The response of industrial production to the price of oil: new evidence for Thailand

Jiranyakul, Komain

National Institute of Development Administration

April 2016

The response of industrial production to the price of oil: new evidence for Thailand

Komain Jiranyakul
School of Development Economics
National Institute of Development Administration
Bangkok, Thailand
Email: komain_j@hotmail.com

Abstract:

This paper examines the oil price-industrial production nexus in Thailand by using multivariate cointegration test. In addition, Granger causality is also used to examine the impact of oil price uncertainty on industrial production growth. The main focus of this paper is on one sector of the economy, i.e., manufacturing sector. Monthly data from 1993 to 2015 are utilized. Empirical results reveal that there is a stable long-run relationship between industrial production and real oil price along with other variables. Industrial production adjusts rapidly to shocks to lending rate, price level and oil price. Furthermore, there exists long-run causality running from lend rate, price level and oil price to industrial production. Furthermore, industrial production growth does not respond to oil price shock and oil price uncertainty. These findings give policy implication.

Keywords: Industrial production, oil price shock, oil price volatility, cointegration, causality
JEL Classification: C22, Q43

1. Introduction

   From theoretical point of view, an increase in oil price should adversely affect output while a decrease in oil price should induce an expansion of output. An oil price shock can be defined as a rise or a fall in the price of oil that can affect macroeconomic variables (see Hamilton, 1983: Mork, 1989, and Hooker, 1996, among others). Most empirical studies on the relationship between oil price shocks and macroeconomic variables seem to support the oil-real activity nexus some studies do not seem to strongly support this phenomenon. An oil shock might have different impacts on different economies due to different characteristics. Lee et al. (1995) argue that an oil price shock is likely to have greater impact on real output. An oil price shock can also reflect both the unanticipated component and the time-varying conditional variance component. The volatility component exerts a significant impact on output growth.

   Numerous empirical studies have conducted for both advanced and emerging market economies. For Asian economies, Cunado and Perez de Gracia (2005) examine the oil prices-macroeconomy relationship by looking at the impact of oil price shocks on both inflation and economic growth rates for some Asian countries over the period 1975-2002. Their main findings are that there is no cointegration between oil prices and economic activity in these countries. This implies that the relationship is just a short-run phenomenon. The results of Granger causality test show that oil price shocks cause economic growth rates in Japan, South Korea and Thailand when oil prices are defined in local currency. In addition, evidence of asymmetry in oil price shocks-economic growth relationship is found only in the case of South Korea. However, Zhang (2008) examines the relationship between oil price shock and

economic growth in Japan by using a nonlinear approach and finds the asymmetric effects of oil price shocks on economic growth.

Du et al. (2010) use monthly data to investigate the relationship between the world oil price and China's macroeconomy. They find that the world oil price significantly affects economic growth and inflation in China. The impact is nonlinear.[1] Park et al. (2011) use a structural vector autoregressive model to examine the impacts of oil price shocks on regional industrial production in South Korea. They find both short- and long-term response of industrial production and price level to oil price shocks. Cunado et al. (2015) employ a structural vector autoregressive model to investigate the macroeconomic impact of structural oil shocks in four of top oil-consuming Asian economies, namely Japan, South Korea, India and Indonesia. They find that economic activities and price levels in these four Asian countries respond differently to oil price shocks, depending on the specific characteristics of each country. Gupta and Goyal (2015) examine how oil price fluctuations affect the Indian economy through various channels. The finds that oil prices are pro-cyclical to output, price level and other variables.

As previously mentioned, several techniques can be used to examine the oil price-real activity relationship. Economic activity can be measured by aggregate output such as real GDP or industrial production. The present paper uses industrial production as a measure of real activity by relying on the notion that manufacturing production for exports can stimulate real GDP of the country. Furthermore, the international oil price expressed in US dollar per barrel is converted to local currency. The advantage of using local-currency oil price is that it can measure the purchasing power of local manufacturing firms. This paper provides evidence of the long-run negative impact of the price of oil on industrial production in Thailand. In addition, oil price volatility or uncertainty does not Granger cause industrial growth. The next section describes the dataset used in this study. Section 3 provides empirical results and the last section gives concluding remarks.

