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RESEARCH PAPER

The Impact of Iran Oil Sanctions on the Exchange Rates: An Analysis Using Google Search Index

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Abstract
Iran has faced oil and banking sanctions since 2012. Following the sanctions and instability of the exchange rates, the Rial has sharply lost its value. Rising economic unrest has widened the gap between the official exchange rate and parallel market rate. However, the depreciation of Iran's Rial does not show a uniform trend, and the decline path has been complicated. We know that sanctions against Iran have created new expectations, concerns, and attention. Google Trends has provided an analytic tool for measuring and monitoring people's expectations based on their Internet search data. This study attempted to analyze and model the exchange rate trends in Iran using sanctions-related expectations extracted from Google Trends. The Google search index (GSI) of the sanctions demonstrated the agent's expectations. Monthly data and the autoregressive distributed lag (ARDL) method were used for estimation. The results indicated a significant and positive impact of GSI on the unofficial exchange rate (UER) and just a positive impact on the real unofficial exchange rate (RUER). We can conclude that the effects of sanctions appear partly through changes in people's expectations that can be extracted using GSI. Moreover, the difference in inflation showed a significant positive effect on the market exchange rate in Iran. Thus, an improvement in the expectations through reducing the international tensions and a perspective shift can strengthen the Rial exchange rate. Moreover, the policymaker can control the volatility and depreciation of the exchange rates in Iran by restricting the M2 growth through an appropriate long-run monetary policy.
Keywords: Google Search Index, Sanction-Related Expectations, Exchange Rates, Difference in Inflation, Iran Oil Sanctions.
JEL Classification: D84, E31, F31, F51, Q43.

Introduction

Since 2008, mainly under the pretext of the nuclear programs, Iran has faced many conflicts in its relations with some European and American countries. High conflict intensification between the two sides has led to the imposition of oil and banking sanctions against Iran, which have affected the economy of the country. At the same time, the instability and collapse of the exchange rate have been observed in the Iranian currency market since 2011. The official exchange rate has fallen far from market rates. Thus, a situation of dual exchange rates has been formed. This decline is partly attributed to negative expectations and speculative activities. This paper attempted to analyze the effects of sanctions, sanctions-related expectations, and other factors on Iran's currency market.

The international sanctions against Iran can be classified into three categories including the United States sanctions, the UN Security Council sanctions, and the European Union

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sanctions, mainly implemented after 2006. The most significant international sanctions may be the sanctions implemented in 2012 by the UN Security Council, the United States, and the European Union, and new sanctions have been imposed by the United States from the beginning of 2018.

In the following implementation of 2012 sanctions against Iran and through difficult and prolonged negotiations, a comprehensive nuclear agreement was obtained between Iran and six countries, including the United States, Britain, France, Germany, China, and Russia in 2015. Afterward, a large part of Iran's nuclear-related sanctions was suspended or canceled. Restrictions on oil exports and some other sanctions were lifted. Banking transactions and international investment were facilitated, and Iranian banks were allowed to re-engage with foreign banks. The Joint Comprehensive Plan of Action (JCPOA) was endorsed as an international agreement by the UN Security Council. The positive trend of negotiations and agreements led to stability in the foreign exchange market and minimized the gap between official and unofficial exchange rates in Iran.

However, Trump who opposed the agreement during his campaign, after being elected as the US President and several threats to exit the agreement, officially announced in May 2018 that his government intended to withdraw from the deal to stop Iran's regional and nuclear policy as well as Iran's missile program. Meanwhile, the United States re-imposed the sanctions against Iran which had been previously suspended due to JCPOA. These sanctions have been implemented since August 2018. Thus, during the period 2010-2019, various sanctions have been announced and implemented against Iran which has led to many fluctuations and instability in Iran's economy.

After the last US threat to exit the JCPOA and in response to increasing uncertainty, in April 2018, the central bank of Iran started applying restrictions on foreign currency transactions to shut down a flourishing black market and halt the Rial's slump; however, the Rial has sharply lost its value. Rising economic unrest has widened the gap between the official exchange rate and parallel market rate. Table 1 summarizes the most important events related to the international sanctions against Iran during this period.

Table 1. The Important Events Related to International Sanctions against Iran

Date	Related events
July 2006	The UN Security Council sanction against Iran (resolution 1696): The Security Council called on Iran to suspend its nuclear program (threats of imposing sanctions against Iran). The United States sanctions are announced against some Iranian banks (Sepah Bank, Saderat Bank (Export Bank), and Bank Melli Iran (National Bank of Iran).
March 2008	The UN Security Council sanction against Iran (resolution 1803): The members of the United Nations were requested to voluntarily restrict their cooperation with Iranian banks. The members were required to end their cooperation with the National and Export banks of Iran due to the financial facilitation of Iran's nuclear and missile programs. The members were allowed to inspect Iran's imports and exports transported through ocean freight or air freight.
June 2010	The UN Security Council sanction against Iran (resolution 1929): Sanctions were announced against the Iran shipping company. The members were required to ban Iranian banks from opening new branches and conducting transactions.
June 2012	The EU and the US announced the implementation of comprehensive oil and banking sanctions.
November 2013	The initial nuclear agreement was achieved.
July 2015	A comprehensive nuclear agreement was achieved (JCPOA).
January 2016	The implementation of the comprehensive nuclear agreement (JCPOA) was announced.
May 2018	The US announced unilateral withdraw from the JCPOA and re-imposed the previously lifted sanctions.
August 2018	The US announced the implementation of the first part of sanctions against Iran.
November 2018	The US announced the implementation of the second part of sanctions (all sanctions) against Iran.

Source: Research finding.

It appears that the Iranian foreign exchange market has been affected by international sanctions. The exchange rate of the Iranian Rial has declined to less than one-tenth of its value since 2010. Various factors may affect this depreciation including sanction-related expectations, inflation in Iran and its differences with major economies, and reduced oil revenues. However, the depreciation of Iran's Rial does not show a uniform trend; on the contrary, the decline path has been complicated. For example, in some sections of the sanctions period, oil revenues have not diminished altogether, but the exchange rate of Rial has sharply declined. On the contrary, for example, after Iran's elections in 2013, while the oil revenue was fixed or even shrinking due to the shale oil shock, the real exchange rate of Rial has even improved. Could these controversial trends be attributed to change in expectations and concerns of economic agents? And how can we measure the sanctions-related expectations of the agents?

It is well known that expectations of economic agents have an important impact on variables and rates in an economy. Estimating and assessing expectations were among difficult tasks in the past, but Google Trends (www.google.com/trends/) has provided an analytic tool for measuring and monitoring expectations based on Internet search data. Expectations and concerns of people are reflected in their internet searches. Thus, Google Trends can be used to identify people's expectations and predict their behavior (Choi and Varian, 2012). Economic researchers have pointed out that Google Trends provides early indicators of future behaviors (Nuti et al., 2014; Mellon, 2013; 2014). In recent years, economists have widely used Google Trends to predict economic behavior and variables, e.g. inflation (Guzman, 2011), stock's return (Kim et al., 2019), etc. The query volumes on a web search engine are excellent indicators of public concern, which could be quantitative measures of exchange rates events (Ji and Guo, 2015). Accordingly, this study attempted to analyze and model the exchange rate trends in Iran using sanctions-related expectations extracted from Google Trends. Also, in this paper, the internet information concerning economic events, which is derived from search query volumes in Google, is introduced in an analytical framework to identify the magnitude and significance of the market response to exchange rates related events in the Iranian economy over the Apr-2010 to Sept-2018 period.

The remainder of the paper is organized as follows: Section 2 reviews theoretical and empirical literature related to the study. The research model and results of the estimation are presented in Section 3. Finally, conclusions are drawn in Section 4.

