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Modeling exchange rate and economic sanctions against Iran utilizing the Markov switching method

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Abstract

Exchange rate stability in the market plays a key role in both competitiveness and as far as reducing economic uncertainty. The exchange rate in Iran has been fluctuating for several years now due to political factors, specifically economic sanctions. Utilizing the Markov switching method, this study has endeavoured to model the direct effects of sanctions on the exchange rate and the indirect impact of sanctions and inflation on the exchange rate between 1985- and 2021. The exchange rate in Iran is dual in nature, meaning there are two systems that govern it: 1-Characterized by low average exchange rates and high standard deviation; 2-High average inflation and low standard deviation. Hence, in this article, two models specified by Markov switching shall be used. The findings reveal the probability of staying in the low exchange rate system is higher than the probability of remaining in the high exchange rate one. In addition, the probability of transition from the low exchange rate system is higher than the opposite probability (due to the stability of the low exchange rate in the country). The findings also show that sanctions have a low and positive effect on the exchange rate. Moreover, the impact of inflation on the exchange rate is positive.

Keywords: international sanctions, inflation, exchange rate, Iran
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1 Introduction

From 1914 onwards, the world's military and economic powers have chosen to resort to economic and political sanctions instead the of war to advance their objectives vis a vis country they have conflict with. Economic sanctions can be classified into three groups: import sanctions, export sanctions and financial sanctions [6]. Sanction is a coordinated action by a group that includes the refusal to conduct business relations or any relationship with another person or group with the aim of punishing or compensating for losses [15].

The Islamic Republic of Iran has been subject to unjust sanctions by certain Western countries for more than thirty years. In recent years, these sanctions have plateaued to their highest level, encompassing most banking activities, the Central Bank of Iran (CBI) as well as the petroleum (oil, gas, petrochemicals) sector [1].

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The impact of sanctions on the exchange rate, by creating uncertainty for domestic and foreign producers and investors, prevents the bolstering of investments in the economy and therefore has a negative impact on the exchange rate. Sanctions can also increase rent-seeking and speculation in the foreign exchange market by widening the gap between the official exchange rate and the free market, and lead to diversion of resource allocation. Therefore, resources instead of moving to production and employment, are spent on speculation and rent-seeking in the foreign exchange market and has a negative impact on employment. On the other hand, by banning the transfer of technology to Iran, sanctions weaken the competitiveness of domestic producers (in competition with foreign companies), consequently, hindering domestic production and employment. Furthermore, banking and insurance sanctions, via disrupting the trade exchanges of the country's exporters can have negative effects on the export sector, which in turn can induce hikes in the exchange rate within society [23].

Banking sanctions, especially the CBI sanctions, led to the disruption of the country's monetary exchanges and wreaked havoc on the country's commercial activities. Even revenues from non-oil exports were also severely disrupted. On the demand side, however, the country's importers still had an urgent need for foreign exchange. However, due to the lack of foreign exchange resources, the supply of foreign exchange for the country's import needs faced multiple problems (same source). The primary objective of this article is to assess how economic sanctions and inflation affect the exchange rate. This study shall proceed as follow: first the theoretical foundations and background of the research; next the model particulars; followed by the estimation and analysis of the data; and finally research conclusions.

2 Research background

2.1 International background

Dizaji and Bergeijk [7] analyzed the "Shocks from sanctions on Iran's sanctions targets." Toward this objective, a dynamic model in combination with reaction functions was utilized. For assessment, it was assumed that the European Union and the United States of America had imposed a complete embargo on purchases from Iran. The findings demonstrated that sanctions have significant/meaningful effects on the variables (VAR) of the Iranian economy. However, the impact of sanctions are limited over time (2-4 years from their imposition). Adjustments in economic structures reduces the economic and political effects of sanctions. Oxenstierna and Olsson [25] examined the "Impact of sanctions on Russia" in 2014. The findings revealed that sanctions have had negative economic effects on both sides. On the western side, the United States has not suffered much from sanctions on Russia since US exports to Russia were less than one percent, however, European countries have sustained more losses because of their extensive trade with Russia in the energy and agricultural sectors. Yelena & Faryal [32] evaluated the impact of oil prices and sanctions on the Russian economy using quarterly data for 1999-2015 plus the vector regression method (VAR). In this research, a virtual variable was utilized to evaluate the effects of sanctions. The findings indicated that the Russian economy has been severely affected by fluctuations in oil prices and sanctions (impacting the studied variables of inflation rate, real exchange rate and GDP).