2. Data and Methodology

Monthly data used in this study are obtained from various sources and consist of 276 observations. The series of industrial production index, lending interest rate, consumer price index, and US dollar exchange rate are retrieved from the Bank of Thailand website. The Brent crude oil price series expressed in dollar per barrel is obtained from the US Energy Information Administration. The dataset covers the period from January 1993 to December 2015. The real oil price series is obtained by multiplying crude oil price by the US dollar exchange rate and deflating by the consumer price index. All series are transformed to logarithmic series. The unit root test for stationarity used in this paper is the KPSS test proposed by Kwiatkowski, Phillips, Schmidt and Shin (1992), which is the powerful unit root testing procedure. The results are reported in Table 1.

The variables in Table 1 are defined as follows: y is the log of industrial production index, r is the log of lending rate, p is the log of consumer price index, and op is the log of real oil price series. The KPSS test statistic of each variable in level is larger than the 5% critical value, and thus the null hypothesis that each series is stationary is rejected. In other words, each series contains unit root. For first difference of each series, the KPSS test statistic is smaller than the 5% critical value. Therefore, the null hypothesis that the first difference of each series is stationary cannot be rejected. It can be concluded that each variable is integrated of order 1 or each series is I(1) series because it contains one unit root in level, but not in its first differences.

---

[1] Wei (2013) also finds evidence of nonlinear relationship between oil prices and other variables such as industrial production and consumer price index at the low frequency domain in Japan.

Table 1
KPSS unit root testing results.

Variables in levels	intercept	intercept and trend
y	1.902 [14]	0.228 [13]
r	1.170 [14]	0.303 [14]
p	1.886 [14]	0.207 [14]
op	1.617 [14]	0.267 [13]
Variables in first differences		
Δy	0.198 [40]	0.094 [43]
Δr	0.127 [11]	0.082 [11]
Δp	0.104 [7]	0.079 [6]
Δop	0.179 [1]	0.086 [1]
Critical value at the 5% level	0.463	0.086

Note: Optimal bandwidth in bracket.

In order to examine the long-run relationship between industrial production and its explanatory variables, namely lending rate, price level and real oil price, this paper makes use of Johansen (1991) cointegration test in a multivariate framework. The model used in this paper is presented in the reduced from in Eq. (1) as the following:

$$\Delta X_t = C + \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + ... + \Gamma_p \Delta X_{t-p} + \alpha\beta^{\prime} X_{t-1} + e_t \qquad (1)$$

$$X_t^{\prime} = [y_t r_t p_t op_t]^{\prime}$$

where y_t is the industrial production, r_t is the lending rate, p_t is the price level, and op_t is the real oil price. The matrix Γ_i, i=1,2,….p is the matrix of short-run parameters, $\alpha\beta^{\prime}$ is the information on the coefficient matrix between levels of the series, and e_t is the vector of the error terms.[2] All crises dummy variables are not included in Eq. (1) because these crises will affect the dollar exchange rate, which is used to convert the international oil price to the domestic oil price. The existence of cointegration reveals that there is a long-run equilibrium relationship between industrial production and the three explanatory variables.

In case of the existence of cointegration, the error correction mechanism (ECM) is used to examine the short-run dynamics between a change in industrial production, a change in lending rate, inflation rate and a change in real oil price. The ECM is expressed in Eq. (2) as the following:

$$\Delta y_t = \phi_0 + \sum_{i=1}^{k} \phi_{1i} \Delta y_{t-i} + \sum_{i=}^{k} \phi_{2i} \Delta r_{t-i} + \sum_{i=1}^{k} \phi_{3i} \Delta p_{t-i} + \sum_{i=1}^{k} \phi_{4i} \Delta op_{t-i} + \lambda e_{t-1} \qquad (2)$$

---

[2] The relevant elements of the matrix α are adjusted coefficients and the matrix β contains the cointegrating vector. Johansen and Juselius (1990) explain that there are two likelihood ratio test statistics to test for the number of cointegrating vectors. The two tests are the trace test and the maximum eigenvalue test. In addition, the two test statistics can be compared with the critical values to determine whether cointegrating vectors exist.

where e_{t-1} is the error correction term (ECT), which is the lagged value of the corresponding error term obtained from the estimate of cointegrating relation expressed in Eq. (1).[3]

The negatively significance of the estimated coefficient of the ECT (λ) indicates that any deviation from the long-run equilibrium relationship will be rapidly corrected. Furthermore, one can use the Wald coefficient restriction test can be used to test for long-run and short-run causality between industrial output and lending rate, price level and real oil price variables (see Oh and Lee, 2004). The null hypothesis $H_o : \lambda = 0$ is tested for long-run causality running from the three independent variables to industrial production. In addition, the null hypothesis $H_o : \phi_{1i} = \phi_{2i} = \phi_{3i} = \phi_{4i} = 0$ is tested for short-run causality.