Literature Review and Theoretical Framework

The Google Trends, Expectations, and Exchange Rates

Expectations have played an increasing role in economic theories in recent decades. It is well known that the expectations of economic agents affect their choices and behaviors. In addition, the agents' behaviors form future economic events. In other words, agents and markets are usually forward-looking. Thus, for example, if people expect a stock price to fall two weeks later, they will sell in 13 days period to avoid that fall and this behavior will change the price trend (Da et al., 2015). Therefore, people's expectations about events and the future strongly affect the behaviors of agents and economic variables (Sameti et al., 2012).

Nowadays, many economic activities leave a digital fingerprint such as internet searches which has bred a new data-oriented research field (Ji and Guo, 2015; Da et al., 2015; Mao et al., 2011). Thus, the query volumes on a Web search engine can be an excellent indicator of public expectations and concerns. Recently, data constructed from Internet-based platforms such as Google have been widely used to analyze economic and financial variables and have been indicated to be effective in short-term forecasts. As mentioned earlier, Google Trends

has provided a tool for measuring and monitoring Internet searches data. Expectations, concerns, and attentions of agents are reflected in their internet activities such as Web searches. Thus, Google Trends can be used to evaluate people's expectations as an indicator of future economic behaviors. Google Trends can also be used to predict economic variables. Moreover, Da et al. (2011) indicated that the Google Search Volume Index (GSVI) is a measure for revealed attention. If a keyword has been searched in Google, attention has been paid to it, and this attention can be considered as an information source.

However, with the introduction of Google search volume as a direct and objective measure of expectations, concerns, and attentions, many researchers have investigated the relation of Google searches with economic variables, events, and markets such as foreign currencies, stocks, and commodities as a new and expanding area of studies. Smith (2012) investigated the impact of search activity on the exchange rates and their volatilities. He indicated that Google searches for the keywords economic crisis + financial crisis and recession showed strong predictive power in the foreign currency market. These results supported that volatility is linked to the stochastic rate, at which information flows into the marketplace. The results also showed the potential for Google to become a source of information for economic markets.

Bijl et al. (2016) attempted to forecast stock returns using Google Trends. Although some researchers have found that high Google search volumes predict high returns for the first one to two weeks, these authors found that high Google search volumes sometimes lead to negative returns. They have also examined a trading strategy based on selling and buying stocks using Google search volumes. Kim et al. (2019) indicated that high Google searches predicted increased volatility and trading volume in the Norway stock market. They claimed that Google Trends was more related to the future than current trading activity.

There are also some studies in commodity trading like the oil market about the relationship between Google searches and market behavior. Yu et al. (2019) investigated the relationship between Google Trends and oil consumption. The study used cointegration and Granger causality tests to analyze the predictive power of the Google Trends on oil consumption. The authors forecasted oil consumption trends and values using certain Google searches. Li et al. (2015), Cormack et al. (2017), and Campos et al. (2017) attempted to use Google Trends for predicting some energy markets. These studies indicated the predictive power of the Google search volume index (GSVI) for improving the forecast accuracy of crude oil prices and their volatility. Bordino et al. (2012) revealed the existence of a positive correlation between today's stock-related web search traffic and the trading volume of the same stocks in subsequent days. Mao et al. (2011) performed a comparison of the predictive relationships between different mood indicators and the Dow Jones Industrial Average index, trading volumes, and market volatility. Furthermore, Rao and Srivastava (2013) studied the forecasting models using large-scale discussions and search behavior data. Their results showed that human behavior traces on the web can provide good insights, enabling a better understanding of the market's movements in oil, gold, forex, and stock.

We know that sanctions against Iran have created new expectations and concerns. The Google Search Index (GSI) can be an analytical framework to identify the magnitude and significance of the market response to sanctions-related events. Expectations about sanctions-related events may affect the behavior of agents and economic variables such as exchange rates. However, GSI can be interpreted as a proxy for agents' expectations and attention (Li et al., 2015). Moreover, the severity of sanctions against Iran has not been fixed during the period. Google search volumes about Iran's sanctions can also be an indicator of the strength and weakness of sanctions. Therefore, GSI could be a quantitative measure of sanctions-related events and sanction-based expectations.

There are almost only three tools for a researcher to trace the search volume data on a large scale, Google trends (selected in this paper), MSN Ad Intelligence, and Yahoo Clues. Google Trends is the main instrument to understand international web trends, which collect data from more than 100 countries, while the queries in English of Bing and Yahoo have mainly come from the United States (Ji and Guo, 2015). Moreover, according to Global Stats, Google had more than 90% of the search engine market share in Iran from Apr 2010 to Sept 2018. Thus, we used it to ensure data reliability in this paper.

Some studies evaluate the effects of Western sanctions on Iran and Russia's economy. These studies, such as Tuzova and Qayum (2016) and Tayebi and Sadeqi (2017), used a dummy variable for the sanctions period. Although a dummy variable of sanctions is useful, it only takes values 0 and 1. We know that it has been changing the severity of sanctions against Iran: sometimes highly intense and strict, and sometimes milder and moderate. Thus, sanctions-related expectations and concerns have not also been fixed. The GSI is not an absolute query volume; rather, it is a relative index ranging from 0 to 100, set by the Google Corporation, in which 100 represents the maximum query volume over the selected period. Higher frequency data can be extracted from the GSI if there is a large enough search volume for the query word/phrase under analysis (Ji and Guo, 2015). The application of the GSI indicator of sanctions instead of a simple dummy variable demonstrates the severity or weakness of sanctions and trends of sanction-based expectations during the period. Therefore, in this study, we used the GSI indicator of sanctions instead of a simple dummy variable. This approach has an advantage in that it measures the magnitude effect of events with the time series of internet concerns and searches, instead of considering the events as dummy variables whose values are restricted to 0 or 1. So, this paper attempted to investigate the relationship between the exchange rate and GSI of sanctions-related events as a measure of expectations. To the best of our knowledge, there is no prior work that models Iran's economic variables using GSI.

Exchange Rates and Inflation

Many studies investigated the relationship between inflation and exchange rates, especially in high inflation economies (Samadi and Moeeni, 2012; Mirdala, 2014; Karagoz et al., 2016; Moeeni and Tayebi, 2019). Takhtamanova (2010) presented empirical evidence of the relationship between the exchange rate and CPI inflation for a set of fourteen OECD countries. Tayebi and Sadeqi (2017) investigated the impact of CPI on the exchange rate in Iran. They indicated a direct and significant effect of CPI on the foreign exchange rates.

According to the theoretical literature, inflation in a country can show a major impact on the value of the country's currency. Let's use an example; it is assumed that we have two countries and two currencies, each with an annual inflation rate of 2%: China (Yuan) and the United States (Dollar). If inflation in China rises from 2% to 5%, this will tend to reduce the value of Yuan for several reasons (https://www.investopedia.com). First, inflation occurs when a central bank prints more money than the country produces goods, which means that for each produced good, there is more money in the economy. This situation leads to a higher price of each good. Higher inflation means prices in China rise faster than those in the US, which makes Chinese goods more expensive both domestically and abroad. Higher prices mean that Chinese goods will become less competitive relative to US goods. From the perspective of the US consumers, they buy fewer Chinese goods than before that will affect the exchange rate. The exchange rate of Yuan should be reduced to sell these goods and achieve a new equilibrium.

Second, on the other hand, from the perspective of Chinese consumers, with the rise of domestic prices, they will find goods from the US cheaper. They will tend to exchange more

Yuans for Dollars to buy more imported goods. Therefore, increasing sell and supply of Yuan will lead to decreasing its exchange rate. Thus, a change in inflation could lead to a change in the exchange rate of currencies. For example, if inflation in China is higher than that in the US, the exchange rate of Yuan against Dollar could be depreciated.

Typically, in a country with lower inflation rates, the exchange rate will increase relative to other currencies as its purchasing power increases. During the second half of the 20th century, countries with low inflation included Japan, Germany, and Switzerland while the United States and Canada achieved low inflation later. In the second group of countries with higher inflation, their currencies depreciate relative to the currencies of their trading partners. Higher inflation is usually correlated with a weaker currency (https://www.investopedia.com). Therefore, in this new study, we investigated the impact of the difference in inflation between Iran and the United States on the exchange rate of USD/Rial.