In an article, Nademi and Khochiany [22] analyzed movements/fluctuations in the stock market currency and gold within the Iranian economy. For this purpose, they deployed the Wavelet Coherence Analysis and Econophysics, for the period 1998-2016, and studied the mobility and two-way relationship of these markets in the Iranian economy (with weekly frequency). The findings of the Wavelet Coherence Analysis show that in the short-term time horizon (2006-2009) and the medium-term time frame (1994-1997), the relationship between the stock market rate of return and the exchange rate was negative (opposite phase). However, long term (2008-2011), the stock rate of return moves pursuant to the exchange rate and is considered a regressive variable. In addition, the correlation between the rate of return on stocks and gold coin prices indicate that the intensity of the relationship between these two variables was not very high during the study period; However, the relationship between these two variables during the 16 to 64 week interval of 2002-2005 was quite intense in the opposite direction.

In their study, Kazemi and Ezzati [17] assessed the "Impact of economic sanctions on Iran's industrial production" utilizing the simultaneous equation system model. Compliant with the results, it can be expected that sanctions will have a negative effect on Iran's industrial sector production and employment. The effect of sanctions on the exchange rate can not be considered a direct effect, but the sanctions do directly target imports of raw materials and machinery, as well as investment and foreign exchanges. For Iran, Samadi and et al., [27], in an article titled "The Interaction Between Financial Markets, the COVID-19 Pandemic & Economic Sanctions: The Case of Iran", reviewed the primary financial markets in the Iranian economy, specifically stock, currency, oil, and gold markets. The sharp fluctuations in these markets, especially those caused by the severe sanctions imposed on Iran in May 2018 plus the outbreak of COVID-19, have caused increasing confusion and uncertainty among investors.

2.2 Domestic background

In an article, Amini [3] conducted an: "Analysis of sanctions impact on oil sales & exchange rate fluctuations in Iran" The findings revealed that the sanctions imposed on the sale of Iranian oil have exacerbated exchange rate fluctuations, due to the fact that more than 57% of Iran's foreign exchange earnings come from the sale of oil.

To study the effects of sanctions in Iran, Garshasbi & Yousefi-Dindarloo [12] in a study called "The effects of international sanctions on macroeconomic variables in Iran", identified twelve variables that were highly impacted by sanctions. These variables were utilized in the sanctions indexation process, and included the official exchange rate, parallel market exchange rate and the price index of exported and imported goods. According to the findings of this study, the direct effects of sanctions have been significant only in terms of economic growth and as far as trade. There also appears to be a direct relationship between the severity of sanctions and their effects on economic variables.

Tayebi and Sadeghi [30] in an article studied the "Effects of international sanctions & other factors impacting the exchange rate in Iran" for the period 1981-2015. They assessed the effects of international sanctions utilizing a specified exchange rate model and the self-explanatory method with Distributed Intervals (ARDL). Moreover, oil export revenues and the monetary system had a positive and significant effect on the exchange rate, and the variables of consumer price index (CPI) and GDP had a direct and significant effect on the exchange rate as well.

Nademi et al., [23] studied "Econometric modeling of sanctions impact on foreign exchange market & its transfer mechanism to macroeconomic variables in Iran." The macroeconomic variables of the country included inflation and unemployment. For this purpose, a variety of econometric models including ARMAX, GARCH and Markov switching models have been utilized. The outcome of estimating the research models indicate that sanctions have had three direct effects on the foreign exchange market, including a hike in the exchange rate, an increase in the gap between the official exchange rate and the free market, and a jump in exchange rate fluctuations.

Barkhordari and Abolhassani [4] in a study examined the "Factors determining the exchange rate in Iran with emphasis on the role of economic sanctions" between 2017-2019. Toward estimating the long-term relationship between the variables, the self-regression model with distributed interrupt (ARDL) was utilized and the short-term relationships were analyzed using the vector error correction mechanism (ECM). The findings demonstrated that the imposition of economic sanctions in 2012 had a decisive effect on the exchange rate.

