. International trade is the purchase and sale of goods and services by companies in different countries. Consumer goods, raw materials, food, and machinery all are bought and sold in the international marketplace. International trade allows countries to expand their markets and access goods and services that otherwise may not have been available domestically. As a result of international trade, the market is more competitive. This ultimately results in more competitive pricing and brings a cheaper product home to the consumer [7]. Globalization of trade offers immediate benefits: faster growth, higher living standards, and new economic opportunities. On the downside, not all countries have benefited equally from the globalization phenomena. Those that do not have the technical capabilities, infrastructure, and institutional capacity found themselves falling behind even further. Exchange rates play a central role in international trade because they allow us to compare the prices of goods and services produced in different countries [8].

3. Exchange Rate

The exchange rate is the price of one currency in terms of another currency. In another word, the required amount of one currency to buy some of another currency is the exchange rate. Therefore, this rate can be a conversion factor. In general, the exchange rate is the relative price of foreign currency to domestic currency, which has always been considered by the economic and financial community as one of the macroeconomic factors. In fact, this rate reflects the economic conditions of a country and is a factor for comparing the national economy with the economies of other nations [9].

Exchange rates have a penetrating effect on all other prices. If the currency market is inefficient, currencies are often incorrectly priced. This distortion will spread over all other markets, and it causes the misallocation of resources that leads eventually to welfare losses. On the other hand, inefficiency in currency markets can lead to excessive exchange rate volatility. Exchange rate volatility is inevitable when rates float, but excess exchange rate volatility increases the exchange rate risk and may decrease the flow of trade and investment [10].

3.1. Factors Affecting Exchange Rates Directly

In reality, the factors which influence the value of a currency at any particular moment are highly complex. While interest rates are a key part of the equation and while the effect of a change to interest rates is often immediately noticed in exchange rates, the overall number of factors that affect exchange rates is highly complicated [11].

3.1.1. Interest Rates

Interest rates are a key factor in determining the value of a currency. Interest rates are set by central banks. They refer to the amount you pay back on loans and how much you'll be paid to save with a bank. If it were possible to remove all the other elements that contribute to the value of a currency, an increase in the interest rate would cause the value of a currency to rise. Essentially, this is because higher interest rates in a particular currency offer investors (those who buy a currency) a higher return relative to other currencies. As a result, investors are attracted to a currency and invest in it more heavily. As more investors are attracted, demand for the currency increases, and its value goes up. The opposite relationship is true for decreasing interest rates.

That is, lower interest rates tend to decrease the value of a currency [11]. As Figure 1 higher interest rates boost the demand and reduce the supply of currency, increasing the exchange rate into E2 and vice versa.

Moreover, if interest rates are high, people get more for their money when they save in a bank. As a result, people save more and spend less. People are also less likely to take out loans as they are more expensive. This means purchases of goods like houses drop due to poor-value mortgages. If people are spending less money, the demand for goods and services and consequently the currency goes down. As such, businesses take action to entice people into spending. Usually, this means dropping prices. When prices drop, inflation goes down [11].

On the contrary, when interest rates are low, people can afford to borrow more money and are rewarded less for saving in the bank. So, people decide to spend their money instead. More loans are taken out and consumer spending on larger goods, like homes, and consequently demand the currency increases. And, as demand for spending increases, businesses can put their prices back up. This brings the cycle back to the beginning as inflation starts to build once again [11].

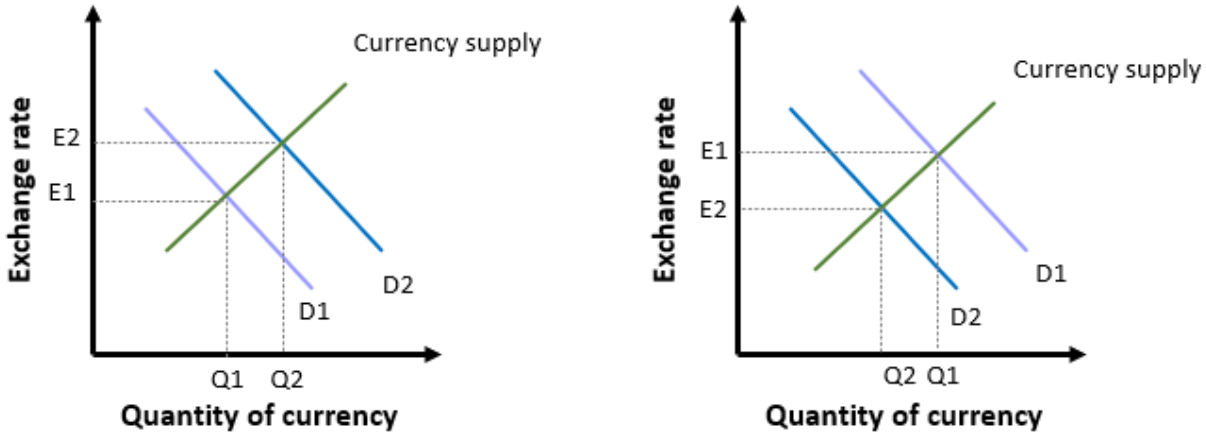


***Figure 1**. Supply currency and shifts in demand on the foreign exchange market*

3.1.2. Inflation

Inflation is caused by a faster increase in the level of money supply relative to wealth production, which is gauged by the GDP. Inflation and interest rates have an inverse relationship and are key to the performance of currency markets. A good general rule is that if inflation affects the foreign exchange rate, the effect is usually negative rather than positive [11].

Inflation and Interest rates get involved in a multitude of ways. Perhaps the most notable is when interest rates are high, the value of a currency tends to increase. However, this is not always the case. Sometimes interest rates go up when the economy is weak. This happens when inflation is soaring. A very high inflation rate is extremely likely to negatively impact the country's exchange rates with other countries [11].

Where inflation occurs in a country, the value of the goods it produces increases. This in turn will cause a decrease in foreign demand for those goods. Overseas buyers will then buy less of those goods, causing a decrease in demand for the currency and a fall in its value (Figure 1). For a currency to rise in value from an increase in interest rates, a country must strike a balance between interest rates and levels of inflation [11].

3.2. Factors Affecting Exchange Rate Indirectly

Investors prefer to move their money into healthy economies. A strong, stable economy makes their investments less risky and more profitable. Investors evaluate whether a rate hike is due to a healthy economy or exclusively to tame inflation. If they assume the latter, increasing rates may not have the desired effect on a currency [11].

3.2.1. General Economic Health and Stability of a Country

The other important thing to consider is that interest rates and rates of inflation are only two factors in a much wider landscape. Ultimately, the number of factors that influence the value of a currency is very large and certain currencies enjoy a favorable rate of exchange for reasons other than the interest rates they have. In some cases, currencies enjoy a favorable exchange rate despite having low-interest rates. The euro, for example, despite having very low-interest rates since 2008, has had very favorable exchange rates against many of the world's currencies [11].

It is important to remember that attracting foreign investments is one thing; retaining them is another. If a country is seen as being economically or politically unstable, or there is a chance its currency could devalue suddenly, investors aren't likely to hold the currency in large amounts or for long periods [11].

Some of the main things which influence the general economic health and stability of a currency are as follows:

3.2.2.The Balance of Trade

If a country has a balance of trade deficit, then imports will exceed exports. As this happens, demand for foreign exchange will exceed supply and in turn, the local currency will depreciate. Likewise, a positive balance of trade will cause the local currency to increase in value. A country's balance of trade is often compared to those of its major trading partners to assess the value of a currency concerning its major trading partners [11].

3.2.3. Government Fiscal and Monetary Policies

Generally speaking, non-expansionary fiscal and monetary policies reduce expenditure which helps to bring stability to a currency and increase its value. Similarly, the higher rates of expenditure associated with expansionary fiscal and monetary policies and increased levels of inflation normally destabilize a currency, causing a fall in its value [11].

3.2.4. Public Debt

If government accrues more debt while borrowing to finance economic growth than is earned through growth, this can lead to increased levels of inflation. National governments may also end up printing money to pay their debts, which in turn can cause further inflation. Inflation, as we said earlier, deters foreign investment which causes a fall in the value of a currency [11].

3.2.5. Government Exchange Rate Intervention

In many cases, governments intervene in their currency's exchange rate through their central bank. If a change to the exchange rate is likely to affect the economy and the trading opportunities of a country or if there is another long-term strategy in mind, central banks can affect the exchange rate. The principal method through which this is achieved is through buying and selling the local currency. If the government would like the local currency to increase in value, they can buy up reserves of it (causing a shortage and therefore an increase in demand). Similarly, if they would like to decrease its value, they can sell reserves of it that have been kept. In addition to buying and selling the local currency, central banks, and governments can adjust interest rates, print money, and use various other tools [11].

3.2.6. Economic Strength

As a general rule, increased economic strength and high levels of economic growth do not affect the value of a currency in the short term. However, in the long term, they are one of the key determinants of the value of a currency. Going back to our earlier example of the euro maintaining its high value despite having low-interest rates, much of the reason behind this is that the countries which use the euro are seen as relatively economically strong compared to others [11].

3.2.7. Political Stability

In a similar way to economic strength, the political strength of a country also has a long-term effect on the value of a currency. A country with a stable government will be less likely to experience economic shocks and to have stable financial policies and this tends to attract foreign investment. Many of the developed nations of the world, such as the UK, have far more stable systems of government than the rest of the world. This is a good general predictor of stability in a country's economy as a whole and its currency [11].

4. Outlook of Iran

4.1. Geographical Location

The country of Iran with a very old history is located in the heart of the Iranian plateau. This country is located in the western part of the world's largest continent and in a rich oil region called the Middle East. Iran officially the Islamic Republic of Iran is bordered by Iraq and Turkey to the west, Azerbaijan, and Armenia to the northwest, through the Caspian Sea with Turkmenistan to the north, Afghanistan and Pakistan to the east, and Kuwait, Saudi Arabia, Qatar, Bahrain, United Arab Emirates and Oman in South through the Persian Gulf and Oman Sea. Owing to its strategic position in the Middle East and Eurasia region, it has always been considered a connecting bridge between the East and the West so that, a significant part of the exchange and historical silk road passed through Iran. Iran covers an area of 1.64 million square kilometers and is the 17th-largest country [12].

4.2. Demographics

As of 2021, the population of Iran is projected at 86.02 million making it the 18th most populous country in the world and the second largest in the Middle East. The Sex Ratio in Iran in 2021 is 101.80 males per 100 females. There are 43.39 million males and 42.62 million females in Iran. Figure 2 indicates the population demographic of Iran. As it is obvious, 68.1% of Iran's population is aged 15-64 years. The literacy rate for Iranians above the age of 15 years as of 2020 was 85.5% and 80.8% for females and males respectively.

64.37 million people are living in urban areas. In addition to its international migration pattern, with 76.3% of the urban population in 2021, Iran also exhibits one of the steepest urban growth rates (1.32%) in the world according to the UN humanitarian information unit [13].

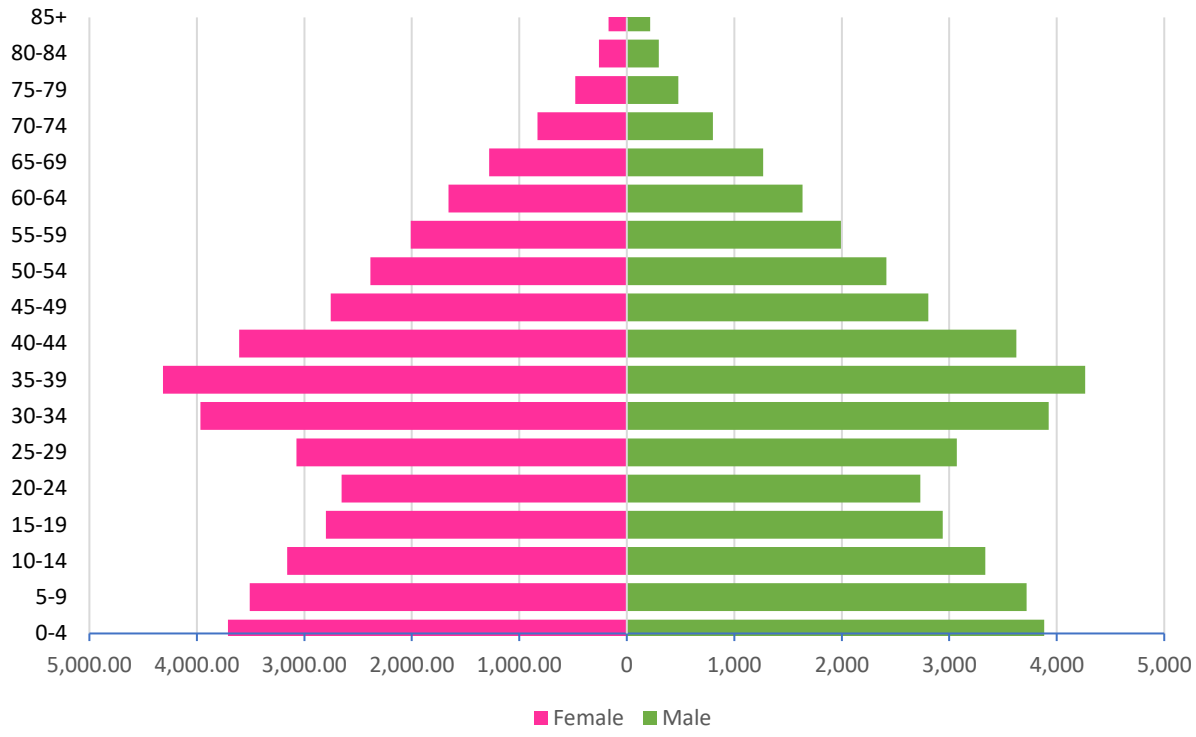


***Figure 2**. Iran's population pyramids, 2022, POPULATIONPYRAMID*

4.3. Natural Resources

After Russia, the U.S., Saudi Arabia, and Canada, with 27.3 trillion U.S. dollars, Iran is the fifth richest country in the world in terms of natural resources such as oil, gas, coal, gold, silver, copper, uranium, crude iron, and phosphate [14].

With one percent of the world's population, it has more than 7 percent of the world's mineral resources, it has the world's second-largest reserves of natural gas after Russia, and the third-largest natural gas production after Indonesia and Russia. It also ranks fourth in proven crude oil reserves. Iran is OPEC's second-largest oil exporter and is an energy superpower. Iran also ranks among the world's top 10 oil producers and top 5 natural gas producers. It is a founding member of the United Nations, the ECO, the OIC, and the OPEC [15] [16] [17].

Although the petroleum industry provides the majority of economic revenues, about 75 percent of all mining sector employees work in mines producing minerals other than oil and natural gas. These include coal, iron ore, copper, lead, zinc, chromium, barite (the world's sixth largest producer), salt, gypsum, molybdenum, strontium, silica, uranium, and gold (most as a coproduct

of the Sar Cheshmeh copper complex operations). The mines at Kerman Province contain the world's second-largest lode of copper ore [18].

4.4. Agriculture

The wide range of temperature fluctuation in different parts of the country and the multiplicity of climatic zones make it possible to cultivate a diverse variety of crops, including cereals (wheat, barley, rice, and maize), fruits (dates, figs, pomegranates, melons, and grapes), vegetables, cotton, sugar beets, sugarcane and pistachios, nuts, olives, spices e.g., saffron, raisin, tea, tobacco, berberis, and medicinal herbs. Wheat, rice, and barley are the country's major crops [19].

According to the Food and Agriculture Organization of the United Nations (FAOSTAT), in 2020 Iran was among the top 10 producing countries of agricultural commodities (Table 1) [20].

***Table 1**. Iran's ranks in the world agricultural production in 2020, [20]*

Products	**The rank of Iran in the world**	**Products**	**The rank of Iran in the world**
Apricot	*Third*	Saffron	*First*
Fig	*Fourth*	Date	*Third*
Plums and Sloes	*Fifth*	Walnut	*Third*
Kiwi	*Fourth*	Pistachio	*Second*
Pomegranate	*Third*	Almond	*Third*
Cherry	*Fifth*	Honey	*Third*
Quince	*Forth*	Eggplants	*Sixth*
Watermelon	*Second*	Tomato	*Seventh*
Tea	*Seventh*		

4.5. Economy

Iran's economy is a mixture of central planning, state ownership of oil and other large enterprises, village agriculture, and small-scale private trading and service ventures. Iran's economic activity and government revenues still rely heavily on oil revenues and have, therefore, been volatile. Iran is ranked as an upper-middle-income economy by the World Bank [21]. In 2020, Iran was the number 49 economy in the world in terms of GDP (current US$), number 86 in total exports, number 71 in total imports, the number 65[1] most complex economy according to the Economic Complexity Index (ECI)[2], and the fifth largest trade of goods (exports minus imports of goods) in the MENA[3] region (Figure 3). A positive value means a trade surplus, and a negative trade balance means a trade deficit. In 2021 Iran had the highest GDP in the MENA region (Figure 4).

[1] 57th in 2015, 60th in 2016, 62nd in 2017, 61st in 2018, 65th in 2019

[2] A rank of countries based on how diversified and complex their export basket is. Countries that are home to a great diversity of productive know-how, particularly complex specialized know-how, are able to produce a great diversity of sophisticated products.

[3] MENA, an acronym in the English language, refers to a grouping of countries situated in and around the Middle East and North Africa. MENA countries consist of Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates and Yemen.

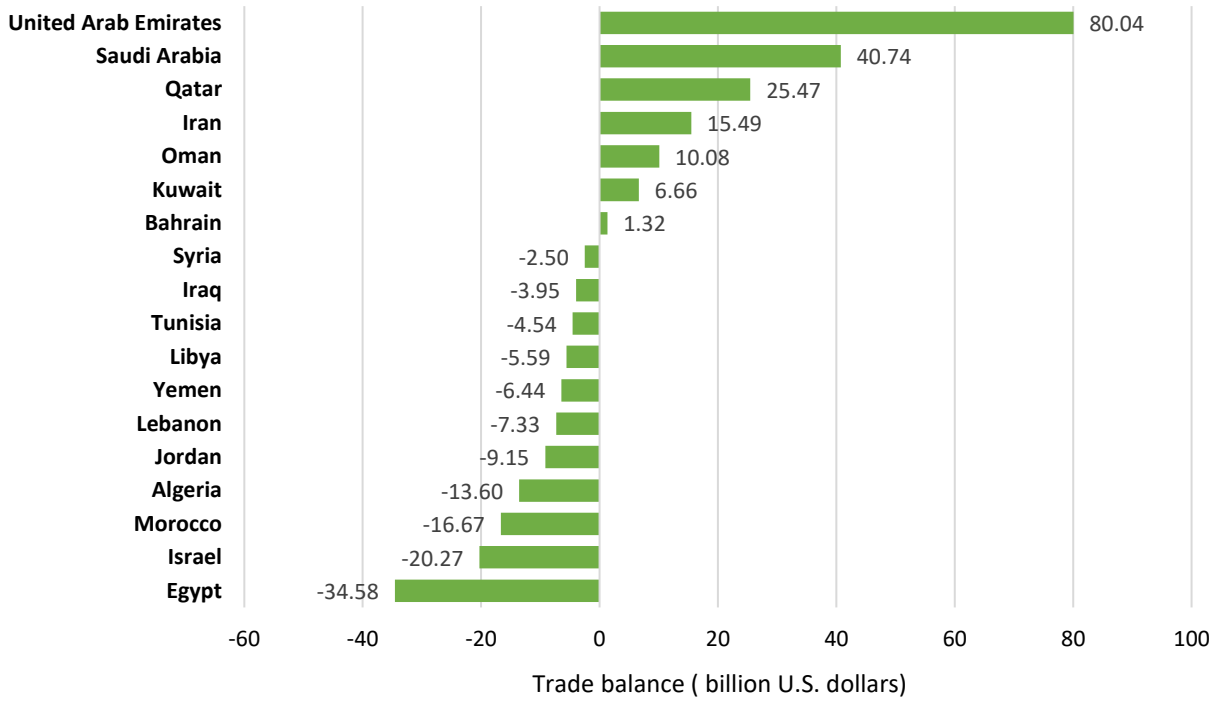


***Figure 3**. MENA countries: Trade balance of goods in 2020- STATISTA.COM*

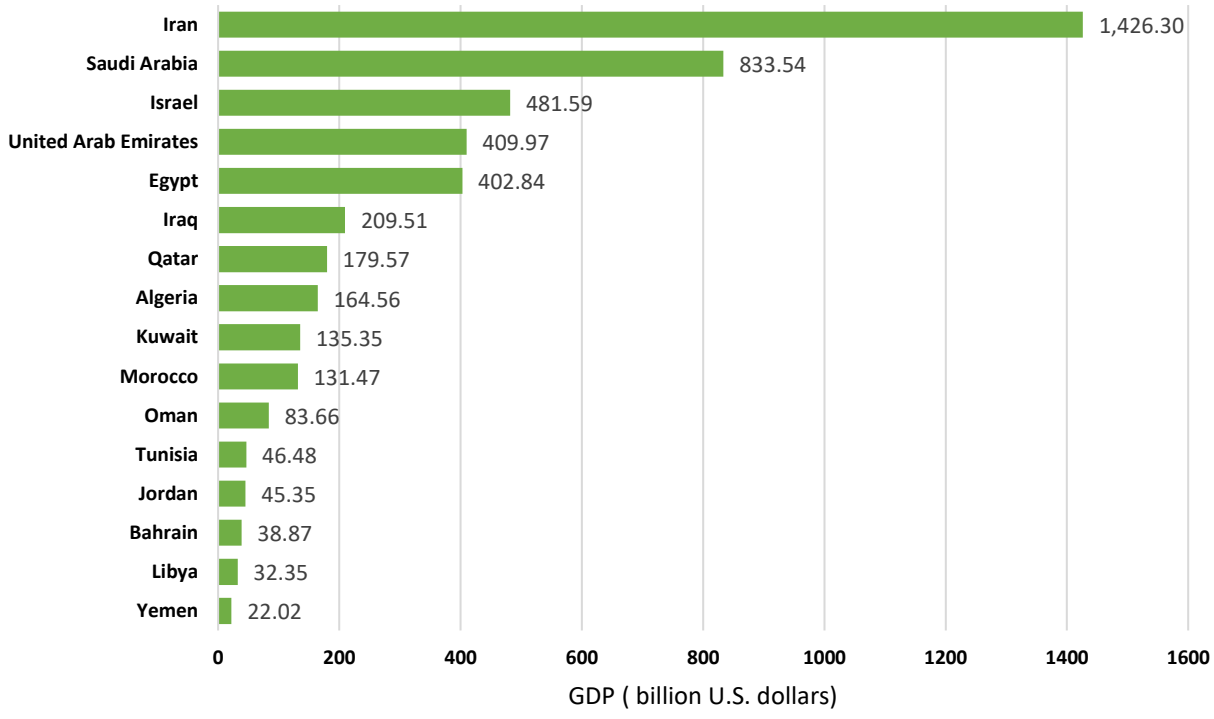


***Figure 4**. MENA region: Gross domestic product (GDP) in 2021, by country- STATISTA.COM*

Iran's economic policies since 1979 and its isolation from international economic relations have had a large negative impact on domestic economic development and Iranians' well-being [22]. Iran's real gross domestic product (GDP) per capita has not yet reached its pre-revolution levels (Figure 5).

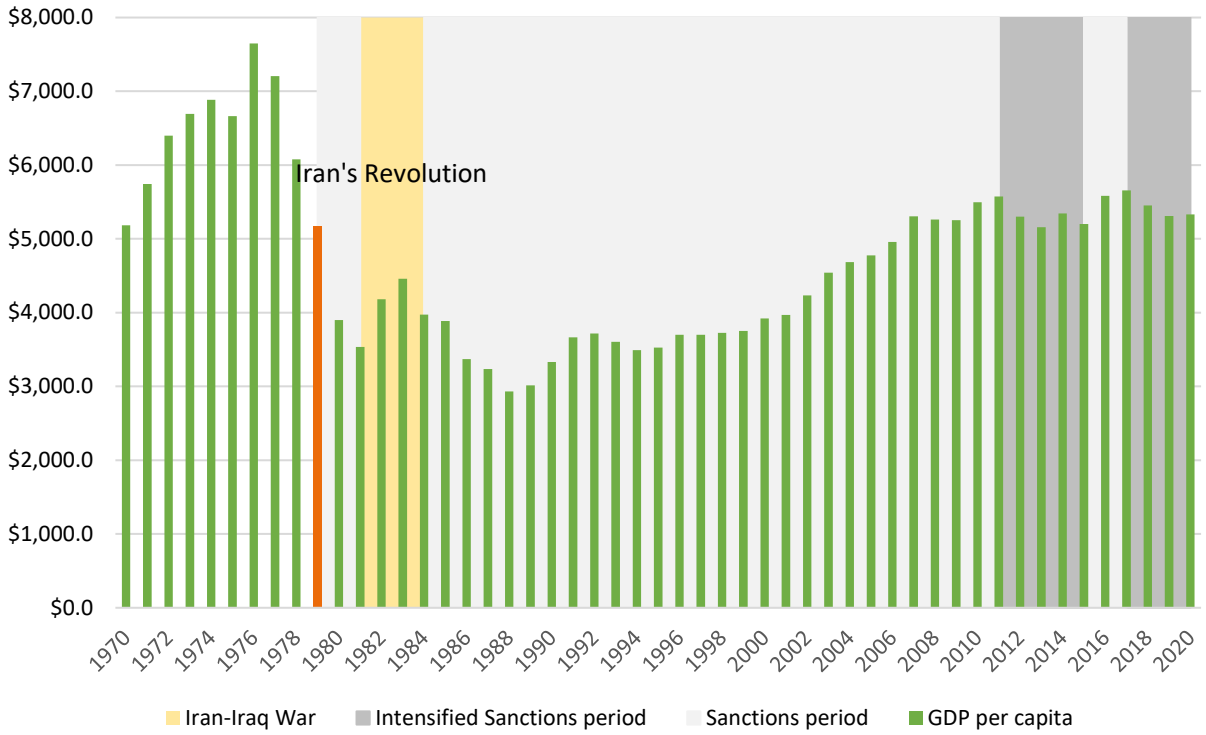


***Figure 5**. GDP per capita (Constant 2015 U.S. $) of Iran, 1960-2020, WORLDBANK.ORG*

This long-run deterioration is caused by several factors:

1. It is firstly because oil production has never reached its level before 1978, which has been due to losses in Iran's global and OPEC market share. Since the Yom Kippur War of 1973, the global oil market had been finding new sources in Siberia, the United States, and elsewhere, while the Islamic Revolution reduced the OPEC market share dramatically. The hostage crisis in Iran after the Islamic Revolution in 1979 was a turning point in Iran's relations with the international community. After this event, Iranian assets worth around USD 12 billion were seized by the US government as the first round of sanctions imposed by the US. Such animosity with the US discouraged multinational enterprises from having foreign direct

investment[4] in Iran, which was specifically operating in the extraction of oil and gas. This further pushed down oil revenues that Iran could have enjoyed in the past 4 decades.

2. The eight-year war with Iraq starting in September 1980 was characterized by destruction, death, austerity, and rationing of primary commodities, as well as average annual consumer price inflation of around 20%. From 1980 to 1988, Iran's real economy shrank by an average annual rate of 1.6%, while along with the growing population per capita real income shrank by a 5.4% average annual rate. Iran's trade (imports plus exports) to GDP ratio dropped to its lowest level of 14% in 1986 and net inflows of FDI became negative.
3. The destabilized economy under sanctions, characterized by very high inflation and a weakening currency, had further serious negative effects on the future of Iran's economy.
4. Revolutionary Iran was lacking economic expertise and suffered from mismanagement of the economy. In addition, being isolated from the international community via heavy sanctions, Iranian authorities have mismanaged resources through the large state-owned enterprises and lack competitive markets [22].

4.5.1. Iran's Exports

Figure 6 indicates Iran's export categories exporting mostly to China ($5.85B), Turkey ($1.16B), Pakistan ($352M), United Arab Emirates ($345M), and Germany ($302M). The top exports of Iran are:

- **Ethylene Polymers**: In 2020, Iran exported $2.17B in ethylene polymers, making it the 11th largest exporter of ethylene polymers in the world. In the same year, ethylene polymers were the 1st most exported product in Iran. The main destinations of ethylene polymers exports from Iran are China ($1.91B), Turkey ($168M), Azerbaijan ($22M), Chinese Taipei ($18.1M), and Armenia ($9.75M).
- **Crude Petroleum**: In 2020, Iran exported $1.18B in crude petroleum, making it the 36th largest exporter of crude petroleum in the world. In the same year, crude petroleum was the 2nd most exported product in Iran. The main destinations of crude petroleum exports from Iran are China ($1.15B) and the Netherlands ($28.8M).

[4] FDI

- **Other Nuts**[5]: In 2020, Iran exported $913M in other nuts, making it the 3rd largest exporter of other nuts in the world. In the same year, other nuts were the 3rd most exported product in Iran. The main destinations of other nut exports from Iran are China ($393M), Germany ($129M), Turkey ($80.3M), Italy ($54.7M), and United Arab Emirates ($42.7M).
- **Acyclic Alcohols**: In 2020, Iran exported $832M in acyclic alcohols, making it the 9th largest exporter of Acyclic alcohols in the world. In the same year, acyclic alcohol was the 4th most exported product in Iran. The main destinations of acyclic alcohols exports from Iran are China ($780M), India ($42.4M), Turkey ($7.95M), Uzbekistan ($889k), and Armenia ($187k).
- **Semi-Finished Iron**[6]: In 2020, Iran exported $595M in semi-finished Iron, making it the 10th largest exporter of semi-finished Iron in the world. In the same year, semi-finished Iron was the 5th most exported product in Iran. The main destinations of semi-finished Iron exports from Iran are China ($528M), Thailand ($53.5M), Jordan ($6.26M), Italy ($5.92M), and Turkey ($1.19M) [23].

[5] Other Nuts are a part of fruit and nuts, edible; peel of citrus fruit or melons. They include Almonds, fresh or dried, shelled, Pistachios, fresh or dried, Nuts edible, fresh or dried, nes, Hazelnuts and filberts, fresh or dried, shelled, Walnuts, fresh or dried, shelled, Almonds in shell fresh or dried, Walnuts in shell, fresh or dried, Chestnuts, fresh or dried, and Hazelnuts and filberts in shell fresh or dried.

[6] Semi-Finished Iron are a part of Iron and steel. They include Semi-finished bars, iron or non-alloy steel <0.25%C, rectangular, nes, Rectangular iron or non-alloy steel bars, <.25%C, width< twice thickness, Semi-finished product, iron or non-alloy steel >0.25%C, and Semi-finished product, iron or non-alloy steel <0.25%C, nes.

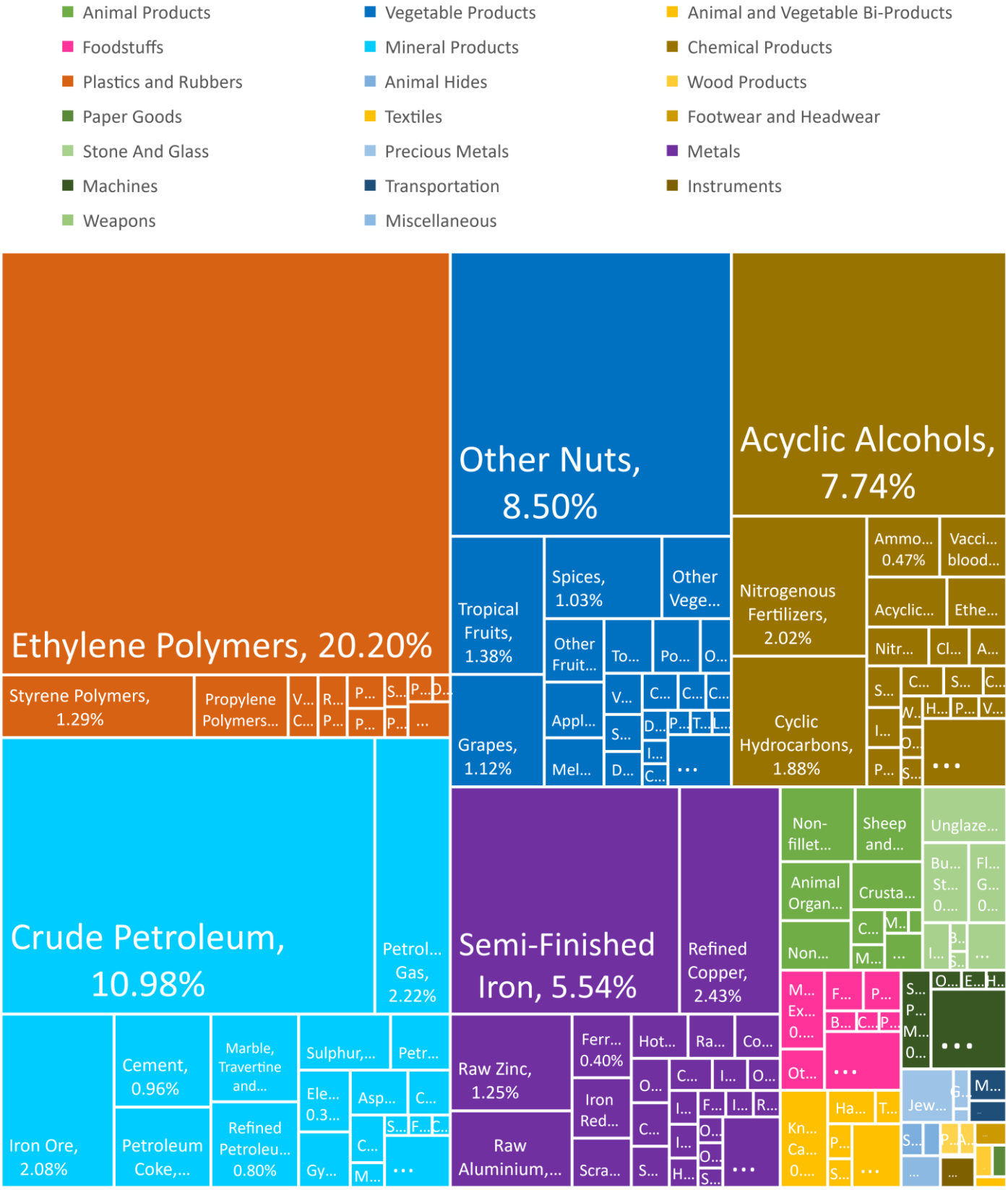


***Figure 6**. Iran's export categories and their value trade in 2020, [OEC.WORLD]*

4.5.2. Iran's Imports

Figure 7 indicates Iran's import categories importing mainly from China ($8.51B), United Arab Emirates ($4.53B), India ($2.24B), Turkey ($2.14B), and Germany ($1.68B). The top imports of Iran are:

- **Broadcasting Equipment**: In 2020, Iran imported $2.23B in broadcasting equipment, becoming the 36th largest importer of broadcasting equipment in the world. In the same year, broadcasting equipment was the 1st most imported product in Iran. Iran imports broadcasting equipment primarily from: United Arab Emirates ($1.89B), China ($328M), Germany ($2.51M), Sweden ($2.09M), and Italy ($1.62M).
- **Corn**: In 2020, Iran imported $1.09B in corn, becoming the 10th largest importer of corn in the world. In the same year, corn was the 2nd most imported product in Iran. Iran imports Corn primarily from: Brazil ($745M), Ukraine ($224M), Bulgaria ($59M), Romania ($54.8M), and United Arab Emirates ($5.32M).
- **Rice**: In 2020, Iran imported $885M in rice, becoming the 5th largest importer of Rice in the world. In the same year, rice was the 3rd most imported product in Iran. Iran imports rice primarily from: India ($876M), Thailand ($5.43M), United Arab Emirates ($3.54M), Kyrgyzstan ($27.6k), and Turkey ($16.5k).
- **Vehicle Parts**: In 2020, Iran imported $625M in motor vehicles; parts, and accessories (8701 to 8705), becoming the 48th largest importer of motor vehicles; parts, and accessories (8701 to 8705) in the world. In the same year, motor vehicles; parts, and accessories (8701 to 8705) were the 4th most imported product in Iran. Iran imports motor vehicles; parts and accessories (8701 to 8705) primarily from: China ($545M), Turkey ($35.4M), United Arab Emirates ($15.2M), South Korea ($6.37M), and France ($3.89M).
- **Soybeans**: In 2020, Iran imported $548M in soybeans, becoming the 19th largest importer of soybeans in the world. In the same year, soybeans were the 5th most imported product in Iran. Iran imports soybeans primarily from: Canada ($303M), Brazil ($245M), and Turkey ($1.09k) [23].