The Review of Empirical Studies

In this section, we reviewed some related empirical studies. First, we reviewed empirical studies on sanctions against Iran and some other countries, and then examined some empirical studies on the relationship between exchange rates and oil revenues.

Impact of Sanctions on Iran's Economy

Torbat (2005) examined the effectiveness of the United States trade and financial sanctions against Iran. The economic cost of the trade sanctions was assessed using the concept of welfare loss. The impact of the financial sanctions was measured by estimating the additional costs that Iran paid on its foreign debts and for financing oil projects. According to the results, the financial sanctions had a stronger impact than the trade sanctions. It is concluded that in general, the economic effects of sanctions have been significant. Faraji Dizaji and Bergeijk (2013) evaluated the economic impact of sanctions on Iran's economy. They used a comprehensive set of vector autoregressive (VAR) models for Iran oil sanctions over the period 2007-2011. The results of the VAR models indicated significant effects of the oil sanctions on key economic variables (government consumption, import, investment, and income). The results indicated that oil and gas rents were important drivers of the macroeconomic variables of Iran and ultimately its political system.

Ezati and Salmani (2014) used a 2SLS econometric method and analyzed the direct and indirect effects of sanctions on Iran's economic growth with an emphasis on the external sector of the economy during 1997-2012. They claimed that sanctions did not have a direct and indirect effect on Iran's economic growth. Considering sanctions against Iran, Faraji Dizaji (2014) investigated the dynamic relationship between government revenues and government expenditures in Iran as a developing oil-based economy using a VAR and a vector error correction model during the period 1990:2-2009:1. The results implied that those sanctions aiming to restrict the government's oil revenues could potentially affect the government's expenditures as an important engine of growth in Iran.

Gharehgozli (2017) estimated the economic cost of sanctions on Iran using the synthetic control method during 2011-2014. The results represented that sanctions reduced Iran's real GDP by more than 17 percent with the largest drop occurring in 2012. Tayebi and Sadeqi (2017) used an autoregressive distributed lag (ARDL) model to estimate the effects of the comprehensive international sanctions of 2012 on the exchange rates. The results indicated that before 2012, sanctions had an indirect and intangible effect on the exchange rates. While negative impulses in oil revenue and the government's budget in 2012 led to a direct and powerful effect on the exchange rates.

Sadat Akhavi and Hoseini (2017) evaluated the impact of economic sanctions, especially sanctions after 2010, on inflation using a time series model during 2003-2014. The results indicated sanctions direct effect on inflation through expectation and an indirect effect on inflation through liquidity. Aghaee and Reza Gholizadeh (2018) developed a panel data model and applied the generalized gravity model to analyze the effect of economic and trade sanctions on Iran's trade relations with major trading partners during 1996-2015. The findings of the study illustrated that intangible sanctions had a less negative effect on the value of Iran's export and import during the period, while the intensified and comprehensive sanctions had a significant negative impact on the volume of export and import in Iran.

Bonyani and Ali Mohammadlu (2018) attempted to identify and prioritize foreign companies interested in participating in the energy sector of Iran following the lifting of sanctions. An integrated model was proposed and data were gathered through questionnaires. The results of data analysis revealed that some well-known European companies in this area had higher positions compared to others. Bolgorian and Mayeli (2019) investigated factors affecting banks' vulnerability in financial sanctions during 2008-2017. The results indicated that banks with higher capital and higher state ownership were more vulnerable. Some researchers have analyzed the impact of oil sanctions on Iran's oil quota during and after the sanctions (Moeeni, 2019; Moeeni and Sharifi, 2020).

Impact of Sanctions against the Other Countries

Neuenkirch and Neumeier (2016) evaluated the impact of sanctions on the poverty gap. They employed a matching approach to account for differences in the countries' economic environment. The results showed that sanctions were adversely affecting those living in poverty as they observed a 3.8 percentage point larger poverty gap in sanctioned countries compared to a control group. Gurvich and Prilepskiy (2016) analyzed the effect of sanctions on Russia by modeling the capital flow components. The results indicated the direct effect of sanctions on funding for sanctioned banks as well as sanctioned oil and gas companies. There was also a significant indirect impact on non-sanctioned companies and the GDP trend.

Dreger et al. (2016) investigated the effects of sanctions and oil shocks on Russia's Ruble based on cointegrated VAR models during 2013:1-2015:3. The results indicated that the Roble depreciation could be mainly related to oil prices. Moreover, unanticipated sanctions influenced the volatility of the exchange rate. Tuzova and Qayum (2016) used seasonal data and a VAR model to investigate the effects of oil prices and sanctions on Russia's economy and exchange rate. The results showed that Russia's economy was heavily influenced by fluctuations in oil prices and sanctions.

Exchange Rate and Oil Revenue Shocks

In the final section of the literature review, we reviewed some studies on the exchange rate changes in oil countries and some other related studies. Korhonen and Juurikkala (2009) investigated the determinants of equilibrium real exchange rates in a sample of oil-dependent countries by utilizing a pooled mean group estimator. The results indicated that oil prices had a significant impact on real exchange rates in oil-producing countries. Farzanegan and Raeisian Parvari (2014) applied a VAR model using impulse response functions and variance decomposition analysis to analyze the dynamic response of oil prices to Iran oil sanctions. The results revealed that oil prices responded negatively to the increasing shock in Iran's oil exports.

Behrad-Amin et al. (2017) examined the effect of oil shocks on Iran's foreign trade in the presence of the exchange rate and inflation targeting policies by estimating an adjusted

Keynesian DSGE model for Iran using the Bayesian method over the 1981-2014 period. The results of the model simulations showed that the severity and duration of the negative effects of oil shocks decreased on export and import in the case of inflation and exchange rate targeting.

Babajani Baboli et al. (2018) investigated the impact of shocks in oil price and exchange rate on inflation in Iran by application of the VAR approach during the period 1991-2016. The results showed that the strong dependence of the exchange rate on foreign exchange earnings and oil revenues allowed the rapid growth of prices in Iran. The effect of shocks was increasing over time. Baghestani and Toledo (2019) set up a forecasting framework to generate multi-period random walk predictions for real effective exchange rates of NAFTA countries. The results showed that the random walk prediction errors for 2008–2016 failed to be orthogonal to changes in oil prices. Thus, it was found that oil price changes accurately predicted directional change in the real exchange rates for up to two (three) months ahead for Canada (Mexico and the US).

The present study is in line with some previous studies such as Ji and Guo (2015) and Tuzova and Qayum (2016). However, it is different in some important ways and variables. This study sought to complete and develop the conducted studies about the impact of international sanctions on Iran's exchange rate. We evaluated the effect of public expectations arising from the imposition of sanctions on the exchange rate using GSI. In addition, in this study, we used the ARDL model and monthly data to analyze the impact of the difference in inflation, oil revenues, and GDP on the market exchange rate in Iran.

