# Supplementary file

For article:

# Quantitative Analysis of Stock Market Resilience during Oil Price Shocks: Evidence from seven Middle East Countries

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Authors:

**Hojat Rezaei Soufi**

PhD in Industrial Engineering, Central Bank of Iran and Amirkabir University of Technology, Tehran, Iran 1591634311.

**Akbar Esfahanipour***

Associate Professor of Industrial Engineering, Department of Industrial Engineering & Management Systems, Amirkabir University of Technology, Tehran, Iran.

* Corresponding author: Address: No. 350, Hafez Ave, Valiasr Square, Tehran, Iran 1591634311, Tel: +98(21)64545300, +98-912-347-9906, Fax: +98(21)6695-4569, Email address: esfahaa@aut.ac.ir

**Mohsen Akbarpour Shirazi**

Associate Professor of Industrial Engineering, Department of Industrial Engineering & Management Systems, Amirkabir University of Technology, Tehran, Iran 1591634311.

**Sepideh Aghajani**

PhD in Department of Industrial Engineering, Alzahra University, Tehran, Iran.

## A. The algorithm for detecting the turning points

There are complex approaches to identifying turning points in the literature. Given that the purpose of this paper is to calculate resilience, in the case of turning points, the applied method of Rezaei Soufi et al. (2021) is used. Here, the algorithm is presented.

Let's define $t_i$ as the turning point when:

the market index ends an increasing trend at $t_i$ and starts a decreasing period, or

the market index ends a decreasing trend at $t_i$ and starts an increasing period

According to the basic models described in Section 3-3, the turning points should be designed to identify simultaneously increasing or decreasing phases of the SMI trend. In this paper, the following algorithm is used to calculate these points.

According to this algorithm, the period of checking the onset of shock begins when a negative market return occurs. Set this time as $t^1$ and the time of local minimum in SMI as $t^0$. The object of this algorithm is to define the $t^-$ (the negative turning point as the start of decreasing phase). The algorithm works by testing the relationship between the new return of each period and the average returns and standard deviation. To identify the beginning of the disaster period, the index's return value of this time must be higher than the threshold obtained from the mean and standard deviation of the return. It is noteworthy that by observing more negative consecutive returns, satisfying the threshold is increased. Similarly, the algorithm can be used for identifying a positive turning point ($t^+$).

**Algorithm1: identifying the negative turning point ($t^-$)**

$t_i$= the *i* th step of time

$r_t = ln\frac{I_t}{I_{t-1}}$

$\bar{r}^-$= the average of negative $r_t$ from $t^1$ to $t^o$

$\sigma_{r-}$= the standard deviation of negative $r_t$ from $t^1$ to $t^o$

Compute the $t^-_{turning\ point}$

for $t=i$

if $r_{ti}<0$ and $r_{ti}<\bar{r}^- - 2\sigma_{r-}$ then $t^-_{turning\ point}=t_i$

else for $t=i$ to $T$

if $\sum_{t=i}^{Lag+i} r_{ti} < \bar{r}^- - \frac{2}{Lag}\sigma_{r-}$ then $t^-_{turning\ point}=t_{i+Lag}$

find the relevant SMI in $t^-_{turning\ point}$

else

There is no negative turning point in the data.

**Algorithm2: Identifying positive turning point ($t^+$)**

$t_i$= the *i* th step of time

$r_t = ln\frac{I_t}{I_{t-1}}$

$\bar{r}^+$= the average of positive $r_t$ from $t^o$ to $t^2$

$\sigma_{r+}$= the standard deviation of positive $r_t$ from $t^o$ to $t^2$

Compute the $t^+_{turning\ point}$

for $t=i$

if $r_{ti}<0$ and $r_{ti}>\bar{r}^+ + 2\sigma_{r+}$ then $t^+_{turning\ point}=t_i$

else for $t=i$ to $T$

if $\sum_{t=i}^{Lag+i} r_{ti} > \bar{r}^+ + \frac{2}{Lag}\sigma_{r+}$ then $t^+_{turning\ point}=t_{i+Lag}$

find the relevant SMI in $t^+_{turning\ point}$

else

There is no positive turning point in the data.

