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Investigating the Nonlinear Effects of Oil Shocks on Inflation: New Empirical Evidence from Iran

A. M. Tehranchian^{1,*}, S. M. Khabaz², S. Hosseinnia Chafjiri³

¹ Professor, Department of Economics, Faculty of Economic and Administrative Sciences, University of Mazandaran, Babolsar, Iran

² M.A. Student in Economics, Faculty of Economic and Administrative Sciences, University of Mazandaran, Babolsar, Iran

³ M.A. Student in Economics, Faculty of Economic and Administrative Sciences, University of Mazandaran, Babolsar, Iran

ARTICLE INFO	ABSTRACT
<p>Article History: Received 2 January 2024 Received in revised form 24 March 2024 Accepted 7 May 2024 Available online 1 June 2024</p>	<p>This study investigates the nonlinear relationship between oil price shocks and inflation in Iran over the period 1978–2022. Utilizing the Hodrick–Prescott filter, the research first decomposes oil price movements into positive and negative shocks. These shocks, alongside key macroeconomic variables such as liquidity and the exchange rate, are then incorporated into a nonlinear Markov-switching model to examine their respective effects on inflation dynamics. The empirical results reveal a significant nonlinear and asymmetric impact: negative oil price shocks exert a more pronounced influence on inflation compared to positive shocks. This asymmetry is largely attributed to the contractionary consequences of falling oil revenues, which reduce money supply and contribute to economic slowdown. In contrast, positive shocks although expansionary have a relatively weaker transmission effect. The study highlights the importance of accounting for this asymmetry in macroeconomic planning. Accordingly, it recommends that policymakers integrate the direction and magnitude of oil price fluctuations when formulating stabilization and inflation control strategies. These findings underscore the necessity of adopting a nuanced approach in energy-exporting economies like Iran, where external oil market volatility can have substantial domestic inflationary implications.</p>
<p>Keywords: Oil Shocks, Inflation, Markov-Switching Model.</p>	

1. INTRODUCTION

Oil and inflation are two fundamental elements in the global economy, each exerting significant influence on people's lives and the economic trajectory of nations. Oil price shocks serving as a key determinant in the pricing of goods and services can substantially impact inflation. Given that oil prices are affected by various factors such as supply and demand dynamics, governmental policies, global developments, and even natural events, fluctuations in oil prices can lead to either inflationary pressures or deflation. According to economic theory, oil price changes

* Corresponding Author: m.tehranchian@umz.ac.ir

Professor, Department of Economics, Faculty of Economic and Administrative Sciences, University of Mazandaran, Babolsar, Iran



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stemming from supply or demand factors influence economic activity. An increase in oil prices typically results in a transfer of income from oil-importing to oil-exporting countries [1] (Kamijani & Haj Heidari, 2023).

Iran, endowed with a significant share of global oil reserves, ranks among the world's largest producers and exporters of crude oil. Due to its heavy reliance on revenues from oil exports, the Iranian economy has been highly susceptible to global economic booms and downturns, experiencing persistent double-digit inflation in recent decades. In Iran's economy, all or part of oil revenues are controlled by the government, which injects these earnings into the economy through fiscal policy tools. A portion of these revenues is converted into local currency by the Central Bank via the domestic foreign exchange market, while the unsold portion adds to the Bank's net foreign assets [2] (Mamipour & Sobhi, 2019). A decline in oil prices leads to reduced revenues, increased government borrowing from the banking system, monetary expansion, and ultimately a rise in the general price level. Conversely, an increase in oil prices boosts government income and allows for expansionary fiscal planning. Hence, oil price volatility directly affects the government's budget and revenues, leading to shifts in fiscal policy.

Both upward and downward fluctuations in oil prices influence the broader economy in direct and indirect ways. In fact, these fluctuations can significantly transform a nation's economic landscape, making oil prices one of the most impactful variables in Iran's macroeconomic environment [3] (Ghalehvandi & Zandi, 2021). Therefore, the relationship between oil price shocks and inflation is highly complex, and studying and forecasting the inflationary implications of oil price changes is of critical importance for policymakers and economic analysts. In this study, the impact of oil price shocks on inflation in Iran is empirically examined using the Markov-switching model over the period 1978–2022 (1357–1401 in the Iranian calendar).

