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Original Research Article

Time Varying Causality Between Official and Unofficial Exchange Rates in Iran

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The daily unofficial exchange rate is crucial role in economic agents' decision-making and expectations in Iran. Hence, policymakers have tried to manage the unofficial market by promoting the official exchange rates as a leading price. In this regard, they have established official platforms for foreign exchange transactions. This study investigates the causal relationship between exchange rates discovered on the platforms and unofficial exchange rates by employing the Hong time-varying causality test based on the DCC-MGARCH method. Empirical results show a unilateral causal effect between the unofficial and official exchange rates. The instantaneous causality test results show an instantaneous unilateral causality from unofficial to official exchange rate over the whole period. However, the reverse is only found for some special sub-periods, such as when the extent of sanctions decreases, and the possibility of the Central Bank's intervention increases.

Keywords: Unofficial Exchange Rates; Official Exchange Rates; DCC-MGARCH; Information Spillover
JEL Classification*:* C10, G14, F31

1 Introduction

Due to foreign exchange controls and government interventions in the foreign exchange market, an unofficial foreign exchange market emerges, which is more common in developing countries (Diamandis & Drakos, 2005; Bahmani-Oskooee et al., 2002; Bouazizi, 2020; Sundar et al., 1997). The unofficial exchange market is sometimes called the black market (if its transactions are announced as illegal) or parallel market. It is formed by the interactions of the demand and supply excluded from the official market (Baliamoune-Lutz, 2010; Bahmani-Oskooee et al., 2002). The main

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incentives for entering this unofficial market on the demand side are investment portfolio diversification, coping with macroeconomic uncertainties, maintaining the purchasing power of wealth against domestic inflation, getting foreign exchange to do illegal foreign transactions, and capital flight. On the supply side, the main incentive is selling foreign exchange at higher prices than the official rate, in which suppliers request higher prices to offset the risks related to supply in illegal markets (Diamandis, 2001).

In developing countries with an exchange rate anchor monetary policy framework, the exchange rate plays a crucial role in forming inflation expectations. In some cases, foreign exchange controls and direct government interventions in the official exchange rate cause the unofficial exchange rate to become the basis for expectations. Due to the similarity of exchange rate characteristics in the unofficial market to the free market, the unofficial exchange rate becomes a critical factor in determining expectations, thereby increasing its importance in the policy-making process. In many developing countries, policymakers consider foreign exchange control and the official exchange rate setting or manipulation as a policy tool to influence the informal exchange rate, underscoring its relevance in their decision-making (Caporale et al., 2018).

Since Iran's monetary policy framework has been based on the exchange rate anchor, exchange rate changes are crucial role for policymakers. Following the unification of exchange rates in the 2000s, the de jure exchange arrangement was a managed floating exchange rate system. In practice, however, the de facto exchange rate arrangement is classified as a peg arrangement relying on the increase in oil exports over the decade. As a result, the monetary policy framework has shifted to the exchange rate anchor, which has remained unchanged according to the International Monetary Fund's annual report, AREAER[1] 2020. For this reason, the exchange rate is one of the critical variables in the Iranian economy. The significant impact of the exchange rate on the formation of inflation expectations has caused it to be considered a sensitive variable from a social and political point of view.

The decline in foreign reserves after the 2018 oil sanctions meant policymakers could not continue stabilizing the exchange rate in a free market. Therefore, the government tried to prevent the IRR's devaluation through foreign exchange controls. One of the side effects of foreign exchange controls is the formation of an unofficial foreign exchange market with higher prices

[1] Annual Report on Exchange Arrangements and Exchange Restrictions

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than official markets (Bahmani-Oskooee et al., 2002). It happened in Iran in 2018, and the exchange rate in this market has become higher than that of the official market. Due to the lack of direct intervention of the central bank in the unofficial market, exchange rate fluctuations in this market have increased. The policymaker uses the official market intervention strategy to manage the unofficial market to prevent the adverse effects of these fluctuations. Examining the causal relationship between the official and unofficial exchange rates shows whether it is successful.

This study examines the causal relationship between official and unofficial exchange rates to evaluate the success of the government's strategy. We employ time-varying Granger causality as outlined in Hong (2001) and extended by Lu et al. (2014). The advantage of using this method is estimating causal changes over time. This means that causality is estimated in each period and therefore changes over time. We use Dynamic Conditional Correlation Multivariate Generalized Autoregressive Conditional Heteroskedasticity (DCC-MGARCH) Hong tests to investigate the extent to which the nature of information spillover between the official and unofficial foreign exchange markets in Iran. The results show that this strategy did not lead to the unofficial market's management, contrary to the government's goal. Conversely, the unofficial exchange rate was the cause of changes in the official exchange rate. The paper is structured as follows: Section 0 briefly reviews the relevant literature. Section 0 describes the theoretical framework and method. Section 0 introduces the data and presents the empirical results. Section 0 provides concluding remarks.

2 Review of Literature

A literature review on the multiple exchange rate systems shows widespread studies on the relationship between official and unofficial exchange rates using different econometric methods with different results for different countries and periods. Nevertheless, most studies emphasize short-run and long-run relationships between official and unofficial exchange rates. Bui (2018) studies the relationship between official and unofficial exchange rates (US dollar) using Johansen's co-integration method and Granger causality test in Vietnam and finds a long-run relationship between official and unofficial exchange rates. Examining the short-run dynamics between two exchange rates using the error correction model (ECM) and Granger causality test shows a unilateral causal effect from the official rate to the unofficial market rate. This finding is true for both stable and volatile periods, implying the rejection of the unofficial market efficiency hypothesis, which contends a leadership

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for the unofficial market exchange rate in official exchange rate determination.