This paper also examines the impact of oil price volatility on industrial production. The reason behind the investigation is that oil price shocks can generate oil price volatility or uncertainty, which in turn affects industrial output. To achieve this goal, the exponential generalized autoregressive conditional heteroskedastic (EGARCH) model proposed by Nelson (1991) can be used. The volatility model is presented in Eqs. (4) and (5) as follows:

$$\Delta y_t = \mu + \sum_{i=1}^{p} b_i \Delta y_{t-i} + v_t \tag{4}$$

$$\log(\sigma_t^2 = \alpha + \beta \log(\sigma_{t-1}^2) + \gamma \frac{v_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \phi \left| \frac{v_{t-1}}{\sigma_{t-1}^2} \right| \tag{5}$$

where $\{v_t\}$ is a sequence of independent and normally distributed random variables with mean of zero and variance of 1. Eq. (4) is the mean equation, which is assumed to follow an autoregressive mode of order p or AR(p) process. Eq. (2) is the conditional variance equation with asymmetric effect if the coefficient γ is significantly non-negative. The advantage of using the AR(p)-EGARCH(1,1) specification is that it does not impose the non-negativity constraint on the parameters in the conditional variance equation.

The Granger causality test can be used to test for causations between a change in industrial production, an oil price shock and oil price volatility. In particular, this paper aims at testing the null hypothesis that oil price volatility causes a change in industrial production. Furthermore, whether oil price uncertainty causes oil price shock or oil price shock causes oil price uncertainty.

3 Empirical Results

Based on the unit root test results reported in Table 1, all series in this paper are I(1) series. Therefore, it is appropriate to test for cointegration by using Johansen's methodology in a multivariate framework. The results of cointegration test using the optimal lag of 1 determined by Schwarz criterion (SC) are reported in Table 2.

The results in Table 2 show that there are 4 cointegrating vectors in the trace test while the maximum eigenvalue test indicates only 2 cointegrating vectors.

---

[3] The main focus of the paper is to investigate how industrial production responds real oil price. Therefore, only one ECM equation is presented.

Table 2

Johansen's cointegration test.

Panel A. Trace test.			
No. of cointegrating vectors	Trace statistic	5% Critical value	p-Value[b]
None[a]	68.710	47.861	0.000
At most 1[a]	30.493	27.797	0.042
At most 2[a]	16.053	15.595	0.041
At most 3[a]	4.548	3.841	0.033
Panel B. Maximum eigenvalue test.			
No. of cointegrating vectors	Max-eigenvalue statistic	5% Critical value	p-Value[b]
None[a]	38.217	27.584	0.002
At most 1	14.440	21.132	0.330
At most 2	11.506	14.265	0.131
At most 3[a]	4.548	3.841	0.033

Note: [a] denotes the rejection of the null hypothesis of no conintegration at the 5% level.
 [b] denotes p-value provided by MacKinnon et al. (1999).

Based upon the results of the two tests, it can be concluded that the first cointegrating vector is precisely confirmed.[4] Based upon the results reported in Table 2, it can be argued that there exists a stable long-run relationship between industrial production and its explanatory variables, namely lending rate, price level and real oil price in Thailand. The estimated long-run coefficients of the cointegrating equation are shown in Table 3.

Table 3

Estimated long-run coefficients.

Dependent variable: y_t		
Independent variable	Long-run coefficient	t-statistic
r_t	-0.807	-4.767***
p_t	2.457	7.743***
op_t	-0.504	-3.973***

Note: *** indicates significance at the 1% level.