The remainder of the paper is structured as follows: Section 1 provides the introduction and general background. Section 2 reviews the theoretical foundations and related literature. Section 3 outlines the research methodology and presents the Markov-switching model framework. Section 4 reports the empirical findings, and Section 5 concludes with policy implications and recommendations.

2. LITERATURE REVIEW

2.1. Theoretical Foundations

In economic literature, oil price shocks refer to the volatile fluctuations in crude oil prices in the global market. These fluctuations are typically influenced by a range of factors such as production levels, demand, national policies, sanctions, exchange rates, and various other economic and political dynamics. In general, the causes of oil price shocks can be categorized into two broad groups: fundamental and non-fundamental factors. Fundamental factors include supply and demand dynamics, while non-fundamental factors are largely associated with financial markets.

Hamilton (1983) is considered one of the earliest scholars to investigate the impact of oil price shocks on macroeconomic variables. His findings suggest that oil price shocks affect the economy through both demand-side and supply-side channels, with demand-side effects manifesting more rapidly [4] (Takrousta et al., 2019). On the supply side, oil shocks influence the productive capacity of the economy; for instance, an exogenous reduction in energy supply leads to a decline in output, alters the rate of capacity utilization, and reduces wage levels [5] (Abounoori & Rajaei, 2010).

Given that oil revenues constitute a major portion of many governments' budgets, the impact of oil price shocks on the demand side is mainly channeled through government fiscal policy. Oil-producing countries benefit from growing oil demand but must remain cautious in the face of supply volatility. If a price increase is driven by demand shocks, oil-producing companies typically experience higher profitability due to increased prices and sales volume. Conversely, if price fluctuations stem from supply-side concerns, producers may restrict output yet still profit from elevated prices. Therefore, oil producers' returns can be used as a control variable to distinguish between demand-driven and supply-driven oil price movements [6] (Gui & Sun, 2024).

Overall, oil prices may be influenced by various sources that generate different types of shocks. Employing general oil price indices without accounting for the heterogeneity of these shocks may lead to inconsistent estimations of their impact on inflation. One key nonlinear source in the transmission of oil price shocks to inflation

is asymmetry, which depends on the direction of the shock. That is, the effects of positive and negative oil price shocks on inflation may differ. This asymmetric transmission may operate through several channels. One such channel is the direct impact of oil price shocks on fuel prices, as fuels constitute a significant portion of the consumer basket and, therefore, have a direct effect on overall inflation. Notably, the higher the inflation trend, the more pronounced the asymmetry becomes [7] (Garzón & Girou, 2021). Hence, a certain proportion of oil price increases is transmitted to inflation through various mechanisms even if small in the short term, the effect can still be statistically significant [8] (Hosseini & Tehampour, 2009).

2.2. Research Background

2.2.1. Domestic Studies

Aboulhasani et al. (2016) [9] investigated the effects of oil shocks on housing sector inflation in Iran over the period 1991–2011 using a Dynamic Stochastic General Equilibrium (DSGE) approach rooted in the New Keynesian framework. Their findings indicated that an oil price shock temporarily increases inflation in both housing and non-housing sectors.

Asna-Ashari et al. (2016) [10] examined the effects of oil price shocks on inflation, economic growth, and monetary aggregates in Iran from 1961 to 2011 using the Koo and Perron methodology. Results revealed that the highest oil price impact coefficients on output, inflation, and money growth were observed in regimes one, one, and five, respectively. Additionally, the duration of oil price impacts on these variables was highest in regimes four, two, and five, respectively.

Rajabi and Karimi (2016) [11] analyzed the effects of oil price shocks on economic activity and monetary policy in Iran using a Structural Vector Autoregression (SVAR) model for the period 1990–2013. Their results suggested that upward price fluctuations and oil market uncertainty, over the long term, reduce economic and industrial growth while increasing monetary expansion and inflation.

Mehnatfar et al. (2018) [12] explored the effects of oil price shocks on inflation in Iran from 1981 to 2014 using quantile regression across different deciles. Findings showed a positive relationship between inflation and oil price volatility.

Takrousta et al. (2019) [4] studied the impact of oil price shocks on inflation in OPEC countries from 2008 to 2016 using a panel vector autoregressive approach. Results indicated that oil shocks linked to national security concerns had no significant inflationary effect, while other types of oil price shocks led to increased inflation in these countries.