Chaudhry & Butt (2014) examine the relationship between official and unofficial exchange rates using the Autoregressive Distributed Lag method (ARDL), error correction model, and Toda and Yamamoto causality test for Pakistan. Their findings show a long-run relationship between the two exchange rates. However, the unofficial exchange rate does not decrease proportionately in response to the decrease in the official exchange rate. Therefore, the hypothesis that implies a stable unofficial market premium as one of the implications of portfolio balance or currency substitution approach is rejected. Also, examining causality implies a unilateral causal effect from unofficial to official exchange rate.

Kula & Aslan (2014) study the long-run and the short-run relationship between official and unofficial exchange rates for 13 MENA countries. Based on the panel co-integration method in a pooled mean group framework, their findings imply a long-run relationship between both rates. The coefficient on the effect of the official rate on the unofficial market rate in the long-run does not differ significantly. It confirms the hypothesis of a stable unofficial market premium. Nevertheless, although statistically significant, the estimated coefficient in the short-run is quite different from unity, implying the rejection of co-integration in the short-run.

Baliamoune-Lutz (2010) analyzes the relationship between official and unofficial exchange rates in Morocco using the Johansen co-integration method and shows a long-run relationship between both rates. The Johansen weak exogeneity test results reject the official exchange rate exogeneity hypothesis, but the unofficial exchange rate exogeneity is not rejected. In addition, the Granger causality test shows a unilateral causal effect from the unofficial market exchange rate on the official rate, implying acceptance of the efficient unofficial market hypothesis. Caporale & Cerrato (2008) examine the long-run and short-run relationship between official and unofficial market exchange rates for India, Iran, Indonesia, South Korea, Pakistan, and Thailand using time series and panel data methods. Their findings confirm these relationships, but the proportionality restriction of the portfolio balance approach does not hold. In other words, the coefficient of the long-run relationship between two rates needs to be uniform, and adjustment to long-run equilibrium in response to short-run shocks needs to be completed.

Love & Chandra (2007) examine the long and short-run relationship between official and unofficial exchange rates for India by using the Johansen co-integration method. The findings show that the long-run elasticity of the

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official exchange rate to the unofficial exchange rate is 1.4, implying the rejection of the stable unofficial market premium hypothesis. In addition, the unofficial exchange rate has a unilateral causal effect on the official exchange rate.

Using a bound testing approach, Bahmani-Oskooee & Tanku (2006) examine the causality between official and unofficial exchange rates for 27 developing countries. Their results imply that the countries under study could be classified into four groups. The first one, which consists of 10 countries, has bilateral long-run relationships between official and unofficial exchange rates. The second one consists of 12 countries, and there is a unilateral causal effect from the unofficial exchange rate to the official exchange rate. The third group comprises of three countries with unilateral causality from official to unofficial rates. Finally, there is no causality between the two exchange rates in the fourth group, which consists of two countries.

Bahmani-Oskooee et al. (2002) delve into the long-run relationship between official and unofficial exchange rates for 49 countries using the panel data co-integration approach. Their findings suggest that government intervention in the exchange market or control of the official exchange rate can lead to a deviation of the official rate from the unofficial rate, but only in the short-run.

Apergis (2000) investigates the causality between official and unofficial exchange rates in Armenia for different time periods. His findings reveal a dynamic relationship, with the period under study (1993-1997) showing distinct sub-periods. Between November 1993 and May 1994, there is causality from the unofficial exchange rate to the official exchange rate. However, over the sub-period from November 1994 to January 1997, the causality shifts from the official to the unofficial exchange rate. Interestingly, for a short time period between these two sub-periods, there is bilateral causality.

3 Theoretical Framework and Methodology

The Granger test was introduced to analyze statistical causality between variables. Following this pioneering method, there have been many contributions to investigating causality and information spillover between variables. One approach is based on a constant causality over time, including the Granger test, Sims test, Hsiao test, Toda and Yamamoto test, and Bounds test. The second approach analyzes the dynamic relationship between variables and considers time-varying causality over time. Non-linear Methods, Quantile Regression-Based Approaches, and Wavelet Transforms

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are the most important. One of the methods that have been of interest recently is the Hong Time-Varying Causality test introduced by Lu et al. (2014). One of the advantages of this test is paying attention to the dynamic causality relationship between variables and identifying periods in which a considerable causality exists between time series (Jammazi et al., 2017). This test is based on estimating the Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroscedasticity Model introduced by Engle & Sheppard (2001) and Engle (2002). In this test, ARMA-GARCH is first estimated for every stationary time series under study. This step aims to omit autocorrelation, create standard residuals, and get a time-varying standard deviation matrix. Then, variables transformed using time-varying standard deviation are used to create a conditional covariance matrix and estimate dynamic conditional correlation coefficients. Finally, Hong's time-varying test statistic is computed employing dynamic conditional correlation coefficients to evaluate information spillover effects.