Mansoori et al., [19] studied the "Economic factors affecting the components of Iran's tax revenues in the context of sanctions between 1985-2018" utilizing the exploratory factor analysis as well as the nonlinear ARDL models. To analyze taxes, three types of personal tax revenues, corporations and customs earnings were utilized in the form of three models. The price of imported goods and the price index of exported goods were the most influential factors. Furthermore, nonlinear model estimation consistent with NARDL findings had a positive and significant effect on personal tax revenue in the long term as far as oil revenue share and sanctions variables. In addition, the variable of GDP per capita has a negative and significant effect on corporate tax revenues in the long run. Ultimately, in the long run, the effect of variables on customs revenue is in accordance with theoretical principles but is not statistically significant. Given the country's economic situation during this time of sanctions, it is a necessity for major changes to be enacted within the tax structure/system.

Karim et al., [16] in their article "The impact of sanctions on household consumption expenditures with emphasis on exchange rate fluctuations & national revenues", assessed the impact of sanctions on domestic spending and analyzed national income/revenue data. Toward that objective, 2019 statistical data was utilized. The emphasis was placed on exchange rate fluctuations and the self-explanatory econometric model with ARDL explanatory intervals. The findings showed that the explanatory variables explain up to 99% of changes in household consumption expenditures in the long run. Sanctions have had a direct negative impact on household consumption in the long run.

3 Theoretical foundations

The impact of exchange rate fluctuations on real activity has been the subject of much debate among economists. The effect of exchange rate fluctuations can be analyzed in two primary categorizes: supply and demand. On the demand side, there is a general belief that devaluation can increase production as well as encourage and expand exports. As a consequence, the country decides to export more of its products to international markets. On the supply side, channels of exchange and macroeconomic interaction complicate matters for policymakers in various countries, especially those importing goods and services. Exchange rate fluctuations pose a threat to emerging economies in terms of financing the national budget to meet public demand. These exchange rate fluctuations are usually explained by economic factors such as inflation, balance of payments, and interest rates [20].

Concerning the relationship between exchange rate and inflation, Dornbusch [8] for the first time studied and modeled how exchange rate changes affect the price index; In other words, the far-sighted study was the trailblazer of other studies on how exchange rate fluctuations are transferred to prices, and its source could be sanctions. An an econometric model was designed by Dornbusch where the effects of exchange rates on prices were analyzed. Moreover, the relationship between exchange rates and domestic prices in terms of market concentration, imports, import substitution and domestic production were assessed [18].

Agenor and Montiel [2] described the major transfer mechanism of how exchange rate fluctuations affect inflation. According to their study, an open economy can directly affect the prices of imported alternative and traded goods. It can indirectly hike the price of final goods via the price of imported inputs. Due to exchange rate fluctuations, currency uncertainty can spike domestic prices. Moreover, via wages, it also raises prices.

Numerous studies have been conducted on the effect of exchange rates on inflation, generally divided int direct and indirect effects. Regarding the effect of exchange rate gaps on inflation, Edwards (1988) stated that improper exchange rate adjustment can lead to inefficiency, inadequate allocation of economic resources, loss of international reserves, weakening production incentives in various sectors and macroeconomic imbalances. On the other hand, the deviation of the exchange rate from the equilibrium level causes uncertainty, and this uncertainty can have negative effects on the economy in dual tracks. First, it reduces domestic and foreign investment and has a negative effect on capital accumulation. Second, exchange rate uncertainty increases trade costs and undermines trade competitiveness. This is especially true and present in economies where secure trade is less common. [26].

In line with Svensson's study (2000), money transfer mechanism is among the roles the exchange rate plays. Accordingly, exchange rate fluctuations can affect inflation via three different channels:

- Exchange rate fluctuations experienced in an open economy affect the relative prices between domestic and foreign goods, hence altering domestic and foreign demand for domestic goods. Consequently, aggregate demand and inflation are indirectly affected by net exports.
- On the other hand, exchange rate fluctuations directly affect the prices of final imported goods in national currency. As a result, it directly affects the consumer price index. Ultimately, the rate of inflation is affected by the price of imported final goods, and this effect is usually achieved in a shorter time period than the indirect effect of net exports.
- Finally, exchange rate changes impact consumer prices and nominal wages through the effect of the import price index in terms of the national currency index.

When these two effects are combined, the inflation rate is affected by the finished cost of domestic production. The important point about the role of the exchange rate in the inflation targeting strategy is that the exchange rate as an asset price is a future variable and a predictor variable. It therefore helps to create expectations, occupying a significant place in monetary policy.