Khoshkelam (2019) [13] examined the short- and long-term effects of oil shocks on inflation in Iran over the period 1990–2016 using a vector error correction model. The findings, from both symmetric and asymmetric models, indicated a negative relationship between oil price shocks and inflation, with long-term negative shocks exerting a greater impact than positive shocks.

Jafari and Golkhandan (2020) [14] analyzed the asymmetric effects of oil price shocks on inflation in OPEC countries (1990–2014) using the hidden panel cointegration method. The results showed that both positive and negative oil shocks raise inflation, though negative shocks have a stronger effect.

Tavakkolian et al. (2022) [15] assessed the effects of oil price shocks on inflation in Iran from 1973 to 2017 using the DSGE framework. Their findings suggested that in the initial stage, increased oil revenues and imports helped control inflation, but in the longer run, inflation rose due to monetary expansion.

Mohammadesmail et al. (2022) [16] investigated the impact of oil shocks on inflation in OPEC countries during 1990–2018 using a panel structural vector autoregressive (SVAR) model. The findings indicated that rising oil revenues led to higher domestic demand and subsequently to inflationary pressures.

Fathi et al. (2023) [17] analyzed the asymmetric effects of oil price shocks on inflation in oil-exporting and oil-importing countries from 1990 to 2018 using the EGARCH approach. The results revealed that inflation's response to oil shocks was asymmetric in both groups of countries.

Karimi et al. (2023) [18] studied the impact of oil revenue shocks on inflation in Iran over the period 1990–2018 using a time-varying parameter vector autoregressive (TVP-VAR) model. Their results showed that the influence of oil shocks on inflation varied over time, shifting from a negative to a positive effect following the 2005 revenue shock.

2.2.2. Foreign Studies

Bass (2019) [19] investigated the impact of global oil price shocks on inflation dynamics in Russia during the period 2010–2017 using the Vector Error Correction (VEC) approach. The findings revealed that both oil prices and consumer inflation exhibited an upward trend in the long term.

Lacheheb and Seraj (2019) [20] examined the relationship between oil price fluctuations and the inflation rate in Algeria from 1970 to 2014 using the Nonlinear Autoregressive Distributed Lag (NARDL) model. Their results indicated a significant positive relationship between rising oil prices and inflation, while the link between declining oil prices and inflation was found to be insignificant.

Chen et al. (2020) [21] analyzed the effects of structural oil price volatility shocks on inflation in China over the period 1999–2016 using the Time-Varying Parameter Structural Vector Autoregressive model with Stochastic Volatility (TVP-SVAR-SV). The study found that the influence of oil price shocks on inflation was partial at each stage and diminished along the pricing chain.

Sultan et al. (2020) [22] studied the relationship between oil prices and inflation levels in India from 1970 to 2017 using Johansen cointegration methodology. The results showed that oil prices significantly affected inflation both in the short term and long term.

Zulfigharov and Neunkirch (2020) [23] evaluated the impact of oil price fluctuations on inflation in Azerbaijan over the period 2002–2018 using the Vector Autoregression (VAR) approach. The findings indicated that oil prices contributed to rising inflation.

Zakaria et al. (2021) [24] investigated the influence of global oil prices on inflation rates in South Asian countries from 1980 to 2018 using cointegration techniques and VAR models. The results confirmed the existence of a cointegration relationship between oil prices and inflation.

Turan and Ozer (2022) [25] examined the effects of global oil price changes on inflation rates in five Central and Eastern European (CEE) countries from 1994 to 2018 using a cointegration approach. The results demonstrated a positive relationship between oil price shocks and inflation.

Cao et al. (2024) [26] explored the consequences of oil price volatility on inflation in G20 countries (including Italy, Brazil, Russia, Japan, Canada, and Mexico) from 1990 to 2019 using a dynamic simulated ARDL model. The results confirmed a long-term relationship between oil price shocks and inflation, showing that oil prices are significantly and negatively associated with inflation over the long run in selected G20 countries.

