Journal of Financial Management Strategy
Alzahra University
Vol. 11, No. 43, Winter 2023

pp. 1-6

Research Paper

Explaining the Nonlinear Response of Tehran Stock Exchange Price Index to Oil Price Shocks Using Markov Switching Regime[1]

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Received: 2023/01/30 Accepted: 2023/06/12

INTRODUCTION

The research focuses on understanding the complexities and factors influencing the dynamics of the capital market, which is considered a critical infrastructure for economic growth. Analyzing stock price behavior is crucial due to the tendency of economic time series, especially stock prices, to undergo significant changes over different periods. The impact of oil price fluctuations on stock prices and other macroeconomic indicators has been widely recognized, as crude oil plays a pivotal role as a primary energy source for oil-importing countries and a substantial revenue generator for oil-exporting nations. However, the existing literature on the role of oil price fluctuations in economic indicators tends to be more prevalent in crude oil-importing countries, with fewer studies conducted from the perspective of oil-exporting nations. Notably, the effects of oil price fluctuations in crude oil exporting and importing countries differ. In major oil-exporting countries like Iran, oil price changes are recognized as one of the most influential factors affecting macroeconomic indicators, particularly stock market indexes. Due to the economic dependence of crude oil-exporting nations on revenue generated from oil exports, the response of stock prices to oil price shocks is typically more pronounced in these countries compared to oil-importing nations. Moreover, higher uncertainty in developing countries, including

1. DOI: 10.22051/JFM.2023.42752.2782

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oil-exporting nations, contributes to a stronger response of stock returns to oil price shocks when compared to developed countries. The paper aims to reconcile conflicting empirical evidence regarding the impact of oil prices on Tehran Exchange stock prices by employing a two-regime Markov process. This approach is designed to provide a more nuanced and comprehensive understanding of how oil price changes influence stock prices in the Tehran Exchange under different regimes or conditions.

MATERIALS AND METHODS

In order to model the dynamics of the real stock price and experimentally investigate the asymmetric effect of oil price on the stock price, first, the dynamics of the real stock price should be decomposed into the following two separable components according to equation (1):

1) $stock_t = stock_t^p + stock_t^T$

Here $stock_t$ is the logarithm of the real stock price index. On the right side of the equation, $stock_t^p$ is the stable component of the stock price index, while $stock_t^T$ is the transient component. The stable component is modeled as a random step according to equation (2):

2) $stock_t^P = \mu_t + stock_{t-1}^P + v_t$

In this random step formula, the vector autoregressive term must have a coefficient of one, which makes v_t shocks have a stable effect on the stock price, which is a random step without drift. Here v_t and ω_t are independent and identically distributed random variables (i.i.d) with the same distribution. The prediction function will also have a time variable period μ_t according to equation (3):

3) $\mu_t = \mu_{t-1} + \omega_t$

The reaction analysis of the logarithm of the real stock price to the logarithm of the real oil price (oil_t) is modeled by the autoregressive process of equation (4) and equation (5):

4) $\varphi(L) . stock_t^T = \gamma_0(L) . oil_t + \gamma_1(L). oil_t . S_t + \varepsilon_t$

5) $\varphi(L) = \sum_{k=0}^{K} \varphi_k . L^k; \ \varphi = 1; \ \gamma_i(L) = \sum_{j=0}^{J} \gamma_{j,i} . L^j$

In the above equation, all the roots of φ(L) are placed outside the unit circle. Like the previous virtual variables, we assume that ε_t is an independent random variable with a uniform distribution that follows a normal distribution. The S_t variable in equation (4) captures the regime changes of stock price reactions to oil prices.