The results in Table 3 suggest that lending rate from financial institutions, price level, and real oil price have a strong and statistically significant impact on Thailand's industrial production. A one percent increase in the lending interest rate causes industrial production to fall by 0.81 percent. However, inflation measured as a change in the consumer price index positively related to industrial production, i.e., a one percent increase in inflation will cause industrial production to rise by 2.46 percent. For the real price of oil, a one percent increase in real oil price causes industrial production to drop by 0.5 percent. Therefore, it can be argued that there is a statistically negative response of industrial production to real oil price. This finding is not in line with the finding by Cunado and Perez de Gracia (2005) that utilize quarterly data and real GDP as a measure of economic activity.

The presence of cointegrating relation suggests that this relationship can be efficiently represented by ECM corresponding to Eq. (1) as presented in Eq. (2). The estimate of Eq. (2) gives the short-run dynamics reported in Table 4.

---

[4] The order of variables entering into the unrestricted vector autoregressive (VAR) model is y_t, r_t, p_t and op_t respectively. The first cointegrating equation indicates that y_t is dependent variable while r_t, p_t and op_t are independent variables in the long-run equilibrium relationship.

Table 4
Short-run dynamics.

| Dependent variable: Δy_t		
Independent variable	Short-run coefficient	t-statistic
Δy_{t-1}	-0.175	-3.001***
Δr_{t-1}	-0.196	-1.774*
Δp_{t-1}	1.193	2.454**
Δop_{t-1}	0.029	1.034
ECT	-0.025	-2.038**
intercept	0.001	0.484

Note: ***, **, and * indicate significance at the 1%, 5% and 10%, repectively.

Based upon the estimate of Eq. (2), the estimated coefficient of the ECT is significantly negative and has the absolute value of less than 1. This suggests that Thailand's industrial production adjusts to its long-run equilibrium at a rapid rate. This also suggests that the estimated ECM equation is found to be stable. In the short run, the impact of a change in lending rate on a change in industrial production is negative and significant at the only 10% level while the impact of a change in price level on a change in industrial production is positive and significant at the 5% level. However, there is no short-run impact of a change in oil price or oil price shocks on a change in industrial production. In Granger causality sense, there can be the long-run causality when cointegration among variables exists. The results reported in Table 4 represent the autoregressive model augmented with the ECT. The Wald test is used to examine whether the coefficient of the ECT is zero. The Wald F-statistic of 5.44 with the p-value of 0.021 rejects the null hypothesis of no long-run causality. Therefore, it can be argued that there is long-run causality running from lending rate, price level and oil price to industrial production.[5] Furthermore, the joint test for short-run causality gives the Wald F-statistic of 3.671 with the p-value of 0.013 rejects the null hypothesis that there is no short-run causality running from the three variables to industrial production.

The impulse response functions shown in Fig. 1 can be used to trace the time path of the impact of structural shocks to industrial production in response to a unit change in shocks to lending rate, price level and oil price. A positive unit shock to lending rate contributes to a permanent decrease in industrial production, but a positive unit shock to price level contributes to an initial increase in industrial production for two months and a decrease at a slowing rate, which does not dissipate. However, the time path of the impact of oil price shock is different, i.e., a positive unit shock to oil price causes industrial production to initially increase, but shows a permanent decrease after four months.

It is possible that oil price shock or a change in the price of oil can cause oil price uncertainty. The estimated results of the volatility model specified in Eqs. (4) and (5) are reported in Table 5.

