Sultan, Zafar Ahmad; Alkhateeb, Tarek Tawfek Yousef; Fawaz, Mahmoud Mohamed

Article

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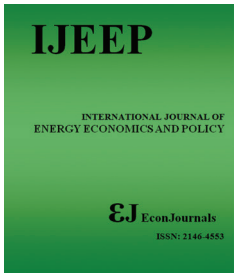
Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Sultan, Zafar Ahmad/Alkhateeb, Tarek Tawfek Yousef et. al. (2020). Empirical investigation of relationship between oil price and inflation : the case of India. In: International Journal of Energy Economics and Policy 10 (3), S. 90 - 94. https://www.econjournals.com/index.php/ijeep/article/download/9015/5000. doi:10.32479/ijeep.9015.



International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(3), 90-94.

Empirical Investigation of Relationship between Oil Price and Inflation: The Case of India

Zafar Ahmad Sultan[1]*, Tarek Tawfik Yousef Alkhateeb[2,3], Mahmoud Mohamed Fawaz[3]

[1]Department of Economics, Langat Singh College, B.R. Ambedkar Bihar University, Muzaffarpur, Bihar, India, [2]Department of Marketing, College of Business Administration, Prince Sattam Bin Abdulaziz University, Alkharj, Saudi Arabia, [3]Kafrelsheikh University, Kafrelsheikh 33511, Egypt. *Email: zsultan.sultan@gmail.com

Received: 23 October 2019 **Accepted:** 24 January 2020 **DOI:** https://doi.org/10.32479/ijeep.9015

ABSTRACT

India is once again facing the problem of rising price of crude oil since 2017 after enjoying low price since 2014. This period has also witnessed moderate rate of inflation in the economy. It is argued that rise in crude oil price also affect the inflation level in the country. The paper using data from 1970 to 2017 intends to examine the relationship between oil price and inflation level in the country. The paper has used Johansen cointegration method to investigate the long run association between the two. It is found that oil price does affect the inflation level in India both in the short run as well as in the long run. In a situation when country is facing problem of decreasing demand for consumption as well as of investment, rise in oil price and its pass through in the form rise in general price level may further deepen the crisis. To increase the demand and keeping the inflation at moderate level the government needs to manage the domestic oil price without transferring the burden on the people. In this light, the government is also required to incentivise the development of alternate source of energy and the technology to economise the use of energy.

Keywords: Oil Price, Inflation, Cointegration
JEL Classification: E

1. INTRODUCTION

The international crude oil price after reaching its bottom level of $29.8 per barrel in June 2016 has once again started showing rising trend and reached to a level of $76.73 per barrel in October 2018 and then to $68.858 per barrel in April 2019. The dispute between Saudi Arabia and Yemen and tension with Iran has raised the oil price level further and is not expected to decline in near future. This is the 5th time the world is facing the problem of oil price shock. Earlier, the world economy witnessed four bouts of oil price shocks, viz, 1973-74, 1979-80, 1990 and 2000. The price of crude oil witnessed constant rise since 2000. However, since 2014 it dipped to as low as about $30 per barrel before showing rising trend once again since 2017. The inflation level in India since 2014 came down to modest level after remaining high during 2006-2014.

The change in oil price is assumed to be associated with changes in many macroeconomic variables including the price level in the economy. The 1970s witnessed a rising inflation across the world including India that went along with rising international crude oil prices. This is followed by declining inflation in the 1980s and in the 1990s following fall in international crude oil prices. Thus, oil price was recognized an important factor influencing price level in oil importing countries. It typically produces cost push inflation in the economy. Economists across the nations agree that oil price does affect price and other variables (Darby, 1982), though they differ in magnitude of the impact on these variables. Bruno (1982) and Bruno and Sachs (1982) has found rise in wages and price and fall in output due to increase in oil price. For the developed countries some favourable conditions like unutilized capacity, availability of oil saving technology might cause relatively less impact on inflation and other macroeconomic variables. But for

the developing countries like India, absence of both the conditions may cause more adverse impact on inflation and other variables.

In the 2000s, the international crude oil price went on rising until 2014 after which it declined. However, in the case of many countries the inflation was relatively at low level during the 2000s when compared with that in the 1970s following rise in oil prices. In the case of India, inflation was high during 2006 to 2014 showing different pattern than world over. However, after 2014 the inflation has remained at modest level. During the period, the price of crude oil has declined significantly to low level but domestic oil price did not fall proportionately. In fact, the government has tried to maintain the price of oil in the domestic market by raising the taxes on that. This is also the period when India experienced high rate of growth of gross domestic product and high capacity utilisation. Hence, the inflation level has not declined but remained at modest level.