The Research Model and Estimation

The present paper aimed to study factors affecting the market exchange rate (USD/Rial) in Iran with emphasis on sanctions-related expectations extracted from GSI. The application of this important index (GSI) is increasing rapidly in economic studies, and this paper used GSI for the Iranian economy for the first time. Some recent studies used a dummy variable for the sanctions period to examine its effects on Iran and Russia's economy. Although the dummy variable of sanctions is useful, it only takes values 0 and 1. We know that sanctions-related expectations and concerns have not been fixed during the sanction periods. Therefore, the application of the GSI indicator of sanctions, instead of a simple dummy variable, demonstrates the severity or weakness of sanctions and trends of sanctions-related expectations during the period. Thus, in this study, inspired by Ji and Guo (2015) and Tuzova and Qayum (2016), we used the GSI indicator of sanctions instead of a simple dummy variable. This paper attempted to investigate the relationship between the exchange rate and GSI of sanctions-related events as a measure of expectations. Due to the research purpose, the following model was considered based on theoretical literature, empirical studies, and the results of estimations tests. The model was estimated using the ARDL method.

$$\mathrm{UER_t} = \alpha_0 + \alpha_1 \mathrm{UER_{t-1}} + \alpha_2 \mathrm{GSI}_t + \alpha_3 \mathrm{DINF_t} + \alpha_4 \mathrm{DINF_{t-1}} + \alpha_5 \mathrm{GDP_t} + \alpha_6 \mathrm{OILR_t} + \alpha_7 \mathrm{IM_t} + \mathrm{u_t} \quad (1)$$

$$\mathrm{RUER_t} = \alpha_0 + \alpha_1 \mathrm{RUER_{t-1}} + \alpha_2 \mathrm{GSI}_t + \alpha_3 \mathrm{GDP_t} + \alpha_4 \mathrm{OILR_t} + \alpha_5 \mathrm{IM_t} + \mathrm{u_t} \quad (2)$$

The market exchange rate or unofficial exchange rate (USD/Rial) is denoted by UER and the real exchange rate (USD/Rial) is denoted by RUER. The real exchange rates were computed by Eq. (3) using the market exchange rates. The market exchange rate is a key macroeconomic variable for economic agents, consumers, and producers. GSI shows public expectations resulted from sanctions. Public expectations can be an important and influential

factor in fluctuations in the economy. We used GSI for the keyword "*Iran Oil Sanctions"* on Google Trends during the period as a measure for expectations. DINF is an index for the difference in inflation between Iran and the United States according to Eq. (4). The numerator shows the cumulative inflation of Iran, and the denominator shows the cumulative inflation of the United States (Von Hagen and Zhou, 2005). GDP is the gross domestic product, and OILR is the revenues of oil and petroleum products exports. Moreover, IM is the value of imports of goods and services, and t indicates the time. The model has been estimated using Microfit 5 and Eviews 10.

$$RUER_t = \frac{UER_t}{(\mathrm{CPI}_{\mathrm{t}}^{\mathrm{Iran}}/\mathrm{CPI}_{\mathrm{t_0}}^{\mathrm{Iran}})} \tag{3}$$

$$\mathrm{DINF}_t = \frac{\mathrm{CPI}_{\mathrm{t}}^{\mathrm{Iran}}/\mathrm{CPI}_{\mathrm{t_0}}^{\mathrm{Iran}}}{\mathrm{CPI}_{\mathrm{t}}^{\mathrm{Us}}/\mathrm{CPI}_{\mathrm{t_0}}^{\mathrm{Us}}} \tag{4}$$

We used monthly data and the logarithmic form of the variables. Quarterly data including GDP, OILR, and IM were converted into monthly data. The estimation period was from April 2010 to September 2018. The consumer price index (CPI) was used to calculate the difference in inflation between Iran and the United States. The CPI data for Iran and the United States was extracted from the Central Bank of Iran and the Federal Reserve, respectively. The model's variables are presented in Table 2. This study is distinguished from previous studies in several important aspects. For the first time, we used the GSI of expectation for Iran's economy. Instead of CPI, the difference in inflation was used. We applied the monthly data showing the detailed trend of exchange rate changes. Finally, we expanded the study period to consider the effects of recent sanctions after 2018.

Before estimation, it is necessary to test the stationarity of the model's variables. Non-stationary variables both in time series and panel models can cause spurious regression. The augmented Dickey-Fuller test was used to check the stationarity of the variables. The null hypothesis is defined as the presence of a unit root. If the absolute value of the test statistic is greater than the critical value at a 95% confidence level, the null hypothesis will be rejected. The results of the stationary test are depicted in Table 3.

Table 2. The Models' Variables

No	Variable	Abbreviation	Source
1	The market exchange rate	UER	CBI
2	The real exchange rate	RUER	CBI and research computations
3	Gross domestic product (constant price)	GDP	CBI
4	Import of goods and services (constant price)	IM	CBI
5	Revenues of oil and petroleum products (constant price)	OILR	CBI
6	The difference in inflation between Iran and the United States	DINF	CBI, FED, and research computations
7	The expectations index from the Google Trends	GSI	www.google.com/trends

Source: Research finding.

Table 3. The Results of the Stationarity Test (Augmented Dickey-Fuller)

Variable	Test statistic	Critical statistic	Result
UER	-2.7642	-2.8909	Nonstationary
d.UER	-10.3951	-2.8912	Stationary (through a first difference)
GSI	-4.2449	-2.8909	Stationary
DINF	1.3079	-2.8909	Nonstationary
d. DINF	-3.1035	-2.8912	Stationary
GDP	-1.2011	-2.8909	Nonstationary
d.GDP	-8.8484	-2.8912	Stationary (through a first difference)
OILR	-3.3266	-2.8909	Stationary
IM	-3.4583	-2.8909	Stationary
RUER	0.33870	-2.8909	Nonstationary
d.RUER	-3.8743	-2.8912	Stationary (through a first difference)

Source: Research finding using Microfit 5.

According to the results in Table 3, some variables are stationary and some are I (1). As mentioned earlier, we used the ARDL method. The ARDL method has some advantages. First, when the sample size is small, other methods do not provide an unbiased estimation. The ARDL method solves this problem because of the consideration of short-term dynamic responses among variables (Pesaran et al., 2001). Moreover, in many economic situations, the effects of some explanatory variables appear to be delayed and, ARDL is an appropriate method for these cases. These advantages lead to a more accurate estimation. Thus, it appears that the ARDL method can be an appropriate estimation method in the present study.

The Model Estimation

As mentioned earlier, we used the ARDL method to evaluate short-term and long-term relationships between the exchange rates of USD/Rial (UER) and explanatory variables as well as the relationships between the real exchange rates of USD/Rial (RUER) and explanatory variables. Optimal lags can be obtained using the Schwarz-Bayesian criterion or Hannan-Quinn criterion. The optimal lags were selected based on the Schwarz-Bayesian criterion due to the small size of the sample. This criterion saves the number of lags in order not to lose the degree of freedom. Thus, for UER, the model of ARDL (1,0,1,0,0,0) and RUER, the model of ARDL (1,0,0,0,0) was specified according to the Schwarz-Bayesian criterion. The estimation results of the dynamic model are presented in Tables 4 and 5.

The coefficients indicate the elasticities of the variables. The results showed that an increase in the exchange rate could also affect next month's exchange rate. This result indicated a dynamic relationship among the changes in the market exchange rate during the period. The growth of the USD exchange rate in the previous month may cause a speculative and increasing demand for US Dollar and could lead to further growth of the USD exchange rate. The model estimation indicated a significant and positive effect of GSI on the exchange rates. Along with the announcement of some unilateral and multilateral sanctions against Iran, certain expectations and concerns have been formed. Data constructed from Google Trends can be used to measure these sanction-related expectations and revealed attention. Tayebi and Sadeqi (2017) attempted to analyze the effects of previous sanctions with a set of dummy variables. However, we used the GSI as a more suitable new index, based on Ji and Guo (2015). GSI also eliminates the need for multiple dummy variables. The results indicated that GSI was a quantitative measure for expectations that affected the exchange rates. Thus, GSI can be applied to evaluate the changes in the foreign exchange market in the Iranian economy.

Table 4. The Estimation Results of the Dynamic Model for UER, ARDL (1, 0, 1, 0, 0, 0)

Variable	Abbreviation	Coefficient	Standard deviation	t Statistic [prob]
The first-lagged term of exchange rate	UER(-1)	0.52278	0.080660	6.4813[.000]
Expectations index from the Google Trends	GSI	0.33652	0.15856	2.1223[.036]
The difference in inflation between Iran and the United States	DINF	1.3683	0.48104	2.8445[.005]
The first-lagged term of the difference in inflation between Iran and the United States	DINF(-1)	-0.9584	0.48071	-1.9937[.042]
Gross domestic product	GDP	0.72179	1.8733	0.38530[.701]
Revenues of oil and petroleum products	OILR	-2.3413	0.85663	-2.7331[.008]
Import of goods and services	IM	-0.48526	0.31979	-1.5174[.133]
Intercept	C	27.8189	23.8349	1.1671[.246]
R-Squared: 0.82796				

Source: Research finding using Microfit 5.