Moussa et al. (2024) [27] analyzed the asymmetric effects of international and domestic oil prices on inflation in Côte d'Ivoire from 2005 to 2022 using a nonlinear autoregressive model. The results revealed that, in the long run, increases in both international and domestic oil prices led to higher inflation rates, with a greater impact attributed to domestic oil prices. Furthermore, the long-run effects of negative oil price shocks on inflation were found to be more pronounced than those of positive shocks.

3. DESIGN OF THE PROPOSED MODEL

In order to examine the symmetry of oil price shocks on inflation, it is necessary to first extract the positive and negative oil price shocks using the Hodrick-Prescott (HP) filter. Subsequently, unit root tests are conducted to assess the stationarity of the variables used in the study. The final step involves specifying the nonlinear Markov-Switching model.

3.1. Extraction of Oil Price Shocks

Various methods exist for calculating shocks in economic variables. For instance, Lee et al. (1995) [28] used the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model to extract oil price shocks. Another common technique is the moving average method; however, this method faces limitations in defining the period length and often results in the loss of both short-term and long-term data information. One of the most widely used approaches is the Hodrick-Prescott (HP) filter, which is preferred because it effectively separates cyclical components from the time series and provides smoothed values that are closely aligned with actual data (Kazerooni & Rostami, 2007) [29]. In the present study, the HP filter has been adopted for extracting oil price shocks.

The Hodrick-Prescott filter, introduced by Hodrick and Prescott in 1989, is a single-equation smoothing technique and is considered more prominent compared to other filtering methods. The underlying logic of this approach is to decompose observed shocks into permanent and transitory components (Sameti et al., 2010) [30].

The HP filter is a two-sided linear filter that produces a smoothed trend path (denoted by s) of oil prices by minimizing the variance of oil price deviations from s , subject to a penalty for the squared second differences of s . The Lagrangian form of the objective function is as follows:

$$\min : L \sum_{t=1}^T (op_t - s_T)^2 + \lambda [\sum_{t=2}^{T-1} [(s_{t+1} - s_t)(s_t - s_{t-1})]^2] \tag{1}$$

Where:

- T denotes the number of observations,
- λ (lambda) is the smoothing parameter that determines the degree of trend smoothness.

The commonly used values for λ are:

- 100 for annual data,
- 1,600 for quarterly data,
- 14,400 for monthly data (Ravn & Uhlig, 2002) [31].

Based on this method, the trend component of the oil price time series representing the expected or forecastable shocks is first extracted. The unexpected (unanticipated) shocks are then obtained by calculating the difference between the actual oil prices and the extracted trend component:

To derive the positive (Pos_t) and negative (Neg_t) oil price shocks, the following procedure is applied: Positive shocks refer to those unanticipated oil price changes whose values are greater than zero, while negative shocks correspond to unexpected changes with negative values. Accordingly, for identifying positive shocks, if the unanticipated component of the oil price change is negative, it is replaced with zero; if it is positive, the actual value is retained. The same logic is applied in reverse for determining negative shocks if the shock value is positive, it is replaced by zero, and if it is negative, the actual (negative) value is used.

$$Neg_t = \min(shock, 0) \tag{1}$$

$$Pos_t = \max(0, shock) \tag{2}$$

3.2. Introduction to the Markov-Switching Model

The Markov-Switching model was first introduced by Quandt (1972) and later expanded by Quandt and Goldfeld (1973). Hamilton (1989) further developed the model for identifying business cycles, leading to its widespread recognition as a regime-switching model and one of the most prominent nonlinear time series models. Granger and Teräsvirta (1993) categorized nonlinear time series models involving regime transitions into two main groups: the first group includes Smooth Transition Regression (STR) models, where the transition variable is explicitly defined and observable, and the shift between regimes occurs gradually with a specified slope. The second group comprises Markov-Switching models, in which regime shifts occur abruptly and are governed by probabilistic transitions estimated through a transition probability matrix (Chang & Jansen, 2005) [33].

In the Markov-Switching framework, different model configurations arise depending on which components of the equation are dependent on the regime variable. In economic studies, the most frequently used configurations include: Markov-Switching in the Mean (MSM), Intercept (MSI), Autoregressive Coefficients (MSA), and Heteroskedasticity (MSH). Table 1 provides an overview of these various types of Markov-Switching models.