In this paper, to examine the dynamics of the causal interaction between official and unofficial exchange rates in Iran, daily returns in these two markets are computed as follows:

$$SER_t = ln(SAER_t/SAER_{t-1}) \times 100 \quad (1)$$
$$UER_t = ln(UNER_t/UNER_{t-1}) \times 100 \quad (2)$$

SER and UER are daily returns of official and unofficial exchange markets and SAER and UNER are official and unofficial exchange rates, respectively.

Based on Lu et al. (2014), a DCC-MGARCH process for vector $Z_t(j)$ is introduced, in which j stands for lag j:

$$Z_t(j)|I_{t-1} \sim N\left(0, D_{t,j}R_{t,j}D_{t,j}\right) \qquad Z_t(j) = \begin{pmatrix} SER_t \\ UER_t \end{pmatrix} \quad (3)$$
$$D_{t,j}^2 = diag\{\omega_{i,j}\} + diag\{\kappa_{i,j}\} \circ Z_t(j)Z_t'(j) + diag\{\lambda_{i,j}\} \circ D_{t-1,j}^2$$
$$u_{t,j} = D_{t-1,j}^{-1}Z_t(j)$$
$$Q_{t,j} = S \circ (ll' - A - B) + Au_{t-1,j}u_{t-1,j}' + BQ_{t-1,j}$$
$$R_{t,j} = diag\{Q_{t,j}\}^{-1}Q_{t,j}diag\{Q_{t,j}\}^{-1}$$

$Z_t(j)$, Usually a DCC-MGARCH (1, 1) is used in empirical studies. After estimating this model, dynamic conditional correlation coefficients for lag j are obtained as follows:

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$$\rho_{pq,t}(j) = \overline{\rho_{pq}}(j) + \alpha_j \left(u_{p,t-1}u_{q,t-1-j} - \overline{\rho_{pq}}(j)\right) + \beta_j \left(\rho_{pq,t-1}(j) - \overline{\rho_{pq}}(j)\right) \quad (4)$$

$$r_{pq,t}(j) = \frac{\rho_{pq}(j)}{\sqrt{\rho_{11,t}\rho_{22,t}(j)}} \qquad p,q = 1,2$$

Based on dynamic conditional correlation coefficients derived from DCC-MGARCH, the Hong time-varying causality test has been introduced to judge the causality linkage between two variables. These tests conclude unidirectional causality from SER to UER (and vice versa), bidirectional causality between SER and UER, and instantaneous causality from SER to UER (and vice versa).

Since nonsynchronous trading is common in financial markets, ignoring contemporary information transfer may result in incorrect findings. For example, suppose there is nonsynchronous trading in markets A and B. If market A is opened before market B is closed, or there is alternation in their trading, using a unidirectional causality test to judge information spillover between them is misleading. The reason is that there is no information spillover from B market to A market, but there may be instantaneous causality or vice versa. Therefore, according to nonsynchronous trading in two markets, it is probable that return moments will be disturbed. The instantaneous causality test uses the cross-correlation function of lag zero to omit nonsynchronous information spillover from market B to market A. In the instantaneous causality test, only synchronous interactions between two markets are considered (Lu et al., 2014; Kanda et al., 2018). Practically, opening and closing the official exchange market in Iran is different from the unofficial market. Specifically, trading continues in the unofficial market after closing the official market. Therefore, it is possible that trading in the unofficial market will affect the official exchange rate the next day. A bidirectional causality test can be used to examine time-varying market integration. Test statistics are as follows:

$$H_{1,t}(k) = \frac{T\sum_{j=1}^{T-1} k^2\left(\frac{j}{M}\right) r_{12,t}^2(j) - C_{1T}(k)}{\sqrt{2D_{1T}(k)}} \quad (5)$$

$$H_{2,t}(k) = \frac{T\sum_{j=2-T}^{T-2} k^2\left(\frac{j}{M}\right) r_{12,t}^2(j) - C_{2T}(k)}{\sqrt{2D_{2T}(k)}} \quad (6)$$

$$H_{3,t}(k) = \frac{T\sum_{j=0}^{T-2} k^2\left(\frac{j+1}{M}\right) r_{12,t}^2(j) - C_{1T}(k)}{\sqrt{2D_{1T}(k)}} \quad (7)$$

K is Kernel function and M is a positive integer, $C_{1T}(k)$, $D_{1T}(k)$, $C_{2T}(k)$, and $D_{2T}(k)$ are as follows:

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$$C_{1T}(k) = \sum_{j=1}^{T-1}\left(1-\frac{j}{T}\right)k^2\left(\frac{j}{M}\right) \quad (8)$$
$$D_{1T}(k) = \sum_{j=1}^{T-1}\left(1-\frac{j}{T}\right)\left(1-\frac{j+1}{T}\right)k^4\left(\frac{j}{M}\right)$$
$$C_{2T}(k) = \sum_{j=1-T}^{T-1}\left(1-\frac{|j|}{T}\right)k^2\left(\frac{j}{M}\right)$$
$$D_{2T}(k) = \sum_{j=1-T}^{T-1}\left(1-\frac{|j|}{T}\right)\left(1-\frac{|j|+1}{T}\right)k^4\left(\frac{j}{M}\right)$$
$$R_{t,j} = diag\{Q_{t,j}\}^{-1}Q_{t,j}diag\{Q_{t,j}\}^{-1}$$

It is impossible to estimate all lagged dynamic correlations in the Hong causality test. This problem is solved by choosing an appropriate Kernel function. As shown in Hong (2001), the choice of non-uniform Kernels and the value of M have trivial effects on the Hong test. In addition, dynamic correlations for large lags approach zero in financial markets. Therefore, Bartlett Kernel is used in empirical research, which is as follows:

$$k(z) = \begin{cases} 1-|z|, |z|<1 \\ 0, |z|\geq 1 \end{cases} \quad (9)$$

When $j \geq M$, Bartlett Kernel is zero, $(k(j/M)=0)$. Therefore, we just need correlation coefficients of lag $M > j > -M$. According to Lu et al (2014), the value of M is 10.