Another view is that the deviation of the exchange rate from its equilibrium level creates problems (costs) for the economy. In this regard, if the valuation of the national currency vis a vis foreign currencies is more than the equilibrium level, it may reduce international competition for a country, and if the valuation of the national currency against foreign currencies is less than the equilibrium level, it induces an increase in the price of imported intermediate goods as well as aggregate demand creating inflationary pressures. Such possibilities are more probable in countries with high and persistent inflation rates such as Iran. Accordingly, if the main source of inflation is foreign, it is expected that inflation will be stable in periods when the exchange rate is well above the equilibrium level and this situation will be resolved by adjusting the exchange rate [31].

4 Research methodology

4.0.1 Specifying the model

From the findings of theoretical resources as well as domestic/foreign empirical studies, it has been revealed that various factors such as: GDP, oil revenues, foreign trade volume, investment share of GDP and inflation affect the exchange rate [4]. However, in calculating the sanctions index, macroeconomic variables affected by sanctions are taken into account. In other words, the above variables are hidden within the index, so in estimating the effects of sanctions on the exchange rate, we use the following empirical model:

$$PEX = \beta_0 + \beta_1 SAN + \beta_2 INF + v_t \tag{4.1}$$

PEX: Parallel Market Exchange Rates

SAN: Economic Sanctions

INF: Inflation Rate (%)

v_t**:** Disruptive Sentence

In Equation (4.1), displaying the effects of sanctions on the exchange rate, the Markov Switching Method is utilized.

4.1 Research method

Assessing the effects of economic sanctions on the exchange rate requires access to statistical data on sanctions. Often the ability of sanctions to affect variables that result from the international relationship of the sanctioned economy with the international economy, and attempts are made, through the enactment of laws and regulations and the provision of enforcement guarantees for the enacted laws, to be first-level variables. In this study, in order to extract the sanctions index based on the study of Garshasbi and Yousefi-Dindarloo [12], the Exploratory Factor Analysis (EFA) was utilized and its impact on the exchange rate was canvassed via the EFA method.

4.1.1 Factor analysis method

Initial work on factor analysis was conducted by Spearman (1904), who is generally known as the "father" of this method. Factor analysis converts a large number of variables that explain a given subject into a smaller number of hidden dimensions called factors. The method of exploratory factor analysis is deployed in instances where the goal is to explore or produce the latent dimensions that make up the phenomenon under study. Factor analysis is a method based on which this single index can be extracted.

The model attempts to explain a set of p observations in each of n individuals with a set of k common factors ($f_{i,j}$) where there are fewer factors per unit than observations per unit ($k < p$). Each individual has k of their own common factors, and these are related to the observations via factor loading matrix ($L \in \mathbb{R}^{p\times k}$), for a single observation, according to

$$x_{i,m} - \mu_i = l_{i,1}f_{1,m} + \cdots + l_{i,k}f_{k,m} + \varepsilon_{i,m}$$

whereby

- $x_{i,m}$ is the value of the ith observation of the mth individual,
- μ_i is the observation mean for the ith observation,
- $l_{i,j}$ is the loading for the ith observation of the jth factor,
- $f_{j,m}$ is the value of the jth factor of the mth individual, and
- $\varepsilon_{i,m}$ is the (i,m)th unobserved stochastic error term with mean zero and finite variance.

In matrix notation

$$X - M = LF + \varepsilon$$

where observation matrix $X \in \mathbb{R}^{p\times n}$, loading matrix $L \in \mathbb{R}^{p\times k}$, factor matrix $F \in \mathbb{R}^{k\times n}$, error term matrix $\varepsilon \in \mathbb{R}^{p\times n}$ and mean matrix $M \in \mathbb{R}^{p\times n}$whereby the (i,m)th element simply $M_{i,m} = \mu_i$.

Also we will impose the following assumption of F:

1. F and ε are independent.
2. $E(F) = 0$; where E is expectation.
3. $Cov(F) = I$ where Cov is the covariance matrix, to make sure that factors are uncorrelated, and I is the identity matrix.

Suppose $Cov(X - M) = \sum$. Then

$$\sum = Cov(X - M) = Cov(LF + \varepsilon),$$

and therefore, from the conditions imposed on F above,

$$\sum = LCov(F)L^T + Cov(\varepsilon),$$

or, setting $\Psi := Cov(\varepsilon)$,

$$\sum = LL^T + \Psi.$$

Note that for any orthogonal matrix Q, if we set $L' = LQ$ and $F' = Q^T F$, the criteria for being factors and factor loadings still hold. Hence a set of factors and factor loadings is unique only up to an orthogonal transformation.