Table 1. Different Configurations of the Markov-Switching Model

Regime-Dependent Component	Error Term Distribution	Equation	Model Name
Mean	$\varepsilon_t \sim IID(0, \sigma^2)$	$\Delta y_t - \mu(s_t) = \sum_{i=1}^p \alpha_i (\Delta y_{t-i} - \mu(s_{t-i})) + \varepsilon_t$	MSM(m)-AR(p)
Intercept	$\varepsilon_t \sim IID(0, \sigma^2)$	$\Delta y_t = c(s_t) \sum_{i=1}^p \alpha_i (\Delta y_{t-i}) + \varepsilon_t$	MSI(m)-AR(p)
Error Variance	$\varepsilon_t \sim IID(0, \sigma^2(s_t))$	$\Delta y_t = c + \sum_{i=1}^p \alpha_i (\Delta y_{t-i}) + \varepsilon_t(s_t)$	MSH(m)-AR(p)
Autoregressive Coefficients	$\varepsilon_t \sim IID(0, \sigma^2)$	$\Delta y_t = c + \sum_{i=1}^p \alpha_i(s_t) (\Delta y_{t-i}) + \varepsilon_t$	MSA(m)-AR(p)

Table 2. Summary of Markov-Switching Model Variants

		MSM		MSI	
		Variable μ	Constant μ	Variable C	Constant C
Constant α_i	Constant σ^2	MSM-AR	Linear AR model	MSI	Linear AR model
	Variable σ^2	MSMH-AR	MSH-AR	MSIH-AR	MSH-AR
Variable α_i	Constant σ^2	MSMA-AR	MSA-AR	MSIA-AR	MSA-AR
	Variable σ^2	MSMAH-AR	MSAH-AR	MSIAH-AR	MSAH-AR

In the MSMH-AR model, both the variance and the mean of the model depend on the regime variable. Considering that some economic variables and empirical observations do not exhibit uniform behavior, such variables can therefore be modeled nonlinearly using the models presented in the above table.

To test the research hypotheses and address the research questions, the following econometric model is proposed, following the approaches of Nasr Esfahani et al. (2003) [34], Tayebi et al. (2015) [35], and Sahabi et al. (2013) [36]:

$$\begin{aligned}
 (DLCPI_t - \mu(s_t)) = \sum_{i=1}^p \alpha_i(s_t)(DLCPI_{t-i} - \mu(s_{t-i})) + \beta_i(s_t)Negdlop_t + \gamma_i(s_t)POSdlop_{t-k} \\
 + DLR_t + DLM_t + \varepsilon_t(s_t) \\
 \varepsilon_t \sim IID(0, \sigma^2(s_t))
 \end{aligned}
 \tag{4}$$

In the above equation, D represents the difference operator, $DLCPI_t$ is the differenced logarithm of the consumer price index, $Negdlop_t$ denotes the negative (decreasing) shock in oil prices, $Posdlop_t$ indicates the positive (increasing) shock in oil prices, LR_t is the logarithm of the unofficial market exchange rate (in rials), LM_t represents the logarithm of the money supply volume based on its components (in billion rials), s_t is the state or regime variable, and ε_t is the disturbance term or error term, which follows a normal distribution.

The parameter p indicates the maximum lag length of the dependent variable, while λ , γ , α , and β are model parameters.

It is noteworthy that the data and statistics for the study variables were collected annually over the period 1357 to 1401 (Iranian calendar) from the Time Series Database and Balance Sheets of the Central Bank and the Organization of the Petroleum Exporting Countries (OPEC). All estimations in this study were conducted using EViews and OxMetrics software packages.

4. EMPIRICAL RESULTS

Table (3) presents the results of the Augmented Dickey-Fuller (ADF) unit root test for the logarithm of the Consumer Price Index (LCPI), positive oil price shock (POSLOP), negative oil price shock (NEGLOP), logarithm of money supply (LM), and logarithm of exchange rate (LR).

Table 3. Results of the Augmented Dickey-Fuller (ADF) Unit Root Test

Variable	With Intercept	With Intercept and Trend	Without Intercept and Trend	Test Result
LCPI	*-3.28	*-3.52	-0.48	I(1)
DLCPI	*-5.87	*-5.91	*-5.90	
LM	*-6.42	*-6.52	*-6.48	I(1)
DLM	*-7.44	*-4.77	*-7.54	
LR	*-4.52	*-4.60	*-4.05	I(1)
DLR	*-9.07	*-9.29	*-9.01	
POSLOP	*-4.49	*-4.71	*-3.46	I(0)
NEGLOP	*-4.79	*-4.93	*-3.84	I(0)

Source: Research Findings

The asterisk (*) indicates rejection of the null hypothesis.