Hong time-varying causality test statistic for null hypothesis of non-existence of causal relationship are asymptotically distributed with mean zero and variance equal one. The test introduced by Lu et al. (2014) is one-sided test. So, to decide about hypotheses, the critical values of upper-tailed are used. If test statistic $H_{i,t}(k)$ is greater than critical values of standard normal distribution, the null hypothesis of no causality is rejected.

4 Data and Empirical Results

In this study, official and unofficial market exchange rates are used. Data are daily over the period from September 2015 to November 2021. Data is taken from www.tgju.org. Official and unofficial exchange rates in natural logarithm form are shown in Figure 1.

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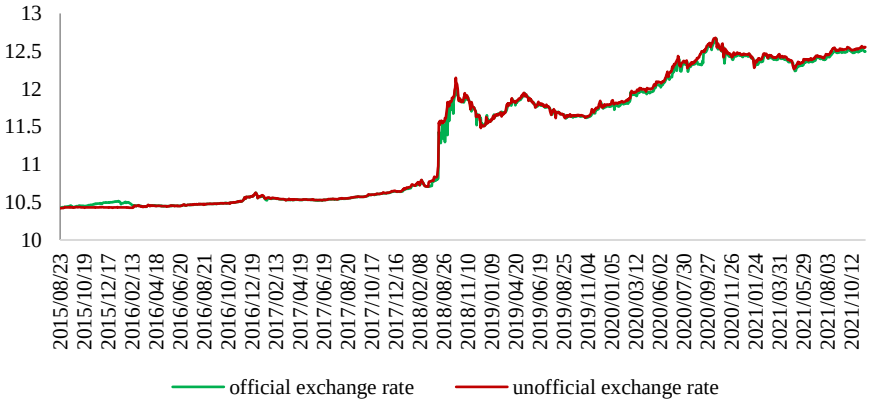

Figure 1. Official and unofficial exchange rates in natural logarithm form.
Source: own illustration, data taken from https://www.tgju.org/

As Figure 1 shows, there is very high co-movement between the two exchange rates. Figure 2 and Figure 3 are daily returns for official and unofficial exchange markets, respectively. It is evident that there are clustered fluctuations phenomena in both series. This could indicate the existence of variance heterogeneity in the series under study.

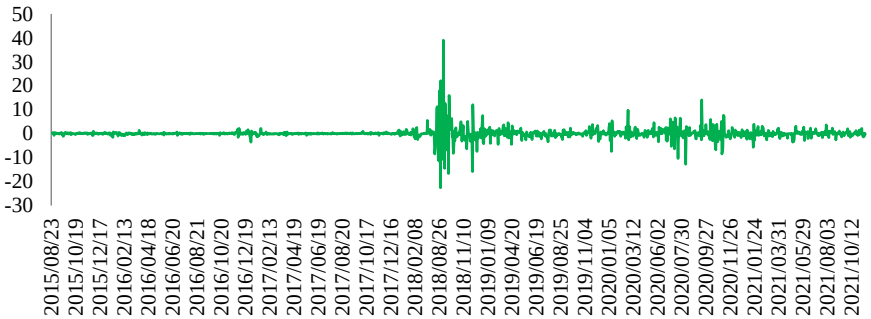

Figure 2. Rate of return of official exchange market.
Source: own illustration, data taken from https://www.tgju.org/

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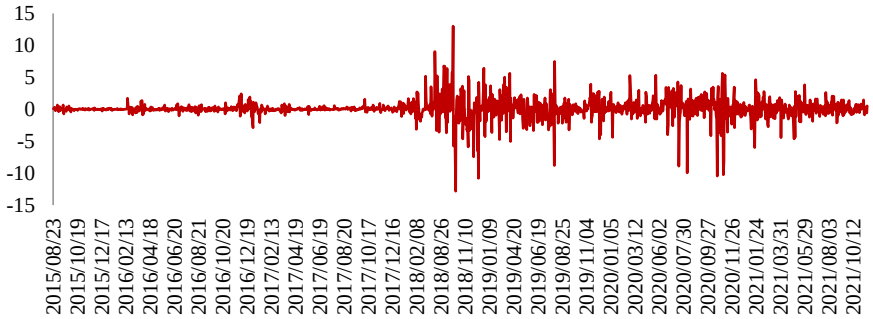

Figure 3. Rate of return of unofficial exchange market.
Source: own illustration, data taken from https://www.tgju.org/

Some of the most important descriptive statistics for the daily rate of return of official and unofficial exchange markets are shown in Table 1. The mean daily return rates of return for official and unofficial exchange markets are 0.09 and 0.1, respectively. Since the variation range for official and unofficial exchange markets are 61.62 and 25.82 percent, respectively, the official exchange rate has lower fluctuations (also, the coefficients of variation for official and unofficial exchange rates are 15.82 and 25.43, respectively). The coefficients of skewness and kurtosis are 2.88 and 72.57 for the rate of return of the official exchange rate, respectively, which means the probability density function of this variable has positive skewness and kurtosis and implies asymmetry of its distribution around the mean. However, these coefficients are -0.78 and 18.11 for the rate of return of the unofficial exchange rate, respectively. This means negative skewness and positive kurtosis for this distribution. The two series' more extended distributions could indicate too many pessimistic and optimistic expectations among traders. Jarque-Bera statistics for the rate of return of official and unofficial exchange markets imply their distributions are not typical.