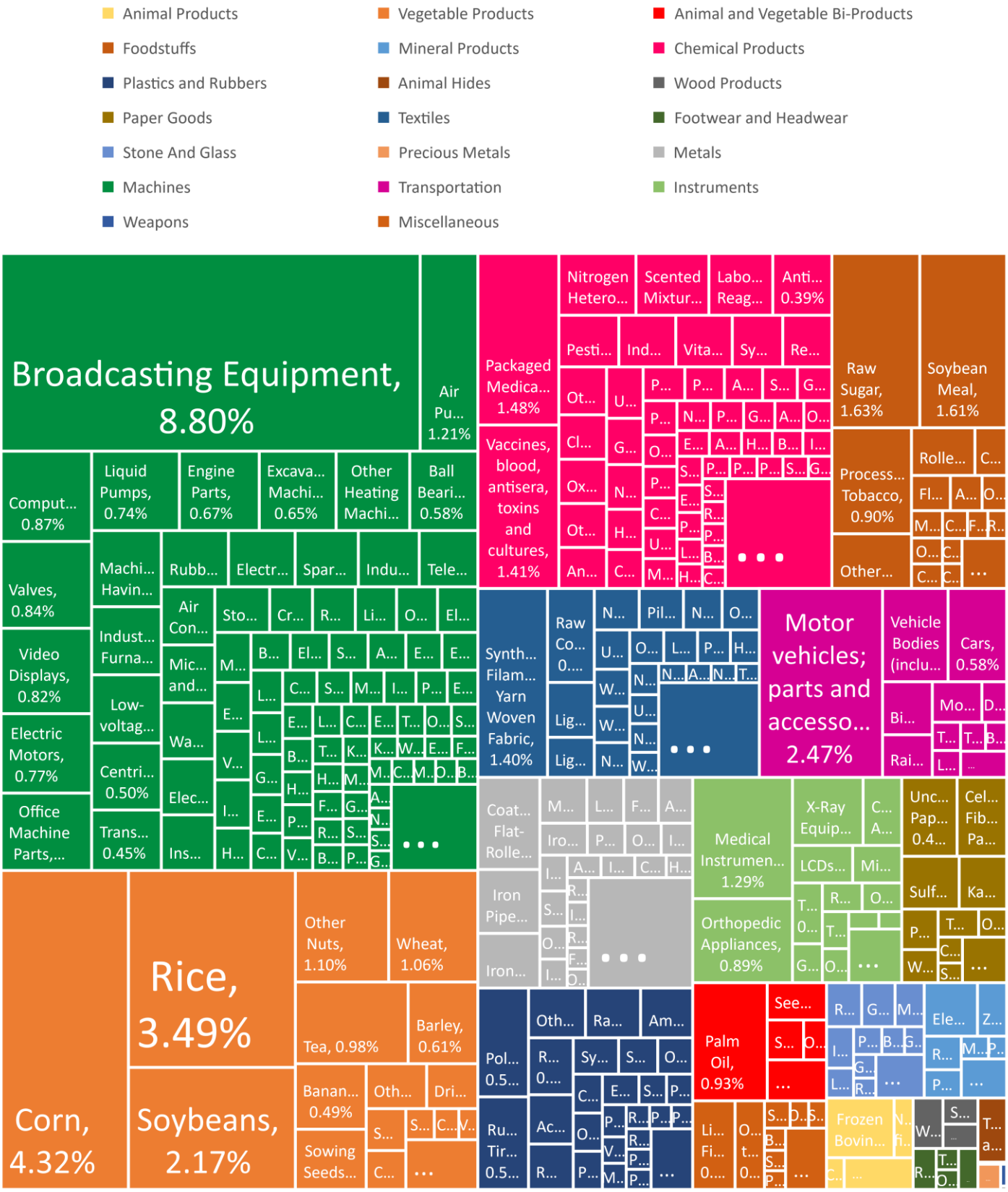


Figure 7. *Iran's Import categories and their value trade in 2020, [OEC.WORLD]*

5. Currency Arrangements History in Iran

A study of the developments in Iran's foreign exchange arrangements since 1957 indicates a shift from fixed foreign exchange arrangements to more flexible ones. In general, during this period, the Iranian economy experienced three types of currency arrangements that have been adopted in 6 different periods. Table 2 summarizes the developments in foreign exchange arrangements in Iran.

Before the Islamic Revolution, the currency system of the country was stable. However, government control and supervision, foreign exchange quotas, and determining the country's priorities for foreign exchange expenditures continued up to 1973. In 1974, oil prices increased significantly in world markets. With the increase in foreign exchange earnings from oil exports, the share of foreign exchange quotas (while maintaining a stable foreign exchange system) was eliminated. After the Islamic Revolution, the country's foreign exchange system was still a fixed exchange rate system, but with the formation of a capital flight atmosphere, the Central Bank implemented controls in order to control and prevent this flow [24].

With the start of the Iran-Iraq war (1980), reducing the possibility of oil exports, increasing demand for imports, and lowering oil prices in world markets, the country's foreign exchange earnings encountered many restrictions. At the same time, the adoption of the import substitution policy, which had begun a decade before the Islamic revolution, increased the need for foreign exchange earnings by high-capacity industries, whose most of the equipment was imported. On the other hand, the import of basic goods needed by society as well as the construction costs of development projects requiring access to foreign exchange resources too [24].

Table 2. Currency arrangements changes in Iran

Currency system	Currency arrangement features	Applied period
Stabilized or fixed	1959-1979	In this regime, the monetary authority targeted a fixed exchange rate, and to maintain it in the foreign exchange market, it constantly used to buy and sell foreign currency and national currency.
Multiple exchange rate system	1980-1992	In this regime, two fixed and floating exchange rates exist simultaneously in a country. In this case, the market is divided into a certain number of different sectors with specific exchange rates for each sector, either fixed or floating. This approach is often used to apply discriminatory behavior to importers of essential goods and products into the country. Therefore, importers of these goods are subject to preferential exchange rates, while importers of non-essential or luxury goods are given different exchange rates.
	1994-2002	
	2011- 2012	
	2018- The present	
managed floating exchange rate	1993	In this regime, a fixed exchange rate was not set, and the rate is flexible and fluctuated according to the requirements of the market. In the presence of large fluctuations, the monetary authority intervened in the market to minimize fluctuations.
	2003-2010	
	2013-2017	

Due to the limited foreign exchange earnings of the country, channeling and optimal allocation of these resources were very important. In addition, since a high portion of the country's foreign exchange earnings came from oil exports and oil price fluctuations were severely affecting the country's foreign exchange earnings, in those years when the country was facing limited foreign exchange earnings, the orientation and proper allocation of resources became extremely important to the extent that the all the above-mentioned requirements and factors led to the multi-exchange rate system and made the country's foreign exchange earnings be allocated to the following priorities:

- The basic goods needed by society should be purchased at the lowest price to provide the basic health needs of society.
- Raw materials and intermediate goods are required by industries with high production capacity to be provided.
- The foreign exchange needs of development projects with implementation priority should be met.

The implementation of the multi-exchange rate system, despite its defects, while the country was facing a crisis and limited foreign exchange resources and financial markets had low importance was quite justifiable. After the Iran-Iraq war and the initial reconstruction, the unification of the exchange rate was one of the priorities of economic transformation. The exchange rate unification policy was first applied in 1993. Due to the imbalance in the balance of payments, which was mainly due to lower oil prices and the problem of repayment of overdue and outstanding debts, the exchange rate unification policy in Iran in 1993 was accompanied by a sharp rise in the exchange rate. In general, the necessary coordination and requirements were not met in all the country's policies to unify the currency. the policies implemented were not successful [24].

Since the exchange rate unification policy with the approach of achieving a more flexible exchange rate plays an important role in improving the performance of various economic sectors, this policy was used again in 2002 and all existing exchange rates were abolished. In 2002, the implementation of the exchange rate equalization policy using the financial support of Central Bank foreign exchange reserves and its financial coverage caused a sharp reduction in the gap between formal and free exchange rates and provided relative stability in the foreign exchange market. The managed floating system was in progress from 2002 to mid-2010. During these years, in addition to the existence of currency from oil and gas exports, the continuous increase in non-oil exports acted as a source for managing the foreign exchange market. Due to the existence of

sufficient foreign exchange resources, establishing relative stability in the foreign exchange market did not encounter any problems [24].

It is important to note that despite the successful implementation of the exchange rate unification policy in 2003 and its continuation until 2011, this market was faced with structural bottlenecks for establishing a managed floating system. The main drawback of this market was the dominance of foreign exchange from oil exports over its supply. In other words, the establishment of a floating system requires the existence and dominance of relatively competitive market factors on both supply and demand sides of the market. However, because the main part of the foreign exchange supply in the country relied on foreign exchange earnings from oil exports, this issue was caused by fluctuations in world oil prices and decisions related to the consumption of oil revenues in the annual budgets of the foreign exchange market was subject to change [24].

From mid-2011 and after the distance of the free-market exchange rate from the official exchange rate, in the periods of 2012 and 2013, relatively severe fluctuations appeared in the country's foreign exchange market. The main change at this time was the tightening of restrictions on financial exchanges and foreign exchange transfers, and with the disruption of foreign exchange remittances, the exchange rate in the open market began to rise. In other words, what reduced the supply of foreign exchange or, to be more precise, the unresponsiveness of the market demand side, was the limitation and existence of a bottleneck in the transfer of foreign exchange. At that time, the country did not face many restrictions on the export of oil, gas, petroleum, and petrochemical products. Another important development was the United States' approval of the voluntary reduction of Iranian oil purchases by oil-importing countries and the European Union's joining the sanctions on Iranian oil. On July 1, 2010, the United States passed a sanction that would have sanctioned Iranian oil buyers if they did not significantly reduce their purchases of Iranian oil. In January 2012 the EU in a new round of sanctions banned imports, purchasing, or transferring all Iranian oil products. The date of implementation of these sanctions was 6 months later, at the beginning of June 2012. From this time on, the supply side of the currency in the market became the short side of the market [24].

From September 2010 to April 2011, rising exchange rates arose out of excess demand for foreign exchange (mainly to finance imports) that remained unanswered due to restrictions on currency transfers. In other words, during this period, currency was a means of exchange, valuation, and international payment, so it was mainly monetary. However, since May 2011, the demand for foreign currency speculation has been added to the trading demand and over time, its amount has

increased sharply. In other words, from this time on, the currency became a means of storing value, and in addition to its monetary nature, it also became a commodity and had a significant effect on the instability of the exchange rate. The exchange rate increased by only 2% in the first period (September 2010- April 2011), while in the second period, more than 40% was added to the exchange rate [24].

In June 2011, the Central Bank acted in order to eliminate the gap between the free market and the official rate, increasing the exchange rates by 11%, but the result was not successful and harmed the foreign exchange market. The most important reason for the increasing speculative demand for foreign exchange is the increase in the expected return on foreign exchange holding and the increase in the expected return on capital. So, people have changed their portfolios in favor of foreign currencies with the hope to make large profits. They have converted all kinds of Rial assets such as stocks, cars, bank deposits, and even residential houses into the foreign exchange market [24].

EU sanctions on the ban on the import, purchase, and transfer of all Iranian oil products, which were approved in January 2012, came into force on 1st July 2012, which reduced the country's foreign exchange earnings. For example, the export value of petrochemical products fell by about 33%, gas condensate by about 12 %, and oil by about 50%, so from this point on the supply side of the foreign exchange market became the short side of the market [24].

Continuous increase in exchange rates in the free market, the negative outlook for the future of sanctions, foreign exchange earnings and foreign exchange reserves of the country, expansion of economic rent space following the gap between formal and free exchange rate, increasing inflationary pressures and diminishing influence of officials' comments on market participants and the passage of new EU sanctions on oil purchases from Iran has put the country on the brink of a currency crisis and the dollarization of the economy. On the other hand, the consumption of foreign exchange resources more than the number of imports in situations where there was a need to maintain foreign exchange reserves, a sharp rise in exchange rates in the free market, rising prices, invasion of foreign exchange markets with speculative purposes or conversion of assets into currency, have presented an unfavorable outlook for the Iranian economy to economic policymakers [24].

6. Iran's Exchange Rate Crisis

In chapter 2, the factors affecting Iran's exchange rate volatility over 2015-2022 will be reviewed.

But as Western sanctions against Iran are almost the major cause in the formation of currency fluctuations, first, the definition of sanctions and also the sanctions imposed before 2015 are discussed to give a better image of Iran's economy for evaluation of the exchange rate over 2015 until the present.

6.1. Sanction

6.1.1. Sanction Definition and Its Objectives

International sanctions are political and economic decisions that are part of diplomatic efforts by countries, and multilateral or regional organizations against states or organizations either to protect national security interests or protect international law and defend against threats to international peace and security. These decisions principally include the temporary imposition of a target of economic, trade, diplomatic, cultural, or other restrictions that are lifted when the motivating security concerns no longer apply, or when no new threats have arisen [25].

While sanctions are designed as a non-violent instrument to persuade governments to comply with the interests of the imposing countries (often viewed as a more humane option than military intervention), they have the aim of changing the policy of the target country by inflicting severe economic damages [26]. Another objective of sanctions is to reduce or slow the development of an adversary's military or strategic capabilities by raising the economic cost of acquiring imports or import substitutes. A third rationale for sanctions is to send a symbolic message of displeasure with another country's behavior. If sanctions are to be used for other than symbolic purposes, policymakers need a strong assurance that there is, at least potentially, some level of economic damage which — if sustained over time — would force the targeted countries to change their objectionable behavior or slow down the development of their military or strategic capabilities. Without this basic agreement, there is no point in considering sanctions except as a symbolic gesture [27].

6.1.1.1. Economic Sanctions

Sanctions can generally be divided into three types: military[7], diplomatic[8], and economic [28]. Among them, economic sanctions have become a popular foreign policy tool in international politics over the last decades [26]. In the modern world, economic sanctions act as a Cold War. After World War II, the USA frequently applied economic sanctions to achieve certain objectives. In a parallel way, several multilateral organizations like the United Nations (UN) have practiced similar measures [29]. Such sanctions usually target the business sectors of the countries and limit their trade and monetary flows [28].

Economic sanctions can be divided into two types: trade and financial sanctions. Trade sanctions are further divided into two groups: boycotts and embargoes. A boycott is a restriction of imports of one or more goods from the target country. It attempts to reduce the target's foreign exchange earnings and its ability to purchase goods. It can also induce damage to a particular industry or sector of the target country. An embargo restricts the exports of certain products to the target country. This technique is very common. However, prohibition on exports can be partial or complete [29].

Financial sanctions restrict or suspend lending and investment in the target economy. Whatever kind of sanctions is applied it fuels inflation in the host economy. Trade restrictions cause inflation while trade openness decreases inflation, therefore, restrictions on openness via boycotts and embargoes (trade sanctions) can increase inflation. Lack of investment inflows is another major cause of inflation. Therefore, any constraint on investment inflows through financial sanctions can increase inflation as well [29].

On the other hand, sanctions can also be classified according to their adopting and performing agents. Thus, sanctions can be grouped into three distinct branches: Unilateral sanctions like US sanctions against Iran, sanctions by some countries or unions such as the European Union sanctions against Iran, and sanctions by UN Security Council like Security Council sanctions against Iran [30].

Over the past decade, secondary sanctions have emerged as a critical—and sometimes controversial—a tool to increase the effectiveness and reach of U.S. primary sanctions programs. Under primary sanctions, the U.S. government restricts U.S. individuals and entities from

[7] Can range from carefully targeted military strikes to degrade a nation's conventional or non-conventional capabilities, to the less aggressive form of an arms embargo to cut off supplies of arms or dual-use items.
[8] Includes actions such as the interruption of diplomatic relations with the targeted country, or the coordinated recall of diplomatic representatives.

economically engaging with a designated foreign entity, as well as limits transactions by non-U.S. persons and entities that have a "U.S. nexus"—such as financial transactions routed through banks in New York City for currency exchange. The U.S. Department of the Treasury's Office of Foreign Assets Control (OFAC) enforces primary sanctions through civil and criminal penalties, sometimes in conjunction with the Department of Justice and state-level law enforcement [31].

In contrast, OFAC applies secondary sanctions to non-U.S. persons and entities who lack a U.S. nexus. After determining that a foreign person has engaged in an activity actionable under secondary sanctions—such as participating in a transaction with an individual included on OFAC's Specially Designated Nationals (SDN) List—the Department of State or Treasury will select from a "menu" of access restrictions of varying severity to impose on the foreign person. These can include measures such as the denial of export licenses or loans from U.S. financial institutions, and in the most severe cases may include designating the foreign person as an SDN. Rather than enforcement through civil or criminal penalties, secondary sanctions rely on the ability of the U.S. government to leverage the dominance of the U.S. financial system to coerce foreign persons to forgo otherwise legal transactions with sanctioned persons [31].

Given the size of the U.S. market and the role of the U.S. dollar in global trade, secondary sanctions provide Washington with tremendous leverage over foreign entities as the threat of isolation from the U.S. financial market almost always outweighs the value of commerce with sanctioned states [31].

6.1.1.2. Economic Sanctions' Impacts

From a theoretical viewpoint, there are different mechanisms through which the imposition of economic sanctions can negatively impact the economy of the target country and consequently its labor market [26].

First, economic sanctions can lead to a sharp contraction in imports and exports. Hufbauer et al. (2009) show that the volume of bilateral trade between the imposing countries and the target state drops dramatically. The contraction in both imports and exports can negatively impact the labor market of the sanctioned economy by causing not only a drop in employment in import-competing and exporting industries, but also a reallocation of labor across different industries [26].

Second, sanctions can cause a slump in international capital flows due to the withdrawal of foreign direct investments. This can happen even in the absence of explicit imposition of trade embargoes or suspensions of international aid and capital flows. According to Whang (2011), as economic sanctions are often used symbolically to stigmatize political regimes, the isolation of the sanctioned economy within the international community is a result of the loss of reputation that discourages foreign firms from providing investments. The reduction in foreign direct investments may spill over into the labor market. Kosová (2010), for instance, finds that while the presence of foreign firms might crowd out domestic production in the short run, this seems to be associated with an increase in the growth and survival of domestic firms in the long run (technology spillover) [26].

Third, as economic sanctions often have the objective to overthrow the target's political regime, by increasing political instability, they can generate uncertainty on the future of the political system, thus producing harmful effects on the country's trade and financial relations, on its domestic and foreign direct investments and therefore on its labor market. The existing empirical evidence suggests that economic sanctions are indeed associated with increased political instability and societal conflicts which in turn are estimated to have adverse effects on both investment and economic growth [26].

Fourth, sanctions are also followed by an increase in the shadow economy as both individuals and governments may promote illegal economic activities. As Andreas (2005) put it: ''sanctions can unintentionally contribute to the criminalization of the state, economy, and civil society of both the targeted country and its immediate neighbors, fostering a symbiosis between political leaders, organized crime, and transnational smuggling networks. This symbiosis, in turn, can persist beyond the lifting of sanctions, contributing to corruption and crime and undermining the rule of law". The criminalizing consequences of sanctions cause an increase in transaction costs and lead to more unproductive use of the available resources. This is especially true in the labor market as workers can switch from formal to informal sectors based on their expected employment prospects [26].

The size of the impact of economic sanctions on the target's economy and labor market may depend on a variety of factors. On one hand, it may depend on the severity of the sanctions. UN sanctions, for example, can differ in their level of severity, ranging from restrictions on arms and other military hardware to restrictions on trade in primary commodities and the freezing of public and/or private assets to embargoes on all or most economic activity between UN member states

and the target. Similarly, previous US sanctions vary from retracting foreign aid and banning loans, grants, or credits to restricting trade, finance, and investment to imposing embargoes on all economic activities between the US and the sanctioned country [26].

On the other hand, the size of the effect changes whether it relates to unilateral sanctions versus multilateral ones. The former should, in principle, have smaller effects than the latter as the target country can potentially circumvent the sanctions by switching to alternative trading partners. On the contrary, when sanctions are multilateral - as in the case of UN sanctions - the target country cannot avoid losing access to goods or markets by increasing its trade with other partners. Neuenkirch and Neumeier (2015), indeed, find that UN sanctions are associated with a decrease in the sanctioned country's GDP per capita growth rate by more than 2 percentage points, while US sanctions are associated with a drop by nearly 1 percentage point [26].

6.2. Sanctions Against Iran and The Effects (1979-2015)

There have been several sanctions against Iran imposed by some countries, especially the United States, and international entities. In the contemporary world, Iran is the country that is most affected by economic sanctions, mainly imposed by the USA.

6.2.1.U.S. Unilateral sanctions, 1979-2005

The first sanctions were imposed by the United States in **November 1979** after a group of radical students seized the American Embassy in Tehran and took hostages. President Jimmy Carter issued an executive order seizing Iranian property, totaling $12 billion, in the U.S. That freeze was eventually expanded to a full trade embargo (except food and medicine) until an accord was signed with Iran and the hostages were released in 1981. Part of the assets was unblocked, and the embargo was lifted [32].

During the Iran-Iraq war (1980-1988), the US increased sanctions against Iran. In **January 1984** the US prohibited foreign aid, grants, use of credit, or financial assistance and restricted the transfer of weapons and ammunition and all US assistance to Iran [29].

In **March 1984**, the export of aircraft and related parts and components was prohibited, except with valid licenses [29].

In **February 1987**, Iran was accused of not taking adequate actions to control narcotics production, trafficking, and money laundering. Hence, financial assistance to Iran by Export-Import banks and Overseas Private Investment Corporations[9] was prohibited. US representatives in international banks were instructed to vote against loans to Iran [29].

In **September 1987**, due to Iran's attitude against peaceful settlement in the Iran–Iraq War and ongoing support of international terrorism, the export and re-export of self-contained underwater breathing apparatus and related equipment to Iran were prohibited [29].

In **October 1987**, the prohibition expanded to include 15 high-tech products, and the United States US imposes a ban on the import of Iranian goods and services, mainly crude oil. in response to Iran's actions from 1981 to 1987 against the U.S. and vessels of other countries in the Persian Gulf and support for terrorism. Exceptions were petroleum products refined from Iranian crude oil [29].

In October 1992, in response to Iran's efforts to access sophisticated technology with military applications, the export of dual-use items to Iran is prohibited [29].

Following increasing concern about Iran's pursuit of weapons of mass destruction and support for terrorism, in **May 1995** President Bill Clinton issued two executive orders that banned all bilateral trade and investment in Iran. The following year, he signed the Iran and Libya Sanctions Act (ILSA), which imposed sanctions on any firm that invested in Iran's energy sector above a certain monetary threshold (in 2006, the sanctions against Libya were lifted). The Iran Sanctions Act was a "secondary" sanction, meaning companies not based in the U.S. were also subject to sanctions under a threat: if companies chose to do business with Iran's energy sector, they could not also do business with the United States. European countries, however, viewed these sanctions as "extraterritorial," and the European Union threatened to challenge the sanctions in the World Trade Organization. The U.S. relented and agreed to waive the energy sanctions in exchange for European commitments to cooperate more robustly in countering Iran's development of weapons of mass destruction [29].

[9] OPIC

6.2.2. International Sanctions, 2006-2015

In **August 2001**, the United States extended ILSA for another 5 years against Iran and in January 2002, blocked Iran's bid to join the World Trade Organization (WTO) in response to claims that the country had supported terrorism and sought to develop weapons of mass destruction [29].

France, Germany, and the United Kingdom began negotiating with Iran in 2003, following the revelation that the Islamic Republic had been secretly constructing a uranium enrichment facility at Natanz and a heavy water production plant at Arak. But following the election of Mahmoud Ahmadinejad as president in 2005, negotiations collapsed, and Iran ended its suspension of uranium conversion. The following year, in 2006, the International Atomic Energy Agency[10] formally referred Iran to the UN Security Council, finding Tehran in noncompliance with its obligations. After another round of negotiations collapsed in the **summer of 2006**, the United Nations, the United States, and the European Union, in a multilateral international effort, imposed a new round of sanctions against Iran [33].

From 2006 to 2010, the Security Council passed six resolutions that targeted Iran's nuclear and ballistic missile programs. While the sanctions are limited in scope (i.e., they do not impose broad sanctions on Iran's energy or financial sectors) they provide international legal justification for more expansive sanctions. In particular, Resolution 1929 noted "the potential connection between Iran's revenues derived from its energy sector and the funding of Iran's proliferation-sensitive nuclear activities." This language led to European action targeting Iran's oil and gas sectors, and eventually paved the way for a full EU embargo of Iranian oil. Over 2006-2007, 5 Iranian banks[11] were prohibited from transferring money to or from United States banks. The most damaging European sanctions focused on Iran's energy and financial sectors [33].

In **2008**, the US Treasury ordered Citigroup Inc. to freeze over $2 billion held for Iran in Citigroup accounts. On **24 June 2010**, the United States Senate and House of Representatives passed the Comprehensive Iran Sanctions. President Barack Obama's administration first enforced ISA/CISADA secondary sanctions in 2010 on the Naftiran Intertrade Company, a Swiss-based subsidiary of the National Iranian Oil Company, and Belarus-based Belarusneft in 2011. EU and UN efforts complemented increasingly stringent sanctions by the United States. These measures expanded the scope of "secondary sanctions," which target parties that do business with Iran,

[10] IAEA
[11] Bank Sepah, Bank Saderat Iran, Bank Melli Iran, Bank Kargoshaee (aka Kargosa'i Bank), Arian Bank (aka Aryan Bank)

particularly non-American companies. These sanctions prohibit nearly all engagement with Iran's financial and energy sectors and have involved a series of unprecedented steps, including the blacklisting of Islamic Iran. Japan and South Korea similarly implemented trade and energy sanctions against Iran in 2010. Both nations also substantially reduced purchases of Iranian crude oil [33].

The EU sanctions followed a set of U.S. unilateral sanctions in **November 2011** that designated the Iranian financial sector as the jurisdiction of ''primary money laundering concern" under Section 311 of the USA PATRIOT Act for the first time in history. In **December 2011** President Obama signed the National Defense Authorization Act for the fiscal year 2012 which imposed severe unilateral sanctions against the Central Bank of Iran. The act prohibited any activity of foreign financial institutions that conduct or facilitate any significant financial transaction with the Central Bank of Iran or any other Iranian financial institutions. The same restriction applies to the foreign central banks if they engage ''in financial transactions for the sale or purchase of petroleum or petroleum products to or from Iran", effectively blocking Iran's oil exports. The sanctions sought to reduce Iranian export earnings as well as restrict the country's access to its foreign reserves mainly to the purchase of humanitarian goods [26].

The European Union imposed an oil embargo in **January 2012** which banned the import, purchase, or transport of Iranian crude oil, natural gas, and petrochemical products, and prohibited the provision of related financing, insurance, or reinsurance. The Iranian Rial depreciated by around 40% in January against the dollar. In addition, the EU froze Iran's central bank's assets and denied the Iranian financial sector access to the Society for Worldwide Interbank Telecommunication (SWIFT) messaging service, as an unprecedented step, in **March 2012**, thus cutting off Iran's access to a secure international payment system. This was to cripple the Iranian financial sector's ability, including Iran's central bank, to conduct international business. This was the first time that SWIFT, a consortium based in Belgium, denied the entire financial system of the country access to its vital service [26].

The national currency depreciated again in October 2012 as the sanctions intensified and the European Union boycott of Iranian oil exports came into effect. These sanctions coupled with ''secondary sanctions" and other extraterritorial measures that the sanctioning countries undertook to discourage companies and individuals of third countries to do business with Iran. Therefore, the effect of enforcement went beyond the sanctioning countries. The combination of sanctions and extraterritorial enforcement practice created a major hurdle in processing

international payments and curbed other bilateral economic flows [26]. This sanction forced Iran to sell its oil at a significant discount and exchange it for other goods. This unexpected situation caused the Rial to lose about two-thirds of its value compared to the US dollar. Access to capital in Iran was severely challenged, forcing the government to intervene in banks' credit allocation, effectively dictating which industries were to be prioritized for funding. Finally, as a result of the sanctions, the country faced difficulties in purchasing intermediate goods [34].

During the 2012–2013 period, the fluctuations of exchange rates on Iran's foreign exchange market were probably one of the most serious stress tests for the country's economy. In July 2012, the Central Bank of Iran (CBI) was unable to control the overpriced exchange rate of the Iranian rial and had to depreciate it. The depreciation of the national currency, cut off from the financial world, lack of petrodollars, and problems with the import of some consumer goods boosted the growth of prices as a result, inflation accelerated, eventually peaking at 35.60% in 2013 (Figure 8) and Real GDP growth fell from 2.6% in 2011 to -7.4% in 2012 (Figure 9) [35].

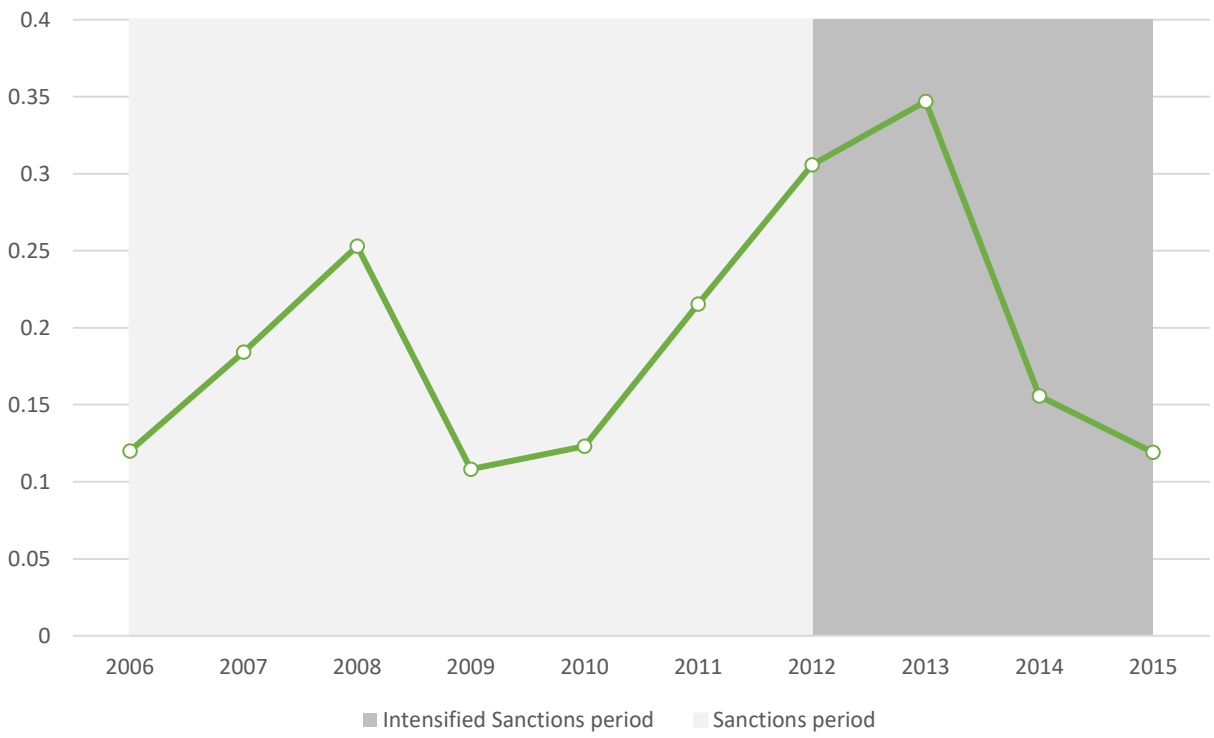


Figure 8. *Inflation, Average consumer price (annual %) over 2006-2015, IMF.ORG*

***Figure 9**. GDP growth (annual %) over 2005-2014, WORLDBANK.ORG*

In 2013, a year after the introduction of the EU's oil trade embargo, the volume of Iran's oil revenues was almost 50% lower than those in 2011. Iran's crude oil exports declined drastically from 2.2 million barrels per day (bpd) to about 990 thousand bpd between 2011 and 2014 (Figure 10). This substantial drop inevitably caused a deficit in the Iranian budget that was heavily dependent on the inflow of petrodollars [35].

Iran's exports and imports of goods and services between 2011 and 2013 were harmed as a result of sanctions. Exports dropped significantly by 32% and imports decreased by 12% in 2012 (Figure 11).

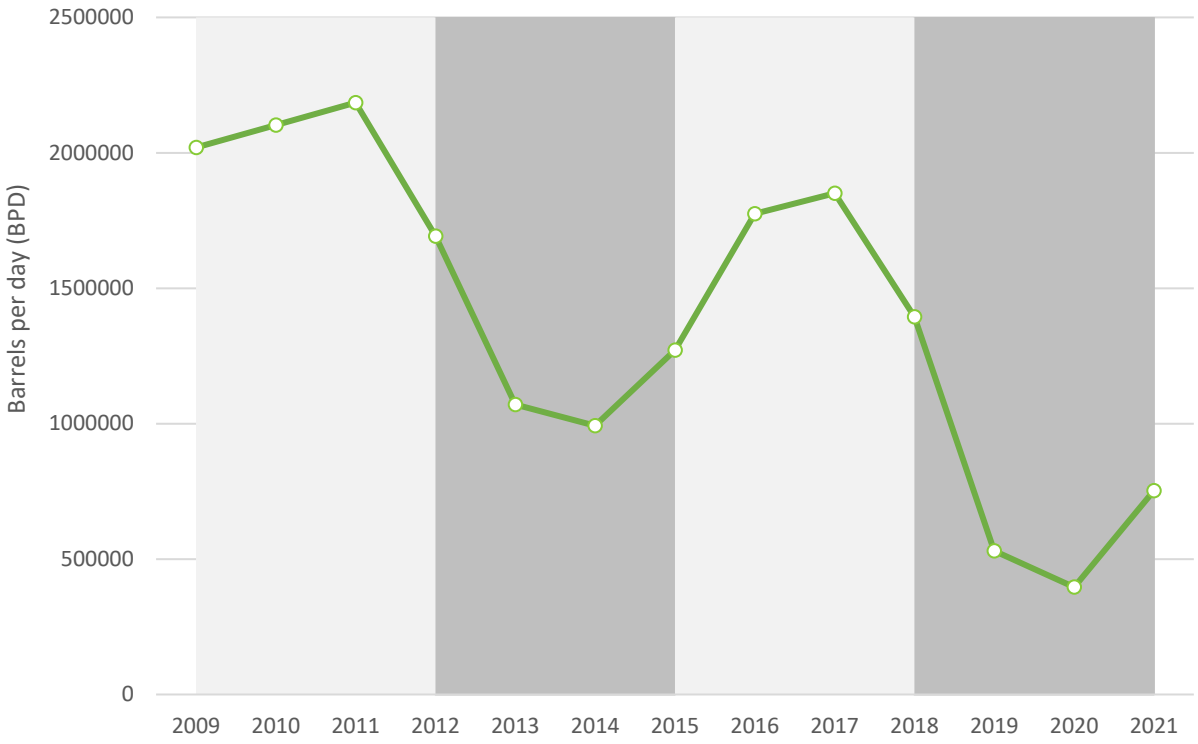


***Figure 10**. Crude Oil Exports for Iran over 2009-2014, FRED.ORG*

In 2012, the official unemployment rate reached 12.2% (more than 19% in unofficial calculations). Social indicators also demonstrated negative tendencies. According to different sources, in 2013, about 60% of the population lived either on or below the poverty line. The wealth gap was huge and kept growing. The income of the three richest deciles of the population was 15-16 times higher than that of the three poorest deciles [35].

However, in 2013–2015, a trend toward economic stabilization emerged in the country. In 2013, the GDP growth rate was still negative at -1.5% against -3.8% in 2012. In 2014, the economy showed positive growth (4.9 %). After 2013, inflation also slowed down, falling about 11% in 2015. Furthermore, the dependence of the budget on oil revenues also decreased [35].