Indexing economic sanctions

The most optimal method to index sanctions is to be able to identify variables that are inherently variable sanctions. Certainly achieving a single variable is much more convenient and to-the-point than having several variables. The factor analysis is a method, which based on it, a single index can be extracted [13].

Exploratory factor analysis in the context of orthogonal factors

The primary aim of factor analysis is to describe, if possible, the structure of covariance (correlation) between a large number of variables, performed via using invisible random values, called factors. If the variables are assumed to be grouped according to their correlation in such a way that all variables in a particular group are strongly correlated with each other, the factor analysis in the form of orthogonal factors is hereby analyzed. In orthogonal models, vector & matrix are random.

Calculating the sanctions index

First off, to estimate the desired pattern for calculating the effects of sanctions on the exchange rate, the sanctions index is computed. Variables affected by sanctions are first layer impact variables and are highly sensitive to the imposition of international economic sanctions and they are often considered by those nations slapping the sanctions on as the primary basis of whether the sanctions are working or not, meaning they are key variables of the country's economy. Table 1 stipulates the Iran sanctions index.

4.2 Markov switching method

A preliminary study of exchange rate behavior was performed using the Markov Switching Model by Engel & Hamilton (1990). They proved that the Markov Switching Model was a satisfactory estimation model for a limited amount of data (they used quarterly exchange rate data). Cheung & Lai (2001) also studied the Markov Switching Model to describe the behavior of eighteen exchange rates and the findings indicated that the Markov Switching Model was a sufficient model to predict the exchange rate. Also utilizing the Markov Switching Model, Engel & Hakkio studied the daily exchange rates of three countries against the US dollar. This study concluded that the data were satisfactory and well estimated by the model, however, the off-sample prediction was very poor due to the incompatibility of the parameters.

Many variables have portions where series behavior changes dramatically; Any macroeconomic variable or financial data over a long period of time will face multiple failures. Such apparent changes in time series may be the consequence of war, a general fear in financial markets, or significant changes in government policies [14]. It should be noted that if a process has undergone changes in the past, these changes may also occur in the future, and this should be taken into account in forecasts. Moreover, regime change should not be considered as a predictable and definite issue, and regime change itself is a random and exogenous variable. In the Markov Switching Model, the time series process is assumed to be a function of an unobserved random variable.

$$P\{S_t = j | S_{t-1} = i, S_{t-2} = k, \ldots, S_{t-n} = n\} = P\{S_t = j | S_{t-1} = i\} = P_{ij} \tag{4.2}$$

This is a Markov chain process with n regime with transition probabilities of p_{ij}, where p_{ij} represents the probability of transition from regime i to regime j [14].

$$P = \begin{bmatrix} P_{11} & P_{12} & \cdots & P_{1n} \\ P_{21} & P_{22} & \cdots & P_{2n} \\ P_{n1} & P_{n2} & \cdots & P_{nn} \end{bmatrix} \tag{4.3}$$

The element r of the j-th column and the name column of the opposite matrix express the probability P_{ij}, the probability that we have the j-regime after the i-regime. For example, p_{12} in the second row and first column indicates the possibility of a change from diet 1 to diet 2. (The same source). Markov switching statement can also be written as follows [22]: The model likelihood function is maximized using numerical calculation methods. Eviews software version 12 was used to estimate the above Markov switching function.

5 Data estimation & analysis

5.1 Factor analysis stages

Factor analysis stages for extracting the sanctions index are summarized as follows:

- Formation of a matrix of correlation coefficients of variables;
- Extraction of factors from the correlation coefficient matrix;
- Rotation of factors in order to maximize the relationship between variables and factors;
- Calculating the factor load (factor score) to determine the desired factors.

Commonalities

Table 2 displays the commonality of variables with factors in the non-rotating factor analysis mode, calculated via the principal component method.

The ratio of the variable to be estimated by the extracted factors (ratio of variance of variable common to the variance of the extracted factor) is estimated in the factor analysis. For example, 0.932% of the variance of the country's share of world crude oil production is common with the variance of extracted factors.

Sampling suitability test

Table 3 describes the sum variance of the available variables extracted by factors.