---

[5] See Granger (1988).
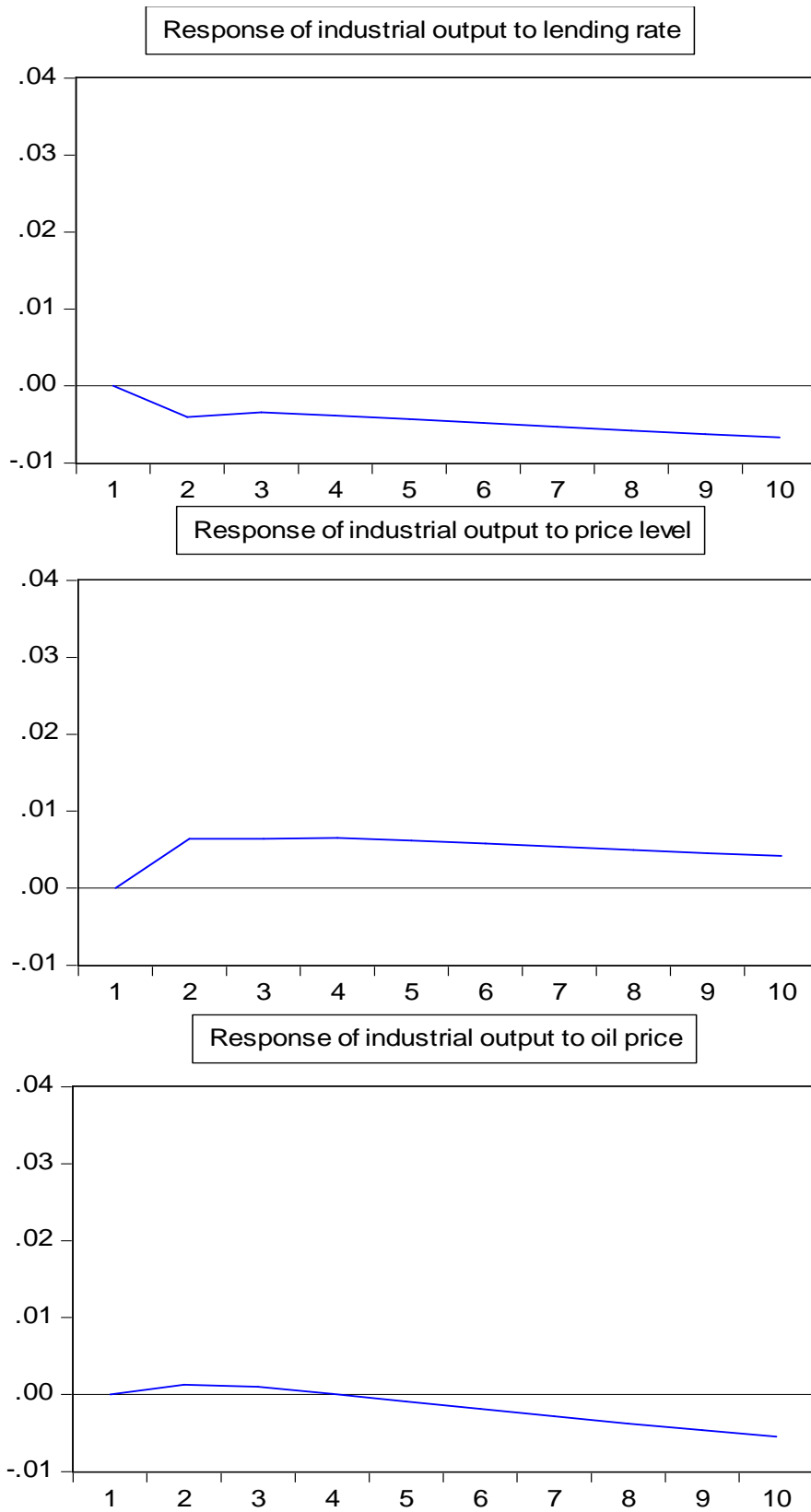
Fig. 1 Impulse response functions

The important questions are that (1) does oil price shock cause oil price uncertainty? and/or does oil price uncertainty cause oil price shock? and (2) do an oil price shock and oil price uncertainty cause industrial production?. The AR(1)-EGARCH(1,1) model is chosen and estimated to generate the oil price uncertainty series. In addition, the standard Granger causality test is conducted to test for causality. The estimate of the AR(1)-EGARCH(1,1) model is reported in Table 5.

Table 5
Estimate of the AR(1)-EGARCH(1,1) model.

Panel A: Mean equation with dependent variable r_t			
Variable	Coefficient	t-Statistic	p-Value
r_{t-1}	0.186***	2.693	0.007
Intercept	-0.002	-0.408	0.683
Panel B: Conditional variance equation with dependent variable $\log(\sigma_t^2)$.			
Variable	Coefficient	t-Statistic	p-Value
$\log(\sigma_{t-1}^2)$	0.913***	15.782	0.000
$v_{t-1}/\sqrt{\sigma_{t-1}^2}$	-0.084	-1.366	0.172
$\lfloor v_{t-1}/\sigma_{t-1}^2 \rfloor$	0.313***	2.724	0.006
Intercept	-0.679**	-2.023	0.043
Panel C: Diagnostic tests.			
Q(4) = 2.272 (p-Value = 0.686), Q(12) = 13.348 (p-Value = 0.344).			
Q^2(4) = 2.361 (p-Value = 0.670), Q^2(12) = 15.765 (p-Value = 0.202).			