The positive tendencies in Iran's economy after 2013 were a result of Hassan Rouhani's victory in the presidential elections in June 2013. They claim that Rouhani had a more effective economic policy. Apart from that, he proved to be more efficient as a diplomat as he launched a new round of negotiations with the international community. This compelled the U.S. allies to be less consistent in implementing the sanctions. These factors can explain some of the positive changes in Iran's economic performance [35].

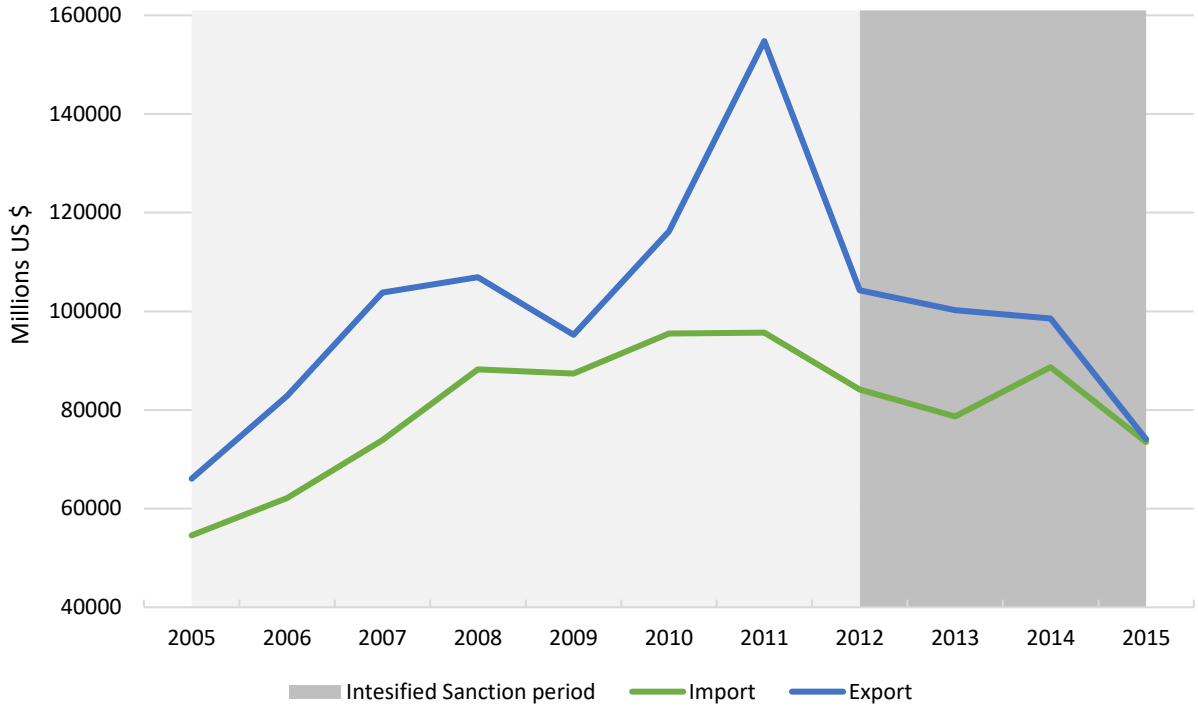


***Figure 11**. Exports and imports of goods and services over 2005-2014, FRED.ORG*

6.3. Iran's Response to The Sanctions

The Iranian government was fast to learn how to live when oil revenues were limited. Sanctions triggered what was previously considered hardly achievable: they compelled the Iranian government to convert its promises to diversify the sources of budget revenue into practical steps [35].

Thus, in December 2012, the Iranian government declared that during the 2010–2012 period, it had managed to create a modern fiscal system in the country, including a value-added tax collection mechanism. Subsequently, the officials in Ahmadinejad's Cabinet stated that it was time to start using this system and increase budget revenue. Although these statements caused a negative reaction from the Iranian parliament, in 2012, the Iranian government increased tax revenue by collecting up to $14 bn (25% more than in 2011) [35].

The diversification was not limited to taxes. In 2012–2013, Tehran boosted the development of almost all economic activities that could not be hurt by sanctions or where sanctions had a minimal impact. Tehran intensified the development of its basic non-oil industries such as steel, cement, and energy production as well as mining. In 2012, the country's non-oil exports accounted for 60% (and according to alternative sources, 75%) of its total exports (compared to

24% in 2002 and 14% in 1992). Iran's non-oil exports accounted for $37.69 bn. In 2014, they were already estimated at $46 bn. This increase in income was guaranteed by the growth of petrochemical products in the structure of Iran's exports: gas condensates, propane, methanol, butane, and polyethylene became the main items exported abroad [35].

The government paid special attention to the management of foreign exchange and financial markets. In a bid to cope with the consequences of the inevitable depreciation of the national currency, Tehran tightened control over foreign exchange transactions and re-introduced a multiple exchange rate system that allowed it to allocate cheaper foreign currency to the importers of essential goods. The Iranian authorities imposed a ban on the import of luxury commodities to decrease the outflow of hard currency from the country. With the same goal in mind, non-tariff methods were introduced to limit the import of goods whose equivalents were manufactured in Iran. At the same time, duty-free imports of gold and silver bullion were allowed, which Tehran started to use in its foreign transactions [35].

No less important for evading sanctions were measures undertaken by Tehran in the international arena. Firstly, it stepped up interaction with its traditional trading partners, trying to ensure their loyalty to Iran and encourage them to counter the sanctions imposed by the United States and its partners. For instance, after the introduction of the oil embargo by the EU in 2012, Iran offered substantial price discounts for the remaining buyers of its hydrocarbons in order to win over their loyalty [35].

In certain cases, the very nature of the sanctions created opportunities to bypass them: the punitive measures were mostly related to sea and air transportation whereas road haulage was left without attention. Meanwhile, Iran's highly developed domestic road infrastructure had multiple junctions with the transportation systems of the neighboring countries, which allowed Iranians to deliver goods to every point in Eurasia without using sea or air routes. As a result, notwithstanding the sanctions imposed in 2010, the media reported a certain increase in the number of petrol tankers crossing Iran's borders with Turkey and Iraq and ferrying across the Caspian Sea from some Central Asian countries [35].

The Iranian authorities also used illegal measures. For instance, from 2010 to 2015, they were periodically accused of attempts to sell oil covertly. Some say that the easiest scheme for Tehran was to falsify documents and sell its oil as if produced in Iraq. One of the probably most extreme methods to conduct secret trade operations with oil was related to its ship-to-ship transfers in the open sea. From 2010 through 2015, Tehran increased its tanker fleet (not only by constructing

new ships but also by buying old oil tankers that were prepared for scrapping). These oil tankers periodically would leave Iranian ports without stating the exact point of destination and could stay in the open sea for some time. If an oil deal was concluded, such a tanker turned off its tracking beacons to hide its position and moved to an agreed point where it met a tanker of the buyer. The load was transferred from one ship to the other in the open sea. After this, the Iranian empty tanker returned to its home port [35].

Thus, during this period of Western sanctions, the Iranian leadership learned several important lessons and gained valuable experience in counterbalancing the negative impact of sanctions [35].

6.4. JOINT PLAN OF ACTION (JPOA)

In **2013**, Iran and the P5+1[12] meet in Geneva. Iranian Foreign Minister and EU High Representative, who leads the P5+1 negotiating team, sign the Joint Plan of Action (JPOA) on **November 24**. The JPOA spells out steps Iran must take—halt enrichment of uranium to 20 percent and provide the UN nuclear watchdog the International Atomic Energy Agency (IAEA) access to monitor Iranian nuclear sites—in order to receive limited sanctions relief, repatriation of some assets frozen abroad. The United States offers limited sanctions relief, including lifting the threat of sanctions on foreign companies dealing with Iran's auto sector or purchasing Iranian petrochemicals [36].

On **20 January 2014**, the IAEA finds that Iran is complying with the terms of the JPOA. The United States and the EU say they have taken steps to waive specific sanctions [36].

[12] The five permanent members of the United Nations Security Council—China, France, Russia, United Kingdom, United States—plus Germany

CHAPTER 2

SANCTIONS AND IRAN'S ECONOMIC CRISIS

1. International Sanctions, 2015-2022, Mapping on the USD/IRR Exchange Rate Fluctuations Graph

In this article, we consider USD-IRR exchange rates from April 2015 to April 2022 for carrying out the analysis in chapter 4. Figure 12 indicates the related data. Iran's foreign exchange market has been facing high rates of risk-based pricing because of the rising political and economic uncertainties for the last four years. Besides studying the economic parameters affecting Iran's exchange rate fluctuations and crisis, the following there are the events that seem to have had significant effects on the USD/IRR exchange rate market since 2015.

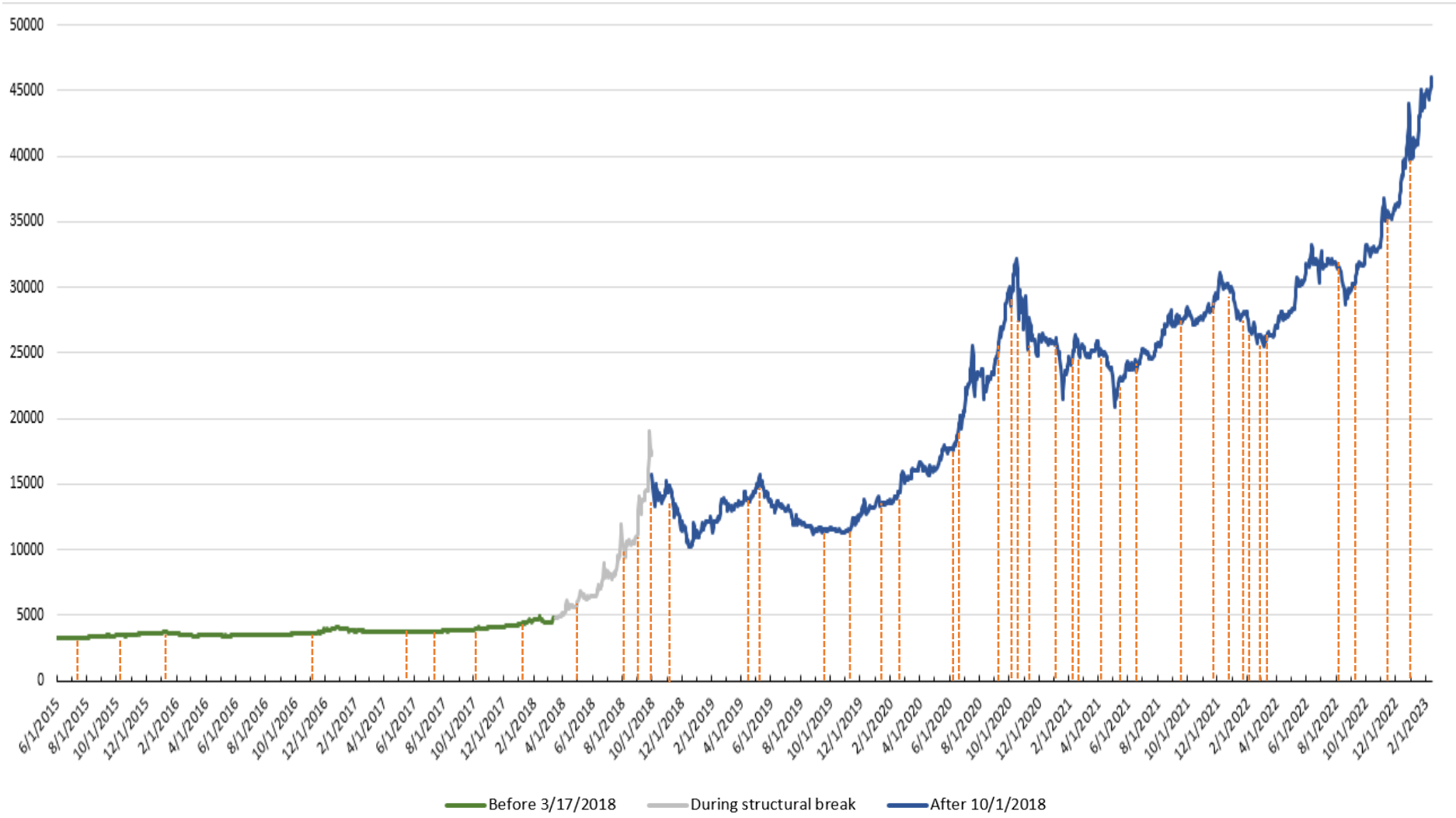


Figure 12. *USD/IRR exchange rate, 2015-2022*

Although Iran was surviving under the 2010–2015 sanctions, it was not developing. Under these circumstances, the lifting of sanctions became one of the top priorities for Tehran. The beginning of the constructive dialogue with the international community and the subsequent adoption of the Joint Comprehensive Plan of Action (JCPOA)[13] helped ease the sanctions burden and launch the process of the country's gradual reintegration into the global economy. First and foremost, the JCPOA lifted limits on the export of Iranian oil and thereby helped increase the country's budget revenue. After 2015, foreign businesses started to investigate investment opportunities in Iran. This process was accompanied by a partial restoration of Iran's ties with the international banking system [35].

On **2 April 2015**, following a series of intense negotiations in Lausanne, Switzerland, between Iran and (P5+1), the two sides reached a provisional agreement on a framework that, once finalized and implemented, would lift most of the sanctions in exchange for limits on Iran's nuclear programs extending for at least ten years [37].

On **14 July 2015***,* the Joint Comprehensive Plan of Action was signed under which the US agreed to cancel most US sanctions against Iran, with some safeguard provisions, in return for limitations on Iran's nuclear program [36].

On **18 October 2015**, Iran and the P5+1 formally adopt the nuclear deal. Iran begins taking steps to restrict its nuclear program. The United States issues waivers on nuclear-related sanctions to come into effect on implementation day. The EU announces it passed legislation to lift nuclear-related sanctions on implementation day [36].

On **16 January 2016** as a result of the JCPOA agreement, UN sanctions were lifted. A portion of the Islamic Republic's nuclear program was suspended. Subsequently, the Western powers lifted many of the previously imposed sanctions. Most Iranian banks were reconnected to the SWIFT network and could engage in international transactions, which was vital for Iran's trade, particularly for the country's oil exports and the broader stability of its currency. Also, Iran gained access to more than $100 bn in assets frozen overseas. Iran's inflation rate fell below 10% for the first time in nearly 25 years [34].

On **8 November 2016***,* Donald Trump was elected as the 45th President of the United States. During the presidential campaign, Trump referred to the JCPOA as the worst deal ever negotiated

[13] Formal negotiations toward JCPOA began with the adoption of the Joint Plan of Action, an interim agreement signed between Iran and the P5+1 countries in November 2013. Iran and the P5+1 countries engaged in negotiations for the next 20 months and, in April 2015, agreed on an "Iran nuclear deal framework" for the final agreement.

and pledged to renegotiate it. The U.S.'s European allies in the P5+1 previously signaled they would resist efforts to renegotiate the deal. In January 2017 Donald Trump took office as the president of the US [38].

On **17 May 2017**, The U.S. renewed sanctions waivers as required by its JCPOA obligations, marking the first time the Trump administration had waived sanctions and taken a proactive step to implement the deal [38].

On **10 July 2017** White House Spokesperson said that at the G20 summit, President Trump encouraged foreign leaders not to do business with Iran. On **25 July 2017**, the U.S. House of Representatives passes H.R. 3364, the Countering America's Adversaries Through Sanctions Act (CAATSA), which would impose new sanctions on Iran, North Korea, and Russia [38].

On **13 October 2017** Trump declared that, as part of a broader new strategy toward Iran, he will not certify under the Iran Nuclear Agreement Review Act (INARA) that the suspension of sanctions under the JCPOA is "appropriate and proportionate" to measures taken by Iran under the deal. Trump's decertification itself did not violate the JCPOA. However, decertification opens a window of 60 days where Congress may re-introduce sanctions waived under the nuclear deal with Iran under an expedited process. In his address, Trump encourages Congress to enact legislation against the JCPOA's "sunset clauses" which set dates after which certain restrictions under the deal on Iran's nuclear program will no longer apply. Trump says if his concerns about the deal are not resolved he will terminate the agreement. Trump also states that he will further sanction the Islamic Revolutionary Guard Corps (IRGC) for its support of terrorism but does not designate the group as a terrorist organization. Immediately following the announcement, UK Prime Minister Theresa May, German Chancellor Angela Merkel, and French President Emmanuel Macron released a joint statement expressing their continued support for the JCPOA [38].

On **12 January 2018***,* the Trump administration announced that it would re-issue waivers on nuclear-related sanctions on Iran to meet U.S. obligations under the agreement. However, Trump says he would not reissue the waivers again and will withdraw from the deal unless Congress passes legislation addressing what he describes as flaws in the agreement [36]. Trump says his administration is also engaging with European allies on a supplemental agreement of unlimited duration that will impose sanctions if Iran tests long-range missiles, thwarts inspections, or makes progress toward a nuclear weapon [38].

On **8 May 2018**, President Trump announces that he is withdrawing the United States from the JCPOA and signed a presidential memorandum to institute the "highest level" of economic sanctions on Iran [38]. The first major depreciation of the rial began in the months leading to the U.S. withdrawal from the JCPOA [39]. Instead of opting for further negotiations while keeping the promises of the deal, Trump completely nullified the deal and withdrew the US from it, and later imposed a full-scale economic war on Iran. In a statement, Secretary of the Treasury Steve Mnuchin states that sanctions will be reimposed subject to certain 90-day and 180-day "wind-down periods." The quick currency devaluation encouraged Iranians to move away from Rial savings and rush to buy gold and foreign currencies [40].

On **7 August 2018,** certain sanctions measures reimposed by Trump (on 8 May) come into full effect. The measures include restricting Iran's purchase of U.S. dollars, trade in gold, precious metals, aluminum, steel, coal, software, and transactions related to sovereign debt and the automotive sector [38].

Licenses allowing certain foodstuffs to be exported to the United States and Iran to purchase commercial aircraft were also revoked [38]. The Trump administration warned that anyone doing business with Iran will not be able to do business with the United States. However, the US will be granting waivers to certain countries. For example, Iraq was granted a waiver that would allow the country to continue purchasing gas, energy, and food products from Iran on the condition that the purchases were not paid for in US dollars.

Knowing what to expect after the previous rounds of sanctions under the Obama Administration, when the new sanctions were imposed Iranians adjusted their expectations on the financial market: people started to hoard foreign currency; excessive demand for US dollars caused the gap between the official and the market exchange rate to widen further, and imports became more expensive [41].

In **September 2018**, the interest rates on current accounts, which were previously very high at around 20 percent, dropped sharply to around 10 percent. Due to declining profits, people sought new opportunities by withdrawing money from accounts. As a rule, one of the places that attracted this stray money was the currency and gold market, which increased the demand for foreign currency [40].

In **October 2018**, the Central Bank of Iran (CBI) implemented measures to allocate currency for major imports through export revenues, using the official exchange rate. This hindered the

depreciation of the rial in the second (unofficial) market only for a short period and then the depreciation path again continued [39].

On **5 November 2018** the second round of sanctions on Iran following Trump's withdrawal from the JCPOA, targeting Iran's banking, oil, shipping, and shipbuilding sectors, come back into effect. In addition to redesignating entities removed from the SDN list under the JCPOA, the United States designates an additional 300 new entities [42].

The administration grants temporary waivers to China, India, Italy, Greece, Japan, South Korea, Taiwan, and Turkey to continue importing Iranian oil at reduced levels. The trade relations with neighboring countries, such as Afghanistan and Iraq, which had increased significantly before 2016, took a significant hit [38].

On **29 April 2019,** President Trump announced the end of oil waivers. The U.S. threatened to sanction countries continuing to buy oil from Iran after an initial six-month waiver announced in November expired [42].

On **8 May 2019***,* Tehran lifted limits on its uranium enrichment. Iran announces that it will no longer be bound by stockpiles limitations on enriched uranium and heavy water reserves in the JCPOA and could restart construction on its unfinished heavy water reactor at Arak and resume higher-level enrichment in the future if the other parties to the agreement do not deliver on sanctions relief [38]. The rial was slightly appreciated [39].

On **20 September 2019***,* the US imposed sanctions on the Central Bank of Iran, the National Development Fund of Iran (NDF), and Etemad Tejarate Pars Co., an Iranian company that was used to transfer money to the Ministry of Defense and Armed Forces Logistics [38].

On **25 September 2019,** Iranian President Hassan Rouhani announced that Iran will not engage in negotiations while under sanctions and affirmed that talks with the United States will only begin if all parties return to compliance with the JCPOA. On 26 September 2019 France, Germany, and the United Kingdom warn Tehran that a fourth violation of the JCPOA will prompt a special dispute mechanism [38].

On **14 November 2019,** the Iranian government announced a major cut in the amount of the petrol subsidies, which led to a price rise of 50% for the first 60 liters per private vehicle per month - and of 200% for anything exceeding that. The corresponding fall in oil revenues paralyzed the government and prevented it from providing any expansionary stimulus to counter the recession in 2019. The government could not able to support its budget because it does not have any

powerful friends from whom to obtain loans or credits [41]. Even the proposal by France's Emmanuel Macron (26 August 2019) to offer Iran USD 15 billion lines of credit required the blessing of US President Donald Trump [38].

In a four-point document, this support was made conditional on a fresh round of talks between Iran and the US (an initiative by Macron on the sidelines of the United Nations General Assembly in New York). However, Iran lost that card too. The Iranian government was left without any foreign aid, and so now it needs to charge its budget domestically, meaning that the pressure will fall on the Iranian population.

Instead of trimming budget costs at the expense of some public entities or boosting the budget via taxing semi-public companies (like bonyads (foundations) or the Setads), which do not pay taxes, the hike in fuel prices was simply tapping the people. Petroleum is the product of an upstream sector and is used in many other sectors either directly or indirectly. Its primary use, for instance, is in the transportation sector, which feeds into many other sectors of the economy. This makes petroleum an important source of shock, which impacts on costs of many other sectors and cascades down through the whole economy [43]. This decision triggered massive nationwide unrest followed by a brutal crackdown. Since then, the rial has continued to lose value [39].

On **14 January 2020**, Britain, France, and Germany triggered the disputed resolution mechanism under the 2015 nuclear deal. It was the strongest action taken by European powers to enforce the agreement. If Iran did not return to compliance, the process could result in the reimposition of U.N. sanctions and ensure that an arms embargo[14] did not expire in October 2020 [38].

In addition to the hard-currency shortfall due to a lack of export revenues, the International Atomic Energy Agency (IAEA) Board of Governors' resolution against Tehran's NPT (Non-Proliferation Treaty) Safeguards Agreement was another factor behind the depreciation of the rial. The first critical resolution against Iran since 2012, lamented the "denial of access to two locations specified by the IAEA under the Additional Protocol and continued lack of clarification regarding Agency questions related to possible undeclared nuclear material and nuclear-related activities in Iran." Following the passing of the resolution, the rial encountered another sharp depreciation against the USD. The IAEA resolution prompted a capital flight through

[14] An arms embargo is a restriction or a set of sanctions that apply either solely to weaponry or also to "dual-use technology."

dollarization in the secondary market. This recalls a similar pattern following a previous IAEA resolution in October 2012 [39].

On **20 February 2020,** Iran reported its first confirmed cases of Covid-19 infections. The coronavirus disease 2019 (COVID-19) has spread over all 31 provinces of Iran, leading to the most cases and death among the Eastern Mediterranean countries. In response, the Government of the Islamic Republic of Iran canceled public events and closed schools, universities, shopping centers, bazaars, and holy shrines; and banned festival celebrations. Owing to the Covid-19 pandemic, Iran closed its borders. Despite the recent increase in hydrocarbon exports, Iran's hard-currency revenues had remained extremely strained, as problems in repatriating these funds persisted. Iran had increasingly exported products and manufacturing to neighboring countries to finance its imports. However, due to the coronavirus pandemic and border closures with neighboring countries, even these exports had been limited. As a result, Iran's currency reserves were shrinking due to the reduction in exports, resulting in a substantial trade deficit [39].

On **21 February 2020,** Iran was placed on the Financial Action Task Force (FATF) blacklist. In June 2016, Iran committed to addressing its strategic shortcomings. Still, since it did not address these shortcomings, FATF stated that in February 2020, Iran did not complete its action plan and blacklisted it. FATF has announced that it will remain on the blacklist until the Iranian regime accepts anti-terrorism financing standards [44].

On **8 June 2020,** the U.S. imposed new sanctions on Iran Shipping Lines (IRISL) and its Shanghai-based subsidiary, E-Sail Shipping Company Ltd (E-Sail) [38]

On **25 June 2020**, the United States imposes additional sanctions on Iran targeted at the country's metal industry. A statement by the U.S. Secretary of State notes that Washington "will continue to exert maximum pressure on Iran until the regime decides to start behaving like a normal country." [38]

On **16 September 2020,** U.S. Secretary of State Michael Pompeo states that the United States will snap back UN sanctions on Iran [38]. The Iranian rial hit another negative record in its value against the USD. This announcement indicating to completely cut off of Iran's financial system with a fresh set of sanctions had a psychological effect on Iran's foreign-exchange market. On October 1, Iran's currency reached yet another new record low [39].

On **8 October 2020**, the US imposed further sanctions on Iran's financial sector, targeting 18 Iranian banks [15]. The aim was to identify and impose sanctions on key sectors of Iran's economy in order to deny the Iranian government financial resources that may be used to fund and support its nuclear program, missile development, terrorism, terrorist proxy networks, and malign regional influence [45].

On **18 October 2020**, the UN arms embargo against Iran was lifted, as envisaged in the JCPOA. Although this is unlikely to transform and modernize Iran's military arsenal, it was celebrated by Iran as a political victory against the U.S. campaign of "maximum pressure," improving expectations in Iran's market. Almost immediately, the rial appreciated against the USD by about 10 percent [39].

In **November 2020**, Biden was elected the 46th president of the United States. The victory of Biden in the US elections has created an optimistic atmosphere in Iran and had an additional positive impact on Iran's market. The rial was briefly appreciated by another 10 percent as a result of this atmosphere. Those holding foreign currency as an investment supplied it immediately to the market to avoid further losses [39].

Iran's administrations thought Biden can be an acceptable partner for Iran. Biden was a key figure in the Obama administration who personally supported the nuclear deal. He worked hard to get the deal approved by the US Congress and Senate. While Biden continues to see the Islamic Republic as a threat to US security, there is evidence that he was likely to pursue Barack Obama's policy of engagement and diplomacy with the Islamic Republic. He also believed that a nuclear deal is the only peaceful solution that prevents the Islamic Republic from reaching a nuclear bomb [46].

On **5 January 2021**, the U.S. Treasury Office of Foreign Assets Control imposed a new round of sanctions on Iran's steel industry. Treasury Secretary Mnuchin said in a statement that "the Trump Administration remains committed to denying revenue flowing to the Iranian regime as it continues to sponsor terrorist groups, support oppressive regimes, and seek weapons of mass destruction." [38]

[15] Amin Investment Bank, Keshavarzi Iran Bank, Maskan Bank, Refah Kargaran Bank, Shahr Bank, Eghtesad Novin Bank, Gharzolhasaneh Resalat Bank, Hekmat Iranian Bank, Iran Zamin Bank, Karafarin Bank, Khavarmianeh Bank, Mehr Iran Credit Union Bank, Pasargad Bank, Saman Bank, Sarmayeh Bank, Tosee Taavon Bank, Tourism Bank, and Islamic Regional Cooperation Bank.

On **8 February 2021,** US President Joe Biden said, that he would not lift economic sanctions against Iran until Iran complies with the terms of the 2015 JCPOA nuclear deal. On the other hand, Iran said that it would suspend the implementation of the Additional Protocol, if the other parties to the 2015 nuclear pact do not fulfill their obligations by February 21, 2021 [47].

On **18 February 2021**, the United States sent a letter to the United Nations Security Council formally rescinding former President Donald Trump's request that all sanctions lifted following the JCPOA be re-imposed on Iran [48].

On **6 April 2021**, the first round of negotiations started in Vienna. The parties stated that lifting the USA's sanctions, the steps for Iran and the USA to implement the deal, and the actualization of the process in an order which will satisfy both parties, have been discussed in the negotiations [48].

On **19 May 2021***,* the fourth round of Joint Commission negotiations wraps up in Vienna. Iran and the United States have failed to reach an agreement on several limited but crucial issues [38].

On **20 June 2021**, the sixth round of negotiations adjourned, and no deal is reached, but parties express optimisms and agree to reconvene in July [38].

On **20 September 2021**, the seventh round of talks begins in Vienna, after a three-month hiatus.

On **27 September 2021**, a 1.4 percent decline in one day was owed to a negative comment by the UN's International Atomic Energy Agency, which said Iran has not fully honored a deal made on September 12. Iran's battered currency which has declined ninefold since 2017 was sensitive to news about the dispute Iran has over its nuclear program with the United States and its European allies [49].

On **29 November 2021**, after five-month hiatus after the sixth round, which ended on June 20, the seventh round started. Iran and the signatories of the Joint Comprehensive Plan of Action (JCPOA) met in Vienna to resume a six-round talk exploring possibilities to restore the JCPOA deal. The announcement of Iran's return to the negotiating table created a positive atmosphere for the sake of the future of the JCPOA. However, this optimistic atmosphere was replaced by negative discourses, with some prominent statements and developments in the seventh round [50].

On the first day of the negotiations, Bagheri Kani stated that "the texts obtained and agreed upon in the previous rounds will be again renegotiated". In this regard, on the fourth day of the nuclear

negotiations in Vienna, Iran submitted two draft proposals. The US and E3 have made remarks about the drafts Iran has proposed. White House Spokesperson Jen Psaki said at the press conference on the subject, "the new Iranian administration did not come to Vienna with constructive proposals. The first six rounds of negotiations made progress in finding creative compromise solutions to many of the hardest issues. Iran's approach this week was not, unfortunately, to try to resolve the remaining issues". The seventh round of nuclear talks concluded on Friday, December 3. Diplomats have returned to their capitals for consultations on the next steps. The seventh round ended on 17 December. Considering the latest evaluations and statements from the parties, it is very difficult to be optimistic about the future of the negotiations [50].

On **27 December 2021**, the eighth round of talks kicked off in Vienna [38]. The negotiations seek to restore the original JCPOA and bring the US back into the agreement. Following a JCPOA Joint Commission meeting between Iran and the five world powers (Russia, the UK, Germany, China, and France). Both negotiation parties were hopeful about the signs of progress made.

On **17 January 2022**, Iran's foreign ministry spokesman says that talks in Vienna are making progress, but key issues remain unresolved. On 19 January 2022 U.S. President Joe Biden, speaking about efforts to restore the JCPOA, says, "it is not time to give up," and "there is some progress being made" [51].

On **28 January 2022**, the eighth round of talks to re-establish the nuclear pact pauses in Vienna. German, French, British, Russian, Chinese, and Iranian diplomats return home for consultations with their governments, according to European Union political director Enrique Mora, who is chairing negotiations, after five weeks of the longest-running talks yet [38].

On **8 February 2022**, the eighth round of talks resumes in Vienna after a 10-day break for political consultations [38].

On **1 March 2022**, the ninth round of talks begins, with some reports indicating progress towards a final agreement.

On **11 March 2022**, talks in Vienna to restore the nuclear deal are paused, according to European Union foreign policy chief Josep Borrell. Borrell attributes the pause to “external factors” affecting the negotiations [51].

On **5 August 2022**, the tenth round of talks concludes without a final agreement, but parties agree to continue negotiations in the future.

On **16 September 2022**, civil unrest and protests against the government of Iran associated with the death in police custody of Mahsa Amini began [52].

On **12 November 2022**, the Rial lost 13.8% of its value since nationwide protests. The economic Ecoiran website said traders saw little hope for the revival of Iran's nuclear deal with world powers and saw Western pressure increasing over Tehran's crackdown against the protests and its military ties with Russia. These include the alleged sales of drones used by Russia in the war in Ukraine, which Tehran and Moscow have denied [52].

In **January 2023** the eleventh round of talks begins in Vienna, with parties still working towards a final agreement.

2. Structural Deficiencies of the Iranian Economy

Although in 2015–2018, the Iranian leadership was successful in starting the recovery of the country's economy, it could not ensure its sustainable growth and the improvement of social conditions. There were several reasons for that [35].

Firstly, the United States, unlike other players, did not completely remove its extraterritorial sanctions. Washington justified this by referring to Iran's regional policies (which it considered aggressive), the human rights situation in Iran, and alleged facts of money laundering by the Iranian authorities. As a result, most of the financial sanctions imposed by the United States remained in place, and only nuclear-related sanctions were lifted. This prevented the complete restoration of Tehran's ties with the international financial system and made potential investors very cautious about funding projects in Iran. In addition, in 2015–2016, foreign companies were not sure whether Obama's successors would honor the JCPOA and adhere to its principles, which increased political risks associated with investments in Iran [35].

Secondly, while most sensitive sanctions imposed in 2010–2015 were lifted by the EU, Iran's economy continued experiencing negative repercussions. For instance, due to the lack of access to foreign technologies and equipment and external investments during the sanctions period, Tehran could not promptly modernize the production base and repair fixed assets of its enterprises in key industries. Consequently, by 2015 a large part of these enterprises had been either broken down or outdated and faced a high degree of depreciation. In some industries, such as steel production, for instance, fixed assets required almost complete replacement. This factor

determined the initial huge volume of investments necessary to revitalize Iranian domestic production and make it competitive. Yet there were not enough funds available to make these investments. Iran's domestic financial reserves were exhausted by the years of sanctions while the low profitability and high investment risks associated with the U.S. policies towards Iran did not allow foreign investors to step in and remedy the situation [35].

The adoption of the JCPOA also clearly demonstrated that it would be wrong to blame sanctions alone for all misfortunes of the Iranian economy. Other key factors, which did not allow the country to develop during the short period when the sanctions were eased, included the structural deficiencies of the Iranian economy [35].

2.1. Monetization's Growth and Its Aftermath

The monetization of the government's budget deficit has been cited by experts as the single most important factor for the fall of the rial against the USD and the high inflation rates in Iran [53].

Since the beginning of 2018, Iran has been under the most severe US sanctions aiming at the economic collapse of Iran have led to Iran facing a greater budget deficit. In other words, the Iranian government has been printing money to pay for the gap between its revenues and expenditures [53].

For decades, the Iranian government's response to bank reserve shortages has been to print money, without any solid inflation-control mechanisms, to maintain the required level of reserves for the central bank. Despite some of the fundamental differences between the economic policies of different administrations in Iran, increasing the money supply has been a common policy decision for all administrations. Unlike the developed countries' economy, where the capital market or stock exchange is generally responsible for this task, the bank is the first option for Iran's government to cover the deficit when it is faced with a decrease in financial resources [40].

Providing a part of the government's budget deficit from the foreign exchange resources of the National Development Fund due to the unavailability of these currencies for the central bank has led to an increase in the monetary base, which naturally shows its effect on other monetary variables such as liquidity [40]. Figure 13 illustrates the co-movement of government budget deficit and liquidity.

The report of Iran's Central Bank on the monetary variables of 2012 shows that liquidity was about 4607000 thousand billion Iranian Rials (IRR). The Central Bank report on monetary and banking variables related to 2021 shows that liquidity has exceeded 48320000 thousand billion Iranian Rials. A comparison of these two numbers shows a 949% growth in liquidity from 2012 to 2021.