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Table 1
Descriptive statistics for the rate of returns of official and unofficial exchange markets.

Statistics	Official exchange market return	Unofficial exchange market return
Mean	0.09	0.1
Maximum	39.05	13.01
Minimum	-22.57	-12.83
Standard Deviation	2.35	1.58
Coefficient of Skewness	2.88	-0.78
Coefficient of Kurtosis	72.57	18.11
Jarque-Bera Test	320629.5	15182.64
Jarque-Bera Prob.	0.00	0.00
Augmented Dickey-Fuller Test	-9.67	-36.95
Augmented Dickey-Fuller Prob.	0.00	0.00
Box-Pierce Test	91.36	11.64
Box-Pierce Prob.	0.00	0.04
Number of Observation	1579	1579

Source: Research findings

Based on the Augmented Dickey-Fuller statistic, we have established a unit root in the rate of return of official and unofficial exchange markets. Furthermore, the Box-Pierce statistic for lag 5 indicates the presence of autocorrelation in the rate of returns. This underscores the importance of the GARCH model, which can effectively account for the effects of clustered fluctuations, providing a deeper understanding of market dynamics.

The causality between official and unofficial exchange rates is examined using the Hong time-varying causality test. This test considers information spillover effects between official and unofficial exchange rates for three states: unidirectional, bidirectional, and instantaneous. Unidirectional causality test statistics from unofficial to official exchange rate and official to unofficial exchange rate are shown in Figure 4 and Figure 5, respectively. In addition, instantaneous causality test statistics from unofficial to official exchange rate and official to unofficial exchange rate are shown in Figure 6 and Figure 7, respectively. The bidirectional causality test statistic is shown in Fig. 8. Since economic and political shocks have affected exchange rates, the statistics are interpreted alongside these shocks to understand exchange rate movements better. Firstly, the statistics trends imply time-varying information spillover between official and unofficial markets. Therefore, ignoring the leadership assessment in the exchange rate markets causes policymakers to make convoy mistakes. In addition to the test statistics, their long-run trends are estimated using the Hodrick-Prescott filter and shown in the corresponding figures. The

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statistics are compared to the critical value at 1 percent (2.58). So, the null hypothesis is rejected.

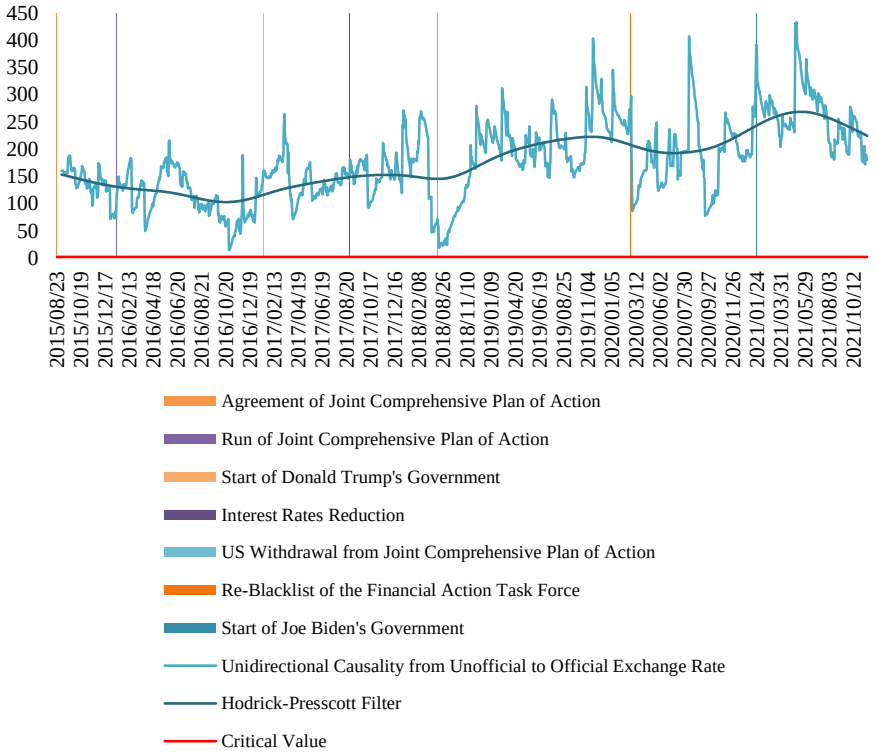

Figure 4. Unidirectional causality from unofficial to official exchange rate.
Source: Research Findings

