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Impacts of Oil Price Shock on Sector Returns with Regime-Switching Approach: New Evidence from Indonesian Stock Market

Mohammad A. Dharmawan[1], Dominicus S. Priyarsono[2]*, Bagus Sartono[3]

[1]School of Business, Bogor Agricultural University, Bogor, Indonesia, [2]Faculty of Economics and Management, Bogor Agricultural University, Bogor, Indonesia, [3]Department of Statistics, Bogor Agricultural University, Bogor, Indonesia.
*Email: priyarsono@ipb.ac.id

ABSTRACT

This study investigates the impacts of an oil price shock on sector returns in the Indonesian stock market. Oil prices and the stock market are both important elements of the Indonesian economy. The research attempts to characterize the impacts and causality relationship between oil price shocks and sector returns, with time segmentation based on structural breaks in oil price data from 1996 to 2016. We applied structural-break analysis to oil prices using the Bai-Perron procedure and identified three break points, thereby dividing the data set into four different regimes. We analyzed the impacts of oil price shocks and sector returns using an unrestricted vector autoregression (VAR) model. The findings indicated that impacts of the oil price shocks on sector returns vary, depending on the regime in which the shocks occurred. In general, during low and stable oil price regimes, the impacts of oil price shocks on sector returns were not significant, whereas for high oil price and high volatility regimes, oil price shocks affected some sectors significantly.

Keywords: Oil Price Shock, Stock Returns, Vector Autoregression
JEL Classifications: C22, E44, G11

1. INTRODUCTION

This research examines the effect of oil price shocks on sector returns in the Indonesian stock market. The Oil and gas industry and the stock market are important aspects of the Indonesian economy. For example, crude oil provided 42% of Indonesia's primary energy mix, still a significant portion despite government endeavors to diversify energy sources (Dewan Energi Nasional, 2016). Since the discovery of the Telaga Said oil field in North Sumatra in 1885, Indonesia's oil production increased to a peak of 1.5 million barrels per day in 1987. Along with a reduced production rate and rising domestic oil consumption, Indonesia has shifted from exporter to become a net importer of crude oil since 2004, and resigned from the Organization of Petroleum Exporting Countries (OPEC) in 2009. Indonesia's oil and gas industry contributed 17.1% of the state's non-tax revenues (Ministry of Finance Republic of Indonesia, 2016). The Indonesian Stock Exchange is also a critical element of the Indonesian economy considering the ratio of total market capitalization to gross domestic product (GDP) reached 45.7% (2016), and the capital market contributed 8.56% of total state's tax revenues (2016).

Historically, oil price changes are difficult to predict, given that they are driven by different regimes over time due to low price elasticity of short-term demand and supply changes, susceptibility of supply to disturbance, and the nature of oil production profile. From the perspective of economic theory, the equilibrium between inventory levels, futures contracts, and the fact that oil is a non-renewable resource determines oil price movements (Hamilton, 2008). At the time of this research, the most recent oil price shock occurred in October 2014, when the price of crude oil fell from around USD $140 per barrel to below USD $30 per barrel. Companies engaged in the use of oil and gas downstream benefit from lower raw material costs whereas companies involved in the oil and gas industry upstream experienced challenges, with reduced revenue from lower selling prices meaning that, consequently, it must reduce the number of workers and activities.

This research has been based on the postulation that an oil price shock will affect the return of a sector. Sector-level analysis is interesting because it can provide information about processes not explained in the aggregate-level analyses (Fama and French, 1997). In addition, understanding the impact of an oil price shock on a sector serves as a basis for decision making regarding investment-asset allocation in the capital market.

2. PROBLEM DEFINITION

Previous studies have suggested mixed results regarding the nature of the relationship between oil prices shocks and stock returns (Chen et al., 1986; Jones and Kaul, 1996; Sadorsky, 1999). Kilian and Park (2009) explained that the variation in responses to an oil price shock depends whether the driver is demand-side or supply-side. Kilian (2009) stated that an oil price shock could be either a supply shock or a demand shock, with shock occurring in the form of a significant increase or decrease in the oil price. The influence of an oil price shock depends on the type of shock, e.g., supply shock, aggregate demand shock, or oil-market specific precautionary demand shock.

Based on that view, the effect of an oil price shock on sector returns is influenced by the combination of regional and global economic factors (aggregate demand), geopolitics (precautionary demand), and the level of production (supply side). The combination of factors driving an oil price shock form a system referred to as the "regime." We identify a regime based on the structural change in oil prices over time, in line with Hamilton's (2008) opinion that changes in oil prices tend to be permanent, unpredictable, and driven by different regimes over time. Prior research by Agusman and Deriantino (2008), using Indonesian data from 1996 to 2008, concluded that no significant relationship exists between oil price shocks and sector returns. Nevertheless, we conjecture that different results could be obtained by applying time-span segmentation based on structural changes in the oil price. Figure 1 illustrates the research framework.

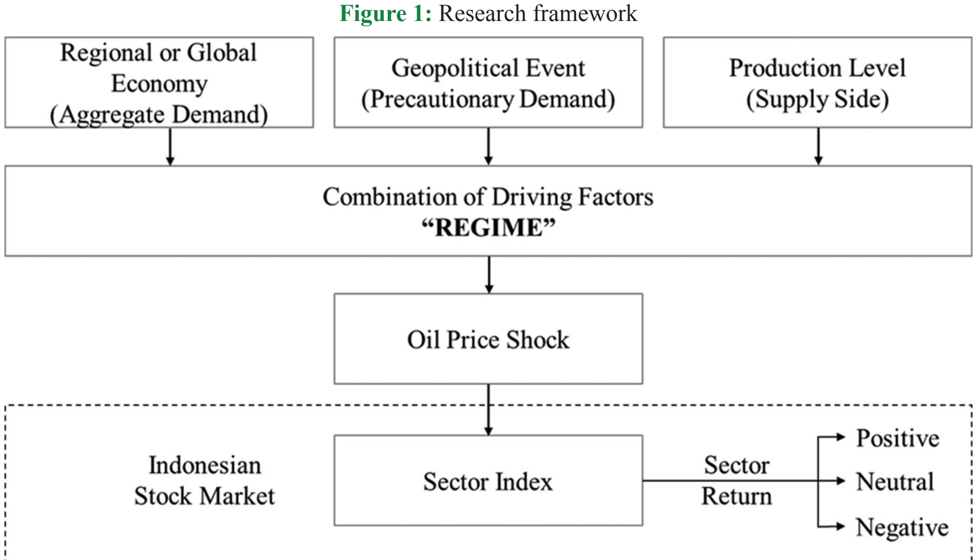
This study examines the effect of oil prices on a sector by considering the specific oil price regime. The research objectives are to identify structural changes in oil prices during the investigation period to be used in classifying and characterizing the oil price regime and to analyze the dynamic relationship between the rate of oil price changes to sector returns in the Indonesian stock market. The dynamic relationship between oil prices and sector returns provided information on the impact that an oil price shock has on a sector. This signaling mechanism provides valuable information for asset allocation decisions. We started with an explorative study on the dynamics of oil prices, identifying the structural changes in oil price over time based on the identified break points; we also classified and characterized the oil price regime. For each identified regime, we analyzed the effect of an oil price shock on sector returns.

3. LITERATURE REVIEW

At the macroeconomic level, Atukeren (2005) used a granger causality test to show that oil price shock caused deterioration in the macroeconomic environment in general. Oil price shocks caused imports to decrease more than exports, thus reducing the adverse effects on GDP. Kilian (2009) used a structural vector autoregression (SVAR) model to examine the US economy and found an inverse causal relationship between macroeconomic aggregates and oil prices. However, a macroeconomic model constructed from oil price assumptions as an exogenous factor could be misleading. A model with oil prices as an endogenous factor should focus on the demand side of the oil market.