Since price of crude oil has once again started rising which may push the domestic price of oil up with consequent effect on overall price level in the economy. In the light of this, the objective of the paper is to understand the linkage between crude oil price and inflation level in the case of India. We have selected India because India is fourth largest oil importing and consuming country in the world. As the country has made the target of achieving five trillion economy, the demand for oil is expected to rise. Since oil is an important input and India imports about 80% of its oil requirements, rise in its price will increase the cost of production, push the inflation level up and may also pose challenges in reaching 5 trillion economy.

The organization of the paper is like this. Nextpart reviews various studies which were done to investigate the relationship between oil price and general price level in the economy. This is followed by brief description of the methodology to empirically examine the link between the two. The empirical results are discussed in next section. Finally, the paper concludes the study.

2. LITERATURE REVIEW

Number of studies have been done to investigate the relationship between oil price and inflation in the economy and it was widely agreed that oil price shock does have an effect on general price level and other macroeconomic variables, however, there is some difference in the magnitude of such affect between different countries depending upon different factors. Bruno (1982) and Bruno and Sachs (1982) has argued that increase in oil price leads to rise in wages and price level and fall in level of output. The study of IMF (2000) estimates that $5 increase in oil price leads to 1.3% increase in inflation after a year. However, the study acknowledge that the magnitude of effect depends upon the effective monetary policy and consumers' and producers' adjustment to such increase in prices. Hamilton (1983) found significant correlation between oil price increase and economic slowdown since during 1948–1972. Kilian (2006) has found that cause of oil shock is also important in its effect on economic growth of the economy like US.

Hamilton and Herrera (2001) and Davis and Hamilton (2003) found nonlinear and asymmetric relationship between oil price and inflation. Recently Shitile and Usman (2020) has applied nonlinear autoregressive distributed lag method to examine the relationship between oil price and inflation decomposed into food, core, other energy and transport and have observed long run asymmetry relation between oil price and inflation and they have also found incomplete pass through of oil price to inflation. Hooker (2002) have also established the relationship between the two. He concluded that the effect of oil price on inflation has reduced after eighties and it is not because of nonlinear relation but because of reduced dependency on oil. Barsky and Kilian (2004), Blanchard and Gali (2007) have also studied the relationship between the two and found that the oil shock does affect the output and price level but its magnitude has reduced since 1980s because of reduced dependency on oil, prudent monetary policy and presence of offsetting shocks. De Gregorio et al. (2007), US (Hooker, 2002; Barsky and Kilian, 2004; Valcarcel and Wohar, 2013), G7 countries (Kilian, 2008) as well as Euro region (Álvarez et al., 2011) have also observed decline in pass through from oil price to general price level.

Bhattacharya and Bhattacharya (2001) using vector autoregression model have found bidirectional relationship between oil price and non-oil price in the case of India. The impulse response function reveals that 20% point rise in price of oilpushes the non-oil price up by 1.3% point which typically happens after 5-7 months interval. Hamilton (1996); Cuñado and de Gracia (2003) observed that rise in mineral oil price causes the decline in the consumers' buying ability and then fall in real output. Mineral oil being an important input, any increase in its price leads to higher cost of production and hence higher price and lower output (Kang and Ratti, 2013a; Du and He, 2015). Long and Liang (2018) in his study did not find any association of oil price with non-oil price. There are other studies also which inspect the connection between oil price and non-oil price. The studies by Mork (1989); Hamilton and Herrera (2001); Du et al. (2015); Evgenidis (2017) reveals such kind of results. These studies use linear method to estimate the relationship between the two.

There are also studies which prefer to use nonlinear method to examine the issue arguing that there can be asymmetric relationship between oil price and non-oil price. This could be due to either cost structures or public regulations or market structures or mixed of these (Ibrahim, 2015). This may also explain the reasons for little or insignificant relation between oil inflation and general inflation (Long and Liang, 2018). Some of the studies have found that oil price pass through has weakened over the years. For example, De Gregorio et al. (2007) has found similar result in the case of industrialised and emerging economies; Hooker (2002); Barsky and Kilian (2004); Valcarcel and Wohar (2013) have found in the case of US; Kilian (2008) in the case of G7 countries and Álvarez et al. (2011) have observed in the case of Euro region.