## B. EGARCH noise recognition algorithm

Using the EGARCH(1,1)-M method proposed by Feng et al. (2014), we calculate the noise of data. According to the method using equation (A-1) and (A-2).

$$\ln i_t = \mu_t + \varphi \ln i_{t-1} + \rho \ln \sigma_t^2 + \varepsilon_t \qquad \text{(A-1)}$$

$$\ln \sigma_t^2 = \omega + \beta \ln \sigma_{t-1}^2 + \alpha \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \qquad \text{(A-2)}$$

Where $i_t$ is the market index in time t, $\mu_t$, $\alpha$, $\beta$, $\gamma$, $\omega$ are constant values, and $\varepsilon_t$ is the residual value.

Considering the $\overline{\varepsilon_k}$ as the mean of residual in *K* days, the offset of residual at day *t* in the regression model can be calculated using equation (A-3). Here, we use the duration of risk based on the market segmentation process as the K value.

$$\Delta_t = \varepsilon_t - \overline{\varepsilon_k} \qquad \text{(A-3)}$$

To calculate the noise component index, first, the relationship between index rates of days should be calculated using equations (A-4) and (A-5).

$$r_t = \mu + \varphi_1 r_{t-1} + \rho \ln \sigma_t^2 + \varepsilon_t \qquad \text{(A-4)}$$

$$\ln \sigma_t^2 = \omega + \beta \ln \sigma_{t-1}^2 + \alpha \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \qquad \text{(A-5)}$$

Accordingly, the noise component index (NCI) can be calculated using equation (A-6).

$$NCI_t = \frac{\varepsilon_t - \overline{\varepsilon_k}}{r_t} \qquad \text{(A-6)}$$

Then the denoised value of $r_t$ ($r_t^{new}$) can be calculated using equation (A-7).

$$r_t^{new} = r_{t-1}(1 - NCI_t) \qquad \text{(A-7)}$$

It is notable that the NCI can be positive or negative.

## C. Statistical analysis

Table C-1. Parameters of marginal distribution model for oil price and capital markets

| | Oil | Saudi Arabia | Kuwait | Qatar | United Arab Emirates | Oman | Bahrain | Iran |
|---|---|---|---|---|---|---|---|---|
| Mean | | | | | | | | |
| μ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (1.432) | (1.213) | (1.007) | (0.456) | (0.682) | (0.725) | (0.403) | (0.658) |
| Dummy | -0.011* | -0.009* | -0.004 | 0.002 | -0.003 | 0.000 | 0.000 | 0.001 |
| | (-3.387) | (-3.345) | (-1.618) | (1.112) | (-0.913) | (-0.564) | (-0.292) | (-0.718) |
| Variance | | | | | | | | |
| Sigma | 2.358 | 1.227 | 0.646 | 1.121 | 0.930 | 0.744 | 0.450 | 0.811 |
| | (2.647) | (2.395) | (2.113) | (1.358) | (1.246) | (1.894) | (1.075) | (2.044) |
| Dummy | 0.007* | 0.003* | 0.004* | 0.000 | 0.000 | 0.000 | 0.000 | 0.003* |
| | (6.234) | (8.645) | (3.645) | (1.701) | (2.138) | (1.935) | (1.472) | (3.829) |
| $\alpha_1$ | 0.082 | 0.093 | 0.013 | -0.052 | 0.033 | 0.008 | -0.004 | 0.019 |
| | (1.812) | (2.132) | (0.994) | (-3.145) | (1.546) | (1.011) | (0.755) | (1.503) |
| $\beta_1$ | 0.834 | 0.818 | 0.923 | 0.753 | 0.808 | 0.794 | 0.788 | 0.811 |
| | (21.123) | (17.231) | (14.732) | (8.462) | (7.352) | (10.268) | (8.889) | (13.333) |
| Λ | 0.217 | 0.114 | 0.0904 | -0.0632 | 0.0619 | 0.0543 | -0.0117 | 0.0787 |
| | (1.523) | (2.142) | (1.678) | (-0.755) | (0.832) | (0.722) | (-0.256) | (1.125) |
| Asymmetry | -0.512* | -0.265* | -0.193* | -0.182* | 0.073* | -0.213* | -0.165* | 0.188* |
| | (-2.932) | (-2.321) | (-2.024) | (-1.993) | (1.024) | (-2.149) | (-1.187) | (-2.009) |
| Tail | 12.986* | 11.435* | 10.267* | 9.124* | 8.342* | 9.797* | 10.542* | 10.932* |
| | (99.476) | (65.312) | (77.236) | (53.231) | (47.978) | (50.067) | (44.324) | (52.242) |
| LJ | 23.242 | 21.429 | 19.892 | 20.120 | 19.993 | 18.801 | 19.890 | 20.003 |
| | [0.532] | [0.503] | [0.614] | [0.293] | [0.371] | [0.305] | [0.480] | [0.415] |
| LJ2 | 24.182 | 23.873 | 21.138 | 22.734 | 20.984 | 20.045 | 21.368 | 22.351 |
| | [0.248] | [0.194] | [0.136] | [0.108] | [0.114] | [0.095] | [0.0988] | [0.121] |
| ARCH | 1.425 | 1.245 | 1.313 | 1.109 | 0.942 | 1.083 | 0.931 | 1.197 |
| | [0.358] | [0.491] | [0.403] | [0.178] | [0.278] | [0.204] | [0.182] | [0.312] |
| K-S | [0.821] | [0.722] | [0.632] | [0.562] | [0.432] | [0.401] | [0.505] | [0.593] |
| C-Vm | [0.739] | [0.812] | [0.345] | [0.598] | [0.329] | [0.691] | [0.931] | [0.769] |
| A-D | [0.935] | [0.821] | [0.524] | [0.677] | [0.421] | [0.699] | [0.893] | [0.788] |

