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The threshold effect of exchange rate shocks on stock market fluctuations

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Abstract

This study was conducted mainly to investigate the asymmetric and threshold effect of exchange rate shocks on stock market fluctuations. The variables of exchange rate, gold price, oil price, housing price index, and stock returns from the winter of 2014-6 to the spring of 2021 were used to investigate the threshold effects of exchange rate shocks on stock market fluctuations. The exchange rate shocks were then extracted using the multivariate GARCH technique. In the following, a suitable threshold model was chosen for the effect of exchange rate shocks on stock returns, and the threshold values for the effect of exchange rates on stock returns were determined based on various tests. According to the results, exchange rate shocks significantly negatively affect stock price returns only at high threshold values of the exchange rate shock, i.e. 0.056. The results also showed that exchange rate fluctuations have no significant effect on the stock market in shocks lower than the threshold value of 0.056.

Keywords: threshold effect, stock market, stock returns, exchange rate shocks
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1 Introduction

Exchange rate fluctuations significantly contribute to economic performance in a way that affects international competitiveness, the balance of trade, and, consequently, income and production based on economic theories of exchange rate changes. Foreign goods become more expensive than domestic goods and international competition improves with the depreciation of the country's current currency. This can improve economic activities. In other words, the depreciation of the domestic currency changes the direction of spending from foreign goods to domestic goods. However, the success of currency depreciation in stimulating the balance of foreign trade depends to a significant extent on the shift of demand in the right direction and the capacity of the economy to supply additional demand through more supply of goods [31].

The purchasing power parity (PPP) hypothesis implies that exchange rate changes are determined by the general level of relative prices between two countries, and this relationship will always be maintained with the assumption of

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a constant amount of basket of goods. So, the only way to change the price of the market basket is to change the price of the goods. However, the change in the price level indicates the inflation rate. According to the PPT hypothesis, changes in the inflation rate will change the exchange rate. The exchange rate changes and the comparison of the purchasing power of currencies indicate the high effect of exchange rate fluctuations on the economic situation of every society. On the other hand, international money markets apply policies to deal with this risk. The PPP hypothesis suggests that exchange rate changes affect the full cost of goods and the investment of companies admitted to the stock market. Accordingly, exchange rate changes are determined by changing the general level of the relative prices of the two countries. If this relationship is reversed, exchange rate changes will indicate changes in the ratio of the general price level of the two countries. According to the Fama-French Three Factor model [15], if the exchange rate fluctuates, the ratio of the foreign index to the domestic index must change because the changes in the logarithm of the exchange rate are equal to the difference in the logarithm of the foreign and domestic price index [28].

According to the theory of value, the value of a financial asset at any point in time is equal to the present value (PV) of all the future cash flows of the asset. Therefore, since exchange rate changes affect the PV of companies, their stock price index is affected as well [1]. So, companies may react differently in setting their prices, adjusting their quantities, their sales, and their share of the market when faced with exchange rate changes. The currency depreciation affects the stock price in two ways [24]. It causes export-oriented companies to export more due to their competitiveness, and they are expected to experience more profits and, thus, an increase in their stock prices. On the other hand, non-export-oriented domestic companies will face an increase in the cost of their imported inputs and possibly a decrease in profit margin, and their stock prices are expected to suffer. Therefore, the stock market can move in two directions [25]. Export-based economies argue that having a low or undervalued interest rate will help increase exports, leading to economic activity. According to Hyde [20], exchange rate changes can encourage foreign investors to keep domestic securities, or they can even be in such a way that domestic investors keep the securities of foreign countries instead of domestic securities. Thus, domestic and foreign investors can plan and manage their asset portfolios more accurately by understanding the behaviour of interest rates and exchange rates with the stock price index in the stock market.

The exchange rate affects the stock price index in several ways. First, currency depreciation leads to a decrease in stock prices due to inflationary expectations [2]. If the real exchange rate is considered $RER = e.P^*/P$, a higher nominal exchange rate will decrease the price-to-earnings ratio (P^*/P) in the short run. The low price-to-earnings ratio indicates the higher domestic prices. Therefore, a decrease in the nominal exchange rate creates inflationary expectations in the future. In this way, the stock market considers inflation negative news to prevent the reduction of companies' income [37].