Note: *** and ** denote significance at the 1% and 5% level.

In Panel A of Table 5, the coefficient of the first autoregressive term, r_{t-1}, is positive and statistically significant. In Panel B of Table 5, all coefficients in the conditional variance equation are statistically significant, except for the coefficient of asymmetry, $v_{t-1}/\sqrt{\sigma_{t-1}^2}$. Residual diagnostic tests for this model in Panel C of Table 5 show that the null hypothesis of no residual correlation is accepted by the Ljung-Box test statistics, Q(4) and Q(12). In addition, the null hypothesis of no further ARCH effect is also accepted by the Q^2(4) and Q^2(12). Therefore, it can be argued that the model fits the data quite well. The generated oil price volatility is plotted in Fig. 2.
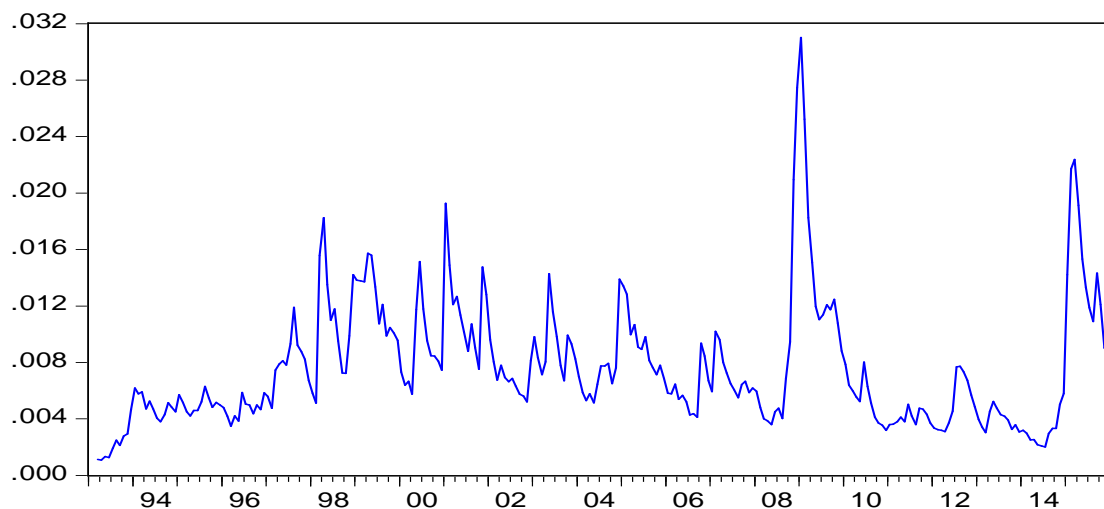
Fig. 2 Oil price volatility or uncertainty.

Fig. 2 shows the plots of uneven oil price uncertainty. Oil price uncertainty appears to be less fluctuating until the adoption of the flexible exchange rate regime in July 1997. In addition, the new oil price shocks occurred in 2000 cause higher uncertainty that lasts until 2009. However, a decline in crude oil price causes a drop in its uncertainty in 2010.

The standard Granger causality test results using the optimal lag of 1 determined by SC are reported in Table 6.

Table 6
Grange causality.

Null hypothesis	F-statistic	p-Value
Oil price shock does not cause oil price uncertainty.	124.67***(+)	0.00
Oil price uncertainty does not cause oil price shock.	5.85**(-)	0.02
Oil price shock does not cause industrial production growth.	2,58 (+)	0.11
Oil price uncertainty does not cause industrial production growth.	0.049 (-)	0.82

Note: *** and ** denote significance at the 1% and 5% level.
+ and – denote positive and negative impact.

The results in Table 6 reveal that the null hypotheses that oil price shock does not cause industrial production growth and that oil price uncertainty does not cause industrial production growth are accepted. Therefore, the finding that oil price shock does not affect industrial growth in the short run is consistent with the result reported in Table 4. In addition, oil price uncertainty does not promote or harm industrial growth. This finding does not support the finding by Lee et al. (1995). However, the null hypotheses that oil price shock does not cause oil price uncertainty and that oil price uncertainty does not cause oil price shock are rejected at the 1% and 5% level, respectively. Therefore, there is bidirectional causality between oil price shock and oil price uncertainty. Even though oil price shock causes oil price uncertainty to increase and oil price uncertainty causes a fall in oil price shock. It does not necessarily imply that oil price shock will not impose a negative effect on industrial production in the long run.