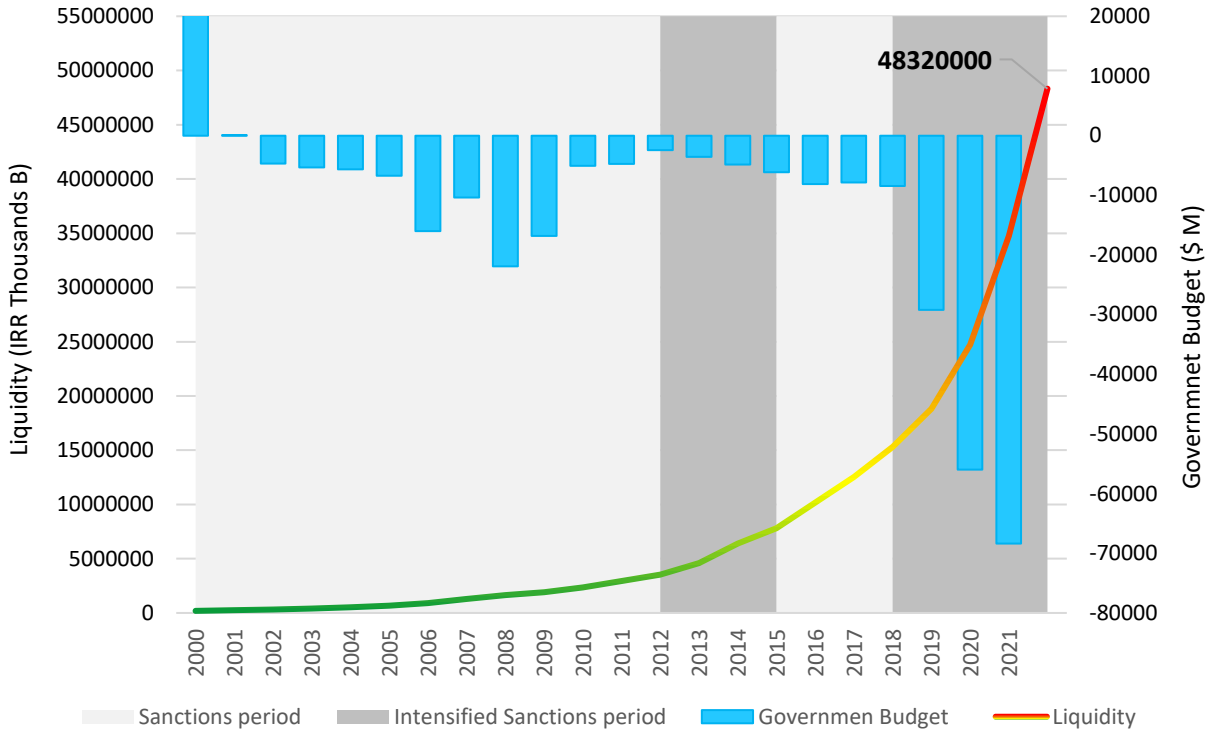


***Figure 13**. Liquidity and Government budget of Iran over 2000-2021, COUNTRYECONOMY.COM*

In theory, increasing the monetary base can boost economic growth because more cash in the hands of consumers can increase consumption and generate economic growth. However, although money in circulation has increased, the purchase of goods and services is not increasing proportionately due to high inflation. Inflation, therefore, has become one of the direct negative impacts of the increasing money supply in Iran [40].

During the same seven-year period (2012-2021) which saw a 10.5 -fold increase in liquidity, Iran's average economic growth rate is almost 1.2%, according to various reports from Iran's Central Bank and Statistics Center. As can be seen from figure 14, it can be concluded that liquidity has

grown disproportionately to Iran's economy and production, rendering it the most important reason for the continuous increase in inflation.

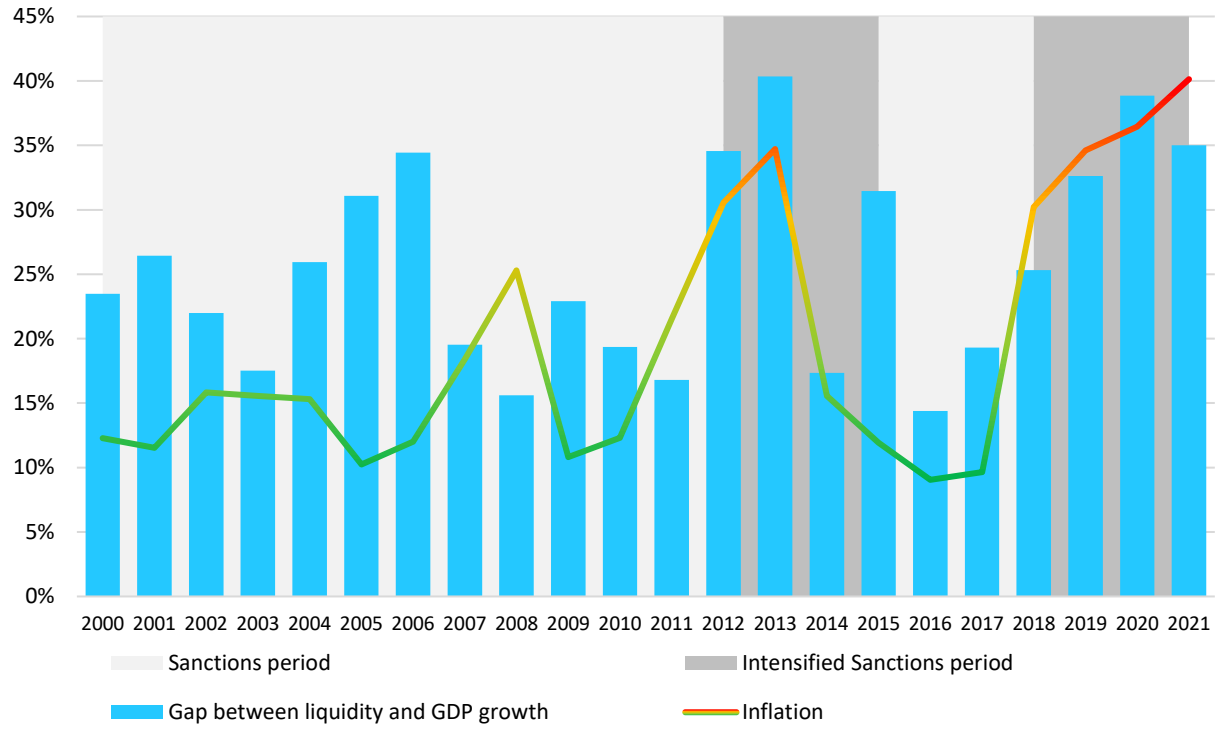


***Figure 14**. The gap between liquidity and GDP and the inflation over 2006-2021*

During hyperinflation, the residents will hold part of their savings in foreign currencies. Of course, this holding of money is intended to maintain the value of money. Obviously, in this condition, the demand for foreign currency would increase and supply of foreign currency would decrease and finally, the exchange rate would increase. In general, inflation tends to devalue a currency since inflation can be equated with a decrease in money's buying power. As a result, countries experiencing high inflation tend to see their currencies weaken relative to other currencies [29].

The following are the factors contributing to an increase in liquidity and inflation:

2.1.1. Budget Deficit

As is obvious in figure 15, Iran has encountered a government budget deficit since 2002 and recorded its minimum in 2021.

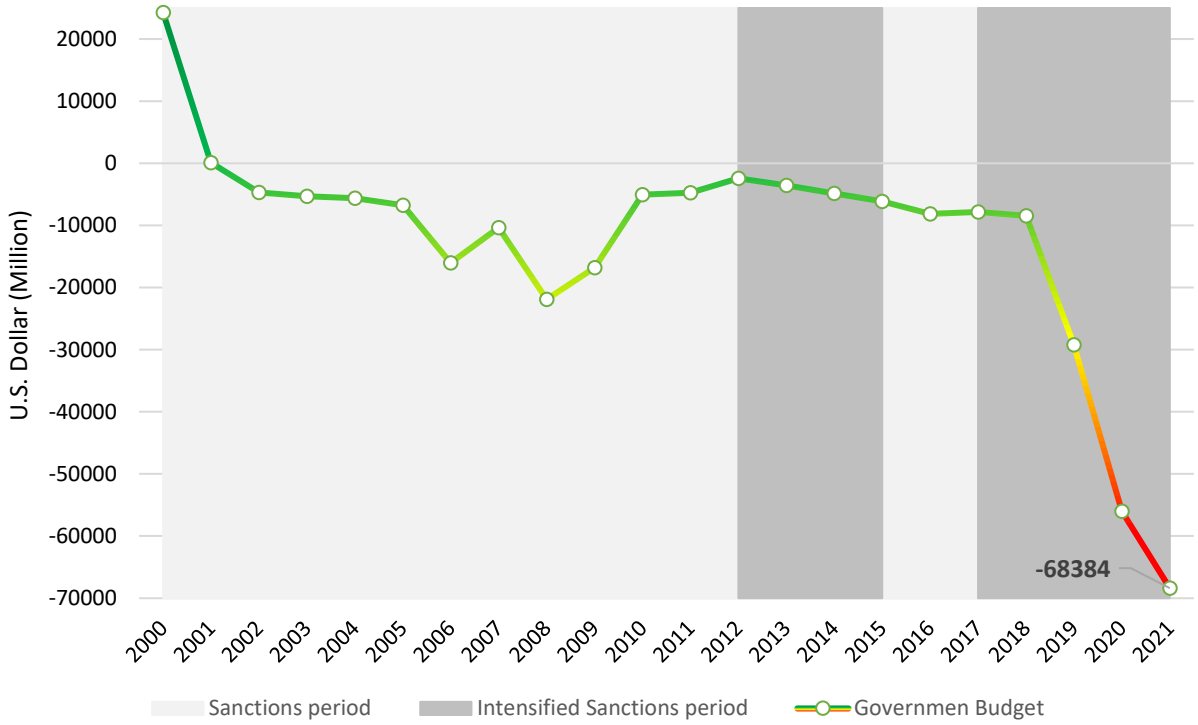


***Figure 15**. Government budget of Iran over 2000-2021, COUNTRYECONOMY.COM*

The Iranian government's deficit is primarily caused by three crises: the sanctions, the shortage of foreign exchange reserves arising from sanctions, sharp declines in oil revenue because of the fall in global oil demand and price, and the sudden and deep domestic and global economic contraction as a result of the pandemic which all led the government has had difficulty in meeting its expenses and increase in the government budget deficit [53].

2.1.1.1. Currency Crisis

2.1.1.1.1. Shortage of Foreign Exchange Reserves

Reserves are assets held in foreign currencies by the Central Bank of Iran and are important for the normal operation of Iran's economy. The reserves are used, among other things, to help manage the exchange rate. And the availability of foreign currency reserves is directly tied to the supply of foreign currencies available to Iranian companies, which need to sell Rials and buy

Euros, Yen, or other currencies to purchase goods and services from foreign suppliers. Foreign currency reserves are also important for managing crises when Iran's balance of payments falls into a serious deficit, as it did during the early days of the COVID-19 pandemic [54].

One of the factors behind the jump in the exchange rate was Iran's lack of access to its foreign exchange reserves. The significant decrease in foreign exchange reserves of the Islamic Republic made the government unable to inject enough currency into the market [54].

The United States has long used sanctions to impede Iran's access to its foreign exchange reserves. The Obama administration (2009-2017) used sanctions to pressure Iran to curtail its nuclear program and come to the negotiating table. Through a series of regulations and designations, Washington made clear that foreign companies and financial institutions that provided "material support" to the Iranian financial system – even by simply processing Iran-related transactions – could find themselves similarly designated and therefore cut off from the U.S. financial system. Foreign banks that hold Iranian foreign exchange reserves responded to these so-called secondary sanctions by freezing Iran's access to their reserves. Limiting Iran's access to the reserves weakened the rial, made the economy more vulnerable to a balance of payments crisis, and made it harder for the Iranian government and Iranian companies to do business abroad [54].

In 2014, Iran gained access to a small portion of its reserves after it reached an interim nuclear deal with the world's six major powers – Britain, China, France, Germany, Russia, and the United States. Iran was allowed to repatriate $4.2 billion in oil revenues held abroad. As a result of JCPOA, Tehran regained access to more than $100 billion in assets abroad. In 2018, however, President Donald Trump withdrew from the JCPOA and reimposed wide-ranging U.S. sanctions – effectively freezing Iran's assets abroad again [54].

Figure 16 illustrates Iran's gross foreign exchange reserves from 2000 to 2021. According to the International Monetary Fund, the average foreign exchange reserves accessible to the Islamic Republic between 2000 and 2017 were about 71 billion dollars. This figure reached about 122.5 billion dollars in 2018, which is the year of the US withdrawal from the JCPOA. After the US withdrawal from the agreement and the implementation of the sanctions, Iran's reserves regressed rapidly to 12.40 billion USD by the end of 2019. Before the U.S. withdrew from the JCPOA, Iran's reserves were all available to the regime. New U.S. sanctions locked up a bit more than $90B of those.

The recession of the oil prices and the fall of Iran's oil export up to 70-80% due to the sanctions have hastened the decline of the foreign exchange reserve and it finally reached 4 billion dollars in 2020. The amount of Iran's overall reserves regressed to 40 billion USD in 2020. However, 36 billion USD out of 40 are blocked in the third countries[16] because of the sanctions. In this way,

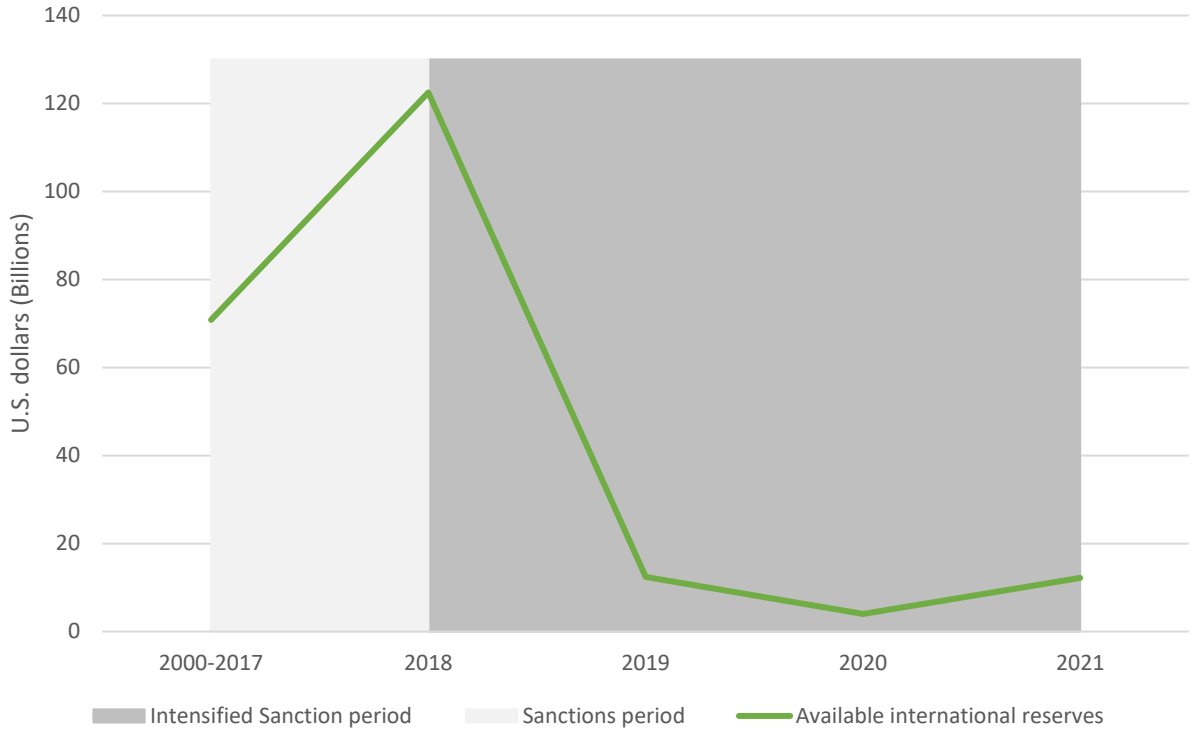


***Figure 16**. Gross International Reserves held by Central Bank for Iran over 2000-2021, IMF latest regional report for the Middle East and Central Asia*

Iran's total foreign exchange reserves, whether accessible or blocked, were 40 billion dollars, which is equivalent to less than a third of Iran's total foreign exchange reserves in 2018 [54].

2.1.1.1.2. Increased Exchange Demand

On one hand, owing to economic and political uncertainty Iran encounters capital flight. Central bank's statistics indicated that since 2005 Iran had lost around $170 billion in the capital while foreign investment also dropped significantly due to various sanctions during the same period. The highest capital drain during this period, according to the CBI, amounted to over $19 billion in 2017, followed by $16 billion in 2018. The precise amount of capital leaving Iran is very difficult

[16] Iran had frozen assets in the following countries: $7 billion in South Korea; $6 billion in Iraq; $20 billion in China; $1.5 billion in Japan; $1.6 billion in Luxembourg.

to calculate but it can be deducted from the official data on the net capital account deficit. According to the CBI's latest report, the net capital account deficit stood at $9.3 billion during the fiscal year ending March 20, 2022 [55].

The hard currency outflow from the country is invested in various ways including in real estate, stocks, bonds, cryptocurrencies, or the establishment of companies abroad. Investment in neighboring countries is particularly popular. The high rate of inflation and the huge drop in the value of the national currency has also hugely contributed to the urge to invest in such markets instead of domestic products and services. Iranians have been among the top foreign property buyers in Turkey where investing $250,000 which can help them acquire Turkish citizenship, establish businesses, and engage in international trade without the fear of US sanctions. Iranians established over 4,000 companies in Turkey between 2013 and 2021 which according to Farhikhtegan can amount to around $3 billion in investment. The same goes with the UAE where over half a million Iranians live and thousands of Iranian businesses are based [55].

On the other hand, in recent years, due to the imposed sanctions, the increase in inflation, the decrease in interest rates on bank deposits, and the decrease in the value of the Rial, people have created new expectations about the further growth of the exchange rate. Hence, people have turned to buy foreign currency in order to maintain the value of their capital. It has produced an upsurge in the demand for currency [55].

As a result, the demand for foreign currency has increased while the supply of foreign currency has decreased. This has resulted in an increase in the exchange rate.

2.1.1.2. Oil Revenue Reduction

The Iranian economy is strategically shaped by the income from oil and gas. Holding 11% of the world's total proven oil reserves and as the fifth largest producer within the Organization of Petroleum Exporting Countries (OPEC), Iran both affects the international oil market and is broadly affected by it.

In its more than 40-year history, the Islamic government has remained heavily dependent on oil exports to finance at least half of its known government budget, plus its secret military, intelligence, and regional alliances. The export of crude oil is a major source of income for Iran's government, accounting for 60% of annual budgetary revenues and roughly 90% of all export

earnings. Between 2013 and 2020, Iran's oil value added contributed an average of 20% to the country's GDP.

Figure 17 illustrates the co-movement of the Iranian GDP per capita with fluctuations in real oil prices since 2000. We can observe that the former variable is linked to the trend of the latter.

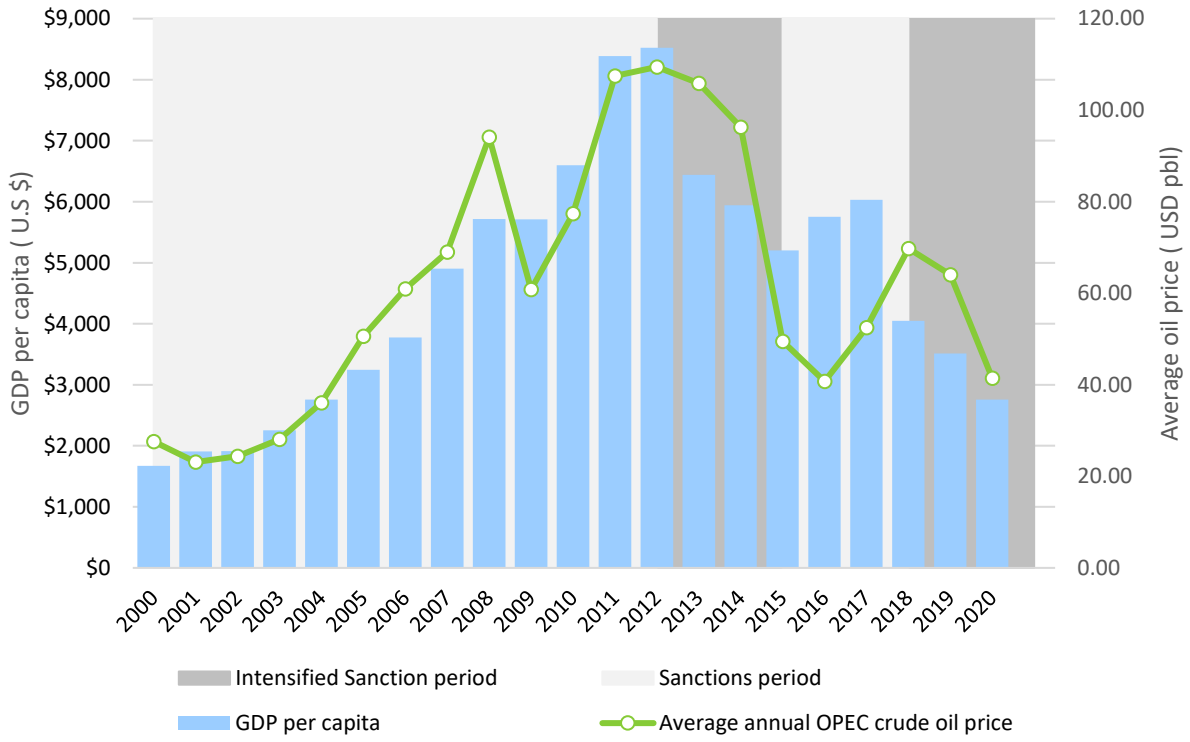


***Figure 17**. The co-movement between GDP per capita and oil price,2000-2020, WORLDBANK.ORG*

The significant share of foreign currency receipts from the sale of oil in foreign currency reserves and the government budget has made the Iranian economy vulnerable to oil shocks and therefore, any significant negative oil price shocks will worsen the budget deficit of the government and create inflationary pressures for the whole economy.

2.1.1.2.1. Sanctions Consequences

Under Presidents Obama and Trump, the United States imposed economic sanctions to prevent Iran from profiting from its oil exports. Oil is traded predominantly in dollars, and oil sales involve a complex web of shipping companies, insurers, ports, pipelines, and refineries—all of which are vulnerable as targets of U.S. secondary sanctions [56].

U.S. sanctions have also discouraged the relatively small number of foreign companies that have the technical expertise needed to upgrade Iran's upstream and downstream capabilities, in turn limiting the long-term growth of its oil industry [56].

The U.S. "maximum pressure" campaign has decimated Iran's oil exports and cut deeply into a vital source of national revenue. Iran does not formally report the volume of oil exports; there is considerable uncertainty about the real figure. In the final three months of 2020, most oil trackers, consultancies, and news organizations have concluded that Iran exported no more than 1 million barrels per day (bpd) of crude oil, but the estimates vary from 300,000 bpd to 900,000 bpd [39]. (Figure 5)

Export numbers are only half the story. China bought the lion's share of Iranian exports, either directly or through intermediaries. And Iran exported limited quantities to Syria. Iran also sold a relatively small amount of ultralight crude, known as condensate, which is sometimes added together with crude in reporting monthly exports. Not all of the Iranian oil shipped to Asia is sold. Some are placed in storage for future use. Iran offers discounts to incentivize buyers to take the risk of violating U.S. sanctions [56].

Iran also has a difficult time accessing the money that it earns because of the rippling effect of U.S. sanctions. Because of the global impact of U.S. secondary sanctions since 2018—both in reducing exports and freezing accounts—Iran has had limited access to its oil export revenues. For example, Iran earned $41 billion in oil exports in 2016 and $53 billion in 2017. But Iran earned only $8 billion to $9 billion in oil revenues from March 2019 to March 2020. And over the next six months, from March to September 2020, parliament claimed that Iran earned only $2.5 billion from oil exports. Even with the uptick in oil prices since the fall of 2020, the government is not likely to meet its revenue target of $18 billion for the fiscal year 2020-21 [56].

2.1.1.2.2. Declining Demand Because of Pandemic

Global crude oil markets have witnessed sluggish demand since March 2020. Virus containment has been in effect to reduce the spread of the novel coronavirus (SARS-CoV-2) in many countries. Containment measures reduced people's outdoor activities which reduced driving and restricted some transportation services and severely impacted tourism, airlines, and shipments. Thus, the rail, freight, and air industrial sectors suffered heavily, and the demand for gasoline, diesel, and jet fuel decreased significantly [57].

The abrupt drop in demand as a result of the continuous deterioration of the COVID-19 pandemic led to crude oil supplies that exceeded the level market fundamentals would determine, resulting in a glut of crude oil and a sharp price fall. The abrupt drop in demand as a result of the continuous deterioration of the COVID-19 pandemic led to crude oil supplies that exceeded the level market fundamentals would determine, resulting in a glut of crude oil and a sharp price fall. What followed was a massive increase in inventory and limited storage capacity, with prices plunging so fast that they triggered a historic negative crude oil price [57].

2.1.1.2.3. The Oil-Related Geopolitical Conflict Between Saudi Arabia and Russia

Amid the turmoil in crude oil markets, an oil-related geopolitical conflict between Saudi Arabia and Russia – the Russia-Saudi oil price war – is remarkable.

Before the oil price war, Saudi Arabia and Russia had cooperated successfully in facing the challenge of the U.S. shale oil revolution since 2016 and created an informal alliance called OPEC+ (13 OPEC members and 10 non-OPEC members) in December 2016. This cooperation defended the market shares of both Russia and OPEC countries and the crude oil price increased, fluctuating at around $60 per barrel from early 2019 to early 2020 [57].

Since the COVID-19 pandemic had created a glut of crude oil in global markets, OPEC initiated the 178th (Extraordinary) Meeting of the Conference on March 5, 2020, in Vienna, Austria. Saudi Arabia, with its allies in the Organization of Petroleum Exporting Countries (OPEC), proposed a production cut in early March 2020 to stabilize crude oil markets. However, this action was met by a challenge from Russia – an oil giant outside the OPEC – whereby it would increase its production and supply. Saudi Arabia responded with an increase in oil production and Russia retaliated in the same way, which resulted in the oil price war. The global crude oil price declined more severely, from about $50 per barrel to roughly $10 per barrel, and fluctuated at this level until the end of March. On April 9 at the 9th (Extraordinary) OPEC and non-OPEC Ministerial Meeting, Russia agreed that it would cut production, and the Russia-Saudi Arabia oil price war ended [57].

2.1.1.3. Global Economic Contraction

Another factor that has severely affected Iran's economy in the past year is the spread of the Coronavirus and its consequences on the government's budget. The special conditions that have prevailed in the country led to a decrease in government revenues and an increase in expenses and subsequently to an increase in the government budget deficit and increased liquidity and consequently inflation.

On the one hand, the income from oil has reduced even further because of the steep decline in oil demand and price brought on by the spread of the Coronavirus, in addition to international sanctions. Also, Iran has increasingly exported products and manufacturing to neighboring countries to finance its imports. However, due to the coronavirus pandemic and border closures with neighboring countries, even these exports have been limited. Moreover, the collapse of domestic demand and the temporary closure of borders for passenger and goods traffic has derailed the country's manufacturing sector. As a result, Iran's currency reserves shrank due to the reduction in exports, resulting in a substantial trade deficit [39].

On the other hand, increasing transportation costs, preventive measures, and dealing with the spread of the coronavirus and the costs caused by them, including treatment and medical expenses increase the government's expenses and, taking into account the decrease in the government's income, it leads to a severe budget deficit.

2.1.2. CBI Loans

Another key driver of the constantly increasing money supply in Iran has been the rising debt owed by domestic banks to the central bank. From the 2011-12 fiscal year to 2017-18, the volume of non-performing loans increased by 240 percent (Figure 18). More than half of Iran's nonperforming loans are highly doubtful or lost funds. Widespread corruption in the banking and political system and a weak banking audit and accounting structure have created a favorable environment for a growing volume of nonperforming loans in Iran [40].

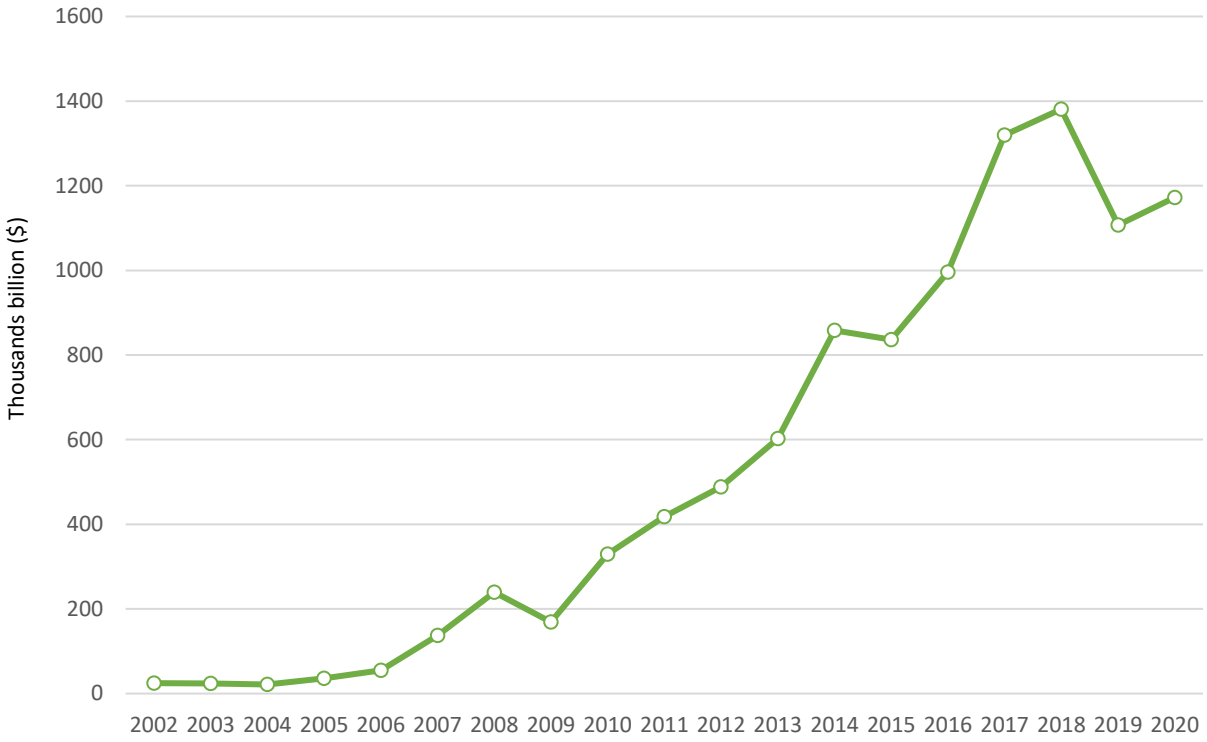


***Figure 18**. Commercial banks' debt to the central bank of Iran (CBI), 2002-2020*

Nonperforming loans are often linked with projects that in some cases are ultimately abandoned. In many cases the loan applications (even those that come with strong recommendations) are fraudulent (i.e. the funds that are received from the banks are not invested in the projects described in the application). In a highly politicized environment, the banks do not have appropriate auditing and monitoring mechanisms to perform due diligence and oversee the project development – and are unable to recover the debt. The central bank also has a relatively weak position in such a system because it lacks political independence from the government, does not

have the technical capacity to carry out appropriate monitoring and auditing procedures, and lacks authority to implement much-needed financial discipline in the country's banking system [40].

To address the issue of excessive borrowing, the central bank began to restructure the banks' debts in 2017 by reducing the interest rate due on the debts from 34 to 18 percent, or 16 percent if they put down collateral. Under the restructuring scheme, state-owned commercial banks managed to reduce their debt to the central bank. As a result, the interest rate on savings deposits was reduced from over 20 percent to a maximum of 15 percent for 1-year deposits (August 2018) [40].

For a long time, the rate of return on savings remained significantly higher than the rate of return on investment. In other words, for Iranian citizens, it was safer and more profitable to park their assets as savings deposits in banks to generate income as opposed to investing those assets in productive economic activities and it has become a social trend among Iranian citizens, regardless of the level of wealth, to deposit liquid assets in commercial banks to earn a living. However, Banks' interest rates on deposits decreased along with the interbank interest rate, which made bank deposits less appealing to people. People withdrew their funds from their bank accounts as a result, and the resulting wandering liquidity went to other financial markets including the stock, gold, property, and foreign exchange markets. Hence, lower interest rates reduced the value of the currency [40].

3. Exchange Rate Depreciation Effects

Although long-term macroeconomic stability may depend on exchange rate volatility, exchange rate instability theoretically has short-term negative consequences on the economy. A country's exchange rate is an indicator of its economy's performance and terms of trade with the global economy. Exchange rate volatility as a sign of instability and uncertainty affects all important economic variables [39].

The volatility in the exchange rate and Iran's currency depreciation are signs of an unhealthy economy. It should be noted that the exchange rate is one of the key factors in the economic system of nations like Iran, where the majority of the government's revenue comes from the export of mineral resources [39]. In the following the economic terms affected by exchange rate volatility are reviewed:

3.1. Unemployment

These days, unemployment is a major issue in emerging nations. In nations with younger populations, like Iran, the issues brought on by unemployment are more evident [58].

The workforce's employment is a significant issue that is affected by various factors. On the one hand, some factors, including population growth, age, population distribution, emigration, and the participation rate of women, affect the labor supply. On the other hand, factors such as investment volume, distribution, technology, and economic expansion all have an impact on labor demand [58].

Due to factors like the early post-revolutionary population explosion, the government's incapacity to produce the necessary number of work opportunities, economic sanctions, and barriers to the import of machinery for the construction of factories, unemployment has risen in Iran. This implies that, in recent years, there has been a gradual increase in the labor supply over the labor demand, which has led to unemployment and a lack of adequate jobs for the workforce, particularly for young people and recent graduates [58].

Asgari and Tofighi's study (2009) shows exchange rate deviation in the Iranian economy rate (overvalued currency) has led to reduced economic growth and employment during the years 1959 to 2007. Behnamian study (2012) indicates a negative relationship between the real exchange rate and unemployment in the Iranian economy during the years 1974 to 2010 [59].

Imami and Karimi (2013) by using the generalized self-regression heterogeneity variance (GARCH) model, measured the real exchange rate fluctuations of 1974-2007, and then, using the ordinary least squares method, the effect of real exchange rate fluctuations on Iran's employment was evaluated. Based on the results obtained in this study, it seems that one of the most important and influential variables on Iran's employment is real exchange rate fluctuations. The coefficient of variation of real exchange rate fluctuations has a negative and significant effect on the employment logarithm of the period under study. This result indicates that employment reacts negatively to the level of real exchange rate fluctuations.

Figure 19 shows the unemployment rate of Iran from 2009-2021. According to the Statistical Center of Iran, the country's unemployment rate has fallen over the course of 2020-2021. But the key driver of this is not business growth, nor job creation. In Iran, as in many other countries, the "unemployment rate" is the proportion of the active population – those of an employable age, and able to take part in economic activity – who have for whatever reason failed to find work. But in fact, data from Iran shows that in times of recession and hardship, large numbers of people in the 'active' labor force are excluded from the labor market due to the loss of opportunities or other personal circumstances and are therefore considered 'inactive'. And indeed, the Census's abstract states that almost 1.43 million members of the 'active' workforce have left the Iranian labor market in one year. This is equivalent to five percent of the 'active' population for 2019-2020 and comes as another 710,000 people reached employment age in the same year. Meanwhile, the report also states that a net total of 1.1 million jobs have been lost in the same period. The employed population in 2020-2021 is about four percent smaller than the employed population in 2019-2020 [60].

During 2017-2021, Iran's population increased by more than three million. But the overall size of the labor force has shrunk by 115,000. In 2021, the Statistical Center reported that out of a total of almost 84 million Iranians, only about 13.4 million have full-time jobs and fewer than 9 million have part-time jobs, while about 1.2 million are temporarily absent from work or on furlough, it is while about 41.32% of the population were considered labor force, about 34,712,161 people. Figure 20 shows the makeup of the labor force [60].