Second, foreign investors will not be willing to keep their assets in money that is depreciating and makes doubtful the return of their capital. So, the stock price will face a drop if foreign investors sell their shares [13]. Third, the effect of the exchange rate reduction on each company is different depending on whether its export or import volume is greater, whether its owner is domestic or foreign, and how much it remains immune to exchange rate fluctuations. The domestic currency depreciation leads to an increase in the costs of companies with heavy imports and a decrease in their share prices. As the dollar strengthens, multinational corporations in the United States earn higher profits. The realized income from foreign subsidiaries has been converted into dollars at a higher rate. Companies that adequately cover their exchange rate risk will take this income and their stock prices will not be affected by exchange rate fluctuations. Accordingly, the stock market, which is made up of a group of companies, will tend to react to the uncertain fluctuations of the exchange rate.

The relationship between the exchange rate and the stock market can be examined from two other perspectives too. On the one hand, currency appreciation increases the opportunity cost of investing in the stock market due to the competition between the currency market and the stock market. With the increase in efficiency in the competing market, investors' resources have flowed from the stock market to the currency market, resulting in a decrease in stock prices. In this situation, the return rate expected by investors in the stock market (discount rate) increases and the demand for buying shares decreases through the discount rate channel. On the other hand, if the import value of the major active industries of the country is high, the increase in the exchange rate causes the production costs to increase faster than the product costs. This can cause a drop in stock prices through the channel of reducing the cash flow of future earnings of companies. On the other hand, if the export value of such industries is high, the relationship between the exchange rate and the stock price will be positive through the channel cash flow of the companies, and the result of the negative effects caused by the competition between the stock and currency markets and the recent positive effect will determine the final relationship between the exchange rate and the stock price.

It is worth noting that the dynamic relationship between the exchange rate and the stock price is not yet universally agreed upon. The theoretical links between stock prices and exchange rates are widely analyzed through the "flow-

oriented" model developed by Dornbusch and Fischer [14] and the "stock-oriented" model developed by Frankel [16] and Branson and Henderson [8]. The flow-oriented model assumes that exchange rate changes affect international competition and the balance of trade, which in turn affect real production and stock prices. Moreover, the stock-oriented model considers the role of international portfolio diversification. As domestic stock prices rise, global investors are encouraged to buy more domestic assets, leading to domestic currency appreciation.

By proposing current-oriented models, Dornbusch and Fischer [14] assume that the country's current account and current balance are two important determinants of the exchange rate. Accordingly, exchange rate changes affect international competition and trade balance, thus affecting real economic variables such as production and real income, as well as future and current cash flows of companies and their stock prices. Domestic currency depreciation (increase in exchange rate) makes local companies more competitive and their exports cheaper in an international comparison. Increasing the advantage of domestically produced goods and, consequently, increasing exports increases income, which in turn increases the share price of companies. Thus, there is a positive relationship between the exchange rate and stock price in these models.

Stock-oriented models assume that the capital account determines the exchange rate. For example, Branson's portfolio balance model and monetary model can be mentioned. Branson's portfolio balance model [7] argues that there is a negative relationship between exchange rates and stock prices. According to this model, the decrease in stock prices causes a decrease in the wealth of domestic investors, leading to a lower demand for money and a lower interest rate. A decrease in the interest rate leads to the outflow of capital and depreciation of the domestic currency and, therefore, an increase in the exchange rate assuming that other conditions are constant [33].

Unlike Dornbusch and Fischer's theory and Branson's theory, Gavin's monetary model [17] argues that there is no relationship between exchange rates and stock prices. However, according to Bhattacharya and Mukherjee [5], risk was considered a qualitative factor until the 1950s until it became quantifiable with Markowitz's efforts, and the standard deviation of cash flows of investment projects in different conditions was introduced as a risk measurement quantity. Markowitz's theory [22] was the origin of the asset portfolio theory. Markowitz hypothesized that investors do not necessarily seek to maximize expected returns because they would only choose the asset with the maximum expected return if they were only looking to achieve the maximum expected return. However, investors have a portfolio of securities in practice. This behavior can be justified as follows: investors pay attention to risk and return phenomena at the same time and make their decisions based on mean and variance. In other words, they compare and choose different investments based on expected return (mean return) and standard deviation (variance squared). If investors are risk-averse and two portfolios are equal in all respects except for the amount of standard deviation, the investment with less standard deviation is chosen.