Table 5. The Estimation Results of the Dynamic Model for RUER, ARDL (1, 0, 0, 0, 0)

Variable	Abbreviation	Coefficient	Standard deviation	t Statistic [prob]
The first-lagged term of real exchange rate	RUER(-1)	0.90550	.063125	14.3446[.000]
Expectations index from the Google Trends	GSI	0.010976	0.0050171	2.1877[.031]
Gross domestic product	GDP	0.30722	0.088983	3.4526[.001]
Revenues of oil and petroleum products	OILR	-0.016459	0.018996	-0.86645[.388]
Import of goods and services	IM	-0.085980	0.047169	-1.8228[.072]
Intercept	C	-2.9115	1.2543	-2.3211[.022]
R-Squared: 0.91620				

Source: Research finding using Microfit 5.

Figure 1 presents GSI for the keyword "Iran Oil Sanctions" on Google Trends during the period 2010-2018. Google Trends offers this data in different forms and even in weekly periods. It should be noted that the high searches at the beginning of the agreement (JCPOA) were due to the positive and optimistic expectations about the lifting of the sanctions, and therefore, we adjusted GSI for this period. In other words, since concerns and negative expectations were insignificant at the beginning of the agreement, in this period (June 2015 to March 2016), we considered the GSI index to be constant and equal to that at the beginning of the period (June 2015). This adjustment is reasonable and necessary. Further studies can also show this period by a dummy variable or an appropriate keyword for GSI. We also tested some other keywords, but the above-mentioned keyword appeared more appropriate. The GSI of this keyword strongly shows people's negative expectations, concerns, and attention, particularly for estimation. Figure 2 shows the monthly trend of the official and unofficial exchange rates (USD/Rial) from April 2010 to September 2018. As these Figures show, whenever Google's search on the sanctions rose, the exchange rate of USD/Rial also increased. GSI has been an acceptable indicator for people's expectations and concerns and an appropriate predictor for the exchange rates. Moreover, GSI index showed a positive but insignificant impact on the real exchange rate over the 2010-2018 period.

According to the estimation results, in total, the difference in inflation between Iran and the United States shows a significant positive effect on the market exchange rate in Iran. It can be stated that a one percent rise in the difference in inflation can lead to a more than 0.41% increase in the exchange rate in Iran. The estimation results indicated the positive and

insignificant effect of GDP on the market (unofficial) exchange rate. The results also showed the positive and significant impact of GDP on the real exchange rate (RUER). This result is consistent with previous studies like Tayebi and Sadeqi (2017). In the period, the data of GDP (constant price) showed limited variation and, as a result, the GDP data did not have the necessary richness to estimate the effect of the variable. The effect of oil revenues on the market exchange rate was negative and significant which is consistent with theoretical expectations. The effect of oil revenues on the real exchange rate was also negative but insignificant,

Finally, the relationship between import and exchange rates (UER and RUER) is complicated and should not be interpreted as causal relations. It can be stated that escalation of sanctions led to reducing export revenues. As a result, the import rate decreased, and the exchange rate of USD/Rial was elevated simultaneously, and therefore, these two variables showed some negative correlation. As shown in Figures 3 and 4, the real import value has decreased from 2011 while the unofficial exchange rate of USD/Rial has increased since 2011. Thus, the estimation results are consistent with such evidence. It should be noted that some previous studies applied this variable, but the removal of the import variable from the model has a trivial effect on the estimation results. This result is in the line with some other studies like Tang (2015). The UER model was also estimated using the dummy variable instead of the GSI. Results and signs are mostly in line with the original model.

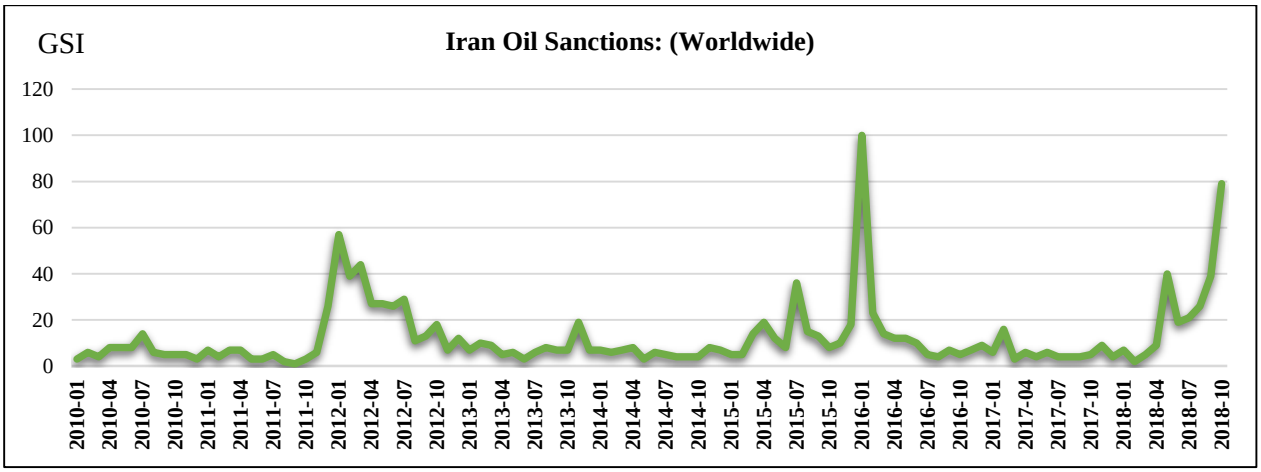

Figure 1. The Google Search Index for the Keyword "Iran Oil Sanction" during 2010-2018
Source: Research finding and www.google.com/trends.

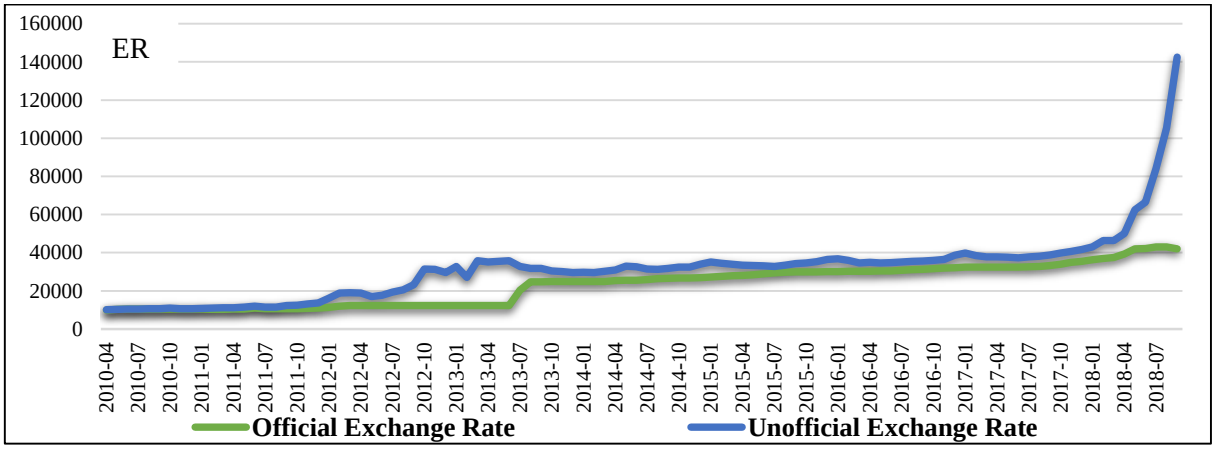

Figure 2. The Monthly Trend of the Official and Unofficial Exchange Rate during 2010-2018
Source: CBI.