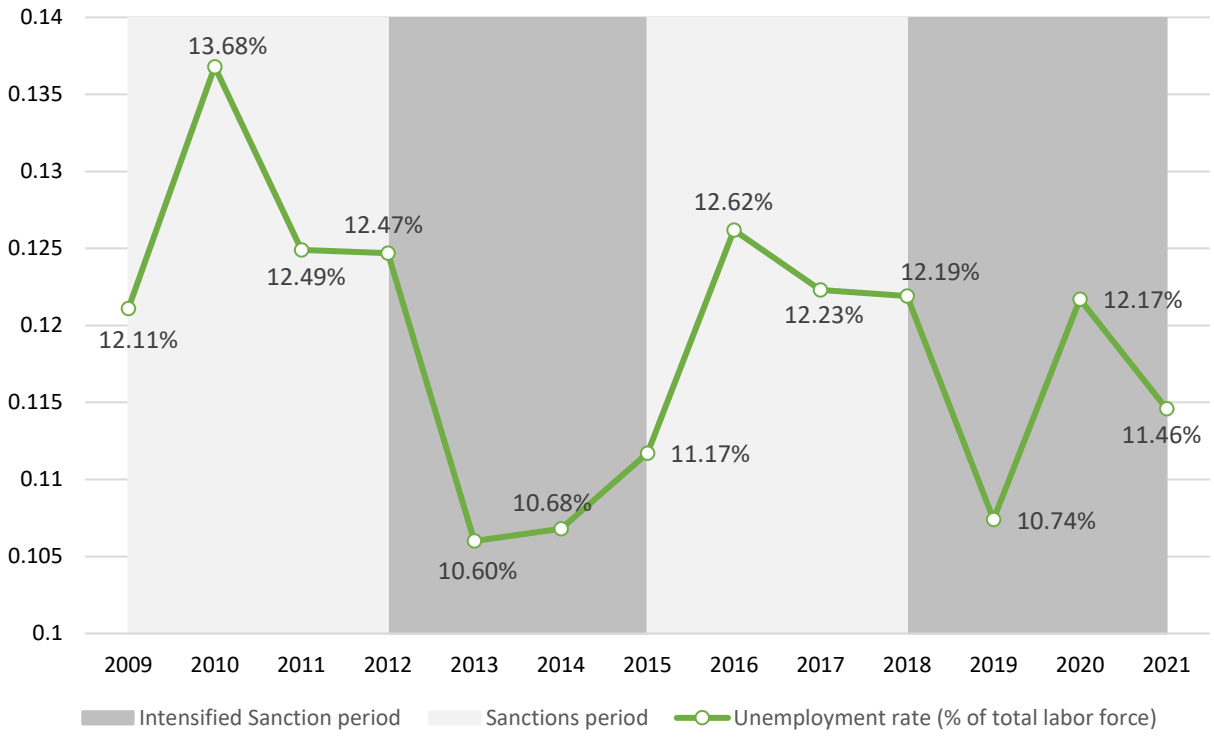


***Figure 19**. The unemployment rate of Iran, 2009-2021, WorldBank*

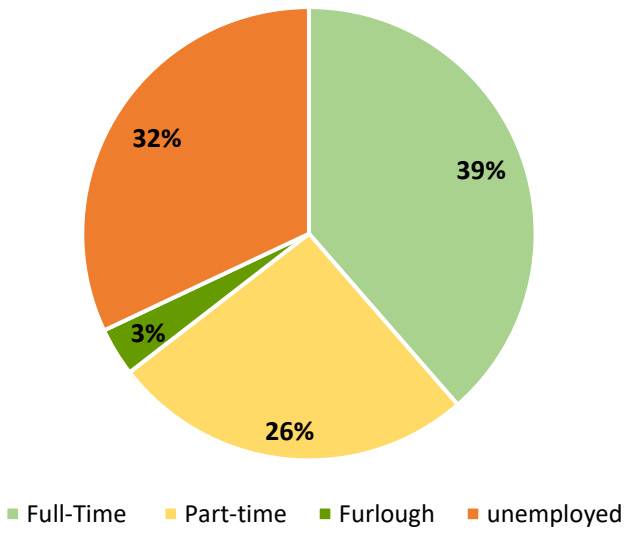


***Figure 20**. Iran's employment to population aged +15, 2020*

The Census states that the total unemployed population – those willing to work, who were not able to find a job for an hour per week in 2020-2021 – stood at more than 2.47 million, of whom about 1.76 million were young people aged 18 to 35. Of these, 962,000 were college graduates.

In effect, 71 percent of those unemployed in Iran last year were relatively young, and 39 percent were well-educated but failed to find work nonetheless [60].

Women have been the most badly affected, with two-thirds of the jobs lost related to women's employment. In 2020, more than 902,000 formerly active women left the labor market and more than 662,000 lost their jobs. Women's share of employment and an active stake in Iranian society, which was fragile even before the pandemic, has become all the more tenuous. According to the latest report published by the Statistical Center of Iran, the rate of women's participation in the economy fell to about 14 percent in autumn 2020, whereas in 2019, this index was at 17 percent. In other words, over one year, due to the escalation of the economic crisis and the coronavirus pandemic in Iran, more than one million women have been cut off from economic activity in Iran and have essentially become housewives. During the same period, the number of men leaving work was only 470,000 [60].

Since its establishment, the Islamic Republic has consistently had one of the lowest rates of economic participation in the world. The International Labor Organization has assessed that in 2019, Iran ranked 14th from the bottom in terms of global participation rates. The World Bank places it ahead of Yemen, Tajikistan, Jordan, Iraq, the Gaza Strip, Algeria, Samoa, Mauritius, Comoros, Syria, Senegal, Moldova, and Egypt. This estimate was based on a participation rate of 48 percent, whereas Iran's participation rate in 2020-21 was just 41 percent. This means Iran now stands where war-torn Yemen did in 2019. Due to sanctions, mismanagement, and the country's isolation from the global market, the economy is unable to create enough jobs [60].

3.2. GDP

A positive shock to the domestic exchange rate (an unexpected increase in the value of the domestic currency) causes exports to become more expensive and, consequently, imports become cheaper. Therefore, the country's competitiveness in foreign markets is reduced and the demand for domestic products is reduced. As a result, domestic production volume and prices are declining. On contrary, the devaluation of the domestic currency against foreign currencies (a decrease in the value of the domestic currency) will increase the price of foreign goods compared to domestic goods and therefore will increase competitiveness between domestic industries and at the international level, and in this case, expenditures from foreign goods will move towards the domestic goods [61].

As Iran is a net importer in the manufacturing sector, the sanctions might be expected to mitigate the negative effects of import competition. However, given the severity and multilateral nature of the sanctions and the fact that Iran's manufacturing sector largely depends on imported inputs (as is often the case in the context of developing countries), it is very unlikely that domestic production could entirely replace imports in the short run [29].

Fluctuations in real exchange rates also affect the real sector by creating uncertainty in the future prices of goods and services. Economic brokers take their decisions on production, investment, and consumption based on the information that the pricing system provides for them. Unreliable and unpredictable prices due to exchange rate uncertainty harm production and investment decisions [62].

Uncertainty in the exchange rate also increases the risk in the economic environment, which leads to an increase in interest rates and a decrease in investment, and as a result, hurts production. In addition, increased exchange rate fluctuations and uncertainty increase the risk of international trade and increase the cost of trade, which reduces trade and, ultimately, reduces production. So, GDP is one of the most important economic variables that shows great sensitivity to the change in the real exchange rate. If the exchange rate is not set properly and in harmony with the domestic and foreign world and a stable and secure environment, the growth of the economy will slow down [63].

Kazerouni et al. (2011) examined the asymmetric effects of the real exchange rate on non-oil exports in Iran during the years 1974-2007 and studied positive and negative exchange rate shocks by using the nonlinear model Markov Switching. They conclude that the variables of foreign income, gross domestic product, the relationship between trade, and the degree of trade openness have a positive and significant effect and positive and negative exchange rate shocks have a negative and significant effect on non-oil exports [64].

Halafi et al. (2003) examined the effect of the deviation of the real exchange rate from its equilibrium path on Iran's economic growth during the years 1961-2001. They used a structural model to measure the real exchange rate deviation index and concluded that real exchange rate deviation hurts Iran's economic growth [64].

Najarzadeh et al examined the effect of exchange rate fluctuations on the growth of real production variables, price levels, and two parts of total demand (consumption and private investment) in Iran during the years 1976-2010. They concluded unanticipated real effective

exchange rate fluctuations affect macroeconomic components by affecting exports, imports, and demand for domestic currency. Unanticipated real effective exchange rate fluctuations affect the supply side of the economy of Iran by affecting the expenditure of imported and intermediate goods. An unforeseen increase in the exchange rate has a significant negative effect on output growth. The reason for this negative effect is that the cost of imported conductors increases and therefore the supply of products decreases. On the other hand, the projected increase in the real exchange rate is significantly inflationary. Therefore, this case creates stagnant inflation in the country [64].

Figure 21 indicates Iran's GDP over 10 years (2010-2020). Since 2012 and intensifying the sanctions, GDP kept decreasing until 2015. From 2015 until US's withdrawal (2018) there have been improvements in GDP and GDP increased over this period. With the US's withdrawal in 2018 and reimposing the sanctions, the gap between official and free-market exchange rates has widened which has led to a considerable decrease in GDP. And finally, the Covid-19 Pandemic intensified the situation.

***Figure 21**. GDP and GDP per capita of Iran, 2010-2020, WORLDBANK.ORG*

3.3. Inflation

If the revaluation of the national currency against foreign currency is above the equilibrium level, it may reduce international competition for a country, and if the devaluation of the national currency against the foreign currency is below the equilibrium level, by increasing the price of mediated imported goods and increasing aggregate demand, it leads to inflationary pressures. The possibility of this situation is stronger in countries with high and persistent inflation rates [29].

In another word, widening the exchange rate gap pushes up imported goods (which do not have an official currency) prices; These imported goods, are either consumer goods whose price increase directly raises inflation or are intermediate and capital goods whose price increases lead to an increase in the index of consumer goods and services through increasing costs production. On the other hand, a positive exchange rate shock in the money market (an unexpected decrease in the value of the domestic currency) causes the economic agents to hold less domestic currency and therefore interest rates fall, and inflation increases [29].

Shi, J. (2000) wrote that the existence of a black-market exchange makes it possible for people to substitute money easily and as a result, the seigniorage reduces. In other words, to protect the value of their money and owe to the availability of currency on the black market, people hold more foreign currency, and consequently, their demand for domestic currency decreases. Hence, government revenue is less than the seigniorage, and to increase its revenue It has to create more money. So, the larger the exchange rate gap, the more banknotes are issued, and as a result inflation fuels [65].

Figure 22 indicates the consumer price index (CPI):

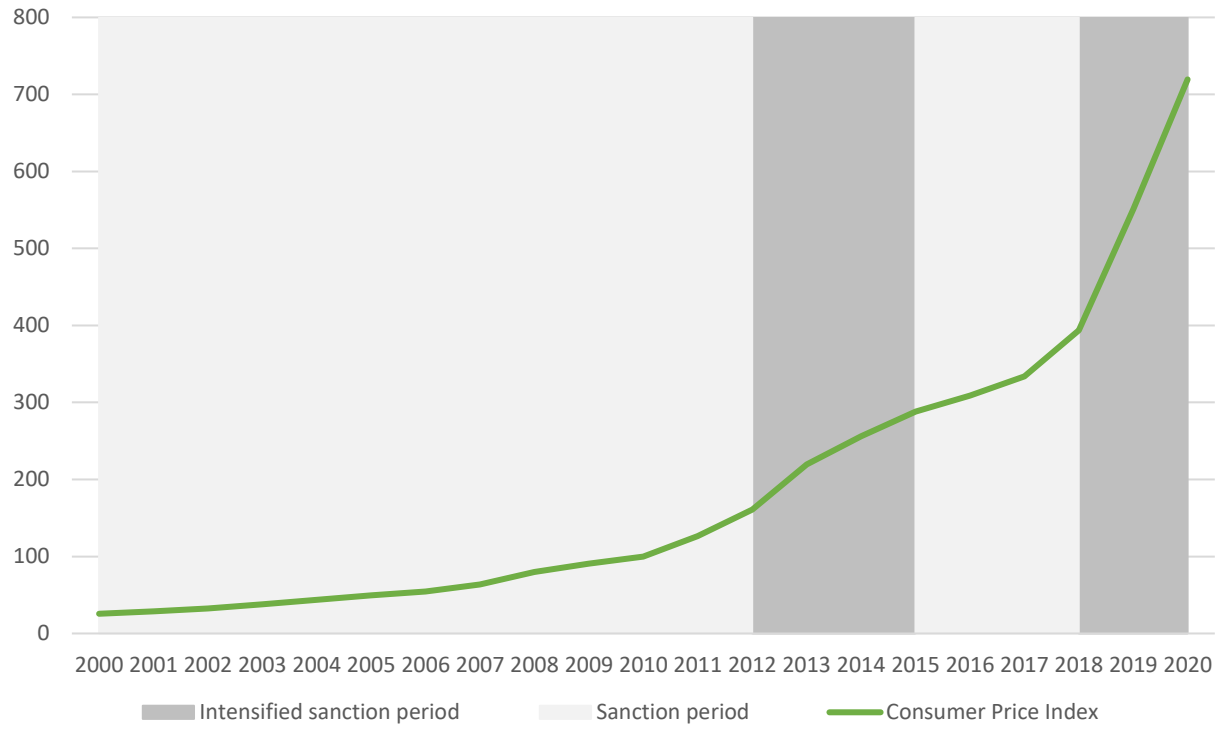


***Figure 22**. CPI of Iran, 2000-2020, WORLDBANK.ORG*

Figure 23 shows the inflation annual percentage (consumer price) from 2009 to 2020. Owing to the sanctions put in 2012, there is an increase in inflation. In 2014, the new government came to power. Many macroeconomic variables, such as bank interest rates, wages, prices of some government goods, etc., based on inflation experienced, had to be reconsidered by the government, and the government targeted this issue in the first place. With the beginning of government actions, the process of reducing inflation began. The new government did not reduce interest rates on deposits in the banking system to the point where interest rates on deposits reached 25 percent. Also, during its activity, it decided to control prices in different sectors through macroeconomic policies. The reason for the decrease in the inflation rate during the activity of the current government was the decrease in the exchange rate and its direct and indirect effect on the decrease in prices in the market; This decrease in the exchange rate was due to the release of the country's foreign exchange resources and the change in market expectations for the future of negotiations and sanctions. The hope of lifting the sanctions was a major factor in the economic recovery in 2013, which led many to sell their currency and coins in the market. By the end of the government, it had reduced inflation to 9 percent. With US's withdrawal in 2018 and reimposing the sanctions, the gap between official and free-market exchange rates has widened, and also the interest rate on current accounts decreased to 10% which has led to a considerable

increase in inflation. And finally, the Covid-19 Pandemic intensified the situation for both GDP decrease and inflation increment.

3.4. Poverty

In addition to the macroeconomic indicators (growth, inflation, and unemployment), which have displayed an undesirable course for the last four years, the socio-economic dimensions or problems created by the faltering economy seem to have created the possibility to shake social stability.

Although poverty in Iran has been steadily rising since the 1979 revolution, it accelerated in 2018. The substantial increase in consumer prices of goods and services coincided with a sharp drop in the purchasing power of Iranian households, leading to the destabilization of the social situation in the country [35].

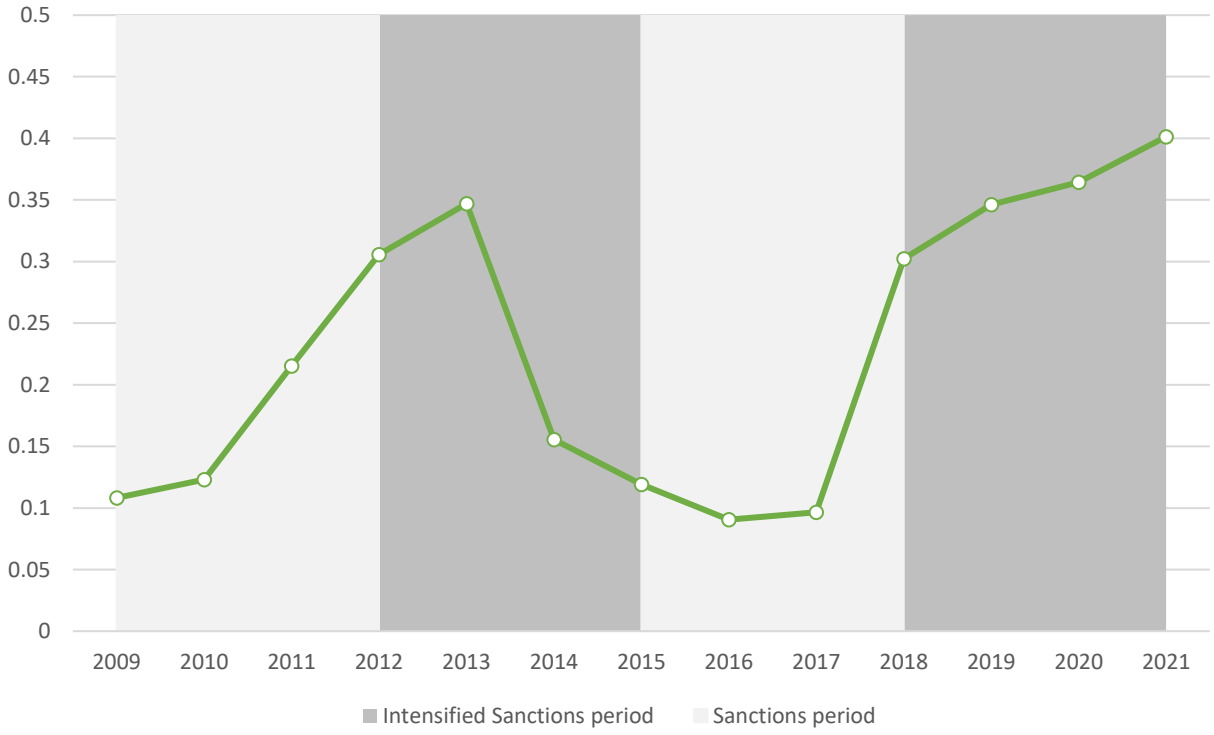


***Figure 23**. Inflation (average consumer price) of Iran, 2009-2021*

Iran Ministry of Cooperatives, Labor and Social Welfare released a "Poverty Monitoring Report" based on the "Household Income and Expenditure Survey, the year 1399 (2019-2020)" recently published by the Statistical Center of Iran. According to the report, the number of middle-income households has been significantly decreasing. In parallel with this deterioration, it has been observed that a crucial part of middle-income households slipped below the "poverty line[17]" [48].

Over March 2018-March 2019, the monthly poverty threshold for a three-person family was 2.000.000 toman, while it was 2.450.000 toman for a four-person family in Iran. The monthly poverty threshold increased by 38 percent over March 2019-March 2020 compared to March 2018-2019. With this increase, the monthly poverty threshold for a three-person family has been 2.760.000 toman and 3.390.000 toman for a four-person family [48].

According to the report prepared by the Iran Ministry of Cooperatives, Labour and Social Welfare, while 26 million Iranians were living below the poverty line in 1398, this number increased by 4 million in 1399, and thus nearly 30 million Iranians have to make end meets with an income below the poverty line. Respectively, Iran's population is 81,8 million, and 82,9 million in these years. Therefore, 31.8 percent of Iranians (roughly one-third) were living below the poverty line in 1398, whereas it increased to 36.1 percent in 1399 (Table 3). This means that one out of every three people has an income below the poverty line [48].

***Table 3**. People population living below the poverty line*

	Number of poor people	**Total Population**	**Poor people/Total population**
2018-2019	26,000,000	81,800,000	31.8%
2019-2020	30,000,000	82,900,000	36.1%
Growth rate	15.3%	1.34%	13.5%

[17] The poverty line (threshold) specifies the minimum income required to meet basic needs such as food, clothing, shelter (rent), electricity, water, fuel, transportation, education, health, and so forth. In general, the term household is used to refer to family, consists of 4 people, and the minimum income required for this 4-person family to meet their basic needs has been identified as the "poverty line". Generally, the poorer a family is, it must allocate a larger portion of its income to food.

As Figure 24 indicates poverty has been a long-standing problem in Iran however it accelerated in 2018.

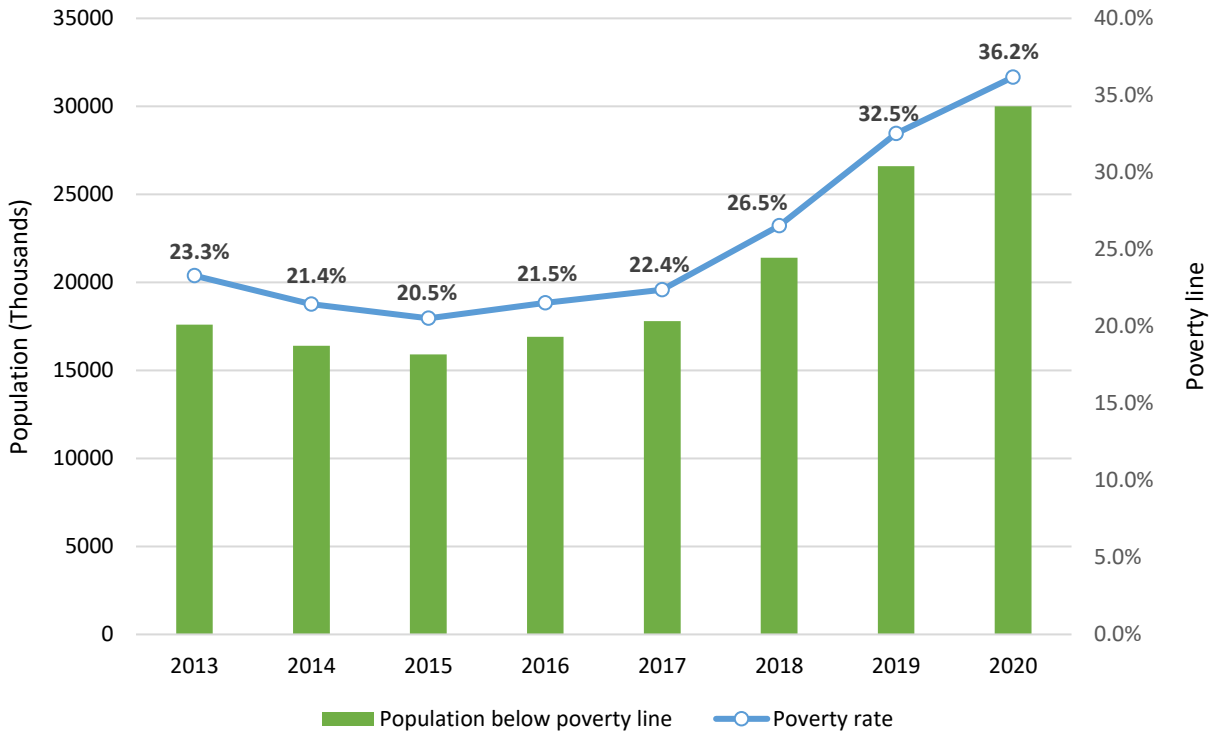


***Figure 24**. Poverty the line and population below the poverty line, 2013-2020*

Because of increasing poverty, the middle class has been fading out. the situation of children is far worse than that of adults. Many children had to drop out of school under the pressure of poverty. As online classes started during the pandemic, even more children dropped out because they could not afford tablets and smartphones. Also, poor nutrition has been responsible for diminishing IQ levels among children. the calorie intake of both adults and children in Iran has dropped below the minimum daily 2100 mark which will affect their intelligence and learning levels [66].

CHAPTER 3

USD-IRR EXCHANGE RATE BEHAVIOR ANALYSIS

1. Data Sets

The collected data is a time-series dataset including the selling price of currency pairs of USA Dollar- Iranian rial (1 USD to 1 IRR) gathered over 8 years (between 6/1/2015 and 2/13/2023) with equal time intervals (Figure 12). The recording frequency is daily and according to Iranian working days (6 working days, Saturday to Thursday. According to the applying intensifying sanctions, the dataset is divided into two sets (Set1, Set2). The set1 includes the data from 6/1/2015 to 3/17/2018 and set 2 includes the data from 10/1/2018 to the end.

1.1. Data Identification

Being stationary is a desirable property and an important concept in the field of time-series analysis and many useful analytical tools and statistical tests and models rely on it. The starting point is to examine the properties of the series graphically and confirm it statistically. Graphs are the most preliminary tool to get a rough idea about the stationarity of the series. However, statistical tests are required for the final decision.

1.1.1. Visual Inspection

The most basic method for stationary detection relies on plotting the data and graphical displays, as many of the broad general features of a time series can be seen visually.

1.1.1.1. Graph

The basic graphical display is the time-series plot, which is a graph of the variable of interest, y_t, versus the time, t, for t = 1, 2, ..., T. Features such as trend and seasonality are usually easy to diagnose through the time series plot.

Figures 25 and 26 shows time series plots for the data set 1 (the green line graph) and 2 (the blue line graph) correspond, displaying the 'sell price' changes in which noticeable trends and changing levels can be seen.

***Figure 25**. Set1 plot (6/1/2015 – 3/17/2018)*

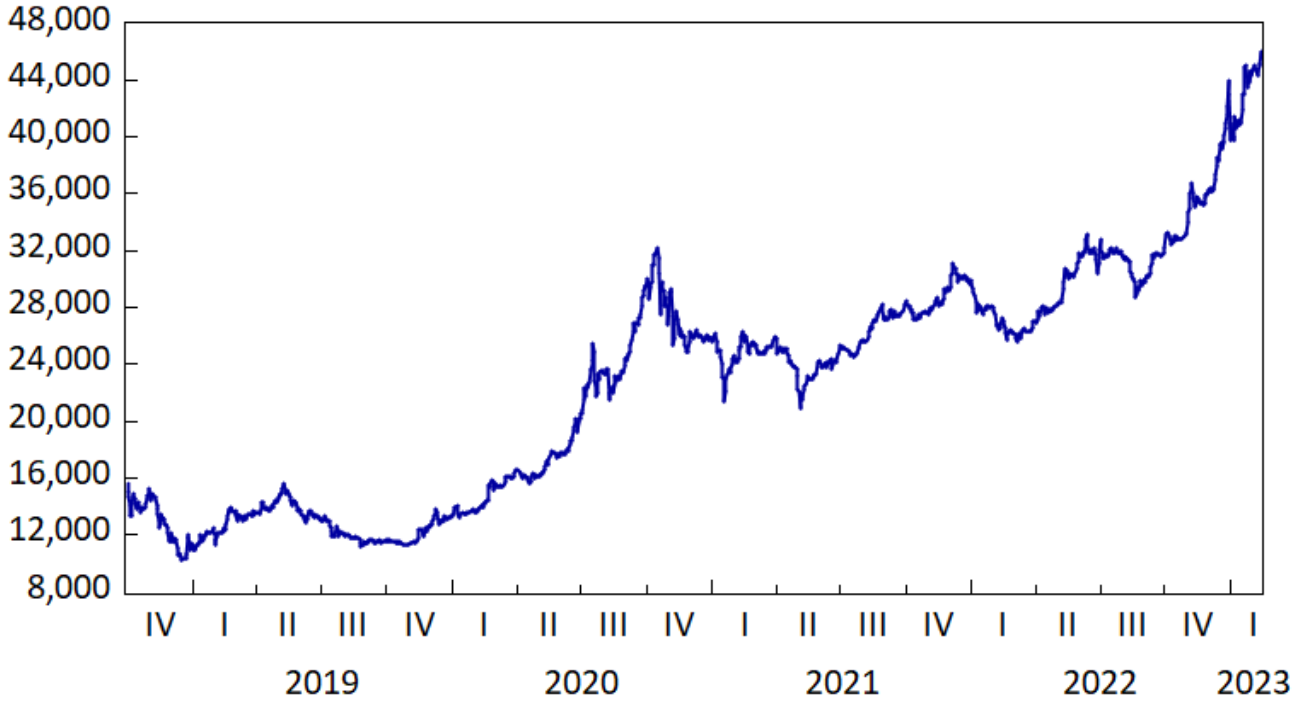


Figure 26. *Set2 plot (10/1/2018 – 2/13/2023)*

1.1.1.2. Correlogram

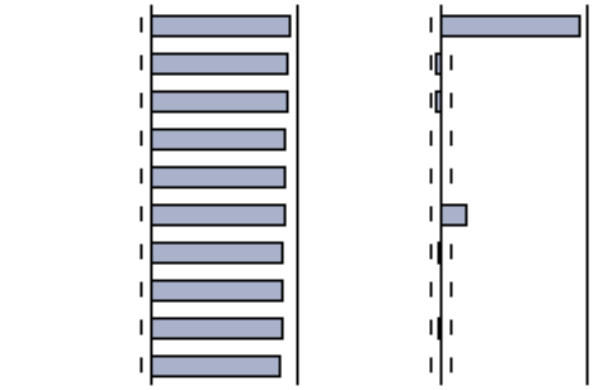
Useful information about the structure of the time series can be obtained by autocovariance and autocorrelation functions. The general rule is that at least 50 observations are required to give a reliable estimate of the ACF, and the individual sample ACF should be calculated up to lag K, where K is about Ln(T), T is the number of periods of data available and K is the time interval which is called lag.

The statistical results are in the form of summary statistical tables and graphs including autocorrelation function (ACF), partial autocorrelation function (PACF), Q-statistic, and its probability. Q-statistic, which is a statistical test that can be used to test a null hypothesis where the data are independently distributed (i.e. the correlations in the population from which the sample is taken are 0 so that any observed correlations in the data result from the randomness of the sampling process).

When plotting the value of the ACF for increasing lags (Correlogram) the values tend to degrade to zero quickly for stationary time series, while for non-stationary data the degradation will happen more slowly.

Based on Figures 27, and 28, in both cases, the sample ACF is very persistent; it decays very slowly and exhibits sample autocorrelations that are still rather large at further lags and finally tails off near zero at the last lags. This behavior is characteristic of a nonstationary time series. Moreover, the table results show that the data do not support the supposition and the null hypothesis is rejected based on p-value=0.0000. It can be concluded that there is a linear dependency between values. The spikes crossing the confidence level borderlines indicate the results as well. Hence, the dataset is non-stationary. However, it should be checked by parametric tests which are more rigorous approaches for detecting stationarity in time series data.

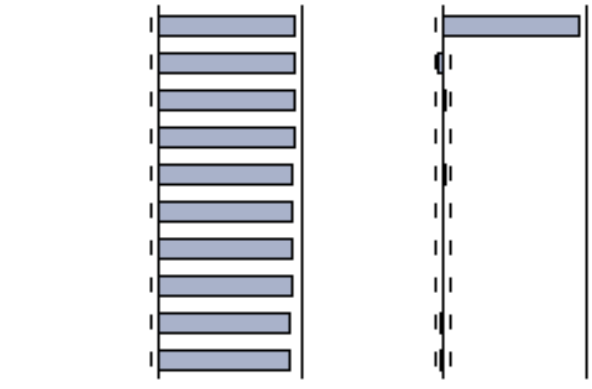
Sample: 6/01/2015 3/17/2018
Included observations: 875



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.991	0.991	862.49	0.000
		2	0.982	-0.030	1709.8	0.000
		3	0.972	-0.037	2541.0	0.000
		4	0.962	0.002	3356.5	0.000
		5	0.952	0.008	4156.7	0.000
		6	0.946	0.176	4947.1	0.000
		7	0.940	-0.011	5727.9	0.000
		8	0.934	0.000	6499.4	0.000
		9	0.927	-0.011	7261.6	0.000
		10	0.921	0.005	8014.5	0.000

***Figure 27**. Autocorrelation function (Set1)*

Sample: 10/01/2018 2/13/2023
Included observations: 1369



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.996	0.996	1361.2	0.000
		2	0.992	-0.025	2712.2	0.000
		3	0.988	0.021	4053.5	0.000
		4	0.984	0.007	5385.3	0.000
		5	0.980	0.021	6708.2	0.000
		6	0.977	-0.000	8022.1	0.000
		7	0.973	0.003	9327.2	0.000
		8	0.970	-0.005	10623.	0.000
		9	0.966	-0.008	11911.	0.000
		10	0.962	-0.022	13189.	0.000

***Figure 28**. Autocorrelation. function (Set2)*

1.1.2. Statistic Tests

Considering the time series plot and ACF, the obvious conclusion which can be come to is that there is an obvious upward trend in this series and a trending mean is a common violation of stationarity. There are two popular models for nonstationary series with a trending mean, trend stationary process (TSP) and difference stationary process (DSP).

The use of unit root tests to distinguish between trend and difference stationary data has become an essential tool in applied research. However, as Perron (1989) points out, structural change and unit roots are closely related, and researchers should bear in mind that conventional unit root tests are biased toward a false unit root null when the data are trend stationary with a structural break. This observation has spurred the development of a large literature outlining various unit root tests that remain valid in the presence of a break.

Hence, we perform both the "Unit root test" and "Breakpoint unit root test" to distinguish the nature of the dataset in terms of TSP and DSP.

1.1.2.1. Unit Root Test

EViews offers a variety of standard unit root tests, including Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), Elliot, Rothenberg, and Stock (ERS), Ng and Perron (NP), and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) tests. All are performed at "level" and the exogenous regressors are included in the equation in 3 forms constant, linear trend, and neither. The lag length is set as the default which is the best one chosen by EViews.

Null Hypothesis H_0 = If failed to be rejected, it suggests the time series has a unit root, meaning it is non-stationary

Alternative Hypothesis H_1 = The null hypothesis is rejected and suggests the time series does not have a unit root, meaning it is stationary

The null hypothesis of KPSS proposes that the dependent variable is stationary.

The unit root output provides information about the form of the test (the type of test, the exogenous variables, and the lag length used), and contains the test output, associated critical values, and in this case, the p-value. In addition, EViews reports the critical values at the 1%, 5%, and 10% levels. The null at conventional test sizes can be rejected whenever the t-statistic value or LM statistic is greater, or the p-value (prob.) is less than the critical values [67].

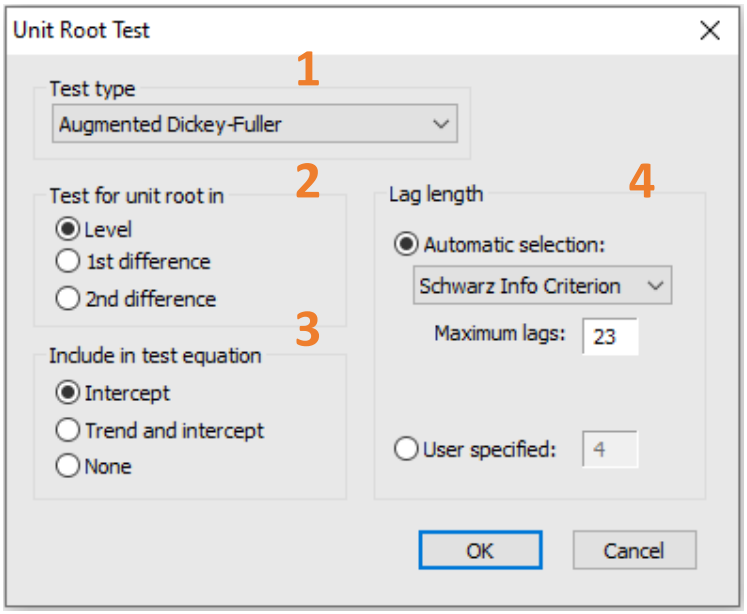


***Figure 29**. Unit root test EViews dialog box*

You must specify four sets of options to carry out a unit root test (Figure 29). The first three settings (on the left-hand side of the dialog) determine the basic form of the unit root test. The fourth set of options (on the right-hand side of the dialog) consists of test-specific advanced settings. You only need to concern yourself with these settings if you wish to customize the calculation of your unit root test.

1- You should use the topmost dropdown menu to select the type of unit root test that you wish to perform. You may choose one of six tests: ADF, DFGLS, PP, KPSS, ERS, and NP.
2- Specify whether you wish to test for a unit root at level, first difference, or second difference of the series.
3- Choose your exogenous regressors. You can choose to include a constant, a constant, a linear trend, or neither (there are limitations on these choices for some of the tests).
4- It allows you to specify how lagged difference terms p are to be included in the ADF test equation. You may choose to let EViews automatically select p, or you may specify a fixed positive integer value [67].