The Markowitz model of portfolio is as follows:

$$\min -\lambda E_p + V_p \tag{1.1}$$

where

$$E_p = \sum_{i=1}^{N} X_i E_i. \tag{1.2}$$

So that:

$$V_p = \sum_{i=1}^{N} \sum_{j=1}^{N} X_i X_j Cov(i,j) \tag{1.3}$$

$$\sum_{i=1}^{N} X_i = 1, \quad \lambda \geq 0 \tag{1.4}$$

where:

λ: The degree of investor risk-taking

E_p: The portfolio expected returns

V_p: The portfolio risks

X_j: part of the total budget allocated to investment j,

X_i: part of the total budget allocated to investment i,

X_i: expected returns of project i,

$Cov(i, j)$: The covariance of investment i with investment j,

λ: The degree of investor risk-taking.

Markowitz puts forward a discussion about the way to keep assets as Markowitz's model of diversification, arguing that there should not be a complete positive correlation between the combination of different assets. This diversification causes the portfolio risk to decrease without reducing the return. However, there should not necessarily be a complete negative correlation to reduce the risk through investment diversification. Only shares or assets should not increase and decrease exactly together. In other words, the lack of positive correlation must be fully established.

The returns of different assets in a portfolio can be combined to reduce risk to a great extent as long as they are not completely correlated. In practice, the returns of different assets are normally correlated due to the effect of economic cycles. The risk can be reduced to a significant extent by diversifying the investment since this correlation is not complete. Portfolio risk can be reduced by diversifying the portfolio as long as the assets are not equally affected by economic conditions.

Rich economic theories that propose different forms of relationships between the exchange rate and the stock price index and the effect of the exchange rate on economic variables including the stock price index through different channels show that the results of studies in this field are different depending on the country and the time studied so that the conclusion of a specific relationship between the exchange rate and the stock price index cannot be extracted. Some relevant studies investigate the causal relationship between the exchange rate and the stock price index, and some investigate the short- and long-run relationship between the two separately.

Miller [23] suggests that if companies use real options to hedge against exchange rate changes, it is expected that, in the case of currency appreciation and depreciation, two different types of behavior will occur for the stock price, which is called asymmetric hedging. Considering the symmetric effects for uneven changes in the exchange causes a bias in the understanding of the effects of these different changes on other macroeconomic variables because the exchange rate changes significantly at different times due to different economic and political factors that are not necessarily in the same direction. Accordingly, hedging the risk of exchange rate changes due to the asymmetric feeling of exporters and importers to positive and negative changes causes different expectations that can neutralize each other's effects and give unexpected results in some cases. In the following, the experimental literature is reviewed.

2 Literature review

2.1 Foreign literature

In a study titled The Dynamic Relationship Between Exchange Rates and Stock Prices for the G7 Countries: A Nonlinear ARDL Approach, Nusair and Olson [27] used linear and non-linear ARDL models to investigate the short- and long-run relationship between stock prices and exchange rates in G7 countries. Both the flow-oriented approach (the exchange rate affects the stock price) and the portfolio balance approach (the stock price affects the exchange rate) are supported in the short run. None of the models are supported in the long run using the linear ARDL models, but the nonlinear ARDL model provides evidence that supports the portfolio balance approach in four of these countries.

Çakır [9] conducted a study titled The Impact of Exchange Rates on Stock Markets in Turkey: Evidence from Linear and Non-Linear ARDL Models. In this study, the asymmetric effect of the exchange rate on three major indices of the stock market in Turkey was investigated using four different ARDL models between 2003 and 2018. For this purpose, bivariate and multivariate linear models were first used assuming symmetry of the effects. Non-linear bivariate and multivariate models were then used to investigate whether the exchange rate has symmetric or asymmetric effects on selected stock market indices in Turkey. The findings show that the exchange rate has asymmetric effects on all three major indices of the stock market, both in the short and long run. Currency appreciation has a significant positive effect on the selected stock markets in the long run, but currency depreciation does not.

In a study titled Linkage Between Exchange Rate and Stock Prices: Evidence from Vietnam by Dang et al. [12], the relationship between exchange rate and stock prices in Vietnam and the asymmetric effect of exchange rate changes on stock prices in Vietnam were investigated. For this purpose, the non-linear ARDL method was used for monthly data from 2001:01 to 2018:05. Asymmetry is estimated both in the long-term relationship and in the short-run error correction mechanism (ECM). According to the results, exchange rate changes have asymmetric effects on stock prices, both in the short and long run. Accordingly, the stock price reacts to depreciation and appreciation at different levels.