4. Concluding Remarks

This paper investigates the oil price-industrial production relationship in Thailand using monthly data from 1993 to 2015. The real oil price series is measured in local currency. The methods employed in this paper are Johansen's cointegration and Granger causality tests. In addition, an oil price shock can cause oil price uncertainty. Therefore, the AR(1)-EGARCH(1,1) model is used to generate the uncertainty series. The impacts of an oil price shock and its uncertainty are examined by using the causality test. The main findings can be summarized as follows. First, industrial production is cointegrated with oil price along with lending rate and price level. The significant coefficient of the error correction term indicates that there is a stable long-run relationship between economic activity in a manufacturing sector and the real price of oil. Second, the impact of an oil price shock on industrial production growth is not observed in the short run. Third, oil price uncertainty does not affect industrial production growth. Policy implication based on the findings in this paper is that energy efficiency as well as alternative energy sources deem necessary for the long-run growth of the country.

References

Cunado, J., Jo, S. and Perez de Gracia, F., 2015. "Macroeconomic impacts of oil price shocks in Asian Economies, Energy Policy, 86(C), 867-879.

Cunado, J. and Perez de Gracia, F., 2005. "Oil prices, economic activity and inflation: evidence for some Asian countries," Quarterly Review of Economics and Finance, 45(1), 65-83.

Du, L., He, Y. and Wei, D., 2010. "The relationship between oil shocks and China's macro-economy," Energy Policy, 38(8), 4142-4151.

Granger, C. W. J., 1988. "Causality, cointegration, and control," Journal of Economic Dynamics and Control, 12(2-3), 551-559.

Gupta, P. and Goyal, A., 2015. "Impact of oil price fluctuations on Indian economy," OPEC Energy Review, 39(2), 141-161.

Hamilton, J. D., 1983. "Oil and the macroeconomy since World War II," Journal of Political Economy, 91(2), 228-248.

Hooker, M. A., 1996. "What happened to the oil price-macroeconomy relationship?," Journal of Monetary Economics, 38(2), 195-213.

Johansen, S., 1991. "Estimation and hypothesis testing for cointegration vectors in Gaussian vector autoregressive models," Econometrica, 59(6), 1151-1580.

Johansen, S and Juselius, K., 1990. "Maximum likelihood estimation and inference on cointegration with applications to the demand for money," Oxford Bulletin of Economics and Statisitics, 52(2), 169-210.

Kwiatkowski, P., Phillips, P. C. B., Schmidt, P. and Shin, Y., 1992. "Testing the null hypothesis of stationarity against the alternative of a unit root: how sure are we that economic time series have a unit root?," Journal of Econometrics, 54(1-3), 159-178.

Lee, K., Ni, S. and Ratti, R. A., 1995. "Oil shocks and the macroeconomy: the role of price variability," Energy Journal, 16(4), 39-56.

MacKinnon, J. G., Haug, A. A. and Michelis, L., 1999. "Numerical distribution functions of likelihood ratio tests for cointegration," Journal of Applied Econometrics, 14(5), 563-577.

Mork, K. A., 1989. "Oil and macroeconomy when prices go up and down: an extension of Hamilton's results," Journal of Political Economy, 97(3), 740-744.

Nelson, D. B., 1991. "Conditional heteroskedasticity in asset returns: a new approach," Econometrica, 59(2), 347-370.

Oh, C. and Lee, K., 2004. "A dynamic equilibrium of electricity consumption and GDP in Hong Kong: an empirical investigation," Energy Policy, 35(1), 51-59.

Park, C., Chung, M. and Lee, S., 2011. "The effects of oil price on regional economies with different production structures: a case study from Korea using a structural VAR model," Energy Policy, 39(12), 8185-8195.

Wei, Y., 2013. "The dynamic relationship between oil prices and the Japanese economy: a frequency domain analysis," Review of Economics and Finance, 3(2), 57-67.

Zhang, D., 2008. "Oil shock and economic growth in Japan: a nonlinear approach," Energy Economics, 30(5), 2374-2390.