Li and Zhao (2011) used a SVAR model, which indicated that demand shocks had a significant effect in the short term; they further noted an influence of US Dollar liquidity on oil price fluctuations. Ftiti et al. (2016) used evolutionary co-spectral analysis and a cointegration procedure to study the impact of the oil price shocks on OPEC countries in the Middle East. They found that oil price shocks had both short-term and medium-term impacts, with medium-term effects greater than short-term effects. Rising oil prices reduced the aggregate supply, lowered productivity, and lowered real wages.

Figure 1: Research framework



At the company level, Zaabouti et al. (2016) used a stochastic frontier approach to study the potential impact of oil prices changes on the value of 19 companies registered in the Tunisian capital market during 2007-2011. Their empirical investigation determined that oil price variations can explain observed distortions in the value of the studied firms. Alsalman (2013) used a simultaneous equation model with ordinary least squares (OLS) and found that active movement of oil prices held back the aggregate stock index. Symmetry in real oil price increases led to an increase in response to stock indices, and the linear model provided a relatively good estimate of the stock index's response to oil price changes. Broadstock and Filis (2014) used dynamic conditional correlation for a sample period of 1995-2013, and found that the correlation between oil price shocks and stock returns varied with time, price shocks varied by their impact on stock returns, and China was more resistant to an oil price shock than the United States.

At the sector level, Shaari et al. (2013) used a cointegration model and a Granger causality test to study the impact of the oil price shocks on sector returns in Malaysia. Their research demonstrated the long-term impact of oil price shocks on agriculture, construction, manufacturing, and transportation sectors; they also found that oil price instability significantly affected the performance of the agricultural sector. In Indonesia, Agusman and Deriantino (2008) used a time-series multi-factor regression model with OLS estimation with data for the January 1996-June 2008 period and found that changes in oil prices did not have a significant impact on the sectors' indices.

4. METHODOLOGY

In this research, the analysis is performed using secondary data on benchmark crude price (WTI) from the United States Energy Information Agency, and sector indices for the Indonesian capital market from the Indonesian Capital Market Institute. We applied structural change analysis to determine the break points of oil priced data during 1996-2016. The interval between the break points is called a regime, each of which have distinct characteristics.

Bai and Perron (1998) developed a methodology for finding multiple structural breaks in time series and testing for their statistical significance using the following model:

$$y_t = x_t^{'}\beta + z_t^{'}\delta_j + u_t \qquad (1)$$

For j = 1..., m+1, where m is the number of breaks, y_t is the dependent variable, x_t and z_t are vectors of covariates, β and δ_j are the corresponding vectors of coefficients, and u_t is the disturbance term. The break locations T_i, i=1..., m, are determined so as to minimize $\sum_{i=1}^{m+1}\sum_{t=T_{i-1}+1}^{T_i}\left[y_t - x_t^{'}\beta - z_t^{'}\delta_j\right]^2$. Alternatively, the breaks are determined sequentially, starting with the single break that minimizes the sum of squared residuals. Then, for each resulting partition, the single break that minimizes the sum of squared residuals is determined. The second break is the one with the lower sum of squared residuals of the two. This process is repeated sequentially to find further breaks. The procedure of global minimization assures that only the biggest breaks that cause the biggest reduction in the sum of squared residuals will be selected (Antoshin et al. 2008).

In a regime, one or more oil price shocks may occur. We investigated the dynamic relationship between oil price rate of change (in percent) and sector indices rate of change (or returns, in percent) in each regime. We modeled the dynamic relationship between oil prices and sector indices using a VAR model.

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + e_t \qquad (2)$$

Where y_t is a vector with dimension k × 1, t is observation period, p is the lag length, c is vector of constants (intercept) k × 1, A_t is vector impulse-response on lag p, and e_t is error term in period t. We use an impulse response function (IRF) to analyze the response of endogenous variables, i.e., sector returns, on the shock from the rate of change in oil prices. Apart from the IRF, we used variance decomposition to estimate the relative contribution of oil price shocks to variability of sector returns, and performed a Granger causality test to examine the causal relationship between oil price shocks and sector returns.

5. RESULTS AND DISCUSSION

5.1. Structural Changes in Oil Prices

Structural change in time-series data is a significant shift of parameter values, causing the linear regression model to be unreliable for use in forecasting. We identified structural changes in oil prices using the multiple structural change analysis procedure from Bai and Perron (1998). This Bai-Perron approach detected three break points, i.e. more than one structural change over the data range, in the AR (1) model of the WTI oil price. The identified breakpoints are October 2003, July 2008, and November 2012, thereby dividing the data set range of 1996-2016 into four regimes, as depicted in Figure 2. The oil price statistics characterizing each regime are provided in Table 1.

Regime 1 began with the onset of the monetary crisis in Asian countries, including Indonesia, causing demand for petroleum to decline in early 1997, only increasing again in some countries as they recovered from the crisis in 1999. Manning (1998) stated that the Asian financial crisis caused many Asian countries to suffer a recession during 1998-1999, while in other nations experienced a slowdown in economic growth. For example, OPEC member countries' revenues decreased, which reduced their investments

Table 1: Characterization of oil prices in each regime

Statistical characteristics	Regime 1	Regime 2	Regime 3	Regime 4
Mean	23.44	65.80	82.82	71.07
Median	23.57	61.78	84.58	60.25
Maximum	36.76	139.96	115.55	107.98
Minimum	11.37	30.33	41.73	32.74
Standard deviation	5.83	24.10	17.68	26.09
Slope	0.134	1.293	0.722	−1.581

to develop oil and gas fields. At the OPEC conference in Vienna on March 30, 1998, OPEC countries agreed to reduce production by 1245 million barrels per day. This was followed by China, Mexico, Norway, Yemen, and Russia all declaring a reduction in oil and gas production by a total of 400,000 barrels/day. The 9/11 attack and the United States commencing a war in Afghanistan as a response serve to mark the end of Regime 1.

Regime 2 commenced with the invasion of Iraq by US-led allied forces. Iraq holds some of the world's largest oil and gas reserves, at the time producing around 2.5 million barrels/day, or 2% of the world's total crude oil production. In contrast to the Afghanistan war, the Iraq war directly affected the balance of the petroleum demand and supply market, and oil demand increased in line with market expectations of an oil supply shortage due to geopolitical incidents in Iraq. During Regime 2, the demand for petroleum from China and new industrial countries also increased to support their rapid economic growth. However, on the supply side, OPEC countries could not immediately increase the production rate due to the limited capacity development during low oil price periods.

Regime 3 began with the 2008 financial crisis. This crisis, recognized by world economic experts as the worst financial crisis since the 1930s Great Depression, caused demand for petroleum to decline drastically and the price of oil to fall sharply. In response to the crisis, the US central bank (the Fed) applied a monetary policy called quantitative easing (QE) as an economic stimulus. QE entailed significantly increasing the money supply, which was then used to buy state debt or other financial assets. The QE policy did produce a return to greater economic activity, which accompanied by increased demand for crude oil. At the end of 2010, a geopolitical spate of revolutions occurred in the Arab world, known as the Arab Springs. Several important oil-producing countries, such as Libya, suffered severe impacts. The combination of QE policies by the Fed (aggregate demand factor) and the Arab Spring turmoil once again boosted oil prices to a higher average level than in the previous regime.