Bahmani-Oskooee and Saha [4] conducted a study titled On the Relation Between Exchange Rates and Stock Prices: A Non-Linear ARDL Approach and Asymmetry Analysis and investigated the symmetric or asymmetric effects of exchange rate changes on stock prices. After introducing the nonlinearity of the adjustment process and

using the ARDL nonlinear approach for co-integration modeling and error correction with monthly data from Brazil, Canada, Chile, Indonesia, Japan, Korea, Malaysia, Mexico, and the United Kingdom, the results showed that exchange rate changes have asymmetric effects on stock prices, although these effects are mostly short run.

In a study titled Untangling the Non-Linear Causal Nexus Between Exchange Rates and Stock Prices: New Evidence from the OECD Countries, Chen and Chen [10] examined the nexus of stock prices and exchange rates for 12 OECD countries by using the vector error correction model, the bounds testing methodology and linear and non-linear Granger causality methods.

Walid et al. [36] conducted a study titled Stock Market Volatility and Exchange Rates in Emerging Countries: A Markov-State Switching Approach. By applying the Switching-Markov GARCH model and using the data from 1994-2000, they investigated the relationship between stock price fluctuations and exchange rate changes for 4 countries (Hong Kong, Singapore, Malaysia, and Mexico). They found that the relationship between the stock and currency markets is a function of the currency regime and that stock price volatility reacts asymmetrically to market events.

2.2 Domestic literature

Golarzi and Khorasani [18] conducted a study titled Assay the Symmetrical and Asymmetrical Effects of the Currency Rate and its Fluctuations on the Return of the Pharmaceutical Industry Stock Via ARDL Linear and Non-Linear Models. The exchange rate, as a fundamental variable, alongside other economic variables, significantly affects stock returns. Therefore, this study investigated the effects of the exchange rate and its fluctuations on the pharmaceutical industry's stock returns through linear and nonlinear models from 2005 to 2021. In this study, the exchange rate fluctuations were first modeled using the GARCH model. The symmetrical and asymmetrical effects of the exchange rate and its fluctuations on the return of the pharmaceutical industry stock were then investigated using both linear ARDL and nonlinear NARDL models. The study shows that in both the short and long term, the impact of the exchange rate on pharmaceutical industry stock returns is greater than the impact of exchange rate fluctuations. Additionally, negative shocks of the exchange rate and its fluctuations have a negative relationship with the pharmaceutical industry's stock returns, while positive shocks of the exchange rate and its fluctuations have a positive effect on the pharmaceutical industry's stock return. The findings suggest that the impact of positive and negative shocks of the exchange rate and its fluctuations have asymmetric effects on the return of pharmaceutical industry stock.

Nahidi Amirkhiz [26] conducted a study titled Asymmetric Effect of Exchange Rate Fluctuations on Stock Return in the Iranian Stock Market. Exchange rate fluctuations were first measured using a graph model. The stock return was then estimated by considering these fluctuations between 1979 and 2021. The results indicated that exchange rate fluctuations have a significantly positive effect on the stock return. Moreover, this study tested the effect of fluctuations between the foreign exchange market and the stock market. Due to the low degree of simultaneous fluctuations between these two markets, investors can reduce their investment risk by allocating their capital between currency and stocks.

In a study titled Asymmetric Effect of Exchange Rate Risk on the Stock Index of Export-Oriented Industries Using the NARDL Model by Sarrafi Zanjani and Mehregan [30], symmetrical or asymmetrical effects of negative and positive dollar shockwaves in the market on indexes of chemical and basic metals industry were investigated by weekly data collected from 2006 to 2016 as the two industries have the most non-oil exports of Iran. The long-term equilibrium relationship was first examined and confirmed by the Pesaran Bound test. The asymmetric effect of positive and negative exchange rate shocks on the examined indices was then confirmed using the Wald test. According to the results of the main model, increasing dollar rates has significant positive effects and increasing dollar rates has no significant effects on both indexes.

Mamipour and Sasanian [21] studied the asymmetric effects of exchange rates on the return of selective industries in the Tehran Stock Exchange using the NARDL model. The main objective of this study was to investigate the asymmetric exchange rate exposure of stock returns in the Iranian stock market at the industry level. The study investigated the effects of positive and negative exchange rate shocks on the price index of various industries in the Tehran Stock Exchange in the form of the CAPM model and using the NARDL model monthly from 2012 to 2015. The results indicate that most industries of the stock market are under the influence of positive and negative shocks of exchange rate and these effects are different for industries. The effects of positive and negative exchange rate shocks on some industries are symmetric and asymmetric on others.