Following there the results of unit root tests with different adjustments:

- INTERCEPT: Considering only intercept, meaning the model has only constant. In this case, all the above-mentioned tests include a constant in the test regression and employ automatic lag length selection using the default approach and maximum lag. The results are described in Figure 29. Since in all cases, the null hypothesis cannot be rejected, so, the dependent variable does have a unit root and is not stationary.

- TREND AND INTERCEPT: Considering trend and intercept means there are both constant and trend in the model. In this case, all the above-mentioned tests include trend and constant in the test regression and employ automatic lag length selection using the default approach and maximum lag. The results are described in Figure 31.

- NONE: In this case, all the above-mentioned tests include neither trend nor constant in the test regression and employ automatic lag length selection using the default approach and maximum lag. It works out only in some tests. The results are described in Figure 32.

- **Augmented Dickey-Fuller (ADF):**

Not only the p-value is greater than 0.05, but also t-statistic is less than the critical values. So, the null hypothesis cannot be rejected and there is a unit root.

Null Hypothesis: SELL_BEFORE has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=20)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.387639	0.9990
Test critical values:	1% level	-3.437609	
	5% level	-2.864633	
	10% level	-2.568471	

- **Dickey-Fuller GLS:**

The t-statistic is greater than the critical values, so the null hypothesis can be rejected and there is a unit root.

Null Hypothesis: SELL_BEFORE has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=20)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		2.697908
Test critical values:	1% level	-2.567611
	5% level	-1.941186
	10% level	-1.616456

- **Phillips-Perron:**

Not only the p-value is greater than 0.05, but also t-statistic is less than the critical values. So, the null hypothesis cannot be rejected and there is a unit root.

Null Hypothesis: SELL_BEFORE has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		1.117889	0.9977
Test critical values:	1% level	-3.437609	
	5% level	-2.864633	
	10% level	-2.568471	

- **KPSS:**

LM-stat is greater than the critical values. So, the null hypothesis can be rejected and the time series is not stationary.

Null Hypothesis: SELL_BEFORE is stationary
Exogenous: Constant
Bandwidth: 23 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.774573
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

- **Point Optimal:**

The p-value is greater than the critical values. So, the null hypothesis cannot be rejected. So, there is a unit root.

Null Hypothesis: SELL_BEFORE has a unit root
Exogenous: Constant
Lag length: 0 (Spectral OLS AR based on SIC, maxlag=20)
Sample: 6/01/2015 3/17/2018
Included observations: 875

		P-Statistic
Elliott-Rothenberg-Stock test statistic		71.59159
Test critical values:	1% level	1.990000
	5% level	3.260000
	10% level	4.480000

- **NG-Perron:**

The absolute value of the MZa is less and MSB and MPT are greater than the critical values. So, the null hypothesis can be rejected.

Null Hypothesis: SELL_BEFORE has a unit root
Exogenous: Constant
Lag length: 0 (Spectral GLS-detrended AR based on SIC, maxlag=20)
Sample: 6/01/2015 3/17/2018
Included observations: 875

		MZa	MZt	MSB	MPT
Ng-Perron test statistics		3.36207	2.70638	0.80497	69.2082
Asymptotic critical values*:	1%	-13.8000	-2.58000	0.17400	1.78000
	5%	-8.10000	-1.98000	0.23300	3.17000
	10%	-5.70000	-1.62000	0.27500	4.45000

***Figure 30**. Set1 Unit Root test output- Intercept*

- **Augmented Dickey-Fuller (ADF):**

The p-value is greater than 0.05, so the null hypothesis cannot be rejected and there is a unit root.

Null Hypothesis: SELL_BEFORE has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=20)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.302122	0.9905
Test critical values:	1% level	-3.968585	
	5% level	-3.414965	
	10% level	-3.129664	

- **Dickey-Fuller GLS:**

The t-statistic is less than the critical values, so the null hypothesis cannot be rejected and there is a unit root.

Null Hypothesis: SELL_BEFORE has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=20)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-0.641824
Test critical values:	1% level	-3.480000
	5% level	-2.890000
	10% level	-2.570000

- **Phillips-Perron:**

Not only the p-value is greater than 0.05 but also t-statistic is less than the critical values. So, the null hypothesis cannot be rejected and there is a unit root.

Null Hypothesis: SELL_BEFORE has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.520856	0.9825
Test critical values:	1% level	-3.968585	
	5% level	-3.414965	
	10% level	-3.129664	

- **KPSS:**

LM-stat is greater than the critical values. So, the null hypothesis can be rejected and the time series is not stationary.

Null Hypothesis: SELL_BEFORE is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 23 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.381514
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

- **Point Optimal:**

The p-value is greater than the critical values. So, the null hypothesis cannot be rejected and there is a unit root.

Null Hypothesis: SELL_BEFORE has a unit root
Exogenous: Constant, Linear Trend
Lag length: 0 (Spectral OLS AR based on SIC, maxlag=20)
Sample: 6/01/2015 3/17/2018
Included observations: 875

		P-Statistic
Elliott-Rothenberg-Stock test statistic		25.20262
Test critical values:	1% level	3.960000
	5% level	5.620000
	10% level	6.890000

- **NG-Perron:**

The absolute values of the MZa and MZt are less and MSB and MPT are greater than the critical values. So, the null hypothesis can be rejected.

Null Hypothesis: SELL_BEFORE has a unit root
Exogenous: Constant, Linear Trend
Lag length: 0 (Spectral GLS-detrended AR based on SIC, maxlag=20)
Sample: 6/01/2015 3/17/2018
Included observations: 875

		MZa	MZt	MSB	MPT
Ng-Perron test statistics		-2.16060	-0.64111	0.29673	25.0195
Asymptotic critical values*:	1%	-23.8000	-3.42000	0.14300	4.03000
	5%	-17.3000	-2.91000	0.16800	5.48000
	10%	-14.2000	-2.62000	0.18500	6.67000

***Figure 31**. Set1 Unit Root test output, Trend & Intercept*

- **Augmented Dickey-Fuller (ADF):**

The p-value is greater than 0.05, so the null hypothesis cannot be rejected.

- **Phillips-Perron:**

The p-value is greater than 0.05. So, the null hypothesis cannot be rejected.

Null Hypothesis: SELL_BEFORE has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=20)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		2.474953	0.9971
Test critical values:	1% level	-2.567611	
	5% level	-1.941186	
	10% level	-1.616456	

Null Hypothesis: SELL_BEFORE has a unit root
Exogenous: None
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		2.306642	0.9953
Test critical values:	1% level	-2.567611	
	5% level	-1.941186	
	10% level	-1.616456	

***Figure 32**. Set1 unit-root test output, None*

- **Augmented Dickey-Fuller (ADF):**

Not only the p-value is greater than 0.05, but also t-statistic is less than the critical values. So, the null hypothesis cannot be rejected and there is a unit root.

Null Hypothesis: SELL_AFTER has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.399933	0.9991
Test critical values:	1% level	-3.434920	
	5% level	-2.863446	
	10% level	-2.567834	

- **Dickey-Fuller GLS:**

The t-statistic is greater than the critical values, so the null hypothesis can be rejected and there is a unit root.

Null Hypothesis: SELL_AFTER has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=23)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		2.510166
Test critical values:	1% level	-2.566654
	5% level	-1.941055
	10% level	-1.616544

- **Phillips-Perron:**

Not only the p-value is greater than 0.05, but also t-statistic is less than the critical values. So, the null hypothesis cannot be rejected and there is a unit root.

Null Hypothesis: SELL_AFTER has a unit root
Exogenous: Constant
Bandwidth: 13 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		1.517929	0.9994
Test critical values:	1% level	-3.434920	
	5% level	-2.863446	
	10% level	-2.567834	

- **KPSS:**

LM-stat is greater than the critical values. So, the null hypothesis can be rejected and the time series is not stationary.

Null Hypothesis: SELL_AFTER is stationary
Exogenous: Constant
Bandwidth: 30 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		4.016764
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

- **Point Optimal:**

The p-value is greater than the critical values. So, the null hypothesis cannot be rejected. So, there is a unit root.

Null Hypothesis: SELL_AFTER has a unit root
Exogenous: Constant
Lag length: 0 (Spectral OLS AR based on SIC, maxlag=23)
Sample: 10/01/2018 2/13/2023
Included observations: 1369

		P-Statistic
Elliott-Rothenberg-Stock test statistic		68.49581
Test critical values:	1% level	1.990000
	5% level	3.260000
	10% level	4.480000

- **NG-Perron:**

The absolute values of the MZa and MZt are less and MSB and MPT are greater than the critical values. So, the null hypothesis can be rejected.

Null Hypothesis: SELL_AFTER has a unit root
Exogenous: Constant
Lag length: 0 (Spectral GLS-detrended AR based on SIC, maxlag=23)
Sample: 10/01/2018 2/13/2023
Included observations: 1369

		MZa	MZt	MSB	MPT
Ng-Perron test statistics		3.11520	2.51448	0.80716	67.3127
Asymptotic critical values*:	1%	-13.8000	-2.58000	0.17400	1.78000
	5%	-8.10000	-1.98000	0.23300	3.17000
	10%	-5.70000	-1.62000	0.27500	4.45000

Figure 33. *Set2 Unit Root test output- Intercept*

- **Augmented Dickey-Fuller (ADF):**

The p-value is greater than 0.05, so the null hypothesis cannot be rejected and there is a unit root.

Null Hypothesis: SELL_AFTER has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.549718	0.8120
Test critical values:	1% level	-3.964767	
	5% level	-3.413099	
	10% level	-3.128558	

- **Dickey-Fuller GLS:**

The t-statistic is less than the critical values, so the null hypothesis cannot be rejected and there is a unit root.

Null Hypothesis: SELL_AFTER has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=23)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-0.573138
Test critical values:	1% level	-3.480000
	5% level	-2.890000
	10% level	-2.570000

- **Phillips-Perron:**

Not only the p-value is greater than 0.05 but also t-statistic is less than the critical values. So, the null hypothesis cannot be rejected and there is a unit root.

Null Hypothesis: SELL_AFTER has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.449448	0.8460
Test critical values:	1% level	-3.964767	
	5% level	-3.413099	
	10% level	-3.128558	

- **KPSS:**

LM-stat is greater than the critical values. So, the null hypothesis can be rejected, and the time series is not stationary.

Null Hypothesis: SELL_AFTER is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 30 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.194671
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

- **Point Optimal:**

The p-value is greater than the critical values. So, the null hypothesis cannot be rejected and there is a unit root.

Null Hypothesis: SELL_AFTER has a unit root
Exogenous: Constant, Linear Trend
Lag length: 0 (Spectral OLS AR based on SIC, maxlag=23)
Sample: 10/01/2018 2/13/2023
Included observations: 1369

		P-Statistic
Elliott-Rothenberg-Stock test statistic		31.30969
Test critical values:	1% level	3.960000
	5% level	5.620000
	10% level	6.890000

- **NG-Perron:**

The absolute values of the MZa and MZt are less and MSB and MPT are greater than the critical values. So, the null hypothesis can be rejected.

Null Hypothesis: SELL_AFTER has a unit root
Exogenous: Constant, Linear Trend
Lag length: 0 (Spectral GLS-detrended AR based on SIC, maxlag=23)
Sample: 10/01/2018 2/13/2023
Included observations: 1369

		MZa	MZt	MSB	MPT
Ng-Perron test statistics		-1.65099	-0.57239	0.34670	30.6449
Asymptotic critical values*:	1%	-23.8000	-3.42000	0.14300	4.03000
	5%	-17.3000	-2.91000	0.16800	5.48000
	10%	-14.2000	-2.62000	0.18500	6.67000

Figure 34. *Set2 Unit Root test output, Trend & Intercept*

- **Augmented Dickey-Fuller (ADF):**

The p-value is greater than 0.05, so the null hypothesis cannot be rejected.

Null Hypothesis: SELL_AFTER has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		2.622329	0.9981
Test critical values:	1% level	-2.566654	
	5% level	-1.941055	
	10% level	-1.616544	

- **Phillips-Perron:**

The p-value is greater than 0.05. So, the null hypothesis cannot be rejected.

Null Hypothesis: SELL_AFTER has a unit root
Exogenous: None
Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		2.743253	0.9987
Test critical values:	1% level	-2.566654	
	5% level	-1.941055	
	10% level	-1.616544	

Figure 35. *Set2 Unit Root test output, None*

Considering all outputs for both data sets (Figures 30,31, and 32 for Set1 and Figures 33, 34, and 35 for Set2), it is totally obvious that for all cases, we cannot reject our null hypothesis indicating having a unit root or being nonstationary. Hence, the dependent variable ("SELL-BEFORE" and "SELL-AFTER") for both data sets is not stationary.

1.1.2.2. Structural Break

The use of unit root tests to distinguish between trend and difference stationary data has become an essential tool in applied research. As shown by Perron (1989), in the presence of a structural break, conventional unit root test methods may show a time series to be non-stationary, which in fact is a stationary series. In other words, a stationary series that has a structural break may be regarded as a non-stationary series by the above-mentioned unit root test methods because these methods do not adjust structural breaks.

EViews offers support for several types of modified augmented Dickey-Fuller tests which allow for levels and trends that differ across a single break date. It is possible to compute unit root tests with a single break where:

•The break can occur slowly or immediately.

•The break consists of a level shift, a trend break, or both a shift and break.

•The break date is known, or the break date is unknown and estimated from the data.

•The data are non-trending or trending [67].

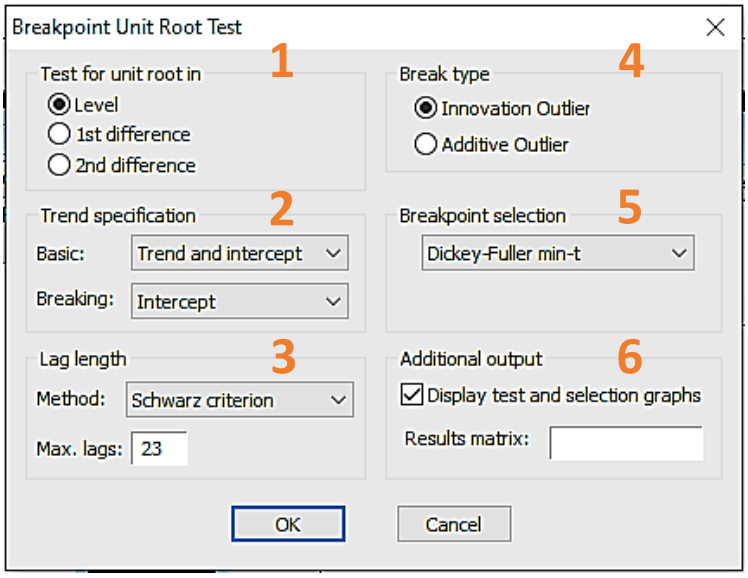


***Figure 36**. Breaking point unit root test EViews dialog box*

For computing the breakpoint unit root test, the dialog is divided into six sections: (Figure 36)

1- This part tells EViews whether you wish to compute the test using the raw data (Level), or whether to test for higher order integration using differences (1st difference or 2nd difference) of the original data.
2- The Trend specification section determines the trend components that are included in the test. Using the Basic dropdown, you may choose between an Intercept only or an Intercept and trend specification. If you include a trend in the specification, you will be prompted to indicate which deterministic components are breaking by choosing Intercept, Intercept, and trend, or Trend in the Breaking dropdown menu.
3- The Lag length section describes the method for selecting lags for each of the augmented Dickey-Fuller test specifications. You may choose between the Akaike criterion (AIC), Schwarz criterion (BIC), Hannan-Quinn criterion (HQC), Modified Akaike, Modified Schwarz, Modified Hannan-Quinn, t-statistic, F-statistic, and Fixed lag specifications. For all but the Fixed lag method, you must provide a Max. lag to test; by default, EViews will suggest a maximum lag based on the number of observations in the series. For the test methods (t-statistic, F-statistic), you must specify a p-value for the tests; for the Fixed lag method, you must specify the actual number of lag using the User lags edit field.
4- The Break type section allows you to choose between the default Innovation outlier and the Additive outlier specifications.
5- The Breakpoint selection section specifies the method for determining the identity of the breakpoint. You can choose between minimizing the t-statistic for in the ADF test (Dickey-Fuller min-t), minimizing the t-statistic for the intercept break coefficient (Intercept break min-t), maximizing the t-statistic for the break coefficient (Intercept break max-t), maximizing the absolute value of the t-statistic for the intercept break coefficient (Intercept break max-abs-t), or providing a specific date (User-specified).
6- The Additional output controls the output produced by the view. The checkbox Display test and selection graphs control whether to show only the test results with the selected break or to show the test results and graphs depicting the break selection criterion results for each candidate break [67].

Two versions of the four models are considered which differ in their treatment of the break dynamics: the innovational outlier (IO) model assumes that the break occurs gradually, with the breaks following the same dynamic path as the innovations, while the additive outlier (AO) model assumes the breaks occur immediately. The tests considered here evaluate the null hypothesis that

the data follow a unit root process, possibly with a break, against a trend stationary with a break alternative. The null hypothesis can be rejected if the p-value is less, or the t-statistic is greater than the critical values [67].

All the following tests are performed in "level" and applied "Dickey-Fuller min t" as a breakpoint selection approach. The output describes the test that was performed, with a description of the underlying series, the trend and break specification and the break type. The second section displays the selected break date.

For more outputs, check Table 4 rows with green check marks, show H_0 rejection at 5% critical values. Red X marks indicate that the H_0 cannot be rejected.

***Table 4**. Set1 Breakpoint unit root test outputs*

TREND SPECIFICATION					
BASIC	**BREAKING**	**LAG LENGTH METHOD**	**BREAK TYPE**	**PROB.**	**H0 rejection**
INTERCEPT					
		AKAIKE	INNOVATION	>0.99	✘
		AKAIKE	ADDITIVE	>0.99	✘
		SCHWARZ	INNOVATION	>0.99	✘
		SCHWARZ	ADDITIVE	>0.99	✘
		HANNAN-QUINN	INNOVATION	>0.99	✘
		HANNAN-QUINN	ADDITIVE	>0.99	✘
		MOD. AKAIKE	INNOVATION	>0.99	✘
		MOD. AKAIKE	ADDITIVE	>0.99	✘
		MOD.SCHWARZ	INNOVATION	>0.99	✘
		MOD.SCHWARZ	ADDITIVE	>0.99	✘
		MOD. HANNAN	INNOVATION	>0.99	✘
		MOD. HANNAN	ADDITIVE	>0.99	✘
		T-STATIC	INNOVATION	>0.99	✘
		T-STATIC	ADDITIVE	>0.99	✘
		F- STATIC	INNOVATION	>0.99	✘
		F-STATIC	ADDITIVE	>0.99	✘
TREND & INTERCEPT	**INTERCEPT**				
		AKAIKE	INNOVATION	0.9038	✘
		AKAIKE	ADDITIVE	0.9605	✘
		SCHWARZ	INNOVATION	0.9361	✘

		SCHWARZ	ADDITIVE	0.9332	✘
		HANNAN-QUINN	INNOVATION	0.9038	✘
		HANNAN-QUINN	ADDITIVE	0.9310	✘
		MOD. AKAIKE	INNOVATION	0.9361	✘
		MOD. AKAIKE	ADDITIVE	0.9730	✘
		MOD.SCHWARZ	INNOVATION	0.9361	✘
		MOD.SCHWARZ	ADDITIVE	0.9332	✘
		MOD. HANNAN	INNOVATION	0.9361	✘
		MOD. HANNAN	ADDITIVE	0.9437	✘
		T-STATIC	INNOVATION	0.9489	✘
		T-STATIC	ADDITIVE	0.9717	✘
		F- STATIC	INNOVATION	0.9489	✘
		F-STATIC	ADDITIVE	0.9732	✘
TREND & INTERCEPT	**TREND & INTERCEPT**				
		AKAIKE	INNOVATION	0.9022	✘
		AKAIKE	ADDITIVE	0.9005	✘
		SCHWARZ	INNOVATION	0.9671	✘
		SCHWARZ	ADDITIVE	0.9661	✘
		HANNAN-QUINN	INNOVATION	0.9389	✘
		HANNAN-QUINN	ADDITIVE	0.9661	✘
		MOD. AKAIKE	INNOVATION	0.9671	✘
		MOD. AKAIKE	ADDITIVE	0.9205	✘
		MOD.SCHWARZ	INNOVATION	0.9671	✘

		MOD.SCHWARZ	ADDITIVE	0.9661	✘
		MOD. HANNAN	INNOVATION	0.9671	✘
		MOD. HANNAN	ADDITIVE	0.9661	✘
		T-STATIC	INNOVATION	0.9635	✘
		T-STATIC	ADDITIVE	0.9667	✘
		F- STATIC	INNOVATION	0.9635	✘
		F-STATIC	ADDITIVE	0.9527	✘
TREND & INTERCEPT	**TREND**				
		AKAIKE	INNOVATION	0.5389	✘
		AKAIKE	ADDITIVE	0.2629	✘
		SCHWARZ	INNOVATION	0.7219	✘
		SCHWARZ	ADDITIVE	0.6298	✘
		HANNAN-QUINN	INNOVATION	0.6225	✘
		HANNAN-QUINN	ADDITIVE	0.5073	✘
		MOD. AKAIKE	INNOVATION	0.7219	✘
		MOD. AKAIKE	ADDITIVE	0.2915	✘
		MOD.SCHWARZ	INNOVATION	0.7219	✘
		MOD.SCHWARZ	ADDITIVE	0.6298	✘
		MOD. HANNAN	INNOVATION	0.7219	✘
		MOD. HANNAN	ADDITIVE	0.6298	✘
		T-STATIC	INNOVATION	0.6884	✘
		T-STATIC	ADDITIVE	0.2643	✘
		F- STATIC	INNOVATION	0.6884	✘
		F-STATIC	ADDITIVE	0.2643	✘

According to the output results (Table 4), it is obvious that the null hypothesis cannot be rejected. Hence, the structural break is not confirmed and Set1 does have a unit root.

The same breakpoint test is applied for Set 2. The Output is available in Table 5 which indicates that there is no structural break and Set 2 has the unit root as well. So, both data sets need to become stationary by taking the difference.

Table 5. *Set2 Breakpoint unit root test outputs*

TREND SPECIFICATION					
BASIC	**BREAKING**	**LAG LENGTH METHOD**	**BREAK TYPE**	**PROB.**	**H0 rejection**
INTERCEPT					
		AKAIKE	INNOVATION	>0.99	✘
		AKAIKE	ADDITIVE	>0.99	✘
		SCHWARZ	INNOVATION	>0.99	✘
		SCHWARZ	ADDITIVE	>0.99	✘
		HANNAN-QUINN	INNOVATION	>0.99	✘
		HANNAN-QUINN	ADDITIVE	>0.99	✘
		MOD. AKAIKE	INNOVATION	>0.99	✘
		MOD. AKAIKE	ADDITIVE	>0.99	✘
		MOD.SCHWARZ	INNOVATION	>0.99	✘
		MOD.SCHWARZ	ADDITIVE	>0.99	✘
		MOD. HANNAN	INNOVATION	>0.99	✘
		MOD. HANNAN	ADDITIVE	>0.99	✘
		T-STATIC	INNOVATION	>0.99	✘
		T-STATIC	ADDITIVE	>0.99	✘
		F- STATIC	INNOVATION	>0.99	✘
		F-STATIC	ADDITIVE	>0.99	✘
TREND & INTERCEPT	**INTERCEPT**				
		AKAIKE	INNOVATION	0.9359	✘
		AKAIKE	ADDITIVE	0.9268	✘
		SCHWARZ	INNOVATION	0.8980	✘

		SCHWARZ	ADDITIVE	0.8962	✘
		HANNAN-QUINN	INNOVATION	0.8980	✘
		HANNAN-QUINN	ADDITIVE	0.9213	✘
		MOD. AKAIKE	INNOVATION	0.9806	✘
		MOD. AKAIKE	ADDITIVE	0.9213	✘
		MOD.SCHWARZ	INNOVATION	0.9806	✘
		MOD.SCHWARZ	ADDITIVE	0.8962	✘
		MOD. HANNAN	INNOVATION	0.9806	✘
		MOD. HANNAN	ADDITIVE	0.9213	✘
		T-STATIC	INNOVATION	0.9359	✘
		T-STATIC	ADDITIVE	0.9392	✘
		F- STATIC	INNOVATION	0.9359	✘
		F-STATIC	ADDITIVE	0.9010	✘
TREND & INTERCEPT	**TREND & INTERCEPT**				
		AKAIKE	INNOVATION	0.9626	✘
		AKAIKE	ADDITIVE	0.9332	✘
		SCHWARZ	INNOVATION	0.9297	✘
		SCHWARZ	ADDITIVE	0.9292	✘
		HANNAN-QUINN	INNOVATION	0.9297	✘
		HANNAN-QUINN	ADDITIVE	0.9292	✘
		MOD. AKAIKE	INNOVATION	0.9892	✘
		MOD. AKAIKE	ADDITIVE	0.9332	✘
		MOD.SCHWARZ	INNOVATION	0.9892	✘

		MOD.SCHWARZ	ADDITIVE	0.9292	✘
		MOD. HANNAN	INNOVATION	0.9892	✘
		MOD. HANNAN	ADDITIVE	0.9292	✘
		T-STATIC	INNOVATION	0.9262	✘
		T-STATIC	ADDITIVE	0.9741	✘
		F- STATIC	INNOVATION	0.9626	✘
		F-STATIC	ADDITIVE	0.9741	✘
TREND & INTERCEPT	**TREND**				
		AKAIKE	INNOVATION	0.7611	✘
		AKAIKE	ADDITIVE	0.3714	✘
		SCHWARZ	INNOVATION	0.6917	✘
		SCHWARZ	ADDITIVE	0.4402	✘
		HANNAN-QUINN	INNOVATION	0.6917	✘
		HANNAN-QUINN	ADDITIVE	0.4402	✘
		MOD. AKAIKE	INNOVATION	0.9020	✘
		MOD. AKAIKE	ADDITIVE	0.3714	✘
		MOD.SCHWARZ	INNOVATION	0.9020	✘
		MOD.SCHWARZ	ADDITIVE	0.4402	✘
		MOD. HANNAN	INNOVATION	0.9020	✘
		MOD. HANNAN	ADDITIVE	0.5423	✘
		T-STATIC	INNOVATION	0.7611	✘
		T-STATIC	ADDITIVE	0.3702	✘
		F- STATIC	INNOVATION	0.7611	✘
		F-STATIC	ADDITIVE	0.3702	✘

1.1.2.3. Differencing

Differencing of a time series in discrete time is the transformation of the series to a new time series where the values are the differences between consecutive values. This procedure may be applied consecutively more than once, giving rise to the "first differences", "second differences",... . The reason to use the differences instead of the values of the time series is that the differences of a broad class of nonstationary time series are stationary time series. Thus, the differencing procedure makes it possible to apply analytical tools and theoretical results developed for stationary time series to nonstationary time series.

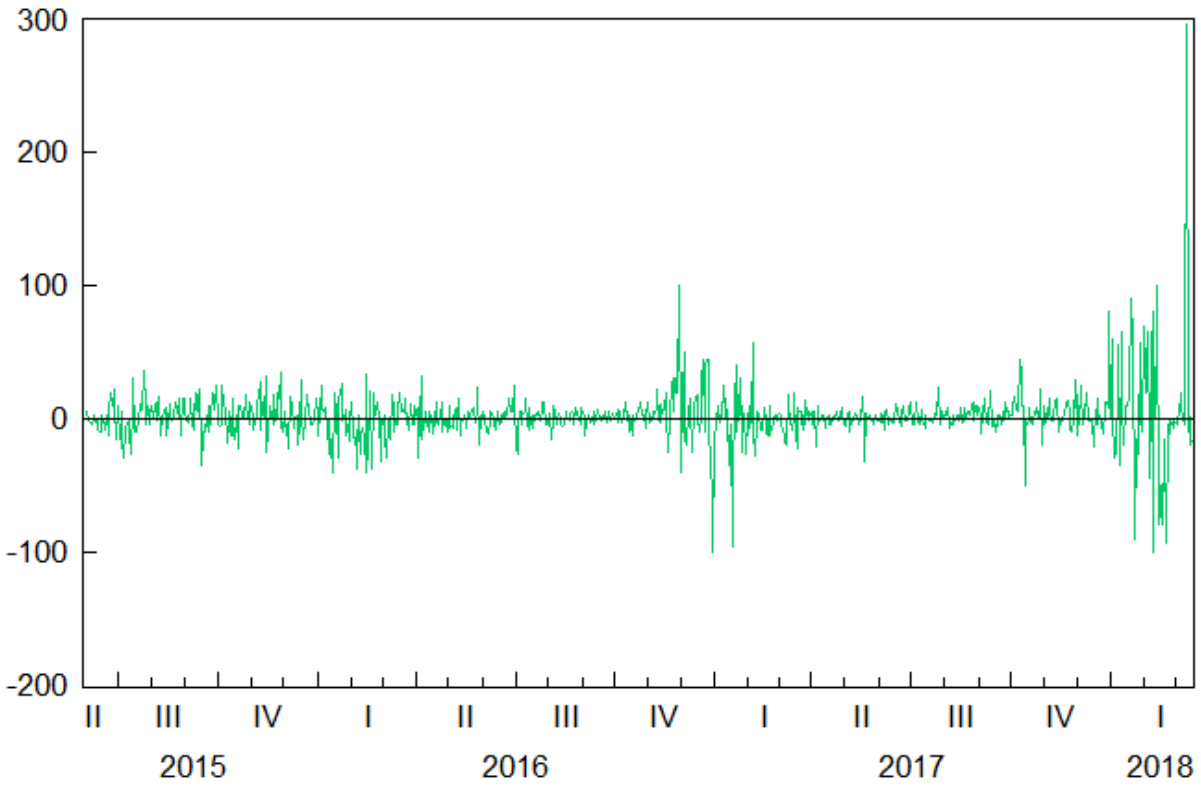


Figure 37. *First difference Set1*

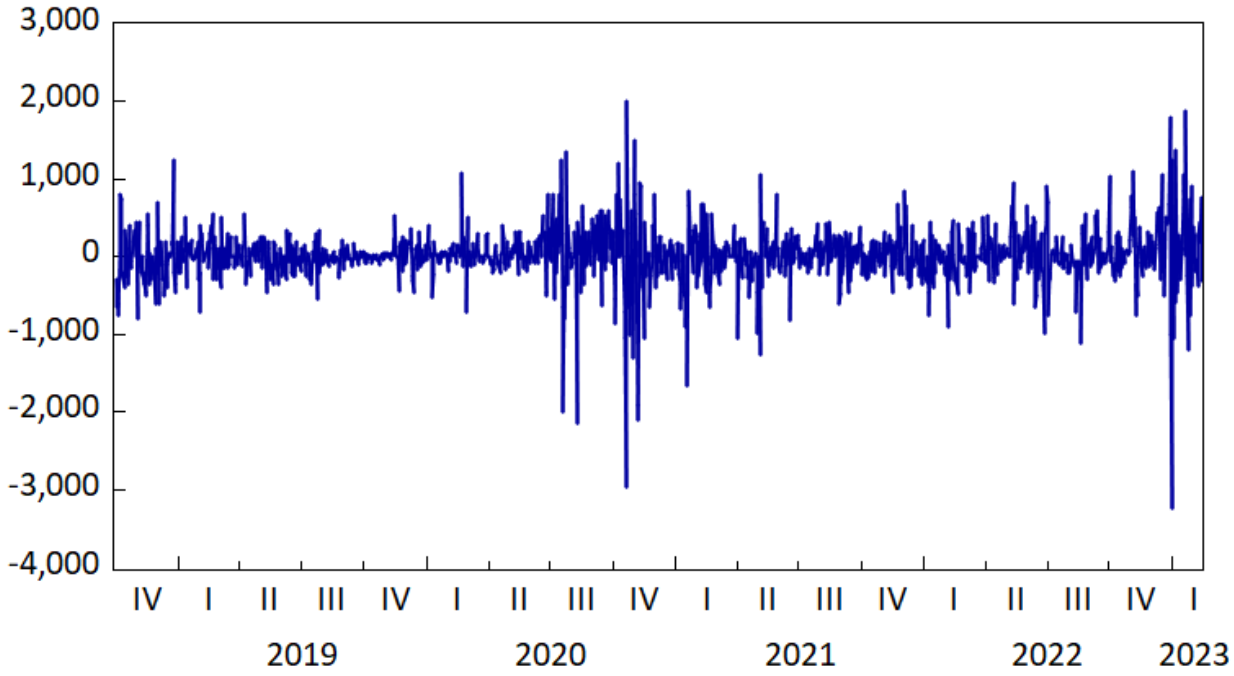


***Figure 38**. First differenced Set2*

The first difference for both data sets is done, and the result is shown in Figures 37 and 38. As it is obvious there are no trends anymore and the data sets are stationary now.

1.2. Mean Equation Estimation

For estimating an equation in EViews:

1- Enter equation specification
2- Choose the method for your model
3- Enter the sample specification [67]

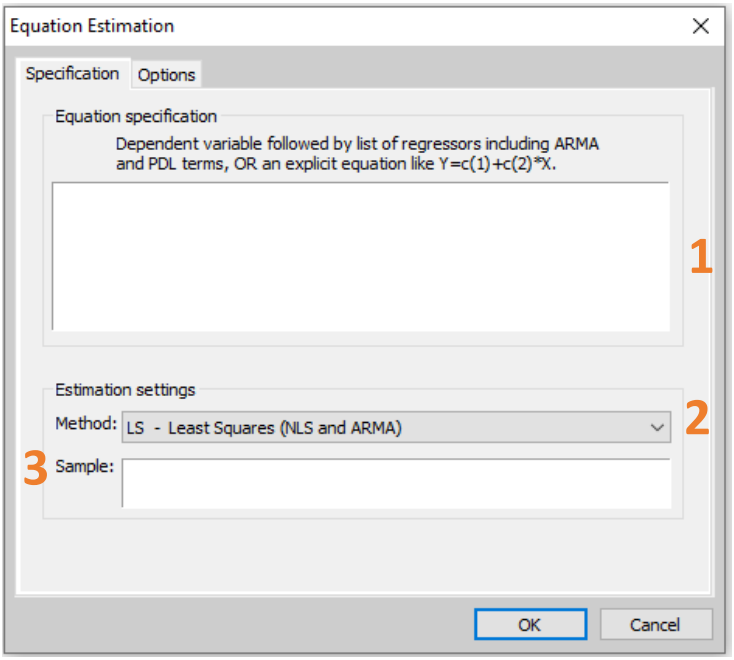


***Figure 39**. Equation estimation EViews dialog box*

1.2.1. ARMA Model

By looking at the autocorrelation function (ACF) and partial autocorrelation (PACF) plots of the differenced series, you can tentatively identify the numbers of AR and/or MA terms that are needed. By the number of spikes crossing the borders (critical values) in ACF the order of the MA model and in PACF the order of the AR model is determined.

Whenever the PACF displays a sharp cutoff while the ACF decays more slowly, we say that the series displays an "AR signature," meaning that the autocorrelation pattern can be explained more easily by adding AR terms than by adding MA terms. Wherever PACF "cuts off" at lag k--this indicates that exactly *k* AR terms should be used in the equation. To find the best model, the

model selection criteria, Schwarz, Akaike, and Hannan-Quinn criteria, should be compared among all proposed models. The fewer the criterion is, the better the model is.

For the sake of output analysis, an ARMA (1,1) model on training time series is performed and the output is shown in Figure 35. For other models' output refer to Table 5.

The related equation is:

Dependent Variable: SELL
Method: ARMA Maximum Likelihood (OPG - BHHH) 1
Date: 04/17/22 Time: 13:01
Sample: 6/01/2015 1/27/2020
Included observations: 1459
Convergence achieved after 122 iterations
Coefficient covariance computed using outer product of gradients

2 Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7818.428	4652.855	1.680351	0.0931
AR(1)	0.999014	0.001272	785.5371	0.0000
MA(1)	0.189869	0.009159	20.73058	0.0000
SIGMASQ	30953.05	295.0755	104.8987	0.0000

R-squared	0.998259	Mean dependent var	6861.548
Adjusted R-squared	0.998256	S.D. dependent var	4218.337
S.E. of regression	176.1765	Akaike info criterion	13.18812
Sum squared resid	45160496	Schwarz criterion	13.20261
Log likelihood	-9616.734	Hannan-Quinn criter.	13.19353
F-statistic	278141.9	Durbin-Watson stat	2.003397
Prob(F-statistic)	0.000000		3

***Figure 40**. ARMA(1,1) output*

1- It is a summary of what is done including the dependent variable, the model, the sample, and the number of observations.