Thus, we observe that quite a number of studies have been done to enquire the association between oil price and inflation level in the economy, but no conclusive evidence could be drawn. India being highly dependent on imported oil and also its growing demand the impact of rising oil price on inflation level in India become quite relevant as the price has once again started showing rising trend.

3. ECONOMETRIC METHODOLOGY

In a country like India which depends upon about 80% of its oil needs on imports, any increase in its price would raise the cost of production that may put pressure on inflation. Oil is an important input in industrial and all other production activities. Any shock in its price would raise the marginal cost of production and would reduce its supply. Rise in cost of production would then transmit to end users in the form of rise in price level through chain of relationship between different sectors. Further, rise in price would cause more outflow of foreign currency leading to depreciation of domestic currency and may lead to inflation. Hence, on theoretical basis we may establish an association between oil price and domestic inflation. But empirically different results have been observed by different studies for different countries. To examine the case of India, we have also included exchange rate in our model. The extracted theoretical framework about the relationship between the two can be expressed in following model form:

$$lP = f(lOP, lER) \quad (1)$$

Where,
P denotes consumer price index (CPI) representing inflation,
OP measures the average level of price level,
ER is nominal exchange rate between US dollar and Indian rupee, and
l is natural log of respective variables.

To examine the association between global oil price and domestic inflation, annual data on oil price, CPI and nominal exchange rate from 1970 to 2017 have been used. The data on CPI and exchange rate has been taken from world development indicator, data on crude oil prices has been taken from world bank commodity prices. Data on all the variables included in the model has been converted in natural log form.

In order to estimate the long run association between oil price and general price level, Johansen cointegration method has been used. The application of Johansen method necessitates that all the variables included in the model ought to have same order of integration. Thus, first of all unit root test needs to be applied on all the variables used in the model to confirm the stationary nature of the variables. In this context, augmented Dicky-Fuller (ADF) test and Philips-Perron test has been applied. If all the variables are found to be integrated of same order, then Johansen method of cointegration method may be applied to estimate the long run association between the variables. Having found cointegration relation between the variables, vector error correction model (VECM) will then be applied to find short run and long run causality between the variables. The robustness of the model will be tested by using various diagnostic tests.

4. EMPIRICAL RESULTS

From the results shown in Table 1, it can be inferred that all the variables included in the model are integrated of first order. The computed value of ADF test for all the variables are more than the critical value. This shows that variables are non-stationary at level. However, the computed ADF value for all the variables are less than the critical value at 1% thus rejecting the null hypothesis of presence of unit root and accept the alternative hypothesis that variables are stationary at first difference. Thus, we may conclude that all the variables are integrated of first order.

Having found that all the variables are integrated of first order, we may proceed to apply Johansen method to examine the long run association between oil price and price level in India. Since lag period affects the result, selection of appropriate lag period becomes important. Table 2 provides the outcome of various criteria for selecting suitable lag period, which suggests that lag of four period would be suitable for the model according to Akaike information criterion.

The Johansen cointegration results with four period lags are presented in Table 3a and b. Table 3a reveals that the trace value for null hypothesis of no cointegration relation is 52.59764 which is more than the critical value of 35.19275. Thus, we reject the null hypothesis of no cointegration at 5% significance level and accept the alternative hypothesis that there is cointegration relationship between these variables. The trace value for null hypothesis of at most one cointegraion is 16.16411 which is less than the critical value of 20.26184. Hence, we accept the null hypothesis of at most one cointegration between the variables. Table 3b reveals the Eigen value statistics. The computed maximum Eigen statistics for null hypothesis of no cointegration is 36.43353 which is more than the critical value of 22.29962. Thus the result confirms that there is atleast one cointegration relation between the variables in question. The table further provides evidence of accepting the null hypothesis of at most one cointegration as calculated value (13.16650) is less than the critical value of (15.89210). Similar inference can also be drawn on the basis of trace statistics given in Table 3b. So, we accept the null hypothesis of at most one cointegration relation between these variables. Thus, from both

Table 1: Unit root test result (ADF and PP test)

Variables	ADF test		PP test	
	At level	First difference	At level	First difference
lP	−2.701229	−5.014872*	−1.971697	−4.932606*
lOP	−2.908477	−6.230079*	−2.922855	−6.232950*
lER	−1.559829	−4.329035*	−1.517166	−4.283174*
Critical values (%)				
1	−4.170583		−4.165756	
5	−3.510740		−3.508508	
10	−3.185512		−3.184230	