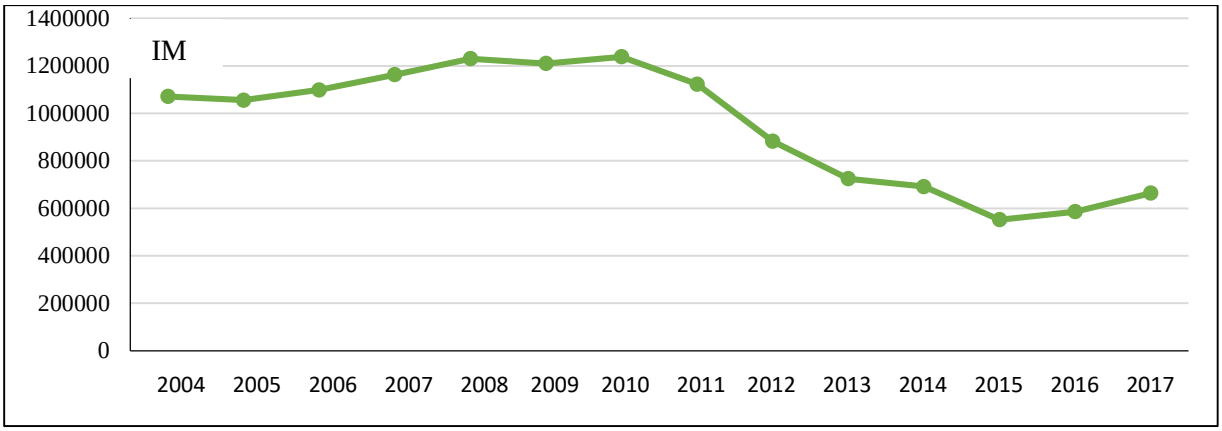

Figure 3. Import of Goods and Services during 2004-2017 (Billion Rials in the Constant Price)
Source: CBI.

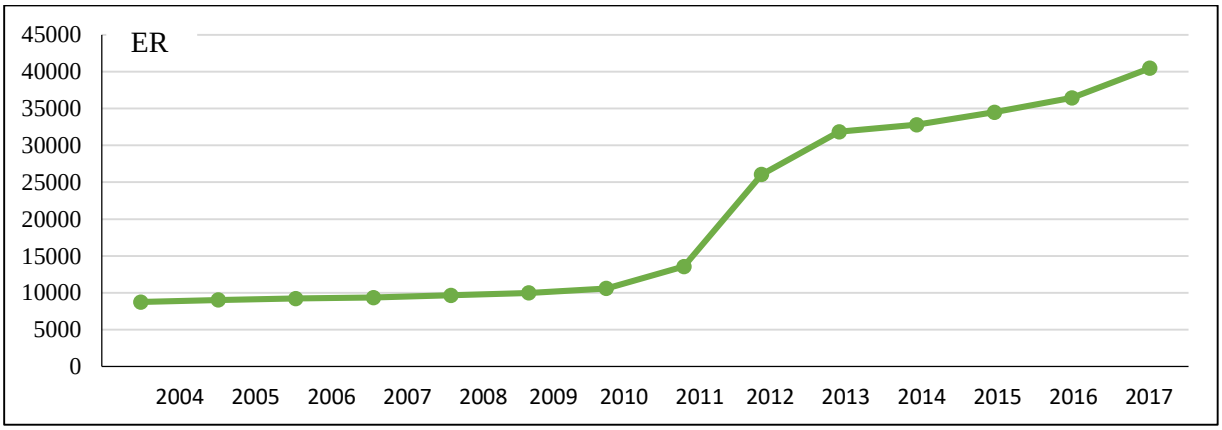

Figure 4. The Unofficial Exchange Rate (USD/Rial) during 2004-2017
Source: CBI.

The Estimation of the Long-run Model

After estimating the dynamic model, the hypothesis of cointegration between the variables was tested. In the Banerjee test, if the summation of the coefficients for the lags of the dependent variable is smaller than 1, the dynamic model will tend towards the long-term equilibrium. Therefore, for the cointegration test in the ARDL model, it is necessary to test the following hypothesis:

$$H_0: \sum_{i=1}^{p} \alpha_i - 1 \geq 0 \quad (5)$$

$$H_1: \sum_{i=1}^{p} \alpha_i - 1 < 0 \quad (6)$$

Considering the optimal lag of the dependent variable, the t-statistic was calculated as follows:

For UER model:

$$t = \frac{\alpha_i^{\lambda} - 1}{S_{\hat{\alpha_i}}} = \frac{0/52278 - 1}{0/080660} = -5/91643$$

For RUER model:

$$t = \frac{\alpha_i^{\lambda} - 1}{S_{\alpha_i^{\wedge}}} = \frac{0/90550 - 1}{0/063125} = -1/4970$$

For UER model, t-statistic is more than the critical value (-4.30) developed by Banerjee et al. (1992) for models with intercept. Thus, the long-run relationship between the variables of the model is confirmed. For RUER model, the t-statistic is less than the critical value developed by Banerjee et al. (1992) for models with intercept. Thus, the long-run relationship between the variables of the model is not confirmed. In addition to the cointegration test, we used the additional variable test (Pesaran et al., 1996) to examine the long-term relationship between the model's variables. According to Tables 6 and 7, the F statistic was more than the critical values of upper bound and lower bound. Therefore, the null hypothesis of the absence of a long-term relationship among the variables was rejected. Given the long-term relationship between the model's variables, the long-run estimation results are presented in Tables 8 and 9.

Table 6. The Results of the Additional Variable Test (Pesaran et al., 1996) for UER

F statistic	95% Lower Bound	95% Upper Bound
5.1194	2.7421	3.9507

Source: Research finding using Microfit 5.

Table 7. The Results of the Additional Variable Test (Pesaran et al., 1996) for RUER

F statistic	95% Lower Bound	95% Upper Bound
4.2718	2.9584	4.1853

Source: Research finding using Microfit 5.

Table 8. The Estimation Results of the Long-run Model for UER

Variable	Abbreviation	Coefficient	Standard deviation	t-Statistic (prob)
Expectations index from the Google Trends	GSI	0.70517	0.33653	2.0954[.039]
The difference in inflation between Iran and the United States	DINF	0.85893	0.39409	2.1795[.031]
Gross domestic product	GDP	1.5125	3.9264	0.38521[.701]
Revenues of oil and petroleum products	OILR	-4.9061	1.8539	-2.6463[.010]
Import of goods and services	IM	-1.0168	0.63129	-1.6107[.111]
Intercept	C	58.2940	49.6787	1.1734[.244]

Source: Research finding.

Table 9. The Estimation Results of the Long-run Model for RUER

Variable	Abbreviation	Coefficient	Standard deviation	t-Statistic (prob)
Expectations index from the Google Trends	GSI	0.064641	0.099348	0.65065[.517]
Gross domestic product	GDP	2.4744	2.1031	1.1765[.242]
Revenues of oil and petroleum products	OILR	-0.14556	0.18220	-0.79889[.426]
Import of goods and services	IM	-0.37014	0.55190	-0.67066[.504]
Intercept	C	-16.6325	25.3691	-0.65562[.514]

Source: Research finding.

The results indicated a long-run significant and positive relationship between the GSI and unofficial exchange rate (UER) in the Iranian economy. The results also showed a positive and insignificant effect of GSI on real exchange rates (RUER). The findings of the study also showed a long-run positive and significant relationship between the difference in inflation and

unofficial exchange rate (UER) and a negative relationship between the oil revenues and both exchange rates (UER and RUER).

The Error Correction Model (ECM)

The error correction mechanism was first developed by Sargan and then was used by Engle and Granger (1987) for correcting the imbalance (Gujarati, 2005). ECM is a type of partial adjustment model. This model measures the velocity of approaching the long-term equilibrium using stationary residuals of the long-term estimation. The estimation of ECM models includes two steps. First, the long-term model must be estimated. Second, lagged residuals of the long-run model are used as an error correction term. Thus, the following equation is estimated:

$$\Delta Y_t = a + b\Delta X_t + cU_{t-1} + e_t \quad (7)$$

The negative coefficient of the error correction term indicates the tendency for long-term equilibrium and the speed of error correction. This coefficient indicates the adjustment percentage of the dependent variable towards long-run equilibrium in each period (Tashkini, 2005). The error correction term is presented in Eq. (8) and Eq. (9).