The specific value for the first factor is 5.291%. Since the maximum total variance estimated by the factors is obtained by dividing the first factor by 12 (number of variables affected by sanctions), the ratio of variance that can be estimated by the first factor is $089/44 = 100 \times (12 \div 291/5)$ declared in the % of variance column. As delineated, the second factor explicates 15.986 and the third factor 10.740% of the total variance of the 12 variables. The twelfth factor explains 0.088% of the total variance. The criterion of variance % explained by the factors is among the most significant criteria for determining the number of factors.

Matrix of components

This matrix contains the coefficients of twelve variables in the four extracted factors. When the factors are orthogonal (non-correlative with each other), these coefficients are the same as the correlation coefficients between the variables in the factors; Therefore, the greater the absolute value of these coefficients (not greater than the unit value), the greater the role of the factors in the total variance of the numbers in the variable. This matrix is stipulated in Table 4. The oil price index plays the most vital role in the first factor.

Component matrix

In line with the component matrix scores in factors, the particulars of factors is thereafter extracted. For this purpose, according to the mean information and variance of the variables affected by the sanctions (in Table 1), these variables are converted into normal standard variables utilizing the Kolmogorov-Smirnov Test and multiplied by the score of each variable in each factor and the sum of twelve components. The corresponding numerical value of each factor was extracted. Table 5 calculates the values for the sanctioned factor.

5.2 Model estimation

The information required in this study were collected from databases such as the CBI, the National Statistics Center and the World Bank (WDI, 2021) and thereafter calculated and estimated in Excel files and SPSS 26 software. Toward this objective, pursuant to accurately introducing the indicators and variables affected by the sanctions and calculating the related descriptive statistics, the extraction of common factors was conducted.

The statistical summary of the variables is presented in Table 6.

Prior to unveiling the findings, it was requisite to perform a reliability test. The outcome of the Dickey-Fuller reliability test are presented in Table 7.

As evidenced above, all model variables are stable/reliable with a significance level of 5%.

The research model can be estimated via the Markov Switching Model with two exchange rate regimes. First, our estimate of the research model via utilizing the Markov Switching Method. The findings of the research model estimation for the Iranian economy between 1984-2014 are detailed in Table 8. Since the production coefficient was not reliable, it was not included in the findings.

The findings tell us that the exchange rate in the Iranian economy follows two regimes, regime 1 (characterized by low average exchange rate and high standard deviation) and regime 2 (characterized by high average exchange rate and low standard deviation). By deploying the Markov Switching Model, the transfer probability matrix, representing the transition between exchange rate regimes, is also estimated, as displayed hereinafter:

$$P=\begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix} = \begin{bmatrix} 0.93 & 0.06 \\ 0.19 & 0.80 \end{bmatrix} \tag{5.1}$$

This matrix indicates that the probability of staying in regime 1 low exchange rate is 93% and the probability of staying in regime 2 high exchange rate is about 80%. In addition, the probability of transition from regime 1 to regime 2 is about 19% and the probability of transition from regime 2 to regime 1 is about 6%. These probabilities demonstrate that the probability of staying in regime 1 or the low exchange rate regime is higher than the probability of staying in the high exchange rate regime. Moreover, the probability of transition from the low exchange rate regime is higher than the opposite probability (due to the low exchange rate's stability in the country).

Figures 1 and 2 reveal the probability of being in the upper and lower regimes at any point in time, based on which it can be stated that the duration of staying in the low exchange rate regime has been 15.5 years and the duration of staying in the high inflation regime has been 5.18 years.

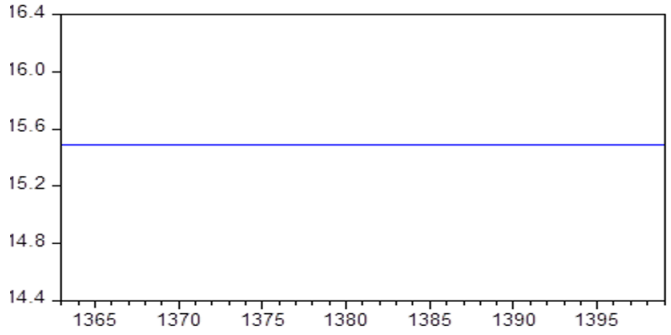

Figure 1: Conditional probabilities smoothed out of low exchange rate regime (regime 1)