Regime 4 began after the Fed ran a third round of QE policy, pouring around USD $40-85 billion a month and setting the Fed rate at near 0%. Later, in June 2013, the Fed announced it would do a tapering-off, a gradual reduction of liquidity supplied into the market until the QE policy ended in October 2014. Meanwhile, in the United States, oil shale development programs that started in 2003 began to produce a significant amount, thus making the United States the world's largest oil producer after Saudi Arabia. The combination of liquidity reduction policies by the Fed, which resulted in lower demand, and an abundance of unconventional petroleum supplies from oil shale suppressed the oil price to the lowest level of around USD $30 per barrel.

5.2. Implications of Oil Price Shocks on Sector Returns

The VAR model was developed to examine the dynamic relationship between the rate of change in the WTI reference oil price and sector returns. Inter-sector interactions occur, but in this study, we assumed no interactions between sectors in the stock market. One VAR model is prepared to depict the dynamic interaction between a change in the WTI oil price with the returns of one sector. Table 2 provides the list of all the sectors in the Indonesian stock market.

We transformed weekly oil price data into the rate of oil price changes (in percent), and sector indices into returns (in percent), as depicted in Figure 3. We performed an augmented Dickey-

Table 2: List of sectors in the Indonesian stock market

Sector class	Sector name	Code
Primary (Extractive)	Agriculture	AGRI
	Mining	MINI
Secondary (Industry and Manufacturing)	Basic Industry and Chemicals	BASI
	Miscellaneous Industry	MISC
	Consumer Goods Industry	CONS
Tertiary (Services)	Property, Real Estate, and Construction	PROP
	Infrastructure, Utilities,	INFR
	Transportation, and Finance	FINA
	Trading, Services, and Investment	TRAD

Figure 2: Breakpoints and oil price regimes during 1996-2016

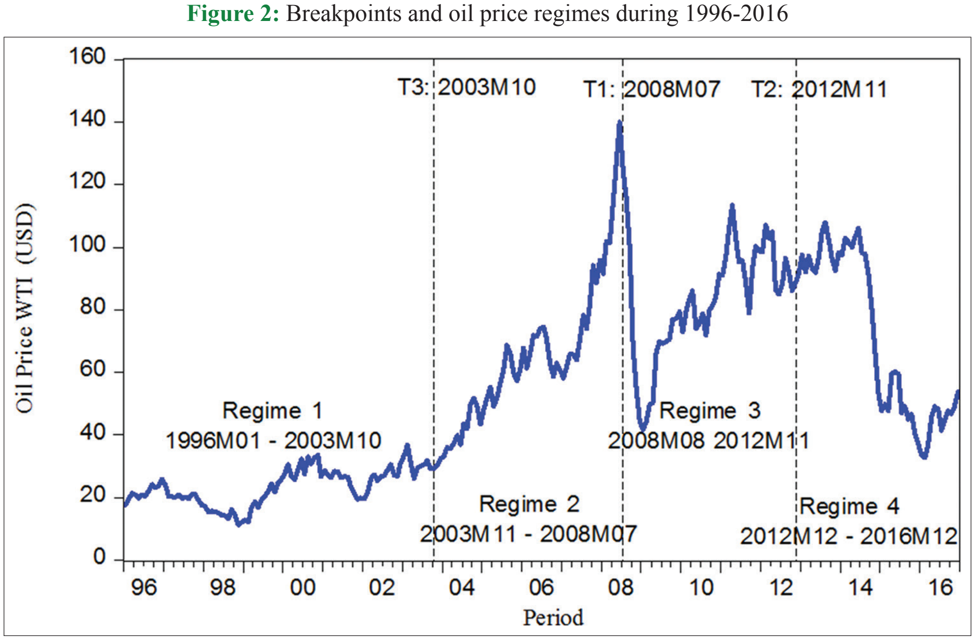


Figure 3: Transformation of WTI oil price into the rate of price change (in percent) and sector indices into sector returns (in percent)

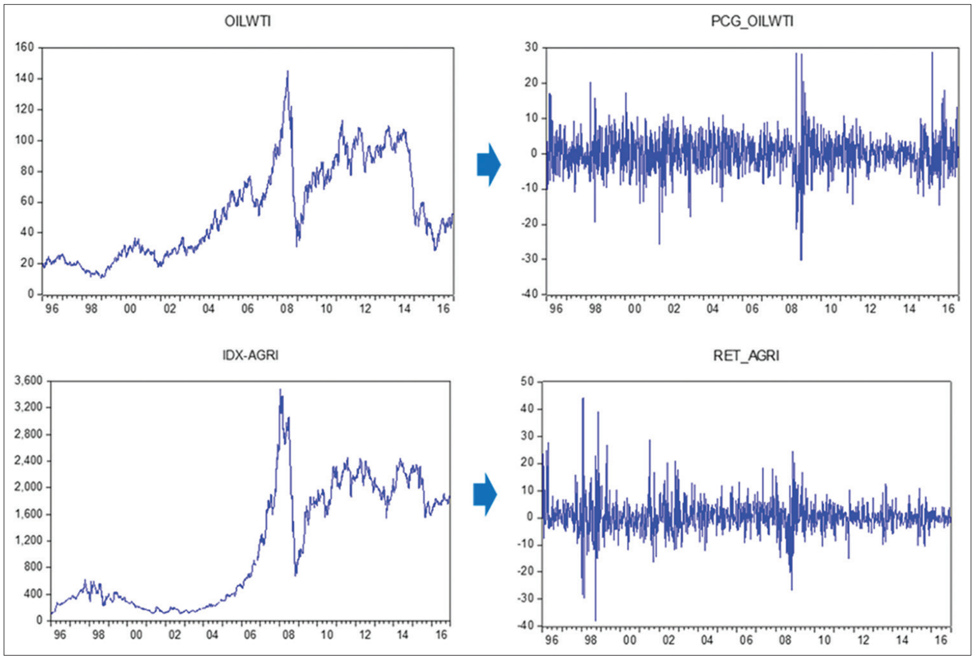


Table 3: Lag length based on AIC criteria (in weeks)

Sector	AGRI	BASI	CONS	FINA	INFR	MINI	MISC	PROP	TRAD
Lag	8	3	11	7	10	9	8	9	10

AIC: Akaike information criterion

Fuller stationary test on the variable oil price rate of change and the returns of each sector. The result allows the null hypothesis of the root unit in the time-series data to be rejected. We can therefore conclude that the time-series data are stationary.

The selection of lag lengths is an important decision in VAR; in this research, we evaluated the lag length using the akaike information criterion (AIC). Table 3 lists the lag length selected based on the AIC criteria.

The IRF predicts the impact of one variable on other variables over the next several periods. For example, the results for IRF calculations showing the response of agriculture sector (AGRI) returns to an impulse of one standard deviation shock in the oil price are given in Figure 4. We provide the IRF and cumulative IRF for other sectors in the appendix of this paper.

The IRF calculation is in standard deviation unit, and to facilitate interpretation of the result, we provide the value of the standard deviation for the rate of changes in the oil price in Table 4. A positive impulse response value indicates that the response occurs in the same direction as the Impulse, whereas a negative impulse response value indicates the response occurs in the opposite direction to the Impulse. Table 5 provides the cumulative impulse response along with the cumulative variance decomposition values for each sector in each regime. The VD indicates the contribution of the oil price rate of change to the variability of each sector's returns. The causal relationship between the oil price rate of change to sector returns is tested by the Granger causality test, and the results are presented in Table 5.