Also, to calculate the impact of oil supply shocks, oil demand shocks and global total demand shocks, a structural vector autoregression is used, the simplest form of this approach is:

$$B_0 y_t = \alpha + \sum_{i=1}^{k} B_i y_{t-i} + \varepsilon_t$$

The matrix form of the structural vector autoregression model is as equation (6):

$$6) e_t \equiv \begin{pmatrix} e_{1t}^{\Delta global\ oil\ production} \\ e_{2t}^{global\ real\ activity} \\ e_{3t}^{real\ price\ of\ oil} \end{pmatrix} = \begin{pmatrix} b_{11} & 0 & 0 \\ b_{21} & b_{22} & 0 \\ b_{31} & b_{32} & b_{33} \end{pmatrix} \begin{pmatrix} \varepsilon_{1t}^{\Delta\ oil\ supply\ shocks} \\ \varepsilon_{2t}^{aggreate\ demand\ shocks} \\ \varepsilon_{3t}^{oil-specific\ demand\ shock} \end{pmatrix}$$

We now factor the e_t shocks obtained from equation (6) into real stock prices obtained from the regime switching models presented in equations (1) to (5). In addition, to obtain the e_t shocks, the constraints of equation six from Killian (2009) are followed; The nonlinear model allows to investigate the reactions of the two upper and lower regimes. According to whether the S_t Variable is zero or one, in equation (4), it obtains the regime type (high/low). Hamilton (1989) captures the type of transition between upper and lower regimes by a Markov modeling process. In the vector of constant transition probabilities, the St Variable takes the value of zero or one according to the modeling of equation (7):

$$7)\ P(S_t = 0 | S_{t-1} = 0) = \frac{\exp(c_0)}{1+\exp(c_0)}$$

$$P(S_t = 1 | S_{t-1} = 0) = 1 - P(S_t = 0 | S_{t-1} = 0)$$

$$P(S_t = 1 | S_{t-1} = 1) = \frac{\exp(c_1)}{1+\exp(c_1)}$$

$$P(S_t = 0 | S_{t-1} = 1) = 1 - P(S_t = 1 | S_{t-1} = 1)$$

The model of fixed transition probabilities means that the probabilities of changing the regime or staying in the regime are fixed. Another flexible method is to model the transition probabilities between regimes as a function of some observable variables.

$$8)\ P(S_t = 0 | S_{t-1} = 0) = \frac{\exp(c_0 + z'_t . a_0)}{1+\exp(c_0 + z'_t . a_0)}$$

$$P(S_t = 1 | S_{t-1} = 1) = \frac{\exp(c_1 + z'_t . a_1)}{1+\exp(c_1 + z'_t . a_1)}$$

RESULTS AND DISCUSSION

The initial step in estimating the model involves determining whether the response of the Tehran Stock Exchange's price index to oil price changes can be characterized by a two-regime Markov model. To assess this, we need to test the significance of the fixed transition probabilities model proposed by Hamilton (1989). The asymmetric reaction can be specified in both upper and lower regimes, as outlined in equation 7.

Table 1. Fixed transition probabilities and duration of regimes

Fixed transition probabilities and duration of regimes		
Low	High	Regimes
0.964231	0.035769	High
0.959349	0.040651	Low
Duration of Regimes		
Low Response	High Response	Regimes
24.59955	1	Ratio

The main feature of the time-varying probabilities model invented by Filardo (1989) is the possibility of floating transition probabilities between regimes using different data. First, it is investigated whether dummy variables including REC, SIGN, SIZE1 and SIZE2 can provide a basis for modeling the origin of the asymmetric response of the price index to oil shocks.

In the table below, the various indices of the z_t vector in equation 8 and the results of the point estimates of the community parameter with the maximum likelihood test from the fixed transition probabilities model are given in the first column. Among all the indices, the parameters of the $Stock_t^p$ component show that the growth of the real stock price index is usually constant and sometimes has slight changes that can indicate periods of stock market decline, and also the σ_ω parameter is statistically significant, i.e. the trend component The stock price does not fluctuate much, so it has a stable effect on the price growth rate. Nevertheless, the parameter σ_v is not statistically significant, that is, when we model the low volatility of prices, we find that there is no significant permanent change in the real stock price.