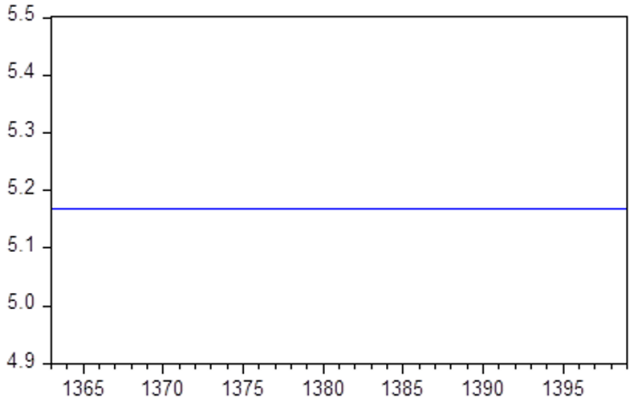

Figure 2: Conditional probabilities smoothed out of low exchange rate regime (regime 2)

Furthermore, the findings of model estimation demonstrate that inflation hikes positively and significantly impact the exchange rate (clear and obvious in line with monetary principles).

6 Conclusion

The sanctions that the country encountered at the beginning of the revolution were mostly political, but those of the last few years are more economically focused, the most obvious of which are the sanctions against the CBI and commercial banks, the petroleum industry, etc. Sanctions indirectly affect the exchange rate. Given the decades-long history of economic sanctions against the Islamic Republic of Iran, one of the most important steps to counter sanctions is the adoption of appropriate policies to strengthen the country's economy against the destructive effects of sanctions.

In this study, the impact of economic sanctions on the exchange rate in the Iranian economy (1985-2021) was assessed and the factor quantification method was utilized to quantify the sanctions index.

Due to the lack of econometric studies in the field of sanctions modeling, this study deployed the Markov switching modeling for assessing the direct effects of sanctions on the exchange rate and its indirect effects (via the exchange rate) on the macroeconomic variable of inflation. In this paper, two models were utilized with Markov switching specification (since the exchange rate in the Iranian economy follows two systems). (4.1) with low average exchange rate characteristic and high standard deviation, and (4.2), with the average exchange rate characteristic being high and standard deviation being low. The probabilities also demonstrate that the probability of transition from a low exchange rate system is higher than the opposite probability (due to the stability of the low exchange rate in the country). The findings of the model estimate also reveal that economic sanctions have a small and positive effect on the exchange rate, while the effect of inflation has a positive effect on the exchange rate.

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Table 1: Variables utilized in economic sanctions on iran

Row	Variable Impacted By Sanctions	Comments/Explanations	Source
1	Imported Goods Price Index (PM)	Base Year Is 2012. For Data Of Last Two Months, Implicit Index Of National Accounts Imports Was Utilized	Central Bank Time Series Data & National Central Bank Accounts
2	Exported Goods Price Index (PX)	Base Year 2012	Central Bank Time Series Data & Central Bank Indicators
3	Exchange Relationship (PX PM)	Obtained From Ratio Of Price Index Of Exported To Imported Goods	-
4	Country's Share Of Global Crude Oil Production (OILPS)	Ratio Of Iran Compared To World Crude Oil Production	BP Statistical Review of World Energy, 2011
5	Country's Share Of Global Export of Crude Oil (OILEXS)	Ratio Of Iran Compared to World Crude Oil Exports	BP Statistical Review of World Energy, 2011
6	Country's Share Of Foreign Direct Investment (FDIS)	Share Of Annual Foreign Direct Investment In Iran Relative To The World	UNCTAD Time Series Database
7	US Share Of Iran's Foreign Trade (USIRITR)	Ratio of Iran's Foreign Trade With The United States To The Total Volume Of Iran's Trade	United States Census Bureau
8	Premium Exchange Rate (PEREX)	Ratio Of Official Exchange Rate Difference From exchange rate to the official exchange rate	Central Bank Time Series Information & Central Bank Indicators
9	Exchange Rate Variance (VAREX)	Variance Of Official & Unofficial Exchange Rate Differences Based On Quarterly Exchange Rate Data	Central Bank Time Series Information & Central Bank Indicators
10	Ratio Of Non-Oil Trade Balance To GDP (TDNOIL)	Calculated By Dividing Real Non-Oil Trade Balance By GDP	National Central Bank Accounts
11	Country's Share Of Global Air Travel (PASAIR)	Calculated Via Dividing Number Of Iranian Air Passengers By Number Of Global Air Passengers	World Bank Time Series Bank
12	Ratio Of Country's Air Fatalities Compared To The World (PASAIR)	Calculated Via Ratio Of Cumulative Number Of People Killed In Airline Crashes in Iran Compered To The Rest Of The World	World Air Accident Database (www.planecrashinfo.com)