Table 4: Standard deviation of the oil prices rate of change

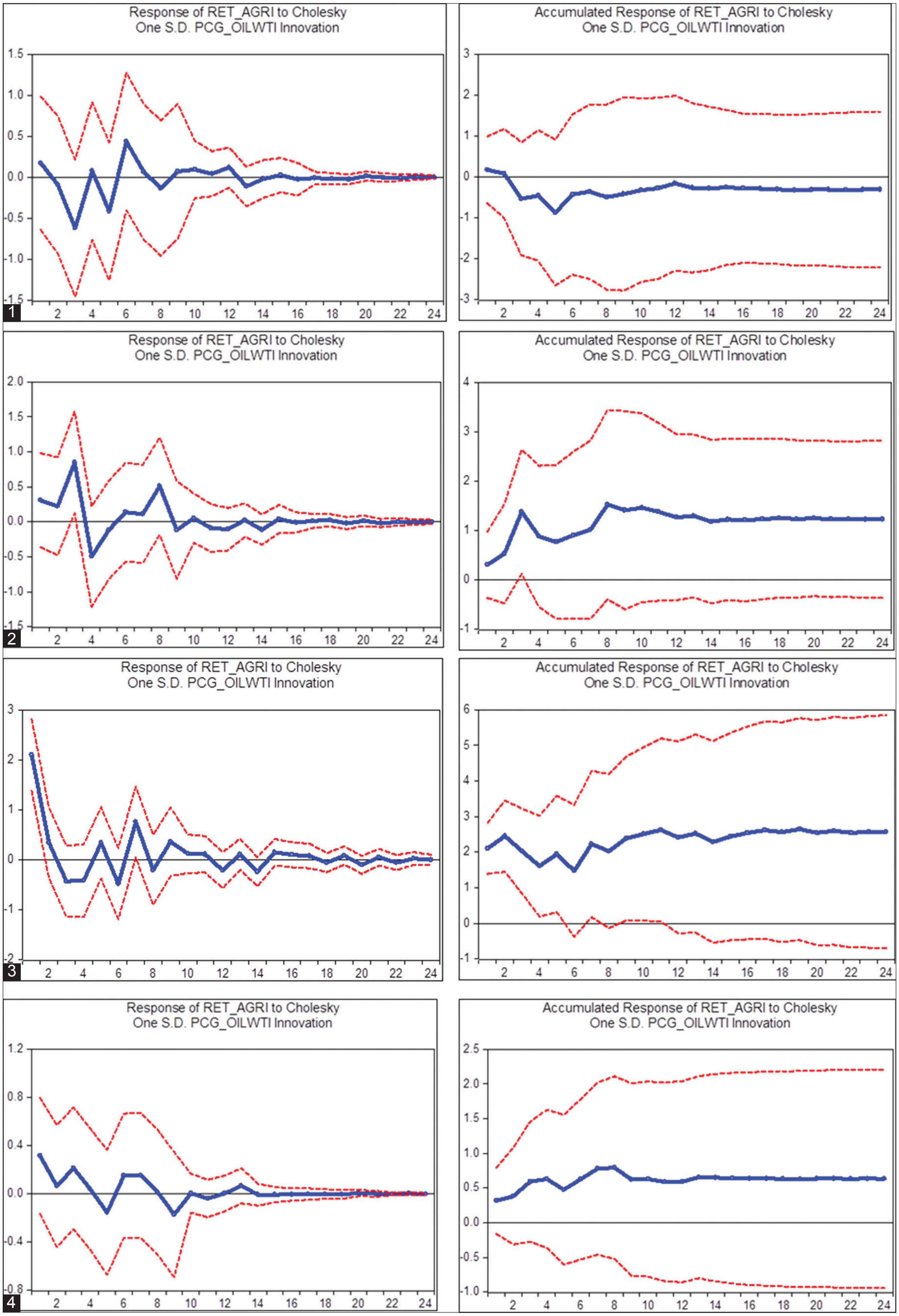
Standard deviation	Regime			
	1	2	3	4
Rate of change in oil price (%)	5.67	4.23	6.72	5.07

Table 5: Cumulative impulse response and variance decomposition of sector returns to innovation rates of changes in oil prices by one standard deviation

Sector	Impulse response cumulative (%)				Variance decomposition (%)			
	Regime				Regime			
	1	2	3	4	1	2	3	4
AGRI	−2.51	6.02	14.90	2.11	1.28	5.38	17.40	2.26
MINI	5.94	3.63	24.69	5.02	1.63	8.90	25.28	15.63
BASI	−0.40	1.03	4.94	2.47	0.75	1.46	11.50	5.01
MISC	3.41	−3.45	19.10	0.50	3.69	6.69	20.67	7.53
CONS	3.32	−1.57	5.73	−1.20	2.51	6.97	14.23	10.78
PROP	13.66	−3.80	13.25	1.25	4.63	6.14	19.27	7.15
INFR	−5.14	−3.58	7.90	2.96	2.49	9.23	15.94	6.98
FINA	5.69	−0.86	9.74	2.23	1.36	3.87	22.99	8.14
TRAD	10.88	−2.30	16.57	0.04	3.48	5.30	25.65	8.09

In Regime 1, the cumulative responses of agriculture (AGRI) and basic industry (BASI) and infrastructure (INFR) sectors' returns went in the opposite direction to the impulse of oil price rate of changes, whereas other sectors moved in the same direction. In this regime, the oil price rate of change did not have a significant impact on any of the sectors' cumulative responses at a 95% level of confidence, as confirmed by the low value of variance decomposition and lower probability that the oil price rate of change "Granger caused" the returns of all most sectors.

Figure 4: Impulse response function of innovation in oil price rate of change (in standard deviation unit) to Agriculture sector return in each regime



In Regime 2, the cumulative responses of returns from AGRI, mining (MINI), and BASI sectors were in the same direction as the impulse oil price rate of changes, whereas other sectors moved in the opposite direction. A significant probability was found of Granger causality relationship between the oil price rate of change and returns of miscellaneous industry (MISC) and infrastructure (INFR) sectors.

Table 6: Probability that the oil price rate of change of "does not Granger cause" sector return

Sector	$P_{\text{(does NOT granger cause)}}$ "oil→sector" Regime (%)			
	1	2	3	4
AGRI	85.20	28.34	6.35	95.72
MINI	78.34	26.39	8.32	32.18
BASI	71.77	34.92	1.98	59.55
MISC	12.40	3.57	13.97	16.36
CONS	82.02	10.62	1.42	88.71
PROP	14.80	23.30	5.44	17.10
INFR	42.15	2.98	2.19	70.82
FINA	91.98	59.70	5.24	39.62
TRAD	28.19	49.23	0.15	61.91

In Regime 3, the cumulative responses of all sectors are in the same direction as the impulse of the rate of change in oil price. With a 90% level of confidence, a significant probability of Granger causality between the oil price rate of change and all sectors returns except the return of Miscellaneous Industry (MISC) sector was observed.

In Regime 4, the cumulative response of returns from the consumer goods (CONS) sector moved in the opposite direction to the impulse of oil price rate of change, whereas other sectors moved in the same direction. There is no significant probability of granger causality between the oil price rate of change and the returns of all sectors.

5.3. Managerial Implications

During low oil prices, Regime 1, the causality relationships were not significant for all sectors. In contrast, during high oil prices, Regime 3, the causality relationships were significant for all sectors, with the exception of the Miscellaneous Industry (MISC) sector. Oil prices rose sharply after the global financial crisis and were characterized by high volatility. The returns of all sectors during the regime moved in the direction of changes in the price of oil. This finding is in contrast to research by Huang et al. (1996), stating that rising oil prices potentially affect the performance of the capital market through the mechanism of a company's cash flow. An increase in the price of oil triggers expectations of reduced profits because oil is an operating cost, and the value of stocks can decline if the capital markets can efficiently transmit the implications of rising oil prices. In line with Li and Zhao (2011), who stated that the effect of USD liquidity on oil price fluctuations cannot be ignored, we suspected the Fed's QE policy contributed to increased sector returns; furthermore, the "Arab Spring" disruptions in oil-producing countries caused greater fluctuations in oil prices.