For UER model:

$$\mathrm{ECM} = \mathrm{UER} - 0.70517\ \mathrm{GSI} - 0.85893\ \mathrm{DINF} - 1\cdot 5125\ \mathrm{GDP} + 4\cdot 9061\ \mathrm{OILR} + 1\cdot 0168\ \mathrm{IM} - 58\cdot 2940 \quad (8)$$

And for RUER model:

$$\mathrm{ECM} = \mathrm{RUER} - 0.064641\ \mathrm{GSI} - 2.4744\ \mathrm{GDP} + 0.14556\ \mathrm{OILR} + 0\cdot 37014\ \mathrm{IM} + 16.6325 \quad (9)$$

The ECM estimation results are shown in Tables 10 and 11.

Table 10. The Results of the Error Correction Model (ECM) for UER

Variable	Coefficient	Standard deviation	t statistic (probability)
dGSI	0.33652	0.15856	2.1223[.036]
dDINF	1.3683	0.48104	2.8445[.005]
dGDP	0.72179	1.8733	0.38530[.701]
dOILR	-2.3413	0.85663	-2.7331[.007]
dIM	-0.48526	0.31979	-1.5174[.133]
ecm(-1)	-0.47722	0.080660	-5.9164[.000]

Source: Research finding using Microfit 5.

Table 11. The Results of the Error Correction Model (ECM) for RUER

Variable	Coefficient	Standard deviation	t statistic (probability)
dGSI	0.010976	0.0050171	2.1877[.031]
dGDP	0.30722	0.088983	3.4526[.001]
dOILR	-0.016459	0.018996	-0.86645[.388]
dIM	-0.085980	0.047169	-1.8228[.072]
ecm(-1)	-0.094500	0.063125	-1.4970[.138]

Source: Research finding using Microfit 5.

According to the results in UER model, the coefficient of the error correction term was significant and equal to -0.47722. As this coefficient lies between 0 and -1, the long-run relationship among the variables was confirmed. This coefficient was negative and its magnitude indicated the speed of error correction toward the long-run equilibrium. The

coefficient showed that in case of a shock and deviation from equilibrium, in each period, 47.72% of short-term imbalances were adjusted to achieve long-term equilibrium. Likewise, according to the results in RUER model, the coefficient of the error correction term was equal to -0.094500. As this coefficient lies between 0 and -1, the long-run relationship among the variables was confirmed.

The Stability and Diagnostic Tests

The stability and diagnostic tests include the LM test and Ramsey test as well as tests for heteroscedasticity and structural stability. The LM test is used to recognize the serial correlation of residuals. According to the results of Table 12 and 13, the null hypothesis was not rejected for both UER and RUER estimated models, and there was no serial correlation between the residual terms. The Ramsey test was also used to test the specification of the model's functional form. The results of the Ramsey test indicated that the model had an appropriate functional form. The results also rejected the heteroscedasticity of the residuals.

We used the plot of the cumulative sum of recursive residuals (CUSUM) and the plot of the cumulative sum of squares of recursive residuals (CUSUMQ) for the examination of the stability of the long-run and short-run models. Figures 5, 6, 7, and 8 showed that both graphs of CUSUM and CUSUMQ were lying between upper and lower critical bounds, implying that short-run and long-run estimates were stable. These figures indicated the stability of the research models.

Table 12. The Results of the Diagnostic Tests for UER

Diagnostic tests	Statistic	Probability
The LM test for serial correlation	0.70977	0.738
The Ramsey test for functional form	0.33567	0.564
Heteroscedasticity	0.045018	0.832

Source: Research finding using Microfit 5.

Table 13. The Results of the Diagnostic Tests for RUER

Diagnostic tests	Statistic	Probability
The LM test for serial correlation	1.4255	0.171
The Ramsey test for functional form	3.2503	0.075
Heteroscedasticity	.71880	0.399

Source: Research finding using Microfit 5.

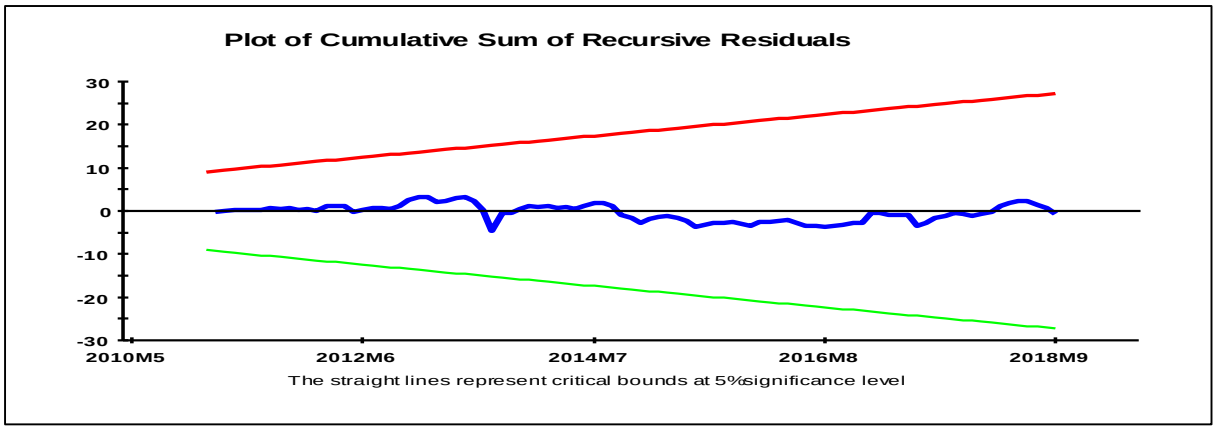

Figure 5. The Cumulative Sum of Recursive Residuals (CUSUM) Test for UER Model
Source: Research finding using Microfit 5.

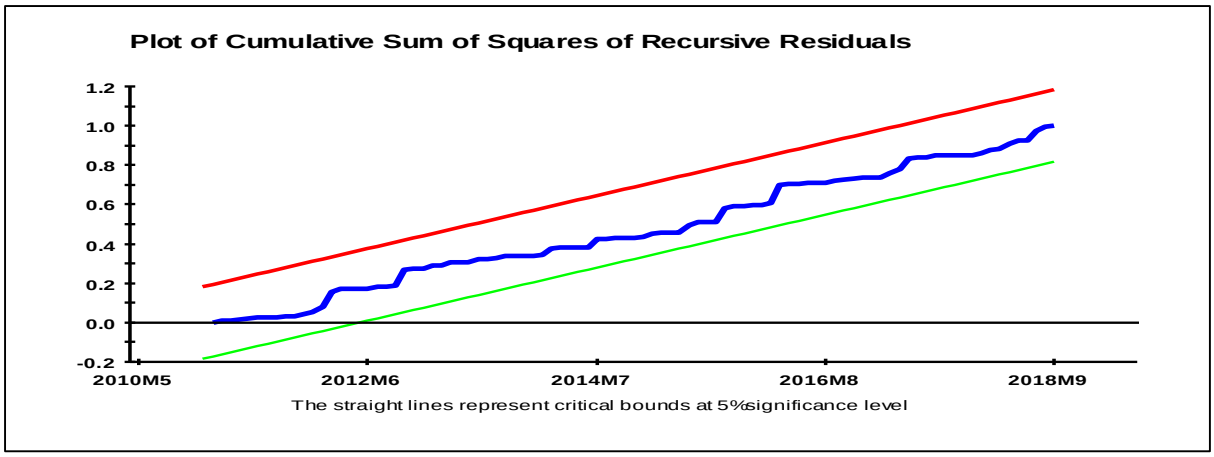

Figure 6. The Cumulative Sum of Squares of Recursive Residuals (CUSUMQ) Test for UER Model
Source: Research finding using Microfit 5.