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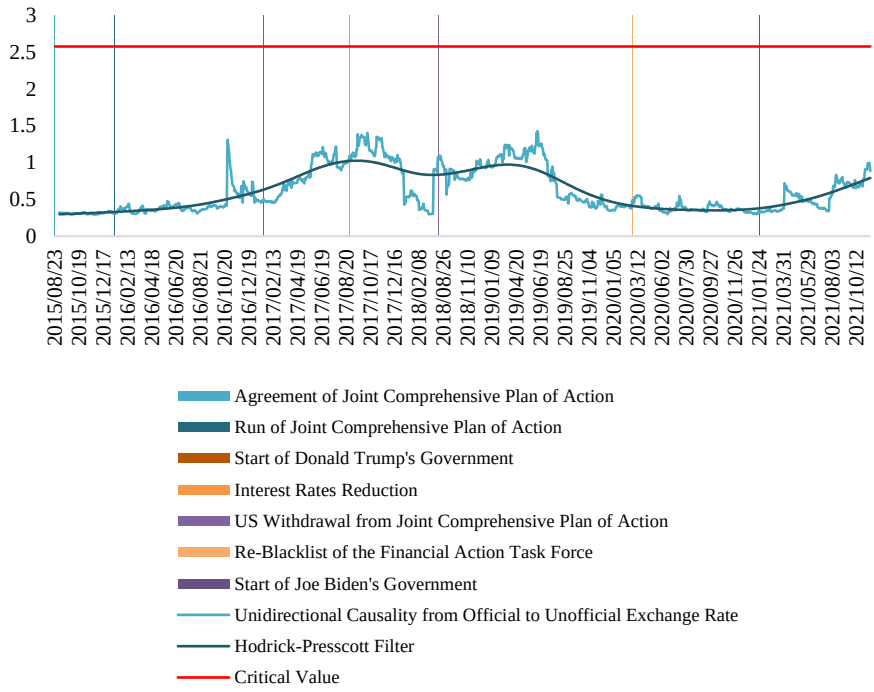

Figure 5. Unidirectional causality from official to unofficial exchange rate.
Source: Research Findings

As Figure 4 shows, the null hypothesis is rejected for all the periods under study by comparing the time-varying causality test to its critical value. Therefore, there is unidirectional causality from unofficial to official exchange rate. Also, it is seen that the trend of the test statistic is decreasing for sub-periods in which there have been optimistic expectations like JCPOA (the agreement between Iran and six world powers consisting of the US, the UK, Russia, China, France, and Germany on nuclear talks) and its implementation or when the interest rates have increased. On the other hand, the announcement that the US will exit the JCPOA has increased the spillover of information from unofficial to official markets. This increasing trend in statistics implies an increase in the leadership power of the unofficial market in Iran's exchange market.

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Figure 5 illustrates that the test statistic for unidirectional causality from the official to the unofficial exchange rate is consistently lower than the critical value (2.58) for the entire period. This indicates the absence of unidirectional causality from the official to the unofficial exchange rate, as the null hypothesis is not rejected.

As mentioned above, the instantaneous causality test omits the effects of nonsynchronous trading and their effects on the information spillover in two markets. The results are shown in Figure 6 and Figure 7. As figure 6 shows, there is unidirectional instantaneous causality from unofficial to official exchange rate because the test statistic is higher than the critical value for the whole period. However, Figure 7 shows unidirectional causality from official to unofficial exchange rate only for some sub-periods because the test statistic is significant. This means the information spillover from the official to the unofficial market only for those sub-periods. Therefore, it is concluded that although there is no unidirectional causality from the official to the unofficial exchange rate, there is an instantaneous spillover of information from the official to the unofficial market. This could be attributed to nonsynchronous trading in two markets or to the high speed of information spillover between two markets. In other words, the causality from official to unofficial exchange rate is evident for higher frequency.

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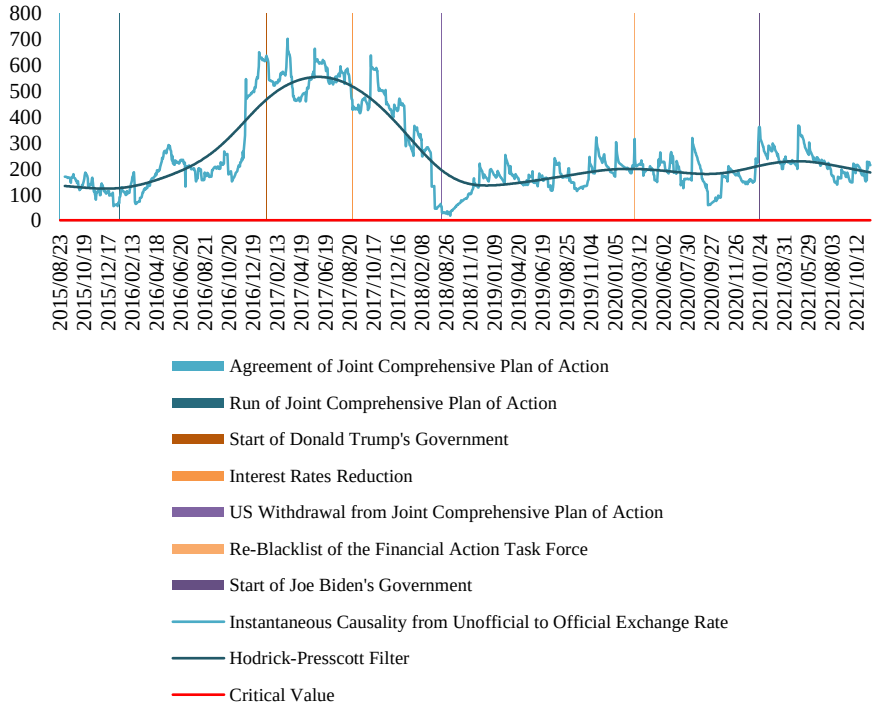