During the transition from low to high oil-prices, Regime 2, the contribution of oil price rate of change to variations in sectors returns were increasing for all sectors as indicated by the increase in VD between Regime 1 to Regime 2. In contrast, during the transition from high to low oil-prices, Regime 4, the contribution of oil price rate of change to variation in sectors return were decreasing for all sectors as indicated by the decrease in VD between Regime 3 and Regime 4.

Changes in oil prices can be a signal of sector returns, depending on the oil price regime. This is in line with Sadorsky (1999), who maintained that rises or falls in oil prices have different effects. An oil price shock in the form of price appreciation has a greater effect than oil price depreciation. This is because oil price appreciation can add to uncertainty and thereby affect investment decisions, whereas the depreciation of oil prices is perceived as reduced material and energy costs, leading profitability to increase.

6. CONCLUSION

This research identified structural changes in oil prices during the 1996-2016 oil prices into four oil price regimes. The separation of the analysis range into different regimes led to different results compared with those of previous studies on the impact of oil price shocks on sector returns in the Indonesian stock market. The dynamic relationship between oil price shocks and the sectors' returns was distinct in each regime, as indicated by the IRF and forecast error variance decomposition. The Granger causality test also showed the different probabilities of a Granger causality relationship between oil price shocks and sectors' returns. The impacts of oil price shocks varied across regimes. During times of high oil prices, an oil price shock tends to generate a significant response from some sectors' returns, whereas during periods of low oil prices, the shock in oil prices did not generate a significant response by the sectors' returns.

We recommended further investigation on the impact of other domestic and foreign macro variables on various sector returns, such as the amount of US Dollar liquidity, international stock market indicators such as the S&P500, and local inflation rate, as well as impacts of various government economic policies.

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APPENDIX

Multiple breakpoint tests: Bai-Perron tests of 1 to M globally determined breaks

Sample: 1996M01 2016M12
Included observations: 251
Breaking variables: C OIL_WTI(-1)
Break test options: Trimming 0.20, Max. breaks 3, Sig. level 0.05

Test statistics employ HAC covariances (Bartlett kernel, Newey-West fixed bandwidth) assuming common data distribution

Sequential F-statistic determined breaks:	0
Significant F-statistic largest breaks:	0
UDmax determined breaks:	0
WDmax determined breaks:	0

Breaks	F-statistic	Scaled F-statistic	Weighted F-statistic	Critical value
1	3.510644	7.021288	7.021288	10.98
2	2.874238	5.748475	7.028759	8.98
3	3.557867	7.115733	10.95803	7.13
UDMax statistic	7.115733	UDMax critical value**	11.16	
WDMax statistic	10.95803	WDMax critical value**	12.15	

* Significant at the 0.05 level, ** Bai-Perron (Econometric Journal, 2003) critical values

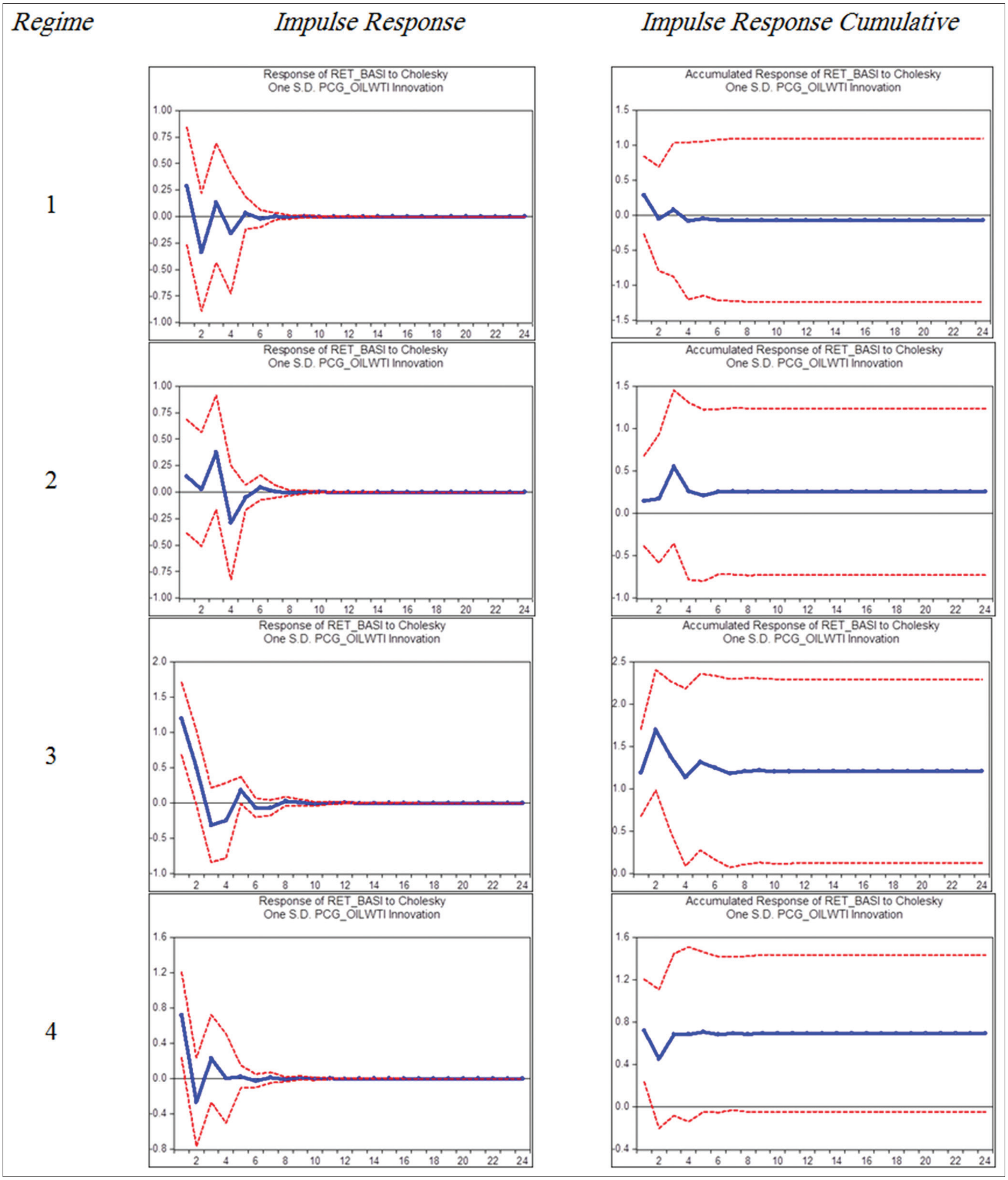
UDMax statistic 7.115733 UDMax critical value** 11.16