Source: [13]

Table 2: Commonalities of variables with factors in non-rotating factor analysis mode

Variable	Preliminary	Extraction
PM	1	0.932
PX	1	0.826
PMPX	1	0.770
OILPS	1	0.940
OILEXS	1	0.932
FDS	1	0.715
USIRITR	1	0.688
PERMEX	1	0.531
VAREX	1	0.855
TDNOIL	1	0.890
PASAIR	1	0.761
DEADAIR	1	0.918

Table 3: Total variance of available variables extracted by factors

Special Quantities				Extracting The Sum Of Squared Loads		
Cumulative %	Total	% Of Variance	Cumulative %	Total	% Of Variance	Cumulative %
1	5.291	44.089	44.098	5.291	44.089	44.089
2	1.918	15.986	60.075	1.918	15.986	60.075
3	1.289	10.740	70.815	1.289	10.740	70.815
4	1.262	10.513	81.328	1.262	10.513	81.328
5	0.615	5.127	86.454			
6	0.514	4.280	90.734			
7	0.449	3.741	94.475			
8	0.364	3.036	97.511			
9	0.232	1.933	99.445			
10	0.038	0.317	99.762			
11	0.018	0.150	99.912			
12	0.011	0.088	100.00			

Table 4: Matrix of orthogonal components

	Components			
	1	2	3	4
PM	0.943	-0.192	0.065	0.035
PX	0.850	-0.189	-0.231	0.119
PMPX	-0.463	0.077	-0.608	0.424
OILPS	0.135	0.880	-0.011	0.383
OILEXS	-0.784	0. 551	-0.0070	0.95
FDS	0.661	0.339	-0.034	-0.403
USIRIT	-0.568	0.313	0.517	-0.012
PERMEX	-0.715	0.100	0.072	0.071
VAREX	0.166	-0.187	0.750	0.480
TDNOIL	0.776	0.444	-0.032	0.301
PASAIR	0.337	0.548	0.133	0.574
DEADAIR	-0.904	-0.083	-0.026	-0.304

Table 5: Sanctions index calculated values

Year	Sanctions Index	Year	Sanctions Index
1363	17.12	1382	4365.24
1364	101.04	1383	6850.96
1365	2486.76	1384	3277.95
1366	2004.76	1385	1252.95
1367	16914.73	1386	819.31
1368	2163.79	1387	67591.94
1369	504.65	1388	2075.56
1370	523.79	1389	36548.33
1371	1794.29	1390	4226005.82
1372	3034.1	1391	32032513.24
1373	11069.8	1392	3278384.34
1374	56572.06	1393	817994.59
1375	31102.98	1394	802195.53
1376	4669.85	1395	1503820.53
1377	476521.7	1396	5761296.68
1378	51209.88	1397	25651220.03
1379	15488.79	1398	63344980.49
1380	57.58	1399	973944354.1
1381	400.07		

Source: Researcher Calculations

Table 6: Variables (statistical summary)

	Average	**Max.**	**Min.**	**Standard Deviation**
PEX	109.9105	109.9105	109.9105	109.9105
SAN	98692783	98692783	98692783	98692783
INF	128.9743	708.08	-7.44	192.4091

Table 7: Dickey-fuller reliability test results for variables

	Statistical Value	Critical Statistics	Probability	Reliability test
DPEX	**-3.4209	-2.9810	0.0417	Reliable
DSAN	**-5.4060	-2.9718	0.02359	Reliable
DINF	**-9.2321	-2.6128	0.0000	Reliable

**: Significance Level 5%

Table 8: Exchange rate model estimation via Markov switching method findings

	Coefficient	Standard Deviation	Z-Stat	Probability
C In Regime 1	**372.42	41.24176	9.030	0.0000
C In Regime 1	**36.43	15.53159	2.345	0.0190
SAN	**1.59E-07	2.90E-08	5.475	0.0000
INF	**2.23	1.69038	1.321	0.1863
LOG (SIGMA)	**4.21	0.146038	28.837	0.0000

* Source: Research Calculations Via Eviews-12 Software