As can be seen from the data in the above table, the positive and negative oil price shock variables are stationary at level (I(0)), while the logarithm of the consumer price index, logarithm of money supply, and logarithm of exchange rate are stationary after first differencing (I(1)).

Table (4) presents the results of the Phillips-Perron (PP) unit root test for the economic variables.

Table 4. Results of the Phillips-Perron (PP) Unit Root Test

Variable	With Intercept	With Intercept and Trend	Without Intercept and Trend	Test Result
LCPI	-2.56	-2.56	0.09	I(1)
DLCPI	*-6.88	*-10.75	*-6.91	
LM	*-6.42	*-6.55	*-6.48	I(1)
DLM	*-38.75	*-38.68	*-39.59	
LR	*-4.95	*-4.74	*-4.51	I(1)
DLR	*-9.85	*-12.20	*-9.69	
POSLOP	*-4.54	*-4.75	*-3.75	I(0)
NEGLOP	*-4.63	*-4.67	*-3.82	I(0)

Source: Research Findings

The asterisk (*) indicates rejection of the null hypothesis.

The findings from the Phillips-Perron test show that the logarithms of the Consumer Price Index, money supply, and exchange rate are not stationary at the level. In the presence of structural breaks in the data, the results of the Dickey-Fuller and Phillips-Perron tests may be invalid. These tests may mistakenly identify variables as integrated of order one when, after accounting for structural breaks, the variable is actually stationary at level.

Ignoring structural breaks may lead to spurious regression. Therefore, in Table (5), the Zivot-Andrews (1992) test, which allows for an endogenous structural break, is estimated.

Table 5. Results of the Zivot-Andrews Unit Root Test

Variable	Break in Intercept	Break in Trend	Break in Intercept and Trend
LCPI	-2.97	*-2.51	*-3.22
LM	*-5.37	*-3.96	*-4.10
LR	*-9.70	-7.88	-7.87

**Source: Research Findings
The asterisk (*) indicates rejection of the null hypothesis.*

Table (6) presents the results of the Lee-Strazicich (2003) unit root test, which allows for two endogenous structural breaks.

Table 6. Results of the Lee-Strazicich (LS) Two-Break Unit Root Test

LS-two break						
Critical Values			Test Statistic	Second Break Year	First Break Year	Variable
10%	5%	1%				
-5.79	-6.15	-6.91	-4.79	2012	1994	LCPI
-5.79	-6.15	-6.69	*-19.45	2013	1988	LM
-5.77	-6.10	-6.75	-4.22	1998	1991	LR

*Source: Research findings
The asterisk (*) indicates rejection of the null hypothesis.*

As observed from the above data, the variables of the logarithm of the consumer price index (LCPI), the logarithm of money supply (LM), and the logarithm of exchange rate (LR), considering two structural breaks, are stationary.

Generally, the presence of a unit root in the studied variables may be due to the failure to consider structural breaks in their trends. Based on the results of standard unit root tests and those accounting for endogenous structural breaks, it can be concluded that oil price shocks are stationary at level, and the logarithm of the consumer price index, logarithm of exchange rate, and logarithm of money supply become stationary at the 95% confidence level after considering two structural breaks. Meanwhile, the Markov-switching model inherently accounts for dozens of endogenous structural breaks. Therefore, the estimated regression model is not spurious. In the present study, to examine the elasticity coefficients of variables, their logarithmic differences have been used.

4.1. Specification and Estimation of the Econometric Model Based on the Markov-Switching Method

After conducting the unit root tests and extracting positive and negative oil price shocks, the Markov-switching model is estimated. For this purpose, the dependent variable, inflation, is modeled as a function of explanatory variables (positive and negative oil price shocks, logarithm of money supply, and logarithm of exchange rate). Lags of inflation, as a function of regime, are also included as explanatory variables. Additionally, the two oil price shocks (positive and negative) are considered regime-dependent.