*Denotes significant at 1%, ADF: Augmented Dicky-Fuller, PP: Philips-Perron

Table 2: Lag selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−60.29166	NA	0.003565	2.876894	2.998543	2.922007
1	130.8098	347.4572*	9.08e-07	−5.400446	−4.913849*	−5.219993*
2	139.9446	15.36301	9.08e-07	−5.406572	−4.555027	−5.090778
3	148.9971	13.99022	9.20e-07	−5.408958	−4.192465	−4.957824
4	159.0166	14.11848	9.06e-07*	−5.455302*	−3.873861	−4.868828

*Indicates lag order selected by the criterion, LR: Sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion

Table 3a: Unrestricted cointegration rank test (Trace)#

Unrestricted cointegration rank test (Trace)				
Hypothesized No. of CE(s)	**Eigen value**	**Trace statistics**	**0.05 Critical value**	**Probability****
None*	0.571426	52.59764	35.19275	0.0003
At most 1	0.263759	16.16411	20.26184	0.1669
At most 2	0.067337	2.997611	9.164546	0.5811

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

Table 3b: Unrestricted cointegration rank test (Maximum Eigen value)#

Unrestricted cointegration rank test (maximum Eigen value)				
Hypothesized No. of CE(s)	**Eigen value**	**Max-Eigen statistic**	**0.05 Critical value**	**Probability****
None*	0.571426	36.43353	22.29962	0.0003
At most 1	0.263759	13.16650	15.89210	0.1280
At most 2	0.067337	2.997611	9.164546	0.5811

Maximum Eigen value indicates 1 cointegrating eqn(s) at the 0.05 level. *Denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) P-values. #Lags interval (in first differences): 1 to 4

Table 4: Granger causality based on vector error correction model: inflation level (lP_t) as dependent variable

Independent variable	lOP_t	lER_t	ECT_{t-1}	Diagnostic tests (P-value)
Chi-square (P-value) [t-value]	(0.0180)	(0.9308)	−0.125867 [−5.22338]	LM serial correlation: 0.1985 Jarque-Bera normality test: 0.0787 Heteroskedasticity: 0.5389

these tables it can be concluded that a long run association does exist between oil price, domestic inflation, and exchange rate.

The normalized equation shows that inflation is positively related to crude oil price and exchange rate. The empirically observed equation is presented as follows

$$lP_t = 1.10 + 0.42lOP_t + 0.95lER_t \quad (2)$$

Finding cointegration relationship between oil price and inflation, long run and short run causality has been examined by using VECM method. The result is shown in Table 4. Different diagnostic tests like serial correlation LM test, White heteroskedasticity and Jarque-Bera normality test confirm the robustness of the model. The error correction term with one period lag is found to be negative (−0.13) and significant which confirms that oil price does Granger cause change in price level in India in the long run. The short run causality test result shows that the probability value for null hypothesis of no causal relationship between price index and oil price from oil price to general price level is 0.018 and hence we reject this hypothesis at 5% and conclude that oil price does does affect the inflation level in India. Hence, we find bothe short run as well as long run causal relationship between oil price and general price level from oil price to inflation level in the country.

5. CONCLUSION

One of the important and positive development in the case of India since 2014 has been coming down of inflation at moderate level. One of the reasons cited by many is decreasing price of crude oil in international market. During 2014 to 2017, India has enjoyed the benefits of low oil price in the form of foreign exchange reserves saved on account of low import bill high economic growth, low inflation etc. Since then oil price has started rising once again which is expected to have some adverse impact on Indian economy. In such backdrop, the paper intended to examine the relationship between oil price and domestic price level in the case of India.

Using the data from 1970 to 2017 we have applied Johansen cointegration method to estimate long run association between oil price, exchange rate and CPI. The result reveals that there is long run cointegration relationship between oil price and domestic price level in India. Further the result also shows that there is positive relationship between oil price and domestic price level. The causality results also confirm that change in oil price does cause change in general price level in India.

This implies that recent trend of rise in crude oil price may be worrisome for India particularly in circumstances when India is facing severe challenge of slowing down in the growth rate of

the economy owing to deficiency of demand. Any rise in general price level may further dampen the demand and slowdown the economy even more. Under such circumstances, government needs to keep the price under control so as not to raise the cost of production and inflation. The government should also provide incentives to develop alternate domestic sources of energy to reduce its dependence on oil and to encourage and facilitate the use of energy saving technology.

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