Table 2. Estimation of statistical population parameters

Time-varying transition probabilities			Fixed transition probabilities	
REC	SIZE	SIGN		z_t
(4)	(3)	(2)	(1)	Parameters
0.0004	0.0002	0.0001	0.0000	σ_v
(0.0012)	(0.002)	(0.00022)	(0.0014)	
0.0443	0.0414	0.0442	0.0476	σ_ε
(0.0031)	(0.0014)	(0.0012)	(0.012)	
0.0015	0.0012	0.0014	0.0021	σ_ω

Time-varying transition probabilities			Fixed transition probabilities	
REC	SIZE	SIGN		z_t
(0.0003)	(0.0006)	(0.0004)	(0.0077)	
1.5122	1.5330	1.5384	1.5018	$\emptyset_1$
(0.0444)	(0.0412)	(0.0401)	(0.0465)	
-0.3789	-0.3995	-0.3921	-0.40	$\emptyset_2$
(0.0356)	(0.0332)	(0.0387)	(0.0252)	
-0.0721	-0.0687	-0.0783	-0.4121	$\gamma_{o.o}$
(0.0576)	(0.0710)	(0.0632)	(0.1952)	
0.0800	0.2456	0.0777	-0.114	$\gamma_{1.o}$
(0.0712)	(0.0635)	(0.0882)	(0.2587)	
1.0014	1.0021	1.1002	0.6891	$\gamma_{o.1}$
(0.3137)	(0.2654)	(0.3021)	(0.3001)	
1.2544	1.0711	1.0905	0.6846	$\gamma_{1.1}$
(0.2887)	(0.2186)	(0.3974)	(0.2232)	
6.2819	4.2234	7.3564	0.4912	c_o
(0.9227)	(8.6541)	(0.6902)	(0.32)	
-0.8221	0.75472	-0.45629	2.0119	c_1
(0.7213)	(0.9772)	(0.6761)	(1.2548)	
-5.1649	-4.729	-6.7534	-	a_{o1}
(2.0111)	(6.7624)	(0.1005)		
0.3642	-5.1764	0.8754	-	a_{o2}
(1.2374)	(9.0192)	(2.8030)		
145.5403	145.0104	141.8624	134.8469	Log Likelihood

CONCLUSION

The results of the current study, employing Hamilton's (1989) method, align with those obtained by Liu et al. (2022), indicating the presence of a non-linear relationship between the Tehran Stock Exchange's price index (weight-value) and oil price shocks. The findings suggest that the reaction of the Tehran Stock Exchange's price index to oil price shocks can be effectively explained using a two-dimensional model. Notably, previous studies have identified two regimes-recession and boom-for the stock market's reaction. However, the present study's results indicate a less distinct connection between the reaction regimes and business cycles. According to the findings, the reaction of the stock market's price index is more closely tied to changes in oil prices than being influenced by the recession or boom variable. This relationship is particularly pertinent given that a significant portion of the study's timeframe coincided with the embargo on the sale of Iranian oil and an economic recession, leading to a reduced explanatory power of the recession variable.

Although the duration of the low reaction regime exceeds that of the high reaction regime during the studied period, recent years have seen a substantial increase in the establishment of the high reaction regime compared to previous years. The rate of change in the reaction regime in the late 1990s has been significantly higher than in the early years of that decade.

Furthermore, while the increase in oil prices positively affects the Tehran Stock Exchange's price index in both regimes, the extent and durability of the reaction of the stock price index are greater in the high reaction regime. In other words, although a price increase in both regimes is favorable for the stock price index, stock prices in the late 1990s react more robustly to oil price changes-especially positive oil price shocks. This underscores the potential for heightened market reactions in the Tehran stock market, necessitating careful consideration from policymakers and precision from market investors, especially in shares with low market value. Overall, it appears that factors such as oil embargoes, reductions in government income and investment, decreased demand in the entire economy, and increased inflationary expectations towards the end of the decade have intensified reactions and fluctuations in the market.

Keywords: Oil Price Shocks, Asymmetric Effect, Stock Price Index, Markov Switching, Structural VAR.

JEL Classification: G18, C13, C24.