WDMax statistic 10.95803 WDMax critical value** 12.15

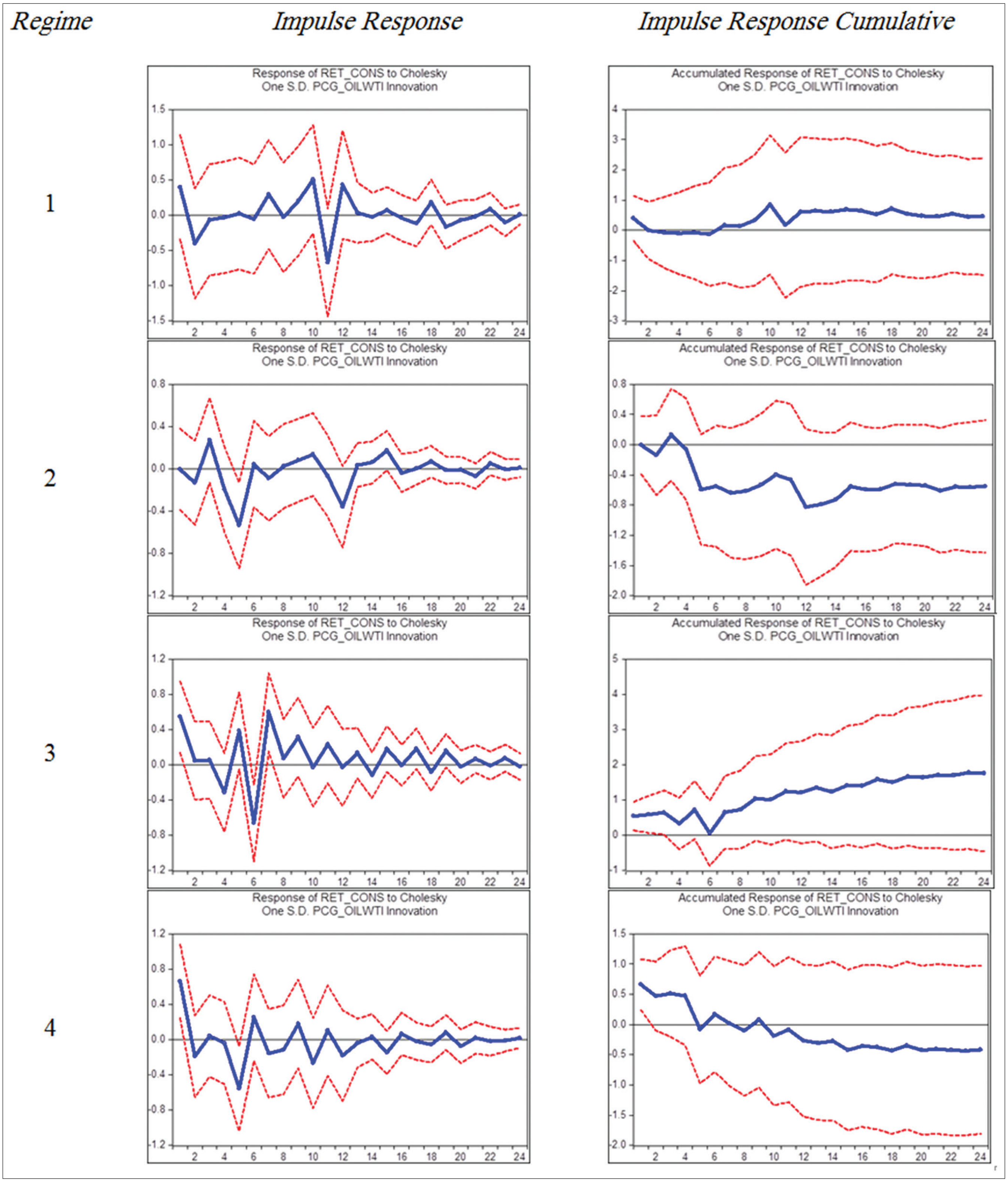
* Significant at the 0.05 level.
** Bai-Perron (Econometric Journal, 2003) critical values.

Estimated break dates:
1: 2008M07
2: 2008M07, 2012M11
3: 2003M10, 2008M07, 2012M11

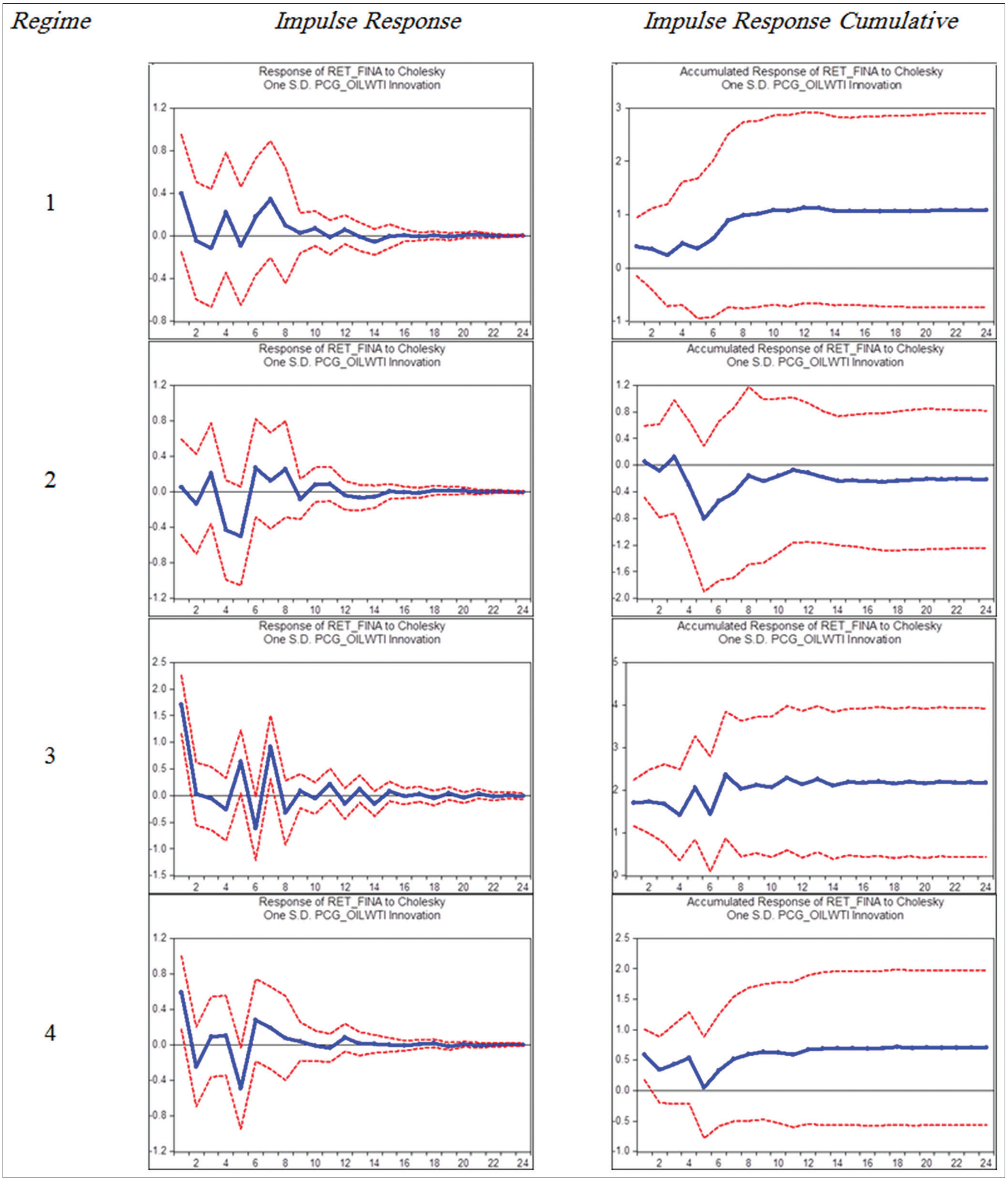
Impulse Response Function for "Basic Industry (BASI)" Sector