The first step in estimating the Markov-switching model is testing the nonlinear relationship between inflation and oil shocks.

To examine the nonlinear relationship between the studied variables, the Likelihood Ratio test has been used. The results are presented in Table (7).

Table 7. Results of the Test for the Existence of a Nonlinear Relationship Between Model Variables

Probability	Degrees of Freedom	LR Test Statistic
0.00	3	*24.95

The asterisk () indicates rejection of the null hypothesis.
Source: Research findings*

According to the results in the table above, the Likelihood Ratio test statistic is 24.95, and the null hypothesis of no nonlinear relationship between the model variables is rejected. Therefore, there is a nonlinear relationship between inflation and oil price shocks in Iran.

After confirming the existence of a nonlinear relationship between the model variables, various Markov-switching models are estimated. Based on the Akaike Information Criterion (AIC), the maximum log-likelihood of regimes (LR), and the optimal lag length for each Markov model, the best model is selected. Then, the estimated models are compared according to the classical assumptions, the value of the maximum likelihood function (higher values indicate a better model), the average value and intercept calculated in different regimes, and the transition probabilities between regimes. The results obtained from model estimation and the selection of the optimal model are consistent with common theories and the macroeconomic literature. In this study, the MSMAR(2)-AR(2) model with two regimes and two lags is identified as the optimal model, and the results are reported in Table (8).

Table 8. Estimation Results of the Markov-Switching Model Dependent Variable: Inflation (DLCPI)

Variable	Coefficient	Std. Error	t-Statistic
AR-1 (Regime 0)	-1.85	0.59	-3.13
AR-1 (Regime 1)	0.68	0.15	4.45
AR-2 (Regime 0)	0.52	0.40	1.31
AR-2 (Regime 1)	-0.15	0.17	-0.90
DLR (log exchange rate diff.) (Regime 0)	1.91	0.48	3.93
DLM2 (log liquidity diff.) (Regime 0)	0.02	0.00	2.98
Constant (Regime 0)	0.23	0.02	10.30
Constant (Regime 1)	0.07	0.01	3.95
Negdlop (negative oil price shock) (Regime 0)	-0.06	0.04	-1.31
Negdlop (Regime 1)	-0.21	0.05	-3.74
Posdlop (positive oil price shock) (Regime 0)	0.05	0.05	0.92
Posdlop (Regime 1)	0.23	0.04	4.75
Sigma (Regime 0)	0.66	0.21	
Sigma (Regime 1)	0.91	0.05	
Statistic	Value		
AIC	-2.40		
SC	-1.85		
Log-Likelihood	62.20		
Number of Estimated Parameters	13		
Mean Inflation (Sample Period)	0.18		
Standard Deviation of Inflation (Sample Period)	0.08		

Source: Research findings

According to the information presented in the above table, the lagged inflation variables up to two periods have a negative impact on inflation in both regimes. The intercept for regime zero is 0.23, while for regime one it is 0.07. The estimated coefficient for the exchange rate is positive and significant, as an increase in the exchange rate is expected to raise the cost of imported and domestically produced goods, thereby increasing inflation. Additionally, since liquidity volume is one of the main factors influencing inflation, its estimated coefficient is also positive and consistent with expectations.

However, the main focus of this study is on the estimated coefficients for oil price shocks. The coefficient for the positive oil price shock (posdlop) in regime zero is 0.05, and in regime one it is 0.23. Thus, the positive oil price shocks have a positive and significant effect on inflation in both regimes during the study period. Furthermore, the coefficient for the negative oil price shock (negdlop) in regime zero is -0.06, and in regime one it is -0.21. Therefore, negative oil price shocks have a negative effect on inflation in both regimes.

Figure (1) illustrates the probabilities of being in each regime, the difference between actual inflation rates and the model's fitted values, as well as the predicted inflation for the next period. The closer the actual values are to the estimated model values, the higher the explanatory power of the model.