The effects of the exchange rate and its fluctuations and shocks on various economic sectors and the stock market require more attention and prediction to maintain economic stability and security to improve the welfare of society and the dynamics of the markets and prevent the harmful effects of the exchange rate on them. So, the main objective

of this study was to investigate the threshold effects of exchange rate shocks on the stock market in Iran. The study is structured as follows: In the second section, the theoretical literature on the relationship between the exchange rate and the stock market is reviewed. The third section describes the methodology and model. In the fourth section, the experimental results of the model are examined, and conclusions and recommendations are provided in the last section.

3 Methodology

There has been a continuous interest in the development and application of non-linear time series models over the past decades. A broad family of non-linear models is the smooth transition autoregressive (STAR) model proposed by Granger and Teräsvirta [19] and Teräsvirta [34]. STAR models seem to separately account for non-linear dependence (in the mean) in economic and financial time series by allowing for regime-dependent behavior.

The features of STR and STAR models are very attractive in modeling economic and financial nonlinear time series. For example, macroeconomic time series and their relationships may be characterized by asymmetries associated with business cycle phases, which makes LSTR models especially applicable [32]. The study model to investigate the threshold effect of exchange rate shock on the stock market is taken from the studies by Tuna et al. [35] and Chun et al. [11] and is as follows:

$$RSP_t = \beta_0 + \beta_1 ACHP_t + \beta_2 OILP_t + \beta_3 NGLD_t + \delta_J UNEX_t + \varepsilon_t \tag{3.1}$$

In Equation (3.1), the exchange rate shock (UNEX) is a threshold variable. The summary of the variables can be seen in Table 1.

Table 1: The variables

Variable	**Notation**	**Source**
The stock price index	SP	The Central Bank of Iran
The land price index in all urban areas	ACHP	The Central Bank of Iran
The unofficial market dollar rate	UNEX	The Central Bank of Iran
The price of Bahar Azadi gold coin	NGOLD	The Ministry of Economic Affairs and Finance
Oil price index	OILP	The Ministry of Economic Affairs and Finance

The data of this study were collected through the databases of the Central Bank and the Ministry of Economic Affairs and Finance. The study period was from the winter of 2014 to the spring of 2022 due to the limitation of the stock price index. The statistical population was Iran. The stock price index is the weighted average of stock price ratios with a weight equal to the stock value at the base year, which is obtained according to the Laspeyres price index as follows (Ministry of Economic Affairs and Finance, 2023):

$$100 \times (\text{base value of shares/current value of shares}) = \text{price index} \tag{3.2}$$

Process ARIMA(P, d, q) for variable x can be represented by the following equation:

$$y_t = f(t) + \sum_{i=1}^{\rho} \varphi_i y_{t-i} + \sum_{j=1}^{q} \theta_t \epsilon_{t-i} + \varepsilon_t \tag{3.3}$$

where

$$y_t = \Delta^d x_t = (1-l)^d x_t \tag{3.4}$$

"$f(t)$" estimates the time trend (if exists). In most economic variables, usually $d = 1$, therefore $\mu = f(t)$ or $d = 0$

$$f(t) = \alpha + \delta_t. \tag{3.5}$$

In the process $q, d, P, ARIMA(P, d, q)$ respectively represent the number of lagged regression terms, the order of differencing, and the number of moving average terms. If d is set to zero, the ARIMA process is converted to an ARMA process. Typically, the Box-Jenkins method is used for estimating ARIMA and ARMA models, consisting of four stages: identification, estimation, diagnostic checking, and forecasting. The number of lagged regression terms

and the number of moving average terms are usually calculated using autocorrelation (AC) and partial autocorrelation (PAC) functions [29].

The parity rate of the dollar with the rial in the unofficial (illegal) currency market was collected by the Central Bank in 1959. It is worth mentioning that the exchange rate in the unofficial market is calculated based on the sampling of the Economic Statistics Department from the unofficial market at 11:00 every day (Central Bank, 2023).

4 Findings

The return of the variables should be calculated first using the following formula before estimating their fluctuations using ARCH-GARCH methods.

$$RX_t = Dlog(X_t) \tag{4.1}$$

where RX is the return of the variables. The unit root of the variables is then examined. The augmented Dickey-Fuller (ADF) test was used to check the reliability of the model variables, the results of which are given in Table 2.