**Note:** The numbers inside parentheses are the maximum likelihood values and the test statistics. The values inside brackets in 6 last rows show the P-values. All significant levels have been considered as %95.

### D. The index of stock markets and oil price

In this section, first the monthly average of crude oil price graph is presented in figure D-1 and next the logarithm of monthly average of Stock Market Indexes (SMIs) for seven understudied countries are presented in figures D-2 to D-8.

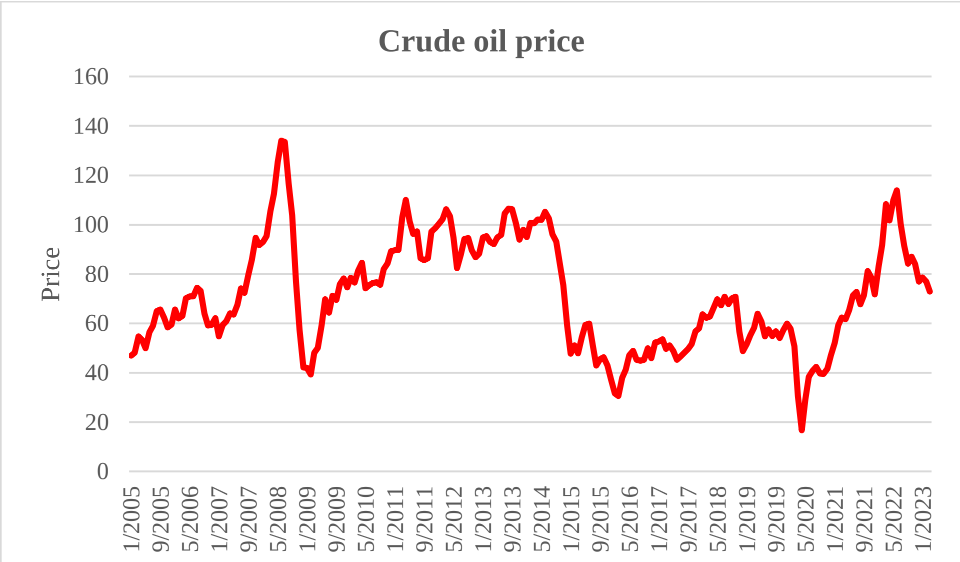


**Figure D-1**. Monthly average of crude oil price graph

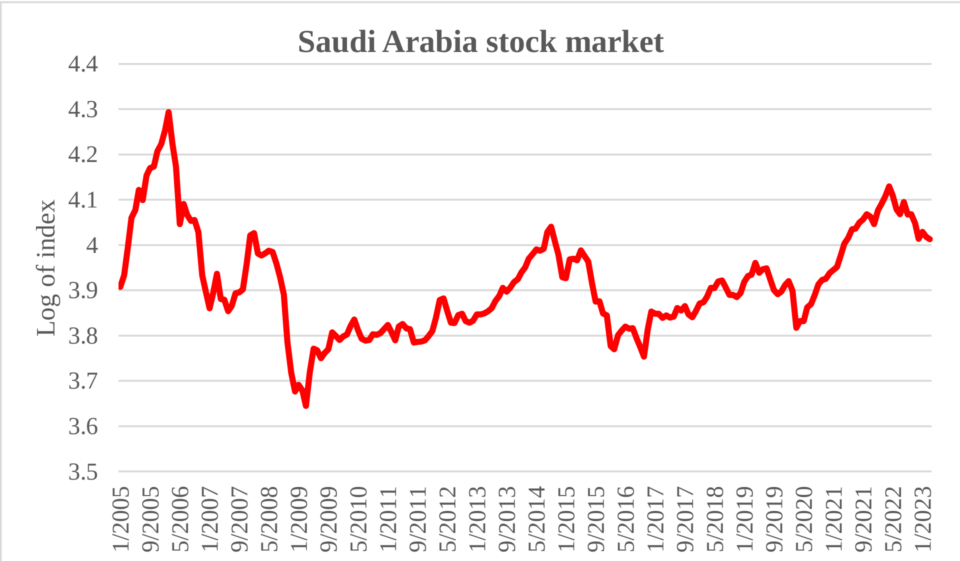


**Figure D-2.** Monthly average of Saudi Arabia's log of stock market index

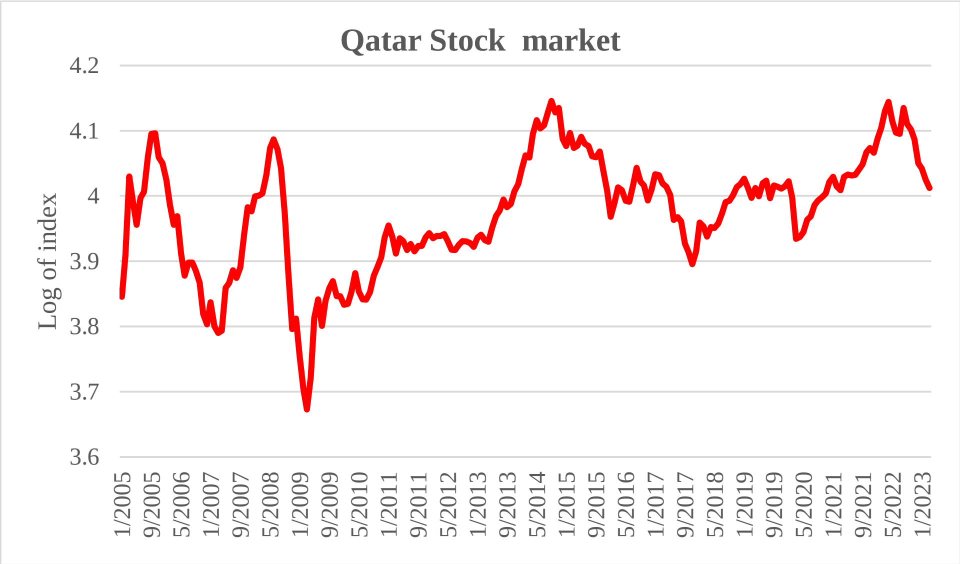


**Figure D-3**. Monthly average of Qatar's log of stock market index

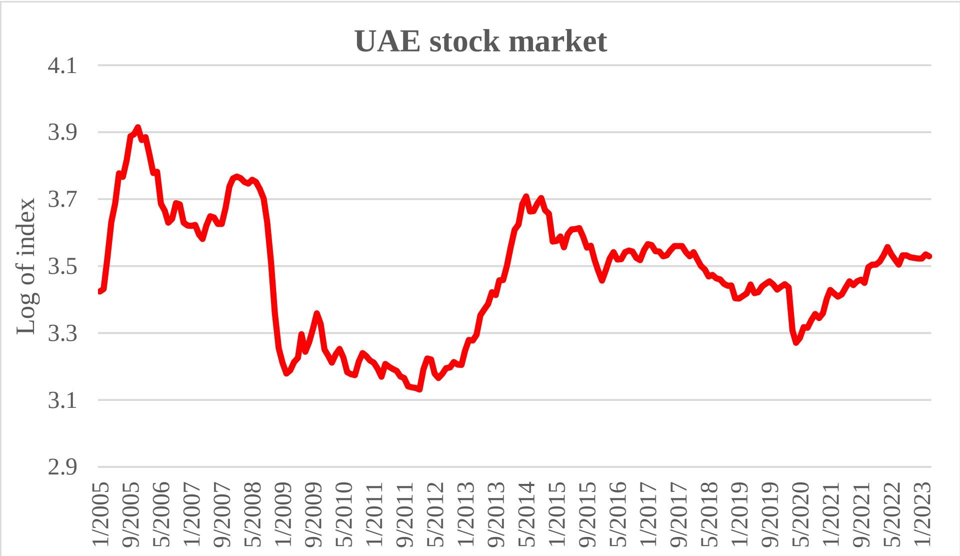