2- There are the variables included in the model as explanatory variables. There are constant, AR (1) and MA (1).

- Coefficient: Here, the coefficient of C is 7818.42, meaning when C increases by 1%, the dependent variable (sell price) increases by 7818.42 percent.
- Std. Error: Tells how accurate the estimations of the coefficients are.
- T-statistics: Helps to test the hypothesis with the null hypothesis which supposes the variables considered in the equation are equal to zero, meaning including the independent variable as an explanatory variable does not contribute to the model.

- Prob.: Is another way to test the null hypothesis. If the p-value is less than 0.05 (at a 5% significant level), the null hypothesis is rejected, and including the corresponding variable contributes to the model.

3- This part includes:

- R-squared: it is a measure of goodness of fit and shows how successful the independent variable is in predicting the dependent variable. The closer to 1, the better the dependent variable is predicted.
- Adjusted R-squared: It is another measure of goodness of fit but penalizes R-squared for including more explanatory variables. If more explanatory variables are included, the R-squared always increases, which is not reasonable to add many variables, however, by adding more variables, the R-squared goes down.
- S.E. of regression
- Sum squared resid
- Log likelihood
- F-statistics & Prob(F-statistics): Includes all the dependent variables together and says whether they contribute to the model. The null hypothesis can be rejected by prob. less than 0.05.
- Mean dependent var: Shows the mean of the dependent variable.
- S.D. dependent var. Shows the standard deviation of the dependent variable.
- Akaike info, Schwarz, Hannan-Quinn criterion: These are model selection criteria.
- Durbin- Watson stat.: Helps us to estimate whether our model has serial autocorrelation. As a rule of thumb, being less than 2, it is evidence of positive and serial correlation in the model.

1.2.1.1. Set 1

Set1 is tested for various models including AR, MA, and ARMA with different orders, and the possible models can be seen in Table 6. Notice, the dependent variable (sell_before) is tested with natural logarithmic form as well (the models begin with L).

For choosing the best fit, the selection criteria (Akaike, Schwartz, Hannan-Quinn criteria) should be checked. The model offering less amount is fitted best. Moreover, the Durbin-Watson statistic is another important criterion that is used to detect the presence of autocorrelation at lag 1 in the residuals (prediction errors) from a regression analysis. This statistic's value is always in the range

of 0 and 4. The value of this statistic should be close to 2 if there is no serial correlation between the residuals. It suggests a positive correlation if it is close to zero, and it indicates a negative correlation if it is close to four. In general, there is no reason to be concerned if this number is between 1.5 and 2.5.

From all models offered in Table 5, the two models with the less model selection criterion (Adjusted R, Akaike criterion, Schwarz criterion, Hannan-Quinn criterion, Durbin-Watson) are L-ARIMA (10,1,0) and L-ARIMA(23,1,0). The related output is shown in Figures 41 and 42.

As it is obvious, the models captured decently the time series, and the fitted models are almost coincident with the actual data.

Table 6. *All proposed models' output summaries for Set1*

Model	Adj R-squared	Akaike criterion	Schwarz criterion	Hannan-Quinn criterion	Durbin-Watson
ARIMA (1,1,0)	0.252165	9.229915	9.246314	9.236189	2.306989
ARIMA (2,1,0)	0.321010	9.134705	9.156570	9.143070	2.083912
ARIMA (3,1,0)	0.332866	9.118293	9.145624	9.128749	2.058301
ARIMA (4,1,0)	0.377134	9.051176	9.083973	9.063723	2.073316
ARIMA (5,1,0)	0.389353	9.032608	9.070871	9.047246	2.026872
ARIMA (6,1,0)	0.397389	9.026505	9.070234	9.043235	2.030384
ARIMA (7,1,0)	0.408886	9.002652	9.051847	9.021472	2.043881
ARIMA (8,1,0)	0.418861	8.986932	9.041593	9.007843	2.030912
ARIMA (9,1,0)	0.425453	8.976791	9.036919	8.999794	2.032138
ARIMA (10,1,0)	0.435955	8.959711	9.025304	8.984805	2.021319
ARIMA (11,1,0)	0.438243	8.956826	9.027885	8.984011	2.003138
ARIMA (13,1,0)	0.443639	8.949627	9.031619	8.980994	2.006584
ARIMA(17,1,0)	0.450133	8.942730	9.046587	8.982462	2.010321
ARIMA(22,1,0)	0.468808	8.915157	9.046344	8.965354	2.042900
ARIMA (23,1,0)	0.475333	8.904334	9.040987	8.956612	2.007498
L-ARIMA(1,1,0)	0.236178	-7.440403	-7.424005	-7.434130	2.310864
L-ARIMA(2,1,0)	0.313108	-7.545174	-7.523309	-7.536809	2.098671
L-ARIMA(3,1,0)	0.328546	-7.566684	-7.539353	-.7556228	2.063739
L-ARIMA (4,1,0)	0.367844	-7.625515	-7.592718	-7.612968	2.060471
L-ARIMA (5,1,0)	0.377324	-7.639404	-7.601141	-7.624766	2.025536
L-ARIMA (6,1,0)	0.382974	-7.647314	-7.603585	-7.630585	2.030488
L-ARIMA (7,1,0)	0.396021	-7.667362	-7.618167	-7.648542	2.037413
L-ARIMA (8,1,0)	0.404702	-7.680563	-7.625901	-7.659651	2.028537
L-ARIMA (9,1,0)	0.411558	-7.690877	-7.630749	-7.667874	2.031927
L-ARIMA (10,1,0)	0.422339	-7.708002	-7.642409	-7.682909	2.024618
L-ARIMA (11,1,0)	0.425924	-7.713015	-7.641955	-7.685830	2.004385
L-ARIMA (13,1,0)	0.431265	-7.719924	-7.637932	-7.688556	2.009279
L-ARIMA (16,1,0)	0.433874	-7.720997	-7.622607	-7.683357	2.014525
L-ARIMA (17, 1,0)	0.437112	-7.725468	-7.621612	-7.685736	2.009840
L-ARIMA(22, 1,0)	0.452311	-7.746218	-7.615031	-7.696030	2.033843
L-ARIMA (23,1,0)	0.457090	-7.753569	-7.616916	-7.701291	2.012165

Dependent Variable: DIFF_LGSELLB
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/21/23 Time: 11:51
Sample: 6/03/2015 3/17/2018
Included observations: 873
Convergence achieved after 34 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.71E-06	3.20E-05	0.240947	0.8097
AR(1)	-0.839496	0.018948	-44.30635	0.0000
AR(2)	-0.716920	0.029275	-24.48917	0.0000
AR(3)	-0.607437	0.031489	-19.29033	0.0000
AR(4)	-0.612697	0.038247	-16.01958	0.0000
AR(5)	-0.477240	0.045670	-10.44976	0.0000
AR(6)	-0.441485	0.045798	-9.639853	0.0000
AR(7)	-0.415483	0.045161	-9.200113	0.0000
AR(8)	-0.329844	0.048599	-6.787020	0.0000
AR(9)	-0.242295	0.040961	-5.915237	0.0000
AR(10)	-0.153124	0.032741	-4.676809	0.0000
SIGMASQ	2.55E-05	3.23E-07	79.01050	0.0000

R-squared	0.429626	Mean dependent var	-5.32E-06
Adjusted R-squared	0.422339	S.D. dependent var	0.006696
S.E. of regression	0.005089	Akaike info criterion	-7.708002
Sum squared resid	0.022298	Schwarz criterion	-7.642409
Log likelihood	3376.543	Hannan-Quinn criter.	-7.682909
F-statistic	58.95778	Durbin-Watson stat	2.024618
Prob(F-statistic)	0.000000		

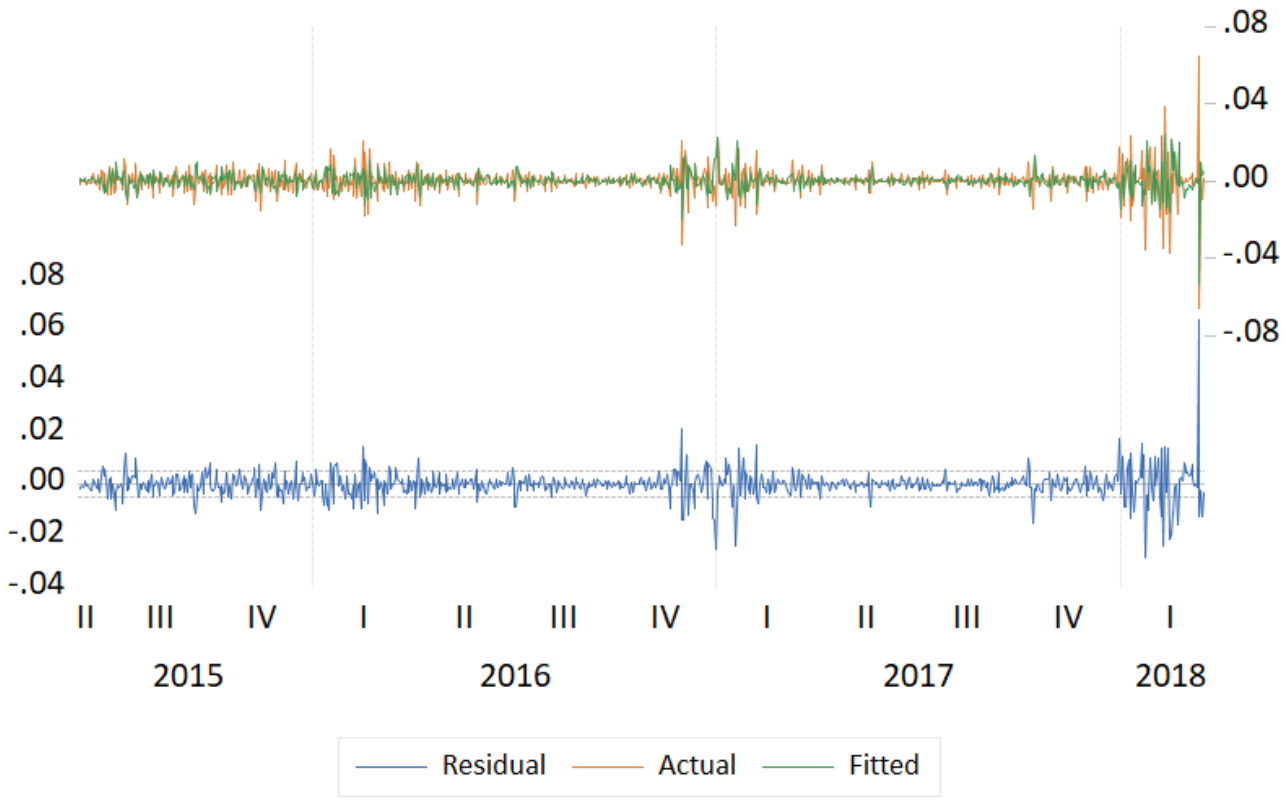


***Figure 41**. L-ARIMA(10,1,0) Actual, fitted and residuals outputs graph , Set1*

Sample: 6/03/2015 3/17/2018
Included observations: 873
Convergence achieved after 166 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.90E-06	1.63E-05	0.239839	0.8105
AR(1)	-0.885274	0.022239	-39.80708	0.0000
AR(2)	-0.787171	0.030851	-25.51503	0.0000
AR(3)	-0.713932	0.035283	-20.23448	0.0000
AR(4)	-0.751225	0.044584	-16.84976	0.0000
AR(5)	-0.673895	0.055184	-12.21186	0.0000
AR(6)	-0.686659	0.054419	-12.61793	0.0000
AR(7)	-0.714832	0.060879	-11.74183	0.0000
AR(8)	-0.654388	0.068487	-9.554966	0.0000
AR(9)	-0.633677	0.071757	-8.830908	0.0000
AR(10)	-0.579756	0.076317	-7.596712	0.0000
AR(11)	-0.479115	0.076739	-6.243454	0.0000
AR(12)	-0.444145	0.083381	-5.326706	0.0000
AR(13)	-0.478051	0.082898	-5.766765	0.0000
AR(14)	-0.396496	0.082748	-4.791622	0.0000
AR(15)	-0.385091	0.077455	-4.971827	0.0000
AR(16)	-0.425879	0.077262	-5.512145	0.0000
AR(17)	-0.353636	0.073302	-4.824352	0.0000
AR(18)	-0.292235	0.064012	-4.565341	0.0000
AR(19)	-0.235364	0.061120	-3.850859	0.0001
AR(20)	-0.245563	0.056454	-4.349751	0.0000
AR(21)	-0.234978	0.049912	-4.707842	0.0000
AR(22)	-0.282659	0.037398	-7.558170	0.0000
AR(23)	-0.111148	0.034905	-3.184314	0.0015
SIGMASQ	2.36E-05	5.79E-07	40.86023	0.0000

R-squared	0.472033	Mean dependent var	-5.32E-06
Adjusted R-squared	0.457090	S.D. dependent var	0.006696
S.E. of regression	0.004934	Akaike info criterion	-7.753569
Sum squared resid	0.020640	Schwarz criterion	-7.616916
Log likelihood	3409.433	Hannan-Quinn criter.	-7.701291
F-statistic	31.59003	Durbin-Watson stat	2.012165
Prob(F-statistic)	0.000000		

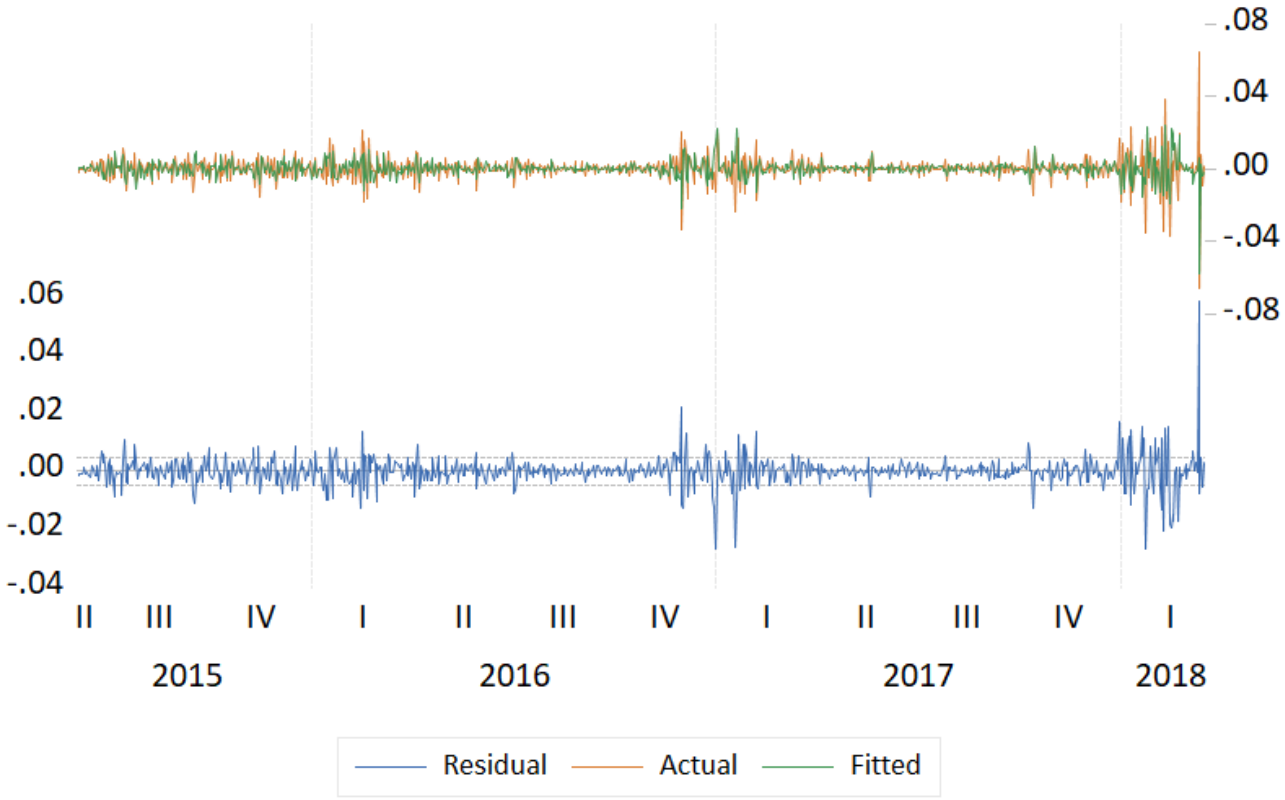


***Figure 42**. L-ARIMA(23,1,0) Actual, fitted and residuals outputs graph , Set1*

According to figures 41 and 42 the mean equations for the estimated models for Set1 would be as follows:

- **L-ARIMA (10,1,0)**

$$sell = 7.7 * 10^{-6} - 0.839 * sell_{t-1} - 0.716 * sell_{t-2} - 0.607 * sell_{t-3} - 0.612 * sell_{t-4} - 0.477 * sell_{t-5} - 0.441 * sell_{t-6} - 0.415 * sell_{t-7} - 0.329 * sell_{t-8} - 0.242 * sell_{t-9} - 0.153 * sell_{t-10} + \epsilon_t \quad \text{(E.q. 3.1)}$$

- **L-ARIMA (23,1,0)**

$$sell = 3.9 * 10^{-6} - 0.885 * sell_{t-1} - 0.787 * sell_{t-2} - 0.713 * sell_{t-3} - 0.751 * sell_{t-4} - 0.673 * sell_{t-5} - 0.686 * sell_{t-6} - 0.714 * sell_{t-7} - 0.654 * sell_{t-8} - 0.633 * sell_{t-9} - 0.579 * sell_{t-10} - 0.479 * sell_{t-11} - 0.444 * sell_{t-12} - 0.478 * sell_{t-13} - 0.396 * sell_{t-14} - 0.385 * sell_{t-15} - 0.425 * sell_{t-16} - 353 * sell_{t-17} - 0.292 * sell_{t-18} - 0.235 * sell_{t-19} - 0.245 * sell_{t-20} - 0.234 * sell_{t-21} - 0.282 * sell_{t-22} - 0.111 * sell_{t-23} + \epsilon_t \quad \text{(E.q. 3.2)}$$

Where sell is the dependent variable name, $sell_{t-k}$ represents the AR terms and k is the number of lags.

1.2.1.2. Set 2

Set 2 is tested for various models including AR, MA, and ARMA with different orders, and the possible models can be seen in Table 7. Notice, the dependent variable (sell_before) is tested with natural logarithmic form as well (the models begin with L).

From all models offered in Table 7, the two models with the less model selection criterion (Adjusted R, Akaike criterion, Schwarz criterion, Hannan-Quinn criterion, Durbin-Watson) are L-ARIMA (0,1,3) and L-ARIMA(8,1,11). The related output is shown in Figures 43 and 44.

As it is obvious, the models captured decently the time series, and the fitted models are almost coincident with the actual data.

***Table 7**. All proposed models' output summary for Set 2*

Model	Adj R-squared	Akaike criterion	Schwarz criterion	Hannan-Quinn criterion	Durbin-Watson
ARIMA (1,1,0)	0.0028043	14.99757	15.00903	15.00186	2.288618
ARIMA (2,1,0)	0.299014	14.90200	14.91728	14.90772	2.128559
ARIMA (3,1,0)	0.331114	14.85596	14.87506	14.86311	2.109824
ARIMA (4,1,0)	0.376048	14.78736	14.81027	14.79593	2.073199
ARIMA (5, 1, 0)	0.388651	14.76776	14.79449	14.77776	2.049541
ARIMA (6,1,0)	0.408124	14.73626	14.76681	14.74770	2.048167
ARIMA(7,1,0)	0.419814	14.71715	14.75152	14.703001	2.044137
ARIMA(8,1,0)	0.435185	14.69119	14.72938	14.70548	2.044047
ARIMA(9,1,0)	0.446345	14.67209	14.71410	14.68781	2.022582
ARIMA (10,1,0)	0.450316	14.66568	14.71151	14.68283	2.013106
ARIMA (11,1,0)	0.454305	14.65918	14.70883	14.67777	2.006275
ARIMA(12,1,0)	0.455313	14.65808	14.71155	14.67809	2.004245
ARIMA(13,1,0)	0.457739	14.65439	14.71167	14.67583	2.013187
ARIMA(14,1,0)	0.464030	14.64357	14.70467	14.66644	2.003034
ARIMA(16,1,0)	0.477746	14.61942	14.68816	14.64515	1.989668
ARIMA (23,1,0)	0.480739	14.61889	14.71436	14.65462	1.999369
ARIMA (0,1,3)	0.484992	14.59936	14.61846	14.60651	1.995630
ARIMA (1,1,5)	0.488284	14.59316	14.62371	14.60459	1.993751
ARIMA (4,1,3)	0.488160	14.59406	14.62843	14.60692	1.996601
ARIMA (5,1,3)	0.491919	14.58790	14.62609	14.60220	2.002662
ARIMA (6,1,3)	0.492359	14.58765	14.62966	14.60337	1.997757
L-ARIMA (1,1,0)	0.215086	-5.095524	-5.084068	-5.091237	2.285168
L-ARIMA (2,1,0)	0.289220	-5.193860	-5.178585	-5.188143	2.142574
L-ARIMA (3,1,0)	0.327459	-5.248307	-5.229213	-5.241161	2.112545
L-ARIMA(4,1,0)	0.366995	-5.307984	-5.285071	-5.299408	2.081557
L-ARIMA(5,1,0)	0.385524	-5.336850	-5.310118	-5.326845	2.056314
L-ARIMA (6,1,0)	0.404621	-5.367543	-5.336962	-5.356109	2.034819
L-ARIMA (7,1,0)	0.412644	-5.380308	-5.345938	-5.367444	2.019624
L-ARIMA (8,1,0)	0.419679	-5.391554	-5.353365	-5.377261	2.028709
L-ARIMA (9,1,0)	0.434053	-5.415737	-5.373730	-5.400015	2.030916
L-ARIMA (10,1,0)	0.441609	-5.428346	-5.382520	-5.411195	2.012221
L-ARIMA (11,1,0)	0.444652	-5.433035	-5.383390	-5.414455	1.996350
L-ARIMA (13,1,0)	0.447267	-5.436250	-5.378967	-5.414811	2.015318
L-ARIMA(14,1,0)	0.458723	-5.456246	-5.395144	-5.433378	2.005289
L-ARMA(16,1,0)	0.469901	-5.475399	-5.406660	-5.449672	1.992759
L-ARIMA0,1,3)	0.476638	-5.494284	-5.475190	-5.487137	1.990547
L-ARIMA (1,1,3)	0.476210	-5.494839	-5.471925	-5.486263	1.988678
L-ARIMA (2,1,3)	0.477153	-5.495892	-5.469160	-5.485887	1.988558
L-ARIMA (7,1,5)	0.483655	-5.502796	-5.449332	-5.482786	1.991719
L-ARIMA (8,1,11)	0.490686	-5.508282	-5.428056	-5.478268	1.989190

Dependent Variable: DIFF_LGSELLA
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/21/23 Time: 12:32
Sample: 10/03/2018 2/13/2023
Included observations: 1367
Failure to improve objective (non-zero gradients) after 44 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.54E-06	1.34E-06	1.148190	0.2511
MA(1)	-0.958774	0.205734	-4.660253	0.0000
MA(2)	-0.065645	0.025133	-2.611942	0.0091
MA(3)	0.024420	0.010723	2.277379	0.0229
SIGMASQ	0.000238	2.94E-05	8.084570	0.0000

R-squared	0.478170	Mean dependent var	2.59E-05
Adjusted R-squared	0.476638	S.D. dependent var	0.021348
S.E. of regression	0.015444	Akaike info criterion	-5.494284
Sum squared resid	0.324860	Schwarz criterion	-5.475190
Log likelihood	3760.343	Hannan-Quinn criter.	-5.487137
F-statistic	312.0114	Durbin-Watson stat	1.990547
Prob(F-statistic)	0.000000		

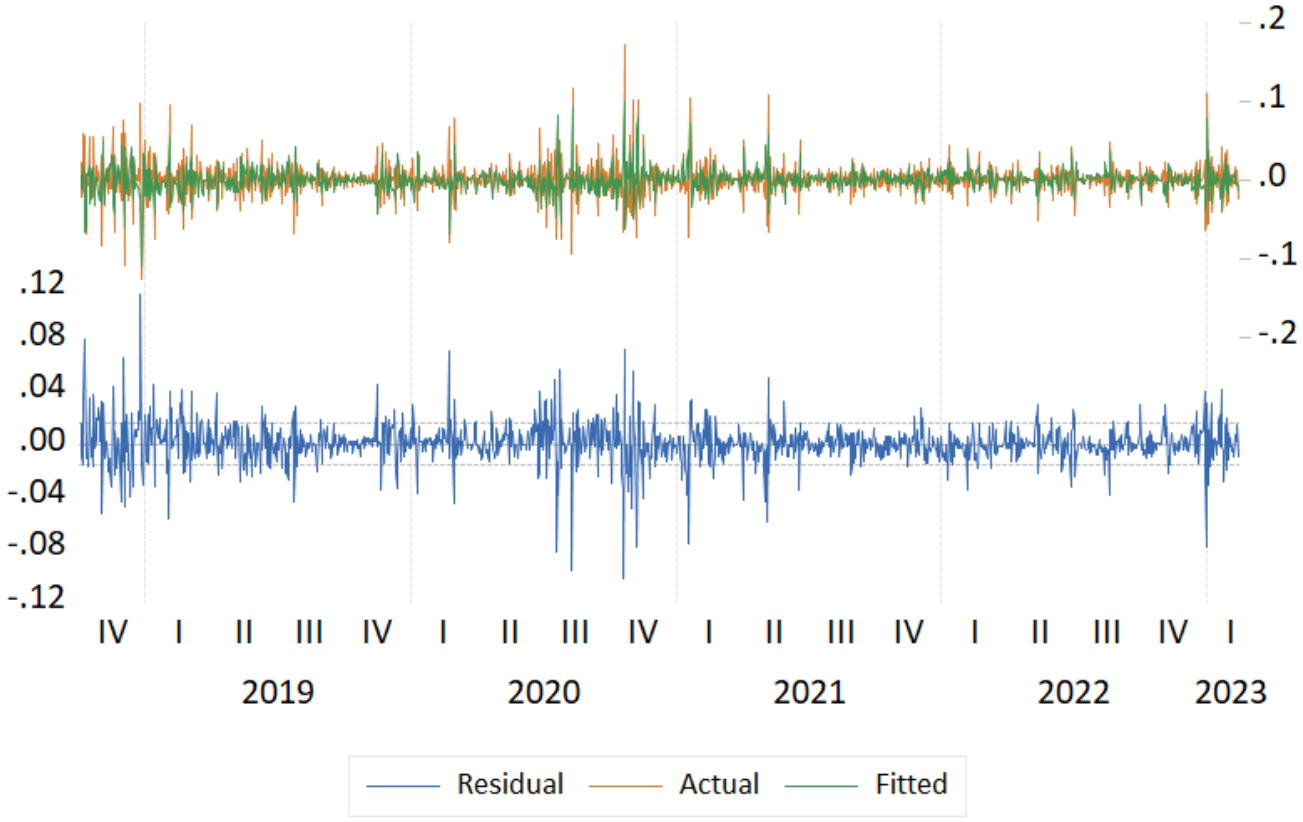


Figure 43. *L-ARIMA(0,1,3) Actual, fitted, and residuals outputs graph, Set2*

Dependent Variable: DIFF_LGSELLA
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/21/23 Time: 12:37
Sample: 10/03/2018 2/13/2023
Included observations: 1367
Convergence not achieved after 500 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.00E-06	3.79E-06	0.791056	0.4291
AR(1)	-1.803900	0.050406	-35.78729	0.0000
AR(2)	-1.261844	0.116055	-10.87281	0.0000
AR(3)	-1.596049	0.146977	-10.85917	0.0000
AR(4)	-2.429090	0.155883	-15.58275	0.0000
AR(5)	-1.636197	0.148603	-11.01054	0.0000
AR(6)	-1.059598	0.143562	-7.380776	0.0000
AR(7)	-1.482331	0.125593	-11.80265	0.0000
AR(8)	-0.860370	0.053193	-16.17440	0.0000
MA(1)	0.861604	0.058378	14.75912	0.0000
MA(2)	-0.527729	0.081009	-6.514439	0.0000
MA(3)	0.272356	0.092400	2.947571	0.0033
MA(4)	0.801495	0.075688	10.58946	0.0000
MA(5)	-0.802366	0.061166	-13.11787	0.0000
MA(6)	-0.613066	0.073981	-8.286749	0.0000
MA(7)	0.438169	0.081623	5.368192	0.0000
MA(8)	-0.614912	0.077886	-7.895039	0.0000
MA(9)	-0.880710	0.072830	-12.09270	0.0000
MA(10)	0.077761	0.030358	2.561437	0.0105
MA(11)	0.078446	0.022434	3.496788	0.0005
SIGMASQ	0.000229	7.41E-06	30.84816	0.0000

R-squared	0.498240	Mean dependent var	2.59E-05
Adjusted R-squared	0.490784	S.D. dependent var	0.021348
S.E. of regression	0.015234	Akaike info criterion	-5.508329
Sum squared resid	0.312366	Schwarz criterion	-5.428133
Log likelihood	3785.943	Hannan-Quinn criter.	-5.478314
F-statistic	66.82776	Durbin-Watson stat	1.989306
Prob(F-statistic)	0.000000		

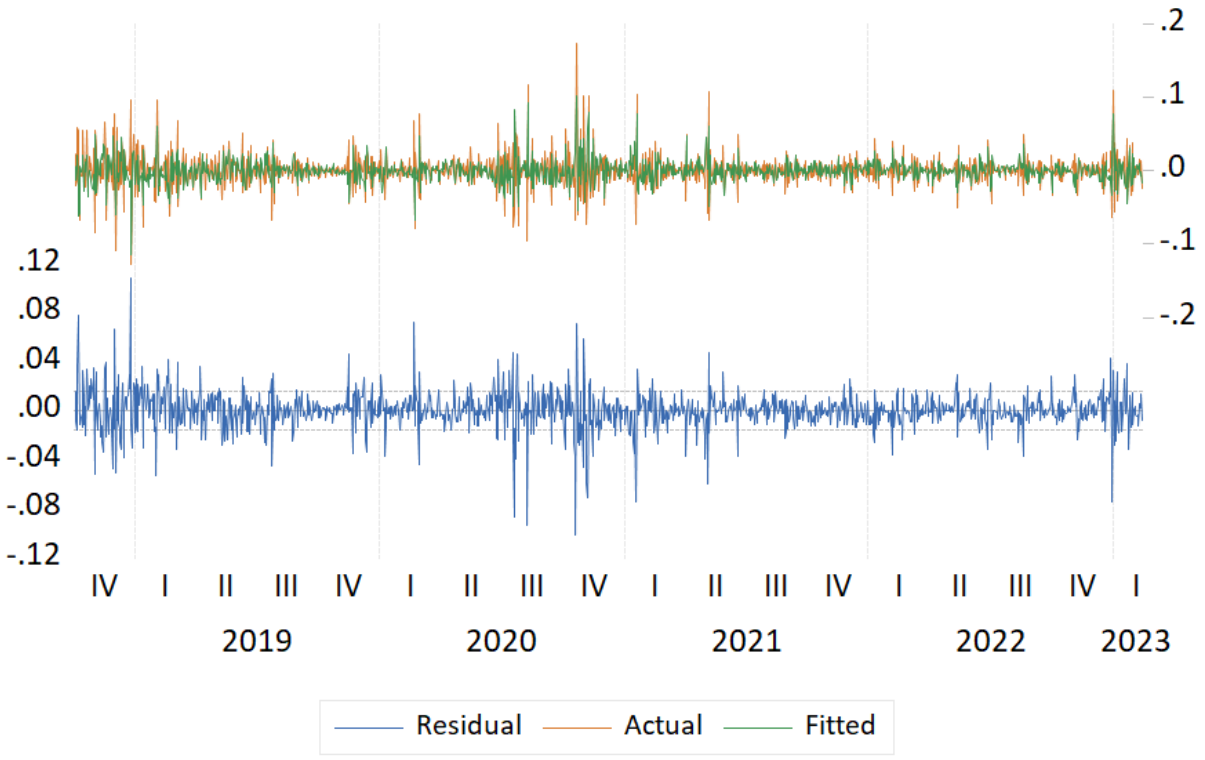


Figure 44. *L-ARIMA(8,1,11) Actual, fitted and residuals outputs graph , Set2*

According to figures 43 and 44, the mean equations for the estimated models for Set1 would be as follows:

- **L-ARIMA(0,1,3)**

$$sell = 0.0000015 - 0.958 * \epsilon_{t-1} - 0.065 * \epsilon_{t-2} + 0.024 * \epsilon_{t-3} + \epsilon_t \quad \text{(E.q. 3.3)}$$

- **L-ARIMA(8,1,11)**

$$\begin{aligned} sell = {} & 0.000003 - 1.803 * sell_{t-1} - 1.261 * sell_{t-2} - 1.596 * sell_{t-3} \\ & - 2.429 * sell_{t-4} - 1.636 * sell_{t-5} - 1.059 * sell_{t-6} - 1.482 \\ & * sell_{t-7} - 0.860 * sell_{t-8} + 0.861 * \epsilon_{t-1} - 0.527 * \epsilon_{t-2} \\ & + 0.272 * \epsilon_{t-3} + 0.801 * \epsilon_{t-4} - 0.802 * \epsilon_{t-5} - 0.613 * \epsilon_{t-6} \\ & + 0.438 * \epsilon_{t-7} - 0.614 * \epsilon_{t-8} - 0.880 * \epsilon_{t-9} + 0.077 * \epsilon_{t-10} \\ & + 0.078 * \epsilon_{t-11} + \epsilon_t \end{aligned} \quad \text{(E.q. 3.4)}$$

Where sell is the dependent variable name, $sell_{t-k}$ represents the AR terms and ϵ_{t-k} represents the MA terms and *k* is the number of lags.

1.2.2.ARCH- GARCH Models

So far, the focus was on modeling the mean of the dependent variable. By taking look at the selected models, it is obvious that the volatility has been stable at the beginning and then increased significantly between the year 2018 and 2019 and it remained quite volatile over this period. Traditional econometrics models assume that the variance of the disturbance term is constant over time. But many economic time series, like the current one, face periods of higher volatility than usual violating the homoskedasticity assumption, which leads to the ARCH model. When modeling ARCH, the variance depends on past squared innovations. First, by checking the existence of ARCH effects, it should be verified whether the model shows periods of higher volatility.

1.2.2.1. Heteroskedasticity Test

This test allows testing for a range of specifications of heteroskedasticity in the residuals of the equation.

Null Hypothesis H_0 = There are no ARCH effects up to the specified lag

Alternative Hypothesis H_1 = There are ARCH effects up to the specified lag

If the p-value is less than 0.05, we reject the null hypothesis and confirm the existence of the ARCH effects. To determine how many ARCH effects, it is better to conclude, the correlogram squared residuals should be checked. The number of spikes crossing the confidence borders in the partial correlation part determines the ARCH effects order.

1.2.2.1.1. Set 1 – Heteroskedasticity Test

Based on Figures 45 and 46, in both squared residuals correlograms, there is one persistence lag in the autocorrelation and confirms the idea of the existence of ARCH effects. In the partial autocorrelation, the first spike is statistically significant (spikes cross the confidence borders), and

the next spike is inside the confidence borders. So, in the Heteroskedasticity test, the ARCH effect number for both models (L-ARIMA(10,1,0) and L-ARIMA(23,1,0)) will be set to 1.