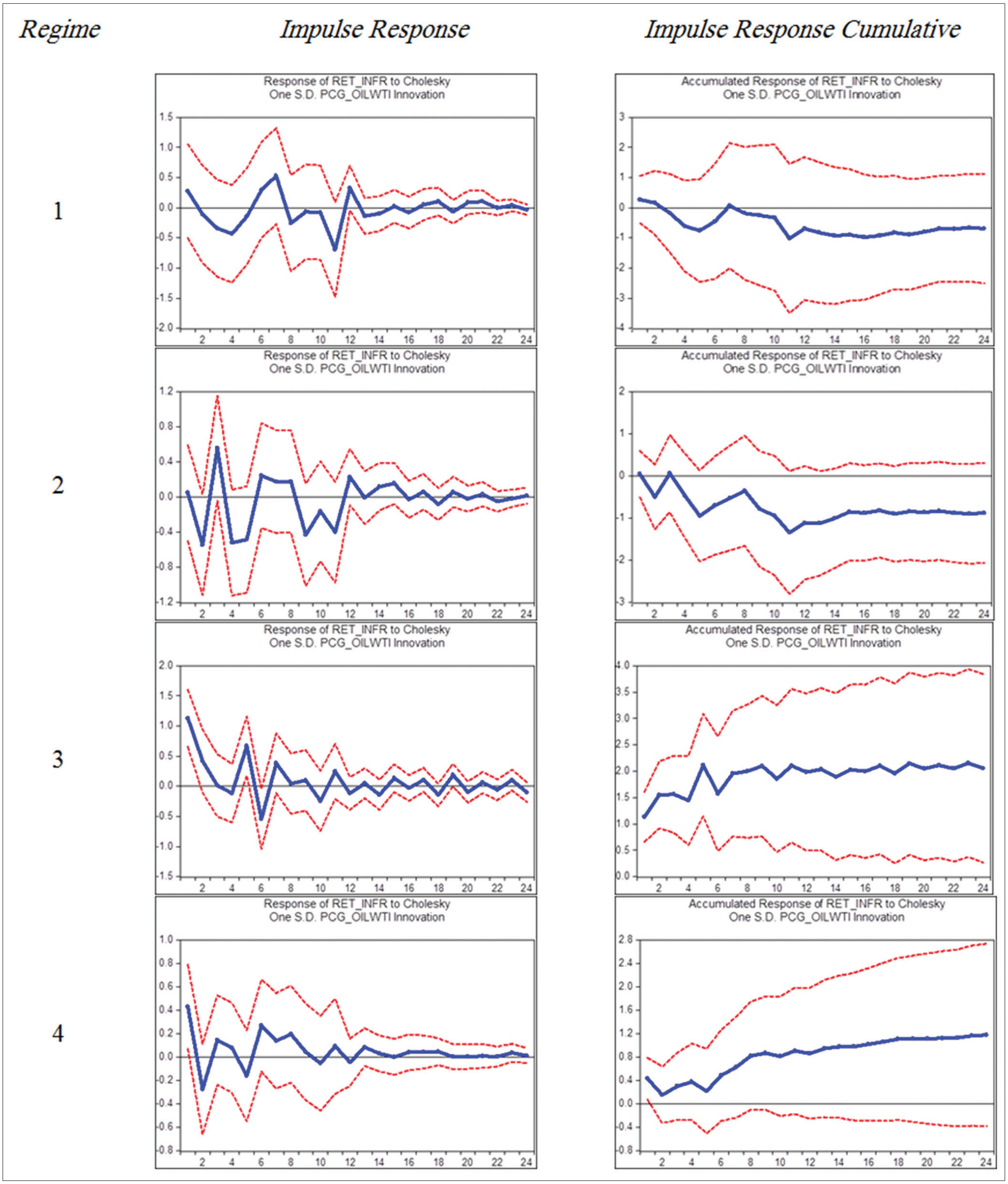
Impulse Response Function for "Consumer Goods (CONS)" Sector



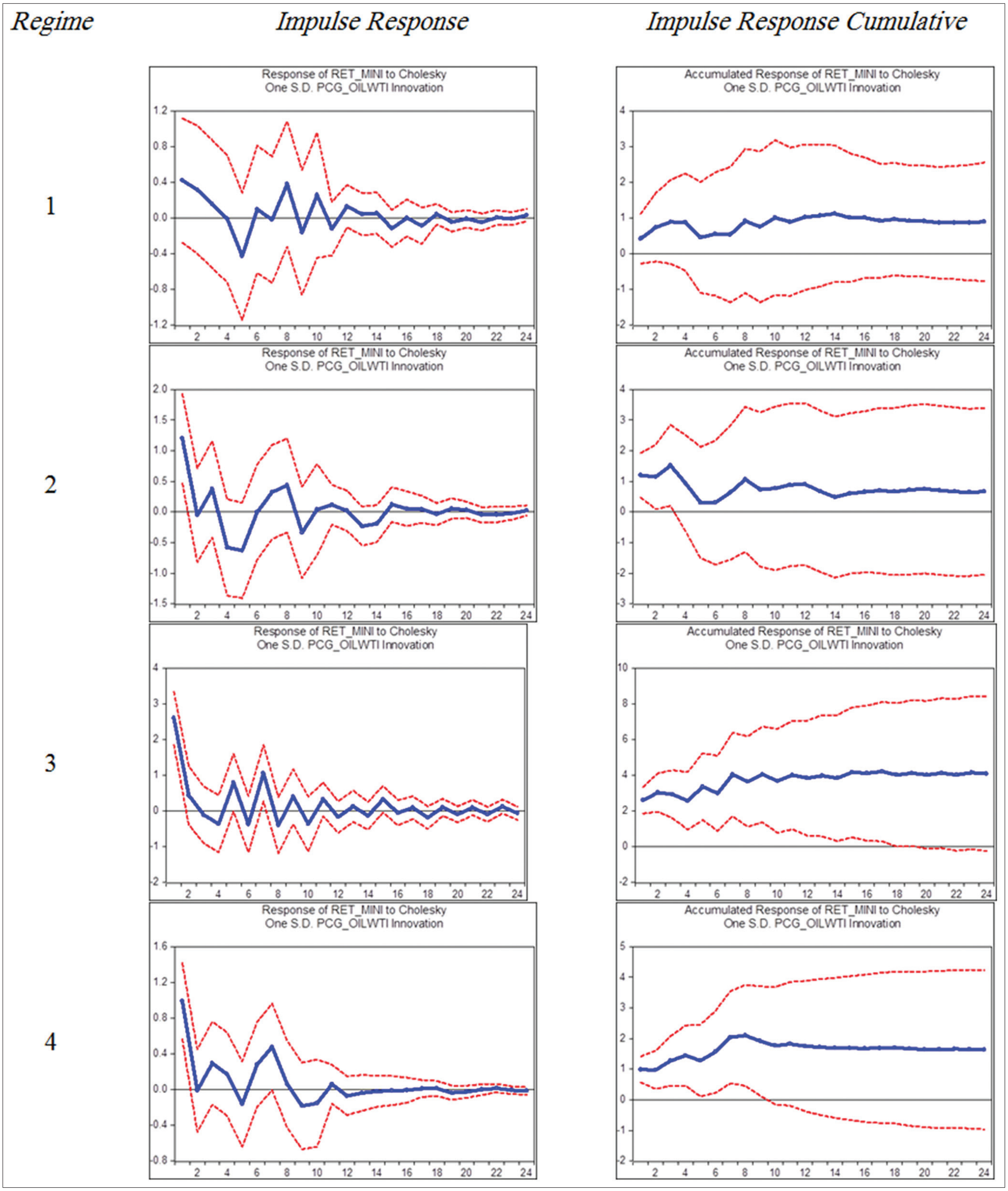
Impulse Response Function for "Financial (FINA)" Sector