Table 2: The unit root test

Variable	Statistic	P-value
RSP	-3.58	0.01
RACHP	-1.67	0.08
RUNEX	-4.15	0.00
ROGOLD	-4.03	0.00
ROILP	-6.07	0.00

According to the table, all the variables are stationary or non-stationary at 95 and 90% confidence levels. So, ARIMA models can be implemented to estimate the shocks of variables. The fluctuations or shocks of the independent variables should be extracted using the GARCH model to test the hypotheses. Stationarity should be checked, the ARIMA model should be estimated, and heterogeneity of variance in the data should be confirmed, respectively, to extract the fluctuations of the variables. Finally, the conditional variance is extracted. The results of the estimation of the ARIMA model of the exchange rate to check the existence of the effects of heterogeneity of variance in the variables can be seen in Table 3.

The GARCH(p,q) process has a conditional variance function as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 = \alpha_0 + \alpha(L)\varepsilon_t^2 + \beta(L)\sigma_t^2 \tag{4.2}$$

where $P > 0$ and $\beta_i \geq 0, \alpha_i \geq 0$, and $1 \leq i \leq p$. For a better definition of conditional variance in the GARCH(p,q) model, all coefficients of the $ARCH(\infty)$ model $\sigma_t^2 = \theta_0 + \theta(L)\varepsilon_t^2$ should be positive, with the condition that $(L)\alpha$ and $(L)\beta$ have no repeated roots, and the roots of $(L)\beta$ are outside the unit circle. This positivity constraint holds if and only if all coefficients $\theta(L) = \alpha(L)/(1 - \beta(L))$ are non-negative (zero or positive). For a GARCH(1,1) process, we have:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2. \tag{4.3}$$

The GARCH process can be weakly stationary if and only if the roots of $\alpha(L) + \beta(L)$ lie outside the unit circle, meaning: $1 < \beta(L) + \alpha(L)$ [6].

The results of the ARCH-LM test are given in Table 4.

The results of Table 4 and the P-value obtained for the F statistic show that the estimated ARIMA model has heterogeneity of conditional variance. Therefore, the shocks of the variables could be extracted. The shock of the exchange rate is shown in the figure below. The results of the linearity of the estimated model with the exchange rate shock are provided in Table 5.

The null hypothesis that there is a linear relationship between the variables is not rejected according to the results of Table 5 and the test of the non-linear relationship between the variables. So, the threshold linear regression estimation is a suitable model. The number of regimes and the sum of squared errors are given in Table 6.

According to Table 6, the regime value of 2 is confirmed to investigate the threshold effects of exchange rate shock on stock price returns. In the following, smooth transition threshold regression (STAR) was estimated by considering the exchange rate shock as the threshold variable. Table 7 shows the model estimation results.

Table 3: The ARIMA model of the exchange rate (EGARCH (1,0,0))

Variable	Notation	Coefficient	Statistic	P-value
Intercept	C	0.06	-5.82	0.00
The first-order moving average	AR (1)	0.46	6.17	0.00
The variance equation				
$LOG(GARCH) = C(4) + C(5) \times ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(6) \times RESID(-1)/@SQRT(GARCH(-1)) + C(7) \times LOG(GARCH(-1))$				
Intercept	C(4)	-2.56	-16.88	0.00
The leading coefficient	C (5)	-1.23	-2.69	0.00
The second virial coefficient	C(6)	1.76	4.02	0.00
The third coefficient	C(7)	0.47	15.22	0.00
R-squared				0.30
Durbin-Watson stat				1.92
Akaike info criterion				-2.17

Table 4: The results of the heterogeneity of variance test (Arch effects)

Test	F statistic	P-value
ARCH effects	112.58	0.00

Table 5: Trasvirta's linear relationship test

Null hypothesis	F statistic	df	P-value
H3: b3=0	0.09	(18,1)	0.75
H2: b2=0| b3=0	0.93	(19,1)	0.34
H1: b1=0| b2=b3=0	2.66	(20,1)	0.11

Table 6: Testing the number of regimes

The threshold variable	SSR	Regime
GARCHRUEX	0.25	2

Table 7: The threshold model of exchange rate shock

The variable type	The variable name	The number of observations	Coefficient	Statistic	P-value
Threshold variable = exchange rate index	Intercept	19	-0.06	-1.39	0.17
	Exchange rate shock > 0.056		3.24	1.11	0.27
	Intercept	7	0.44	3.14	0.00
	Exchange rate shock ≥ 0.056		-3.32	-2.77	0.01
Non-threshold variables	Oil price shock	–	0.47	0.40	0.69
	Gold price shock	–	-2.42	-1.78	0.09
	Housing price shock	–	17.61	1.58	0.12
R-squared			0.78		
F-statistic			11.37		
Durbin-Watson stat			2.31		