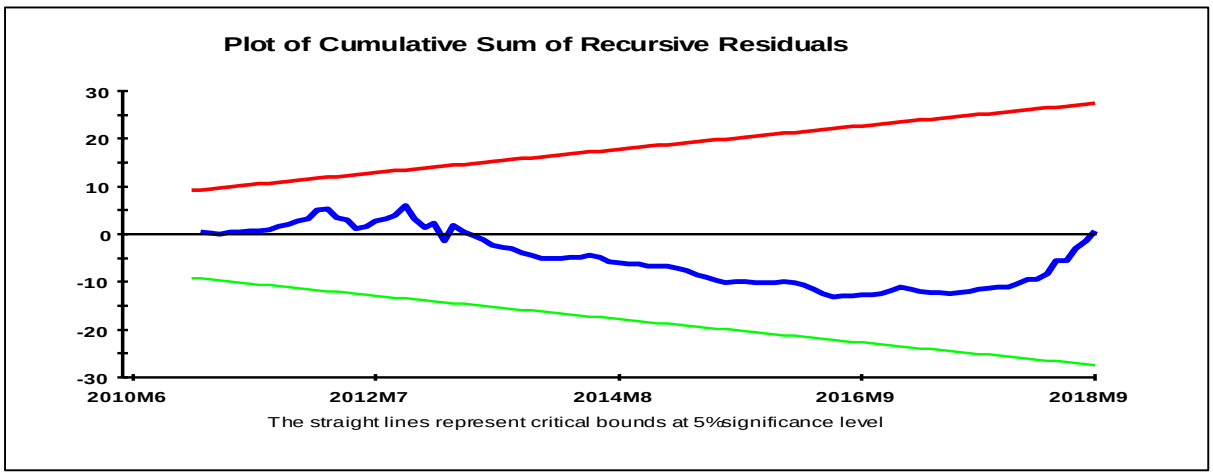

Figure 7. The Cumulative Sum of Recursive Residuals (CUSUM) Test for RUER Model
Source: Research finding using Microfit 5.

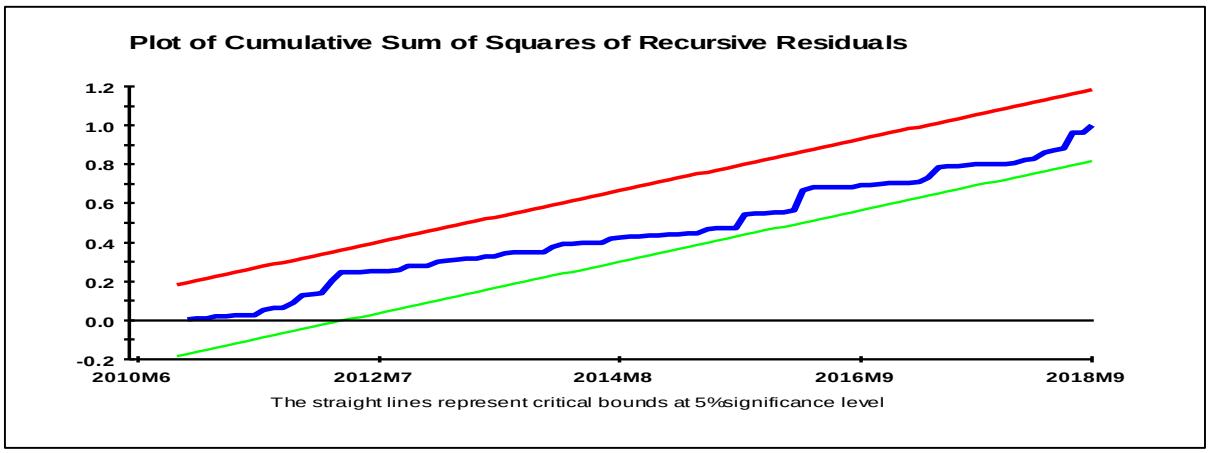

Figure 8. The Cumulative Sum of Squares of Recursive Residuals (CUSUMQ) Test for RUER Model
Source: Research finding using Microfit 5.

Conclusion

Sanctions against Iran have been one of the most important economic problems in the country during the last decade. Since 2008, mainly under the pretext of the nuclear programs, Iran has faced many conflicts in its relations with some European and American countries. These

conflicts have caused the imposition of oil and banking sanctions against Iran. It is necessary to study and analyze the impact of sanctions on economic variables. The exchange rate is considered to be a key macroeconomic rate, changes of which affect other variables. Following the sanctions and instability of the exchange rates in Iran, Iran's Rial has sharply lost its value since 2011. Rising economic unrest has widened the gap between the official exchange rate and parallel market rate.

During a decade, sanctions have been sometimes intense and sometimes mild. A comprehensive agreement was obtained between Iran and six countries in 2015. Afterward, a large part of Iran's nuclear-related sanctions was lifted. However, in early 2018, the United States decided to withdraw from the agreement, and the sanctions were resumed. Again, the exchange rate fell to less than one-tenth of its value before 2010. However, the depreciation of Iran's Rial does not show a uniform trend, and the decline path has been complicated. For example, in some sections of the sanctions period, oil revenues have not diminished altogether, but the exchange rate of Rial has sharply declined. On the contrary, for example, after Iran's elections in 2013, while the oil revenue was fixed or even shrinking due to the shale oil shock, the exchange rate of Rial has remained unchanged and the real exchange rate has even improved.

Various factors may affect this depreciation including sanction-related expectations, inflation in Iran, reduced oil revenues, etc. It is well known that agents' expectations have an important influence on variables and rates in the economy. We know that sanctions against Iran have created new expectations, concerns, and attention. Google Trends has provided an analytic tool for measuring and monitoring people's expectations, concerns, and attentions based on Internet search data. With the introduction of Google search volume, many researchers have used it in economic studies. GSI can be a quantitative measure for sanctions-related events and sanction-based expectations. Therefore, this study attempted to analyze and model the exchange rate trends in Iran using sanctions-related expectations extracted from Google Trends. Some studies used the dummy variable for the sanctions period. However, the application of GSI can demonstrate the trend of sanctions-related expectations and severity of sanctions during the period. Therefore, in this study, we used the GSI of sanctions instead of a simple dummy variable.

The estimation results indicated a significant and positive effect of GSI on the unofficial exchange rate (UER) and just a positive effect on the real exchange rate (RUER). Thus, data constructed from Google Trends can be used to measure sanction-related expectations and revealed attention. It appears that the GSI of some keywords strongly shows people's negative expectations, concerns, and attentions and can be applied to assess changes in the exchange rates in Iran. Moreover, according to the results, the difference in inflation showed a significant positive effect on the market exchange rate in Iran. The long-run relationship was also confirmed between the variables of the model. The results of the long-term model estimation also indicated the impact of the mentioned variables and oil revenues. The negative coefficient of the error correction term indicated that short-term imbalances were adjusted to achieve long-term equilibrium. As the study period increases, the results are likely to improve. In addition, other researchers can use GSI for other keywords to analyze their effects on the exchange rate, inflation, and other economic variables. The Google Trends can be also applied to forecast the exchange rates and other variables. Given the availability of monthly data for the budget deficit, this variable can be added to the model in later studies.

We can briefly conclude the study as follows. First, the effects of sanctions appear partly through changes in expectations. In addition, sanctions-related expectations can be measured using GSI. Second, the results showed that the GSI of sanctions-related expectations could be applied to analyze and explain changes in the exchange rates in Iran. An improvement in expectations through reducing international tensions and a perspective shift could be

immediately monitored through Google Trends. As the GSI of expectations shows, expectations will improve dramatically as soon as first hopes are created and observed. Subsequently, significant effects appear on economic rates which can strengthen the exchange rate of Rial. Third, the difference in inflation affects the exchange rate in Iran. Thus, policymakers can control the volatility and depreciation of the exchange rates by restricting the liquidity growth through an appropriate long-run monetary policy. According to the paper results, there are some recommendable issues for future researches. First, by estimating the models as a system of equations, future researchers could investigate short-run and long-run causality relationships among the variables. Second, similar models can be estimated to investigate the impact of sanction-based expectations and GSI on other macroeconomic variables in Iran.

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