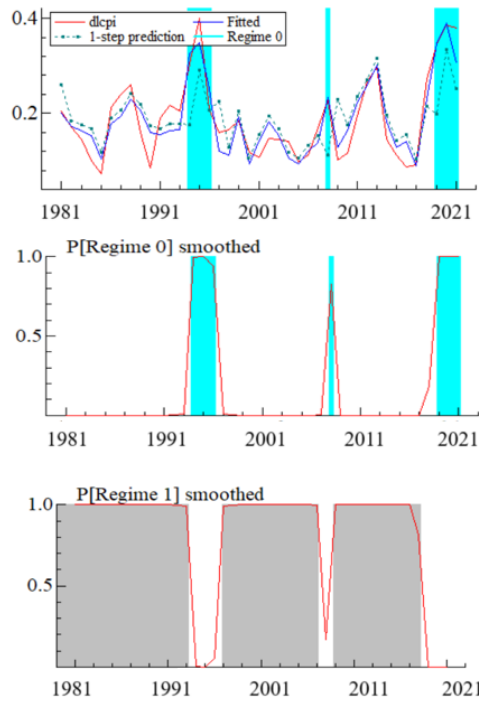


Fig. 1. Fitted Model Plots and Extracted Regimes
Source: Research findings

Table 9 presents the years allocated to the two regimes for the inflation rate extracted and reported. According to the research findings, 7 years, equivalent to 17.07% of the data, belong to regime zero, while 34 years, or 82.93% of the data, fall under regime one. On the other hand, the average duration of staying in regime one (11.33 years) is longer than that of regime zero (2.33 years). Therefore, regime one exhibits greater persistence and stability compared to regime zero in the Iranian economy.

Table 9. Extracted Regime Years for Inflation Rate

Regime One	Years in Regime	Regime Zero	Years in Regime
13	1981 - 1993	3	1994 - 1996
11	1997 - 2007	1	2008
10	2009 - 2018	3	2019 - 2021

Source: Research findings

Table 10. Transition Probabilities Between Regimes

	Regime 0	Regime 1
Regime 0	0.66	0.08
Regime 1	0.33	0.91

Source: Research findings

Diagnostic tests are conducted to examine the normality of the error term distribution, the absence of autocorrelation, and heteroscedasticity. Table (11) presents the results of the tests for autocorrelation, heteroscedasticity, and normality of the error terms.

Table 11. Results of Diagnostic Tests on Error Terms

Test	Test Statistic	Probability
Autocorrelation	0.82	0.99
Heteroscedasticity	0.06	0.97
Normality of Errors	0.31	0.85

Source: Research findings

As the results indicate, the error terms do not suffer from issues of autocorrelation, heteroscedasticity, or non-normality at the optimal lag length used in the estimation.

5. CONCLUSION AND POLICY RECOMMENDATIONS

One of the most important economic goals in economic planning is to achieve sustainable economic growth accompanied by a low inflation rate. This is largely due to the wide-ranging effects and influences of these indicators. In countries where a significant portion of income derives from oil exports, fluctuations in oil prices have a considerable impact on the general price level and economic growth. Among the macroeconomic variables that directly and indirectly affect the general price level are education, health, income, and employment. Therefore, understanding the determinants of the general price level is of great importance. Changes in global oil prices, considering the export quota ceilings of OPEC countries, affect the foreign exchange earnings of the country. Consequently, the supply of foreign currency, monetary base, government revenues, and thus government expenditures are exposed to oil price volatility. It appears that the net effect of all these changes and the interplay among macroeconomic variables manifest in production output and the general price level.

This study examined the asymmetry of oil price shocks on inflation in Iran using the Markov-switching model. The analysis employed data from the Iranian economy over the period 1978–2022 (1357–1401 in the Iranian calendar). The estimation results indicate a nonlinear relationship between positive and negative oil price shocks and inflation, with negative shocks exerting a greater impact than positive shocks. Moreover, the findings highlight the decisive role of money supply contraction and the recessionary effects of declining oil prices.

Based on the study's findings, it is recommended that policymakers, in order to achieve economic stability, carefully consider the asymmetry between positive and negative oil price shocks on inflation when designing and implementing policy measures. In other words, to effectively control the effects of oil price shocks, greater attention must be given to the type and intensity of policies, taking into account this asymmetry.

Declaration

We acknowledge that we used ChatGPT to enhance the academic writing of our manuscript while ensuring the originality and integrity of our work.

Transparency Statement

The data supporting this study are available upon reasonable request to the corresponding author, subject to ethical and confidentiality considerations.

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Declaration of Interest

The authors declare that they have no competing interests.

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