According to Table 7, the exchange rate shock has a significant negative effect on stock price returns only at high threshold values of the exchange rate shock, i.e. 0.056. In other words, a positive shock of one unit reduces the stock price return to 3.32 units, indicating that the increase of the exchange rate shock in its high threshold values causes the transfer of capital from the stock market to foreign exchange. In other words, the exchange rate shock does not significantly affect the stock price return in the regime, but its effect coefficient is -3.32. Among the non-threshold variables, only the gold price shock is significant with a coefficient of -2.42 at the 90% confidence level, indicating its negative effect on stock price returns in the period under review. The values of the coefficient of determination, F statistic, and Durbin-Watson test value obtained show the goodness-of-fit of the model. The results of the test of different threshold values in the equation of the effect of exchange rate shocks on stock price returns can be seen in Table 8.

Table 8: Threshold values of exchange rate shock

Threshold test	F statistic	The scaled F statistic	Critical value
0 vs, 1^*	6.89	13.79	11.47
1 vs. 2	5.94	11.89	12.95

According to Table 8, the threshold value of 2 is significant for exchange rate shock. Autocorrelation and hetero-

geneity of variance tests are provided below to check the reliability of the model.

Table 9: Breusch–Godfrey serial autocorrelation test

F statistic	P-value
0.71	0.40

According to Table 9, the null hypothesis that there is no serial autocorrelation in the estimation model is not rejected. Table 10 shows the results of the heterogeneity of the estimated model.

Table 10: Breusch-Pagan-Godfrey heterogeneity of variance test

F statistic	P-value
0.13	0.99

According to the F statistic and its P-value, the null hypothesis of homogeneity of variance in the estimation model is not rejected and the model does not have heterogeneity of variance.

5 Conclusions and discussions

Examining the macroeconomic structure of a country and its markets indicates that the capital market is one of the most basic markets in any economy. The most common way of making investment decisions in the stock market is to analyze the stock price trend and its return. The exchange rate is one of the factors affecting the stock market returns. Economists are increasingly paying attention to the relationship between stock prices and exchange rates because both play an important role in the development of a country's economy. Stock and currency markets have recently become interdependent due to the increase in international diversity, the correlation between market returns, and the gradual removal of barriers to capital entry and currency restrictions in emerging economies [3]. In an open economy, the exchange rate is a key variable due to its interrelationship with other internal and external variables that have great effects on domestic and foreign economic policies and economic developments.

The variables of exchange rate, gold price, oil price, housing price index, and stock returns from the winter of 2014-6 to the spring of 2021 were used to investigate the threshold effects of exchange rate shocks on stock market fluctuations. The exchange rate shocks were then extracted using the multivariate GARCH technique. In the following, a suitable threshold model was chosen for the effect of exchange rate shocks on stock returns, and the threshold values for the effect of exchange rates on stock returns were determined. According to the results, exchange market shocks have significant threshold effects on stock price returns in Iran during the period under review. Various studies have investigated the non-linear and threshold effect of different market indices on the stock market. The results of the non-linear effect of the exchange rate on the stock market are consistent with the results of studies by Nusair and Olson [27], Çakır [9], Dang et al. [12], Bahmani-Oskooee and Saha [4], and Chen and Chen [10].

The results of the effect of the exchange rate shock on the stock market showed the exchange rate shock has a significant negative effect on stock price returns only at high threshold values of the exchange rate shock, i.e. 0.056. In other words, a positive shock of one unit reduces the stock price return to 3.32 units, indicating that with the increase in the exchange rate and the domestic currency depreciation, investors decide to exit the stock market to maintain the value of their currency. The results also showed that exchange rate fluctuations do not significantly affect the stock market in shocks lower than the threshold value of 0.056. Policymakers and planners can use the results to prevent the damaging effects of exchange rate shocks on the stock market and develop appropriate plans. So, it is recommended to prepare and implement related monetary and financial policies to prevent the sharp increase of shocks in the exchange rate sector up to a threshold level of 0.056 so that they do not negatively affect the stock market.

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