Date: 02/21/23 Time: 13:00
Sample (adjusted): 6/03/2015 3/17/2018
Included observations: 873 after adjustments

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.074	0.074	4.7326	0.030
		2	0.035	0.030	5.8078	0.055
		3	0.062	0.058	9.1732	0.027
		4	0.019	0.009	9.4782	0.050
		5	0.044	0.039	11.185	0.048
		6	0.031	0.021	12.008	0.062
		7	0.022	0.015	12.433	0.087
		8	0.022	0.013	12.863	0.117
		9	0.015	0.007	13.053	0.160
		10	0.022	0.016	13.496	0.197
		11	0.029	0.022	14.250	0.219
		12	0.017	0.009	14.514	0.269
		13	0.018	0.011	14.813	0.319
		14	0.023	0.016	15.290	0.359
		15	0.035	0.027	16.359	0.359
		16	0.070	0.061	20.740	0.189
		17	0.029	0.014	21.494	0.205
		18	0.021	0.009	21.892	0.237
		19	0.052	0.039	24.298	0.185
		20	0.055	0.041	26.976	0.136

***Figure 45**. The correlogram of squared residuals- L-ARIMA(10,1,0)*

Date: 02/21/23 Time: 13:08
Sample (adjusted): 6/03/2015 3/17/2018
Included observations: 873 after adjustments

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.066	0.066	3.8555	0.050
		2	0.054	0.050	6.3958	0.041
		3	0.052	0.046	8.7685	0.033
		4	0.037	0.028	9.9668	0.041
		5	0.039	0.030	11.275	0.046
		6	0.035	0.025	12.326	0.055
		7	0.029	0.020	13.087	0.070
		8	0.029	0.020	13.854	0.086
		9	0.012	0.002	13.981	0.123
		10	0.015	0.008	14.192	0.164
		11	0.017	0.010	14.452	0.209
		12	0.017	0.010	14.695	0.259
		13	0.018	0.011	14.989	0.308
		14	0.026	0.020	15.602	0.338
		15	0.051	0.043	17.881	0.269
		16	0.091	0.081	25.306	0.065
		17	0.028	0.010	26.029	0.074
		18	0.026	0.009	26.626	0.086
		19	0.088	0.073	33.547	0.021
		20	0.085	0.066	40.048	0.005

***Figure 46**. The correlogram of squared residuals- L-ARIMA(23,1,0)*

Heteroskedasticity Test: ARCH

F-statistic	4.725841	Prob. F(1,870)	0.0300
Obs*R-squared	4.711114	Prob. Chi-Square(1)	0.0300

1

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 02/21/23 Time: 13:01
Sample (adjusted): 6/04/2015 3/17/2018
Included observations: 872 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.37E-05	5.12E-06	4.624041	0.0000
RESID^2(-1)	0.073502	0.033811	2.173900	0.0300

2

R-squared	0.005403	Mean dependent var	2.56E-05
Adjusted R-squared	0.004259	S.D. dependent var	0.000149
S.E. of regression	0.000149	Akaike info criterion	-14.78143
Sum squared resid	1.93E-05	Schwarz criterion	-14.77049
Log likelihood	6446.705	Hannan-Quinn criter.	-14.77725
F-statistic	4.725841	Durbin-Watson stat	2.004372
Prob(F-statistic)	0.029982		

***Figure 47**. L-ARIMA(10,1,0) Heteroskedasticity output*

Heteroskedasticity Test: ARCH

F-statistic	3.846199	Prob. F(1,870)	0.0502
Obs*R-squared	3.838073	Prob. Chi-Square(1)	0.0501

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 02/21/23 Time: 13:13
Sample (adjusted): 6/04/2015 3/17/2018
Included observations: 872 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.21E-05	4.49E-06	4.920437	0.0000
RESID^2(-1)	0.066343	0.033828	1.961173	0.0502

R-squared	0.004401	Mean dependent var	2.37E-05
Adjusted R-squared	0.003257	S.D. dependent var	0.000131
S.E. of regression	0.000130	Akaike info criterion	-15.04822
Sum squared resid	1.48E-05	Schwarz criterion	-15.03728
Log likelihood	6563.025	Hannan-Quinn criter.	-15.04404
F-statistic	3.846199	Durbin-Watson stat	2.006603
Prob(F-statistic)	0.050177		

***Figure 48.** L-ARIMA(23,1,0) Heteroskedasticity output*

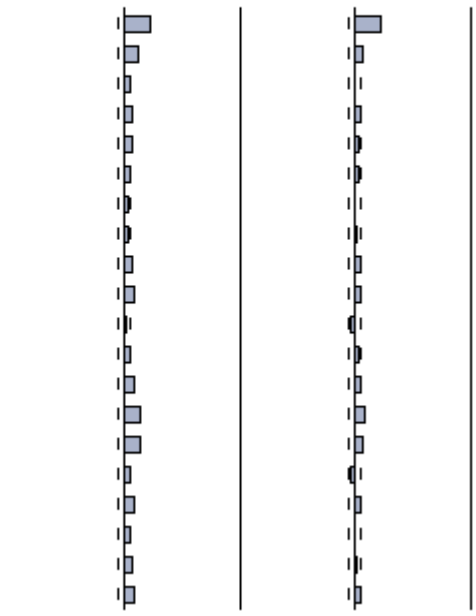
- **L-ARIMA(10,1,0):** Figure 47 shows the heteroskedasticity test output. In part 1, prob Chi-square is 0.0300 meaning the null hypothesis can be rejected and the existence of ARCH effects is confirmed. The second part (Figure 47 shows considering 1 lag is appropriate (p-value is less than 0.05).

- **L-ARIMA(23,1,0):** Figure 48 shows the heteroskedasticity test output. In part 1, prob Chi-square is 0.0502 meaning the null hypothesis can be rejected and the existence of ARCH effects is confirmed. The second part (Figure 48) shows by considering 1 lag is appropriate.

1.2.2.1.2. Set 2 – Heteroskedasticity Test

Based on figures 49 and 50, in both squared residuals correlograms, there are 2 persistence lags in the autocorrelation which confirms the idea of the existence of ARCH effects. In the partial autocorrelation, the first two spikes are statistically significant (spikes cross the confidence borders), and the next spike is inside the confidence borders. So, in the Heteroskedasticity test, the ARCH effect number for both models (L-ARIMA (0,1,3) and L-ARIMA(8,1,11)) will be set to 2.

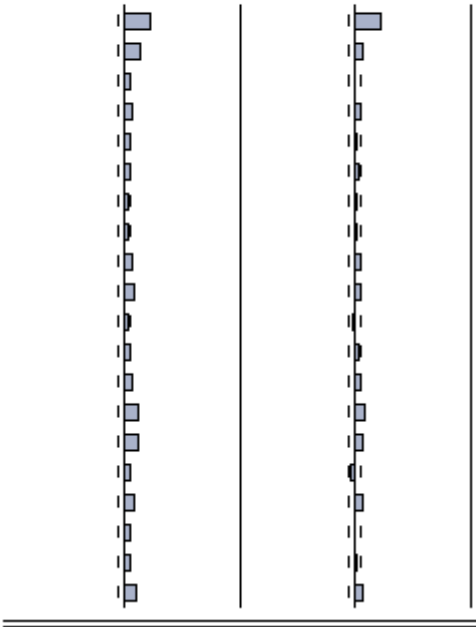
Date: 02/21/23 Time: 14:04
Sample (adjusted): 10/03/2018 2/13/2023
Included observations: 1367 after adjustments



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.237	0.237	76.696	0.000
		2	0.123	0.071	97.336	0.000
		3	0.048	0.005	100.54	0.000
		4	0.080	0.063	109.29	0.000
		5	0.066	0.033	115.20	0.000
		6	0.063	0.031	120.62	0.000
		7	0.034	0.004	122.22	0.000
		8	0.040	0.020	124.41	0.000
		9	0.070	0.051	131.14	0.000
		10	0.084	0.050	140.95	0.000
		11	0.019	-0.027	141.43	0.000
		12	0.046	0.032	144.34	0.000
		13	0.085	0.065	154.36	0.000
		14	0.135	0.092	179.44	0.000
		15	0.141	0.081	207.15	0.000
		16	0.049	-0.025	210.46	0.000
		17	0.094	0.065	222.63	0.000
		18	0.051	-0.004	226.18	0.000
		19	0.067	0.020	232.45	0.000
		20	0.094	0.061	244.77	0.000

Figure 49. *The correlogram of squared residuals- L-ARIMA(0,1,3)*

Date: 02/21/23 Time: 14:06
Sample (adjusted): 10/03/2018 2/13/2023
Included observations: 1367 after adjustments



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.236	0.236	76.162	0.000
		2	0.132	0.080	99.907	0.000
		3	0.044	-0.003	102.61	0.000
		4	0.072	0.056	109.68	0.000
		5	0.051	0.022	113.25	0.000
		6	0.056	0.030	117.53	0.000
		7	0.038	0.013	119.51	0.000
		8	0.033	0.011	120.97	0.000
		9	0.078	0.065	129.41	0.000
		10	0.085	0.050	139.45	0.000
		11	0.028	-0.020	140.50	0.000
		12	0.046	0.029	143.43	0.000
		13	0.075	0.054	151.23	0.000
		14	0.124	0.086	172.44	0.000
		15	0.130	0.074	195.95	0.000
		16	0.043	-0.028	198.54	0.000
		17	0.095	0.070	210.96	0.000
		18	0.045	-0.005	213.80	0.000
		19	0.063	0.019	219.34	0.000
		20	0.100	0.074	233.33	0.000

Figure 50. *The correlogram of squared residuals- L-ARIMA(8,1,11)*

Heteroskedasticity Test: ARCH

F-statistic	44.00958	Prob. F(2,1362)	0.0000
Obs*R-squared	82.85833	Prob. Chi-Square(2)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 02/21/23 Time: 14:09
Sample (adjusted): 10/06/2018 2/13/2023
Included observations: 1365 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000169	2.19E-05	7.717710	0.0000
RESID^2(-1)	0.219896	0.027029	8.135679	0.0000
RESID^2(-2)	0.070668	0.027029	2.614579	0.0090

R-squared	0.060702	Mean dependent var	0.000238
Adjusted R-squared	0.059323	S.D. dependent var	0.000776
S.E. of regression	0.000752	Akaike info criterion	-11.54482
Sum squared resid	0.000771	Schwarz criterion	-11.53335
Log likelihood	7882.342	Hannan-Quinn criter.	-11.54053
F-statistic	44.00958	Durbin-Watson stat	2.000647
Prob(F-statistic)	0.000000		

***Figure 51**. L-ARIMA(0,1,3) Heteroskedasticity output*

Heteroskedasticity Test: ARCH

F-statistic	44.95440	Prob. F(2,1362)	0.0000
Obs*R-squared	84.52702	Prob. Chi-Square(2)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 02/21/23 Time: 14:11
Sample (adjusted): 10/06/2018 2/13/2023
Included observations: 1365 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000161	2.07E-05	7.760369	0.0000
RESID^2(-1)	0.216694	0.027006	8.023851	0.0000
RESID^2(-2)	0.081475	0.027006	3.016902	0.0026

R-squared	0.061925	Mean dependent var	0.000229
Adjusted R-squared	0.060547	S.D. dependent var	0.000733
S.E. of regression	0.000710	Akaike info criterion	-11.65934
Sum squared resid	0.000687	Schwarz criterion	-11.64787
Log likelihood	7960.498	Hannan-Quinn criter.	-11.65504
F-statistic	44.95440	Durbin-Watson stat	1.999128
Prob(F-statistic)	0.000000		

***Figure 52**. L-ARIMA(8,1,11) Heteroskedasticity output*

- **L-ARIMA(0,1,3):** Figure 51 shows the heteroskedasticity test output. In part 1, prob Chi-square is 0.0300 meaning the null hypothesis can be rejected and the existence of ARCH effects is confirmed. The second part (Figure 51) shows by considering 2 lags is appropriate (p-value is less than 0.05).

- **L-ARIMA(8,1,11):** Figure 52 shows the heteroskedasticity test output. In part 1, prob Chi-square is 0.0502 meaning the null hypothesis can be rejected and the existence of ARCH effects is confirmed. The second part (Figure 52) shows by considering 2 lags is appropriate.

1.2.2.2. Arch and Garch Estimation

The existence of ARCH effects confirmed through the heteroskedasticity test leads to estimate ARCH-GARCH models. The procedure is as follows: (Figure 53)

1- **The Mean Equation**: Enter the specification of the mean equation

2- **The Variance Equation**:

- **Class Of Models**: Select the desired model from the Model dropdown menu. In the Order section, choose the number of ARCH and GARCH terms. The default, which includes one ARCH and one GARCH term is by far the most popular specification.
- **Variance Regressors**: In the Variance regressors edit box, you may optionally list variables you wish to include in the variance specification.
- **Restrictions**
- **The Error Distribution**: To specify the form of the conditional distribution for your errors, you should select an entry from the Error Distribution dropdown menu. You may choose between the default Normal (Gaussian), the Student's t, the Generalized Error (GED), the Student's t with fixed d.f., or the GED with fixed parameter. In the latter two cases, you will be prompted to enter a value for the fixed parameter [67].

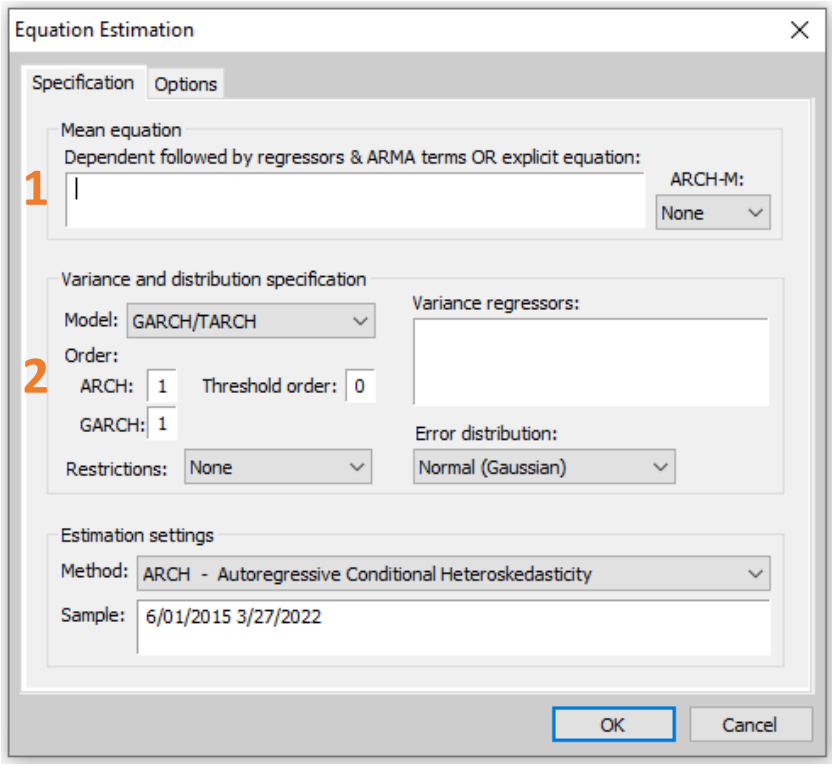


Figure 53. *ARCH-GARCH model estimation EViews dialog box*

1.2.2.2.1. Set 1- ARCH-GARCH Model

Figures 54 and 55 show the ARCH-GARCH models and the selected models. As it is obvious in Figure 54, the p-value for the mean equation terms is still significant (less than 0.05) and ARCH(1,0) looks pretty appropriate for L-ARIMA(10,1,0). Figure 55 indicates that GARCH(1,1) is suitable for L-ARIMA(23,1,0).

Dependent Variable: DIFF_LGSELLB
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 02/21/23 Time: 13:34
Sample (adjusted): 6/15/2015 3/17/2018
Included observations: 863 after adjustments
Failure to improve likelihood (non-zero gradients) after 421 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(12) + C(13)*RESID(-1)^2

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	3.46E-05	5.02E-05	0.688832	0.4909
AR(1)	-0.793941	0.048104	-16.50460	0.0000
AR(2)	-0.685642	0.050519	-13.57199	0.0000
AR(3)	-0.577081	0.051228	-11.26493	0.0000
AR(4)	-0.521854	0.058329	-8.946698	0.0000
AR(5)	-0.384861	0.068119	-5.649831	0.0000
AR(6)	-0.359586	0.066570	-5.401603	0.0000
AR(7)	-0.326237	0.062308	-5.235856	0.0000
AR(8)	-0.245155	0.072285	-3.391516	0.0007
AR(9)	-0.203092	0.063352	-3.205759	0.0013
AR(10)	-0.140461	0.049945	-2.812299	0.0049
Variance Equation				
C	2.98E-05	6.69E-07	44.45645	0.0000
RESID(-1)^2	0.171429	0.037769	4.538827	0.0000

R-squared	0.424468	Mean dependent var	-1.31E-07
Adjusted R-squared	0.417713	S.D. dependent var	0.006733
S.E. of regression	0.005138	Akaike info criterion	-7.749982
Sum squared resid	0.022491	Schwarz criterion	-7.678273
Log likelihood	3357.117	Hannan-Quinn criter.	-7.722534
Durbin-Watson stat	2.107084		

***Figure 54**. ARCH(1,0) model for the L-ARIMA(10,1,0)*

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.29E-05	1.60E-05	0.807589	0.4193
AR(1)	-0.899195	0.045594	-19.72180	0.0000
AR(2)	-0.891176	0.056042	-15.90185	0.0000
AR(3)	-0.758387	0.063375	-11.96660	0.0000
AR(4)	-0.680714	0.064788	-10.50685	0.0000
AR(5)	-0.565599	0.075574	-7.484018	0.0000
AR(6)	-0.593745	0.076436	-7.767846	0.0000
AR(7)	-0.602110	0.078900	-7.631316	0.0000
AR(8)	-0.557261	0.084301	-6.610384	0.0000
AR(9)	-0.571353	0.084065	-6.796560	0.0000
AR(10)	-0.537744	0.091553	-5.873559	0.0000
AR(11)	-0.474840	0.089090	-5.329886	0.0000
AR(12)	-0.376812	0.090204	-4.177333	0.0000
AR(13)	-0.401800	0.091278	-4.401936	0.0000
AR(14)	-0.338214	0.083852	-4.033483	0.0001
AR(15)	-0.382526	0.086579	-4.418250	0.0000
AR(16)	-0.392177	0.086288	-4.544969	0.0000
AR(17)	-0.294072	0.084276	-3.489403	0.0005
AR(18)	-0.262404	0.078071	-3.361079	0.0008
AR(19)	-0.296742	0.084361	-3.517537	0.0004
AR(20)	-0.319877	0.075873	-4.215931	0.0000
AR(21)	-0.337933	0.058379	-5.788636	0.0000
AR(22)	-0.276995	0.050257	-5.511581	0.0000
AR(23)	-0.036924	0.044448	-0.830723	0.4061
Variance Equation				
C	5.36E-06	1.40E-06	3.815146	0.0001
RESID(-1)^2	0.149976	0.029695	5.050449	0.0000
GARCH(-1)	0.599976	0.084835	7.072256	0.0000

R-squared	0.440663	Mean dependent var	1.62E-06
Adjusted R-squared	0.425088	S.D. dependent var	0.006769
S.E. of regression	0.005132	Akaike info criterion	-8.053713
Sum squared resid	0.021756	Schwarz criterion	-7.902982
Log likelihood	3449.828	Hannan-Quinn criter.	-7.995975
Durbin-Watson stat	1.954224		

Figure 55. *GARCH(1,1) model for the L-ARIMA(23,1,0)*

For assessing the models, it is necessary to check whether there is heteroskedasticity because if there is, it means the ARCH or GARCH terms are not sufficient to mitigate the heteroskedasticity in the model. Here the number of lags should be the same as the order of the ARCH or GARCH models.

Figure 56 shows the results of the ARCH LM test of ARCH(1,0) for L-ARIMA(10,1,0). Chi-square is greater than 0.05 meaning the null hypothesis, indicating that there is no heteroskedasticity, cannot be rejected.

Heteroskedasticity Test: ARCH

F-statistic	0.053387	Prob. F(1,860)	0.8173
Obs*R-squared	0.053508	Prob. Chi-Square(1)	0.8171

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 02/21/23 Time: 13:46
Sample (adjusted): 6/16/2015 3/17/2018
Included observations: 862 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.707021	0.163814	4.316009	0.0000
WGT_RESID^2(-1)	0.007879	0.034099	0.231056	0.8173

R-squared	0.000062	Mean dependent var	0.712638
Adjusted R-squared	-0.001101	S.D. dependent var	4.753663
S.E. of regression	4.756278	Akaike info criterion	5.959125
Sum squared resid	19455.08	Schwarz criterion	5.970168
Log likelihood	-2566.383	Hannan-Quinn criter.	5.963352
F-statistic	0.053387	Durbin-Watson stat	2.000176
Prob(F-statistic)	0.817327		

Figure 56*. Heteroskedasticity test output of ARCH(1,0) for L-ARIMA(10,1,0)*

Figure 57 shows the results of the ARCH LM test of GARCH(1,1) for L-ARIMA(23,1,0). Chi-square is greater than 0.05 meaning the null hypothesis, indicating that there is no heteroskedasticity, cannot be rejected.

Heteroskedasticity Test: ARCH

F-statistic	0.393510	Prob. F(1,847)	0.5306
Obs*R-squared	0.394256	Prob. Chi-Square(1)	0.5301

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 02/21/23 Time: 13:50
Sample (adjusted): 7/01/2015 3/17/2018
Included observations: 849 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.901960	0.165161	5.461106	0.0000
WGT_RESID^2(-1)	0.021550	0.034353	0.627304	0.5306

R-squared	0.000464	Mean dependent var	0.921828
Adjusted R-squared	-0.000716	S.D. dependent var	4.721380
S.E. of regression	4.723069	Akaike info criterion	5.945148
Sum squared resid	18894.35	Schwarz criterion	5.956323
Log likelihood	-2521.715	Hannan-Quinn criter.	5.949429
F-statistic	0.393510	Durbin-Watson stat	2.000400
Prob(F-statistic)	0.530629		

Figure 57. *Heteroskedasticity test output of GARCH(1,1) for L-ARIMA(23,1,0)*

So, the previous equations (Eq.3.1 and Eq.3.2) will change to the following equations: (Eq.3.5 and E.q.3.6)

- **L-ARIMA(10,1,0)**

$$sell = 7.7 * 10^{-6} - 0.839 * sell_{t-1} - 0.716 * sell_{t-2} - 0.607 * sell_{t-3} - 0.612 * sell_{t-4} - 0.477 * sell_{t-5} - 0.441 * sell_{t-6} - 0.415 * sell_{t-7} - 0.329 * sell_{t-8} - 0.242 * sell_{t-9} - 0.153 * sell_{t-10} + \epsilon_t$$

Where $\epsilon_t | I_{t-1} \sim N(0, h_t)$ and h_t stands for heteroskedasticity and is not a constant variance and changes over time.

$$h_t = 2.98 * 10^{-5} + 0.171429 * h_{t-1}^2 \quad \text{(E.q. 3.5)}$$

- **L-ARIMA(23,1,0)**

$$sell = 3.9 * 10^{-6} - 0.885 * sell_{t-1} - 0.787 * sell_{t-2} - 0.713 * sell_{t-3} - 0.751 * sell_{t-4} - 0.673 * sell_{t-5} - 0.686 * sell_{t-6} - 0.714 * sell_{t-7} - 0.654 * sell_{t-8} - 0.633 * sell_{t-9} - 0.579 * sell_{t-10} - 0.479 * sell_{t-11} - 0.444 * sell_{t-12} - 0.478 * sell_{t-13} - 0.396 * sell_{t-14} - 0.385 * sell_{t-15} - 0.425 * sell_{t-16} - 353 * sell_{t-17} - 0.292 * sell_{t-18} - 0.235 * sell_{t-19} - 0.245 * sell_{t-20} - 0.234 * sell_{t-21} - 0.282 * sell_{t-22} - 0.111 * sell_{t-23} + \epsilon_t$$

Where $\epsilon_t | I_{t-1} \quad N(0, h_t)$

$$h_t = 5.36 * 10^{-6} + 0.149979 * h_{t-1}^2 + 0.599976 * h_{t-1}$$

(E.q. 3.6)

Where h_{t-i}^2 and h_{t-i} represent ARCH and GARCH terms respectively and i is the number of orders. Also, all the coefficients of ARCH and GARCH are positive, guaranteeing positive variances.

1.2.2.2.2. Set 2- ARCH- GARCH Model

Figures 58 and 59 show the ARCH-GARCH models and the selected models. As it is obvious in Figure 58, the ARCH(1,0) looks pretty appropriate for L-ARIMA(0,1,3). Figure 59 indicates that GARCH(1,1) is suitable for L-ARIMA(23,1,0).

Dependent Variable: DIFF_LGSELLA
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 02/21/23 Time: 14:21
Sample (adjusted): 10/03/2018 2/13/2023
Included observations: 1367 after adjustments
Convergence not achieved after 500 iterations
Coefficient covariance computed using outer product of gradients
MA Backcast: 9/30/2018 10/02/2018
Presample variance: backcast (parameter = 0.7)
GARCH = C(5) + C(6)*RESID(-1)^2

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	6.89E-06	1.38E-05	0.498802	0.6179
MA(1)	-0.876989	0.014754	-59.44063	0.0000
MA(2)	-0.085642	0.018304	-4.678970	0.0000
MA(3)	0.009565	0.015617	0.612463	0.5402
Variance Equation				
C	0.000117	2.00E-06	58.41009	0.0000
RESID(-1)^2	0.171246	0.009372	18.27199	0.0000

R-squared	0.468379	Mean dependent var	2.59E-05
Adjusted R-squared	0.467208	S.D. dependent var	0.021348
S.E. of regression	0.015582	Akaike info criterion	-5.599172
Sum squared resid	0.330955	Schwarz criterion	-5.576259
Log likelihood	3833.034	Hannan-Quinn criter.	-5.590596
Durbin-Watson stat	2.122098		

Figure 58. *ARCH(1,0) model for the L-ARIMA(0,1,3)*

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	4.80E-06	6.88E-06	0.698793	0.4847
AR(1)	-0.379973	0.310581	-1.223424	0.2212
AR(2)	-0.436233	0.382129	-1.141587	0.2536
AR(3)	-0.336984	0.326430	-1.032329	0.3019
AR(4)	-0.516288	0.269180	-1.918004	0.0551
AR(5)	-0.161018	0.264320	-0.609179	0.5424
AR(6)	-0.242856	0.166169	-1.461503	0.1439
AR(7)	0.156500	0.109737	1.426144	0.1538
AR(8)	-0.400327	0.094842	-4.220984	0.0000
MA(1)	-0.560634	0.311053	-1.802374	0.0715
MA(2)	0.024204	0.169947	0.142422	0.8867
MA(3)	-0.108483	0.184849	-0.586875	0.5573
MA(4)	0.158192	0.127203	1.243627	0.2136
MA(5)	-0.307256	0.096983	-3.168151	0.0015
MA(6)	0.035852	0.161216	0.222386	0.8240
MA(7)	-0.368054	0.119105	-3.090152	0.0020
MA(8)	0.534947	0.132677	4.031943	0.0001
MA(9)	-0.371317	0.091261	-4.068721	0.0000
MA(10)	0.034654	0.026424	1.311486	0.1897
MA(11)	-0.010138	0.033722	-0.300644	0.7637
Variance Equation				
C	3.67E-05	3.37E-06	10.90379	0.0000
RESID(-1)^2	0.149745	0.010783	13.88707	0.0000
GARCH(-1)	0.599745	0.028865	20.77745	0.0000

R-squared	0.496585	Mean dependent var	4.94E-06
Adjusted R-squared	0.489442	S.D. dependent var	0.021200
S.E. of regression	0.015148	Akaike info criterion	-5.759499
Sum squared resid	0.307255	Schwarz criterion	-5.671247
Log likelihood	3936.579	Hannan-Quinn criter.	-5.726459
Durbin-Watson stat	2.054760		

Figure 59*. GARCH(1,1) model for the L-ARIMA(8,1,11)*

For assessing the models, it is necessary to check whether there is heteroskedasticity, because if there is, it means the ARCH or GARCH terms are not sufficient to mitigate the heteroskedasticity in the model. Here the number of lags should be the same as the order of the ARCH or GARCH models.

Figure 60 shows the results of the ARCH LM test of ARCH(1,0) for L-ARIMA(0,1,3). Chi-square is greater than 0.05 meaning the null hypothesis, indicating that there is no heteroskedasticity, cannot be rejected.

Heteroskedasticity Test: ARCH

F-statistic	0.876974	Prob. F(1,1364)	0.3492
Obs*R-squared	0.877695	Prob. Chi-Square(1)	0.3488

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 02/21/23 Time: 14:24
Sample (adjusted): 10/04/2018 2/13/2023
Included observations: 1366 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.372740	0.126006	10.89422	0.0000
WGT_RESID^2(-1)	0.025347	0.027067	0.936469	0.3492

R-squared	0.000643	Mean dependent var	1.408425
Adjusted R-squared	-0.000090	S.D. dependent var	4.438870
S.E. of regression	4.439071	Akaike info criterion	5.820230
Sum squared resid	26878.09	Schwarz criterion	5.827872
Log likelihood	-3973.217	Hannan-Quinn criter.	5.823090
F-statistic	0.876974	Durbin-Watson stat	2.001500
Prob(F-statistic)	0.349198		

Figure 60. *Heteroskedasticity test output of ARCH(1,0) for L-ARIMA(0,1,3)*

Figure 61 shows the results of the ARCH LM test of GARCH(1,1) for L-ARIMA(23,1,0). Chi-square is greater than 0.05 meaning the null hypothesis, indicating that there is no heteroskedasticity, cannot be rejected.

Heteroskedasticity Test: ARCH

F-statistic	1.118433	Prob. F(2,1354)	0.3271
Obs*R-squared	2.238125	Prob. Chi-Square(2)	0.3266

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 02/21/23 Time: 14:31
Sample (adjusted): 10/15/2018 2/13/2023
Included observations: 1357 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.124732	0.112970	9.956064	0.0000
WGT_RESID^2(-1)	0.017124	0.027159	0.630507	0.5285
WGT_RESID^2(-2)	0.036522	0.027158	1.344804	0.1789

R-squared	0.001649	Mean dependent var	1.188499
Adjusted R-squared	0.000175	S.D. dependent var	3.813411
S.E. of regression	3.813078	Akaike info criterion	5.516959
Sum squared resid	19686.57	Schwarz criterion	5.528483
Log likelihood	-3740.256	Hannan-Quinn criter.	5.521274
F-statistic	1.118433	Durbin-Watson stat	1.999841
Prob(F-statistic)	0.327093		

Figure 61. *Heteroskedasticity test output of GARCH(1,1) for L-ARIMA(8,1,11)*

So, the previous equations (Eq.3.3 and Eq.3.4) will change to the following equations: (Eq.3.5 and E.q.3.6)

- **L-ARIMA(0,1,3)**

$$sell = 0.0000015 - 0.958 * \epsilon_{t-1} - 0.065 * \epsilon_{t-2} + 0.024 * \epsilon_{t-3} + \epsilon_t$$

Where $\epsilon_t | I_{t-1} \quad N(0, h_t)$ and h_t stands for heteroskedasticity and is not a constant variance and changes over time.

$$h_t = 1.17 * 10^{-4} + 0.171246 * h_{t-1}^2 \qquad \text{(E.q. 3.7)}$$

- **L-ARIMA(8,1,11)**

$$sell = 0.000003 - 1.803 * sell_{t-1} - 1.261 * sell_{t-2} - 1.596 * sell_{t-3} - 2.429 * sell_{t-4} - 1.636 * sell_{t-5} - 1.059 * sell_{t-6} - 1.482 * sell_{t-7} - 0.860 * sell_{t-8} + 0.861 * \epsilon_{t-1} - 0.527 * \epsilon_{t-2} + 0.272 * \epsilon_{t-3} + 0.801 * \epsilon_{t-4} - 0.802 * \epsilon_{t-5} - 0.613 * \epsilon_{t-6} + 0.438 * \epsilon_{t-7} - 0.614 * \epsilon_{t-8} - 0.880 * \epsilon_{t-9} + 0.077 * \epsilon_{t-10} + 0.078 * \epsilon_{t-11} + \epsilon_t$$

Where $\epsilon_t | I_{t-1} \quad N(0, h_t)$

$$h_t = 3.67 * 10^{-5} + 0.149745 * h_{t-1}^2 + 0.599945 * h_{t-1}$$

(E.q. 3.8)

Where h_{t-i}^2 and h_{t-i} represent ARCH and GARCH terms respectively and i is the number of orders. Also, all the coefficients of ARCH and GARCH are positive, guaranteeing positive variances.

It is possible to compare the models as follows:

***Table 8**. The models' comparison after including the GARCH effect, Set 1*

CRITERIA	L-ARIMA(10,1,0)	L-ARIMA(23,1,0)
LOG LIKELIHOOD	-2566.383	-2521.715
AKAIKE CRITERION	5.959125	5.945148
SCHWARZ CRITERION	5.9740168	5.956323
HANNAN-QUINN CRITERION	5.963352	5.94.9429

***Table 9.** The models' comparison after including the GARCH effect, Set 2*

CRITERIA	L-ARIMA(0,1,3)	L-ARIMA(8,1,11)
LOG LIKELIHOOD	-3.973.217	-3740.256
AKAIKE CRITERION	5.820230	5.516959
SCHWARZ CRITERION	5.827872	5.528483
HANNAN-QUINN CRITERION	5.823090	5.521274

According to Table 8, the L-ARIMA(23,1,0) outperforms better for Set1. Based on Table 9, the L-ARIMA(8,1,11) outperforms better for Set2.

CONCLUSION

Iran was the most sanctioned country in the world until it was surpassed by Russia following its invasion of neighboring Ukraine in February 2022. Some of the sanctions imposed on Iran include restrictions on exports of certain goods and services, restrictions on foreign investment, and a ban on the sale of weapons to Iran. In addition, many international financial institutions have been prohibited from doing business with Iran, making it difficult for the country to access global financial markets. The evolution of sanctions against Iran can be divided into several phases, each marked by a different set of circumstances and objectives.

Pre-2010 sanctions: Before 2010, the international community imposed a range of economic and financial sanctions on Iran, aimed primarily at limiting the country's nuclear program. These sanctions included restrictions on Iran's access to international financial systems, a ban on the export of certain goods and technologies to Iran, and an arms embargo.

Post-2010 sanctions: After 2010, the international community imposed much harsher sanctions on Iran in response to the country's continued pursuit of nuclear weapons. These sanctions included an oil embargo, which significantly reduced Iran's oil exports and its primary source of revenue. The banking sector was also targeted, with the restriction of Iranian banks' access to the international financial system and the freezing of their assets abroad.

Post-2015 sanctions relief: In 2015, Iran agreed to limit its nuclear program in exchange for the lifting of some of the international sanctions. This allowed Iran to reintegrate into the global economy and resume oil exports, leading to an improvement in its economic situation.

Post-2018 sanctions: In 2018, the United States withdrew from the Iran Nuclear Deal (also known as the Joint Comprehensive Plan of Action) and reimposed sanctions that had been lifted as part of the agreement. The new sanctions targeted Iran's oil exports, which are the country's main source of revenue, and its access to the international financial system.

The 2018 sanctions on Iran were a significant event that had far-reaching implications for the country and the wider region. The sanctions had a significant impact on Iran's economy, as they restricted its ability to export oil, which is a major source of revenue for the country. As a result of the sanctions, Iran's economy experienced a severe contraction causing significant inflation, currency devaluation, unemployment and consequently a decline in the standard of living for many Iranians.

The 2018 sanctions have been important so that it can be considered as a structural break in the current time series analysis. A structural break in time series analysis refers to a significant change in the underlying relationship between the variables being studied over time. This change can occur due to a variety of reasons, such as shifts in economic policies, natural disasters, or sudden changes in consumer behavior. Structural breaks can result in changes in the statistical properties of the time series, such as the mean, variance, or autocorrelation structure.

As it is proven in the chapter 3, with the start of whispers of withdrawing USA and consequently 2018 sanctions, the time series has shown different models before and after the considered interval. It proves that besides other factors, the 2018 sanctions have been a factor contributing to a structural break in the Rial-US dollar exchange rate behavior.

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Dataset Resources

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