**Figure D-4**. Monthly average of UAE log of stock market index

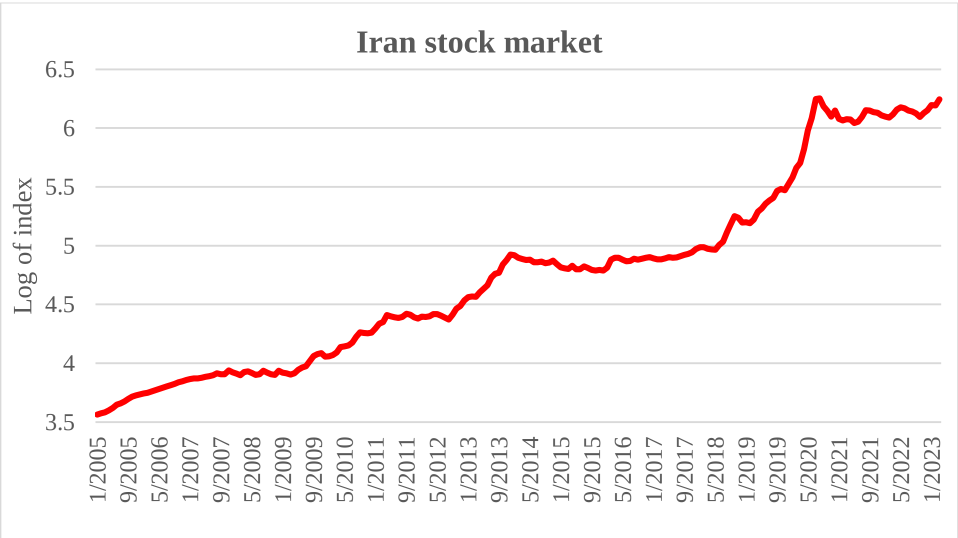


**Figure D-5**. Monthly average of Iran's log of stock market index

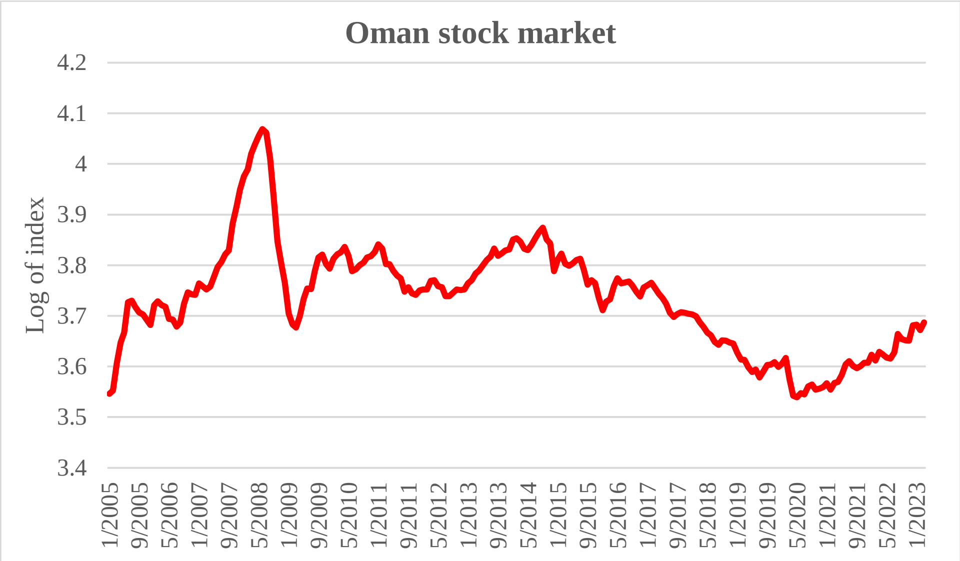


**Figure D-6**. Monthly average of Oman's log of stock market index

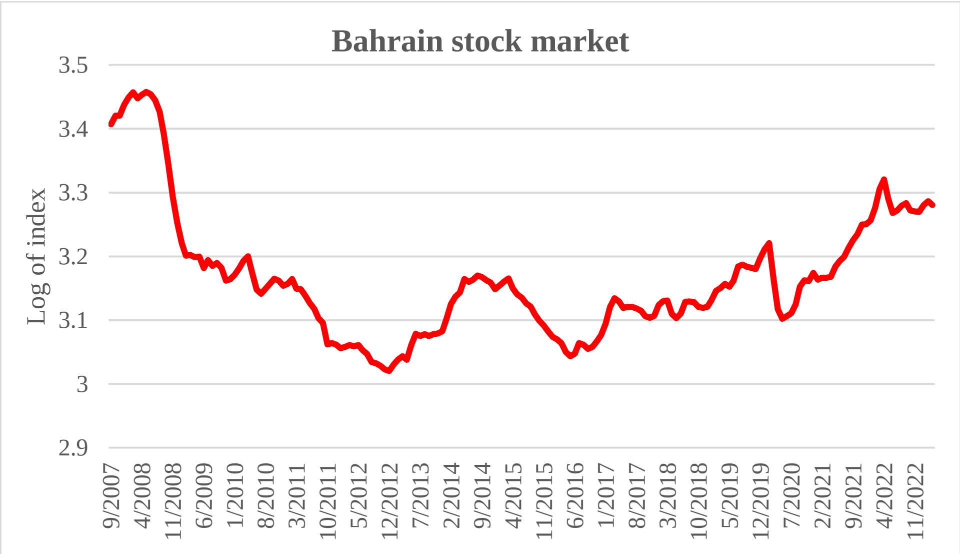


**Figure D-7**. Monthly average of Bahrain's log of stock market index

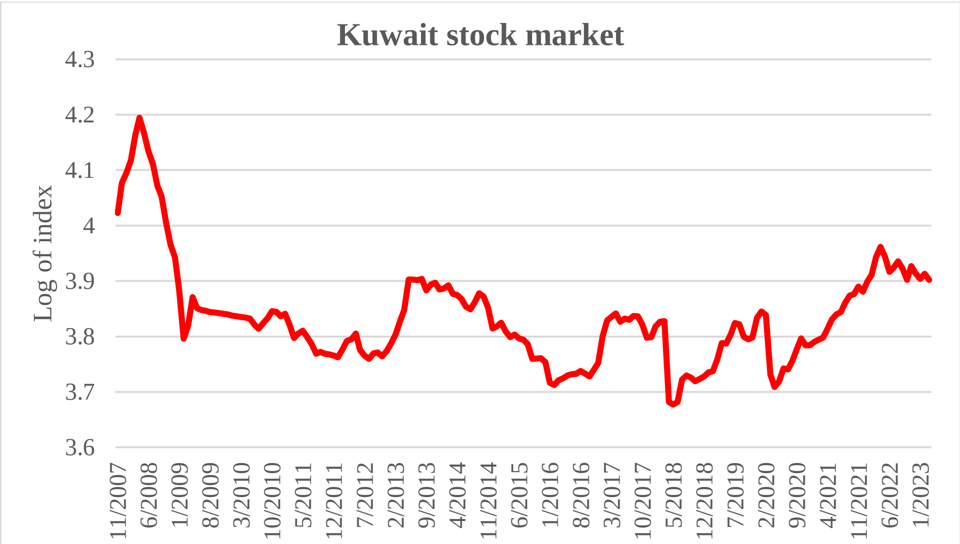


**Figure D-8**. Monthly average of Kuwait's log of stock market index

## References:

Feng, J., Lin, D. P., & Yan, X. B. (2014). "Research on measure of noise trading in stock market based on EGARCH-M model". In *2014 International Conference on Management Science & Engineering 21th Annual Conference Proceedings* (pp. 1183-1189). DOI: 10.1109/ICMSE.2014.6930363 (2014).

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