Figure 6. Instantaneous causality from unofficial to official exchange rate.
Source: Research Findings

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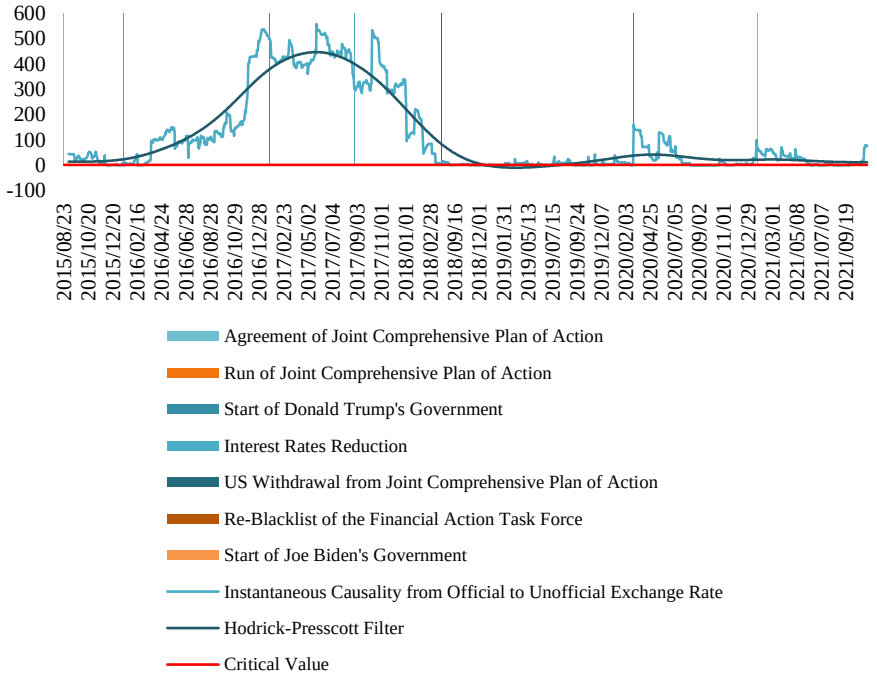

Figure 7. Instantaneous causality from official to unofficial exchange rate.
Source: Research Findings

To complement what the test statistics imply, we trace the economic and political events affecting the exchange rate during the period under study. After the JCPOA and its approval by the Security Council in July 2015, optimistic expectations caused the unidirectional causality test from official to unofficial exchange rate to become significant. However, after the sharp decrease in the oil price and oil income and, therefore, the decrease in the supply of foreign exchange in a few months, the test statistic decreased and became less than the critical value. Again, the implementation of the JCPOA resulted in lower restrictions on oil exports, better financial relations with other countries, lower transaction costs for foreign exchange transactions, and more access to foreign exchange reserves. On the other hand, it became possible for the central bank to intervene in the exchange market to stabilize the exchange rate (the then central bank governor had declared about an 18-billion-dollarcash intervention in 2015-2016). As a result of the above-

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mentioned developments, unidirectional test statistics from official to unofficial exchange rate increased substantially. After the US presidential election in 2016, it became quite probable that the suspension of the sanctions would not be extended and that the US would exit the JCPOA, which implied another shock to the exchange market. On the other hand, the rates of interest on deposits were lowered in 2017. As is seen, these developments brought about a decreasing trend in the unidirectional causality test statistic from official to unofficial exchange rate. Speculative attack in the exchange market in 2018, the announcement of subsidized exchange rate for some imports, the lack of financial instruments to manage the foreign exchange demand, the exit of the US from JCPOA, the impositions of new sanctions, and the impossibility of the widespread cash intervention of the central bank in the exchange market caused the official market to lose its instantaneous leadership for unofficial traders. Therefore, the unidirectional causality test statistic from official to unofficial exchange rate has decreased and has remained low for about two years. In early 2020, the relationship between official and unofficial exchange rates was influenced by two concurrent developments: The COVID-19 pandemic and the stock market bubble. The restrictions related to the pandemic lowered the cash demand for foreign exchange, and the formation of a stock market bubble decreased the speculative demand for foreign exchange temporarily. As a result, the unidirectional causality test statistic from official to unofficial exchange rate increased for a short period. After the stock market bubble burst and increased speculation in the exchange market, the increased uncertainties due to the pandemic, the decrease in oil exports and the decrease in oil prices that limited foreign exchange supply, and the decrease in the non-oil exports to neighboring countries, the unidirectional causality test statistic from official to unofficial exchange rate decreased again and became insignificant. After the US election in 2020 and the renewal of the negotiations related to JCPOA, there have been optimistic expectations, and consequently, there has been an increase in the unidirectional causality test statistic from official to unofficial exchange rate. This renewal of negotiations and the optimistic expectations it brought have instilled hope for future economic stability. Based on the review of the economic and political developments alongside the test statistic, it is evident that the official exchange market has had the role of leadership only in those sub-periods in which foreign exchange reserves have made it possible for the central bank to intervene in the exchange market.