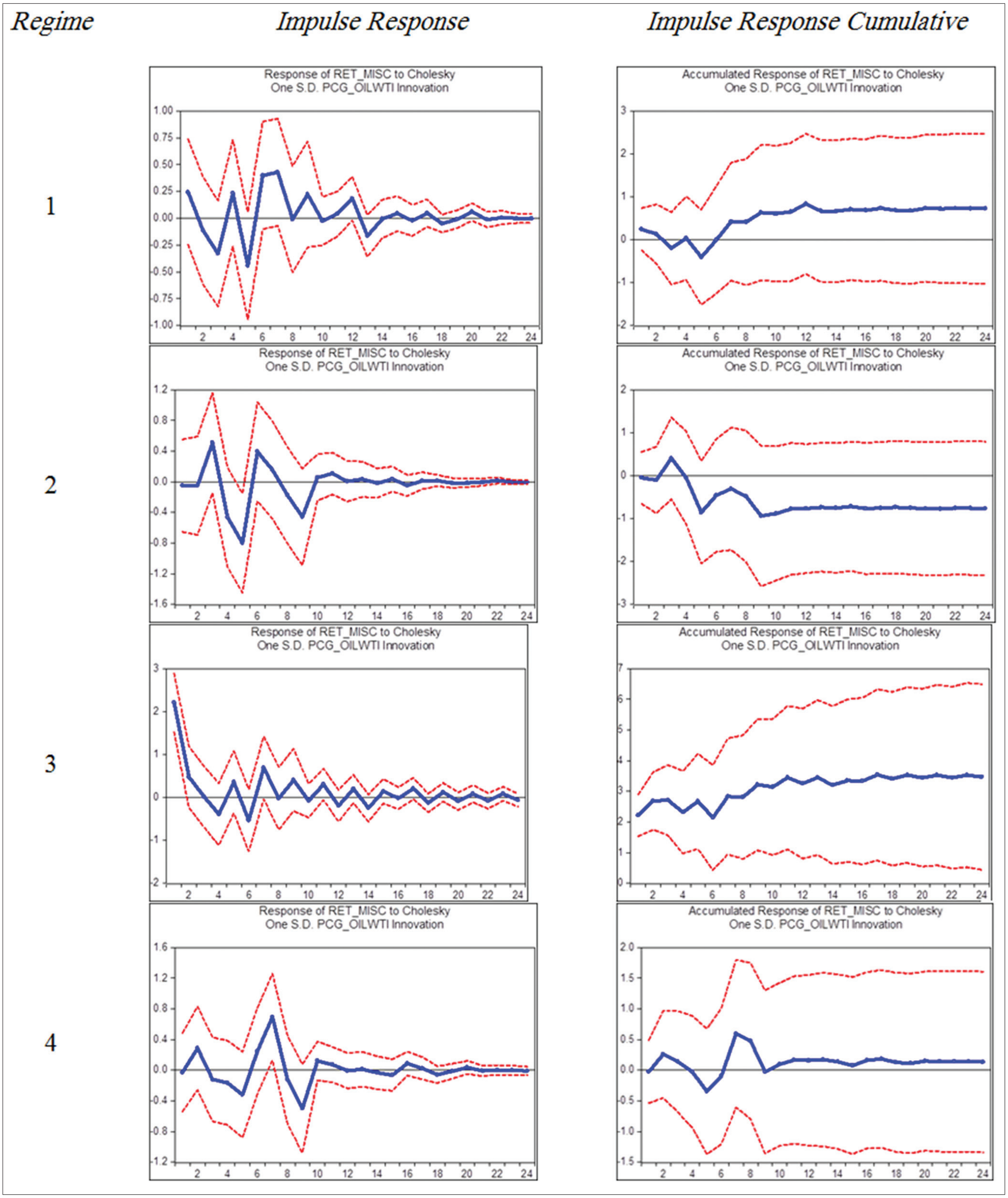
Impulse Response Function for "Infrastructure (INFR)" Sector



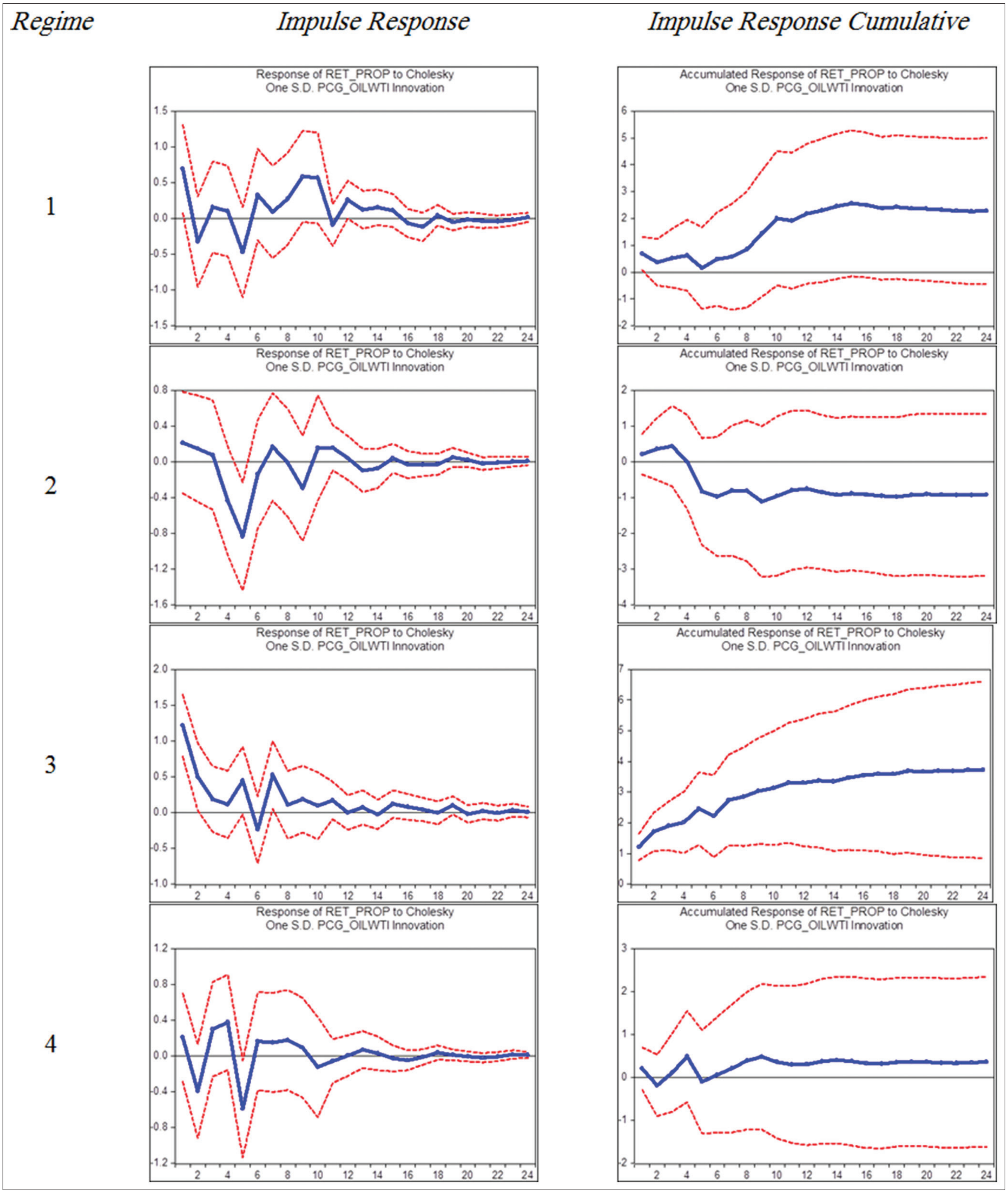
Impulse Response Function for "Mining (MINI)" Sector



Impulse Response Function for "Miscellaneous Industry (MISC)" Sector



Impulse Response Function for "Property (PROP)" Sector



Impulse Response Function for "Trading and Services (TRAD)" Sector