Figure 8 presents the results of the bidirectional causality test statistic between the official and unofficial exchange rates. This statistic is a key

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indicator of the instantaneous spillover effects and the dynamic market integration between the two markets. The data clearly shows that the exchange markets in Iran share information instantaneously, influencing traders in both markets.

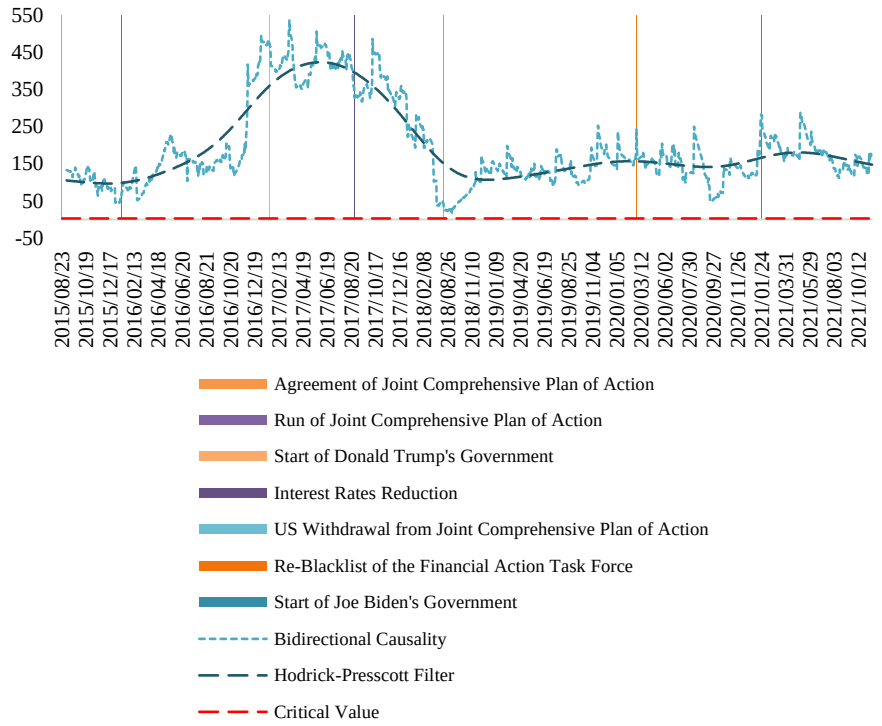

Figure 8. Bidirectional causality Test between official and unofficial exchange rates. *Source*: Research Findings

Based on the findings, it could be concluded that the official exchange rate is the leader of unofficial exchange rate instantaneously just in special cases. Therefore, there is no evidence implying the leadership of the official exchange market in the long-run. This means that there is no empirical basis for management of unofficial market by managing the official market when there are exogenous shocks to the exchange market and there is deviation of the official exchange rate from what its fundamental determinants imply.

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5 Concluding Remarks

The unofficial exchange market is the inevitable consequence of direct and indirect government intervention in the exchange market. It is critical from the viewpoint of policymakers in Iran because the unofficial exchange rate has a significant impact on economic agents' expectations. This has caused the government to try to manage the unofficial market by determining the official exchange rate and its manipulation. To analyze the spillover of information between official and unofficial exchange markets in Iran, the causal relationship between them has been examined. We used the Hong time-varying causality test to estimate the dynamic conditional correlation generalized autoregressive conditional heteroscedasticity model. Three statistical tests (unidirectional causality test, bidirectional causality test, and instantaneous causality test) are computed to decide the direction of causality between official and unofficial exchange rates. In addition, we have tried to evaluate the test statistics in line with economic and political developments.

Our findings show unidirectional causality from unofficial to official exchange rates but not vice versa. Also, it is concluded that the extent of unidirectional causality from unofficial to official exchange rate has been lower when there were optimistic expectations about access to foreign exchange reserves or the interest rate was high. When there were pessimistic expectations about access to foreign exchange reserves, information spillover from unofficial to official exchange rates increased. Therefore, the unofficial exchange market seems to be the leader in Iran's exchange market.

In addition to examining unidirectional and bidirectional causality tests, we have computed instantaneous causality test statistics to omit the effects of nonsynchronous trades on the spillover of information between two markets. Based on the instantaneous causality test results, there is instantaneous unidirectional causality from the unofficial to the official exchange rate, but the reverse is valid just for some sub-periods. In those sub-periods, that official exchange rate has had a causality effect on the unofficial exchange rate; there have been developments like JCPOA, the decrease of restriction on the exports of oil, and more access to foreign reserves so that the central bank has been able to intervene in the exchange market more. On the other hand, when there have been high inflation expectations, multiple exchange rate systems, mismanagement of exchange demand, higher sanctions, and lower foreign reserves, the test statistic of instantaneous causality from the official to the unofficial exchange rate has decreased substantially.

Based on the empirical findings, it is concluded that the official exchange market does not have the role of a leader to the unofficial market, especially

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in time periods in which it has been impossible for the central bank to intervene in the exchange market by injecting oil incomes in this market. Therefore, creating an official market to have the role of leader in the exchange market needs empirical support when the official exchange rate has a deviation from its fundamentals and there is rationing in the foreign exchange market.

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