Journal of Engineering and Applied Sciences 11 (9): 1880-1885, 2016
ISSN: 1816-949X

Exploring the Impacts of Oil Price Shocks on Domestic Inflation

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Abstract: We conduct panel data analyses to investigate the impacts of oil price on determining domestic inflation in two groups of economies, namely the oil importing and oil exporting countries. Each group consists of ten countries. Besides, we also compare the relative effects of oil price with other shocks (domestic output, exporter's production cost and real exchange rate) on domestic inflation. Our results show that oil price has significant impact on determining domestic inflation with larger pass-through rate into domestic inflation in oil importing countries. The oil's impact is relatively smaller than the effects from other factors. The main determinants to domestic inflation include foreign production cost, GDP and real exchange rate. All variables (oil price, foreign producer cost, GDP and exchange rate) have long run impacts on domestic inflation but the impacts are not significant in the short run.

Key words: Oil price shocks, inflation, cointegration, cost, group

INTRODUCTION

Changes in crude oil price may lead to the economic fluctuations in the world economic globally. The effect is particularly felt by the emerging countries that are not financially stable and are weak to the influences of external shocks. On the other hand, inflation is one of the main indicators that can reflect the economic condition/ performance of an economy. Price stability/low inflation is also being one of the main policy objectives that targeted by the policymaker. Stability in prices can secure for economic growth and health, yet provides a good environment for trades and investments. The understanding on the determinants of inflation provides useful information in the policy decision/action so that earlier action can be taken to reduce the negative effect of external shocks and to prevent the stability of economy.

In this study, we particularly focus on the impact of oil price shocks on determining the domestic inflation in two groups of economies, i.e., oil importing and oil exporting countries. In addition, we also compare the effect of oil price shock with other shocks on determining the inflation in these two groups of countries. Applying panel data analyses, our results show that oil price is influential in determining the inflation in these two groups of countries although its impact may not the largest one. Our results reveal that the main determinants to domestic inflation in both groups foreign production cost. All variables (oil price, foreign production cost, real exchange rate and GDP) have long run impact on domestic inflation. The impacts are not significant in the short run.

The concept of pass-through: In this study, we estimate the pass-through effect of oil price on domestic consumer prices. The oil price pass-through rate measures the percentage changed in domestic consumer prices led by a one percentage changed in the oil price. To estimate the oil price pass-through equation, we borrow the concept of Exchange Rate Pass-Through (ERPT) and modify the exchange rate pass-through equation to include the oil price variable in the estimation.

ERPT is equation is constructed to measure the effect of exchange rate changes on domestic inflation based on the concept of law of one price (Sek and Kapsalyamova, 2008). According to this concept, the price of import denominated in the domestic importing country's currency P_t^{im} should hold same as the import price denominated in the domestic importing country's currency P_t^{ex} after multiplying by the exchange rate of importing country E_t which can be written as $P_t^{im} = P_t^{ex}.E_t$ The exporting producer sets P_t^{ex} based on the mark-up λ_t over marginal cost of production C_t which is $P_t^{ex} = \lambda.C_t$. Substituting Eq. 2 into 1, we get $P_t^{ex} = \lambda_t.C_t.E_t$. The mark-up is determined by the demand pressure in the destination market, therefore it can be proxy by the real GDP of the importing country. Using log transformation, we have:

$$P_t^{im} = \alpha_1\lambda_t + \alpha_2 C_t + \alpha_3 E_t \quad (1)$$

Or:

$$CPI_t = \alpha_1 GDP_t + \alpha_2 PPI_t^{US} + \alpha_3 PEER_t \quad (2)$$

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CPI is used to represent the import price of domestic, GDP as the proxy for the markup; Producer Price Index (PPI) of US as the proxy for the production cost of foreign Producer and Real Effective Exchange Rate (REER) is used to represent the exchange rate variable.

The exchange rate pass-through is captured by α_3 which indicate the partial elasticity of import price with respect to exchange rate. This equation is modified in estimating the pass-through effect of oil price on inflation.

Literature review: The studies that focused on the effects of external shocks on domestic inflation are broad. These studies report different factors that contribute to changes in domestic inflation. For instance, Carthy (2007) focused his study in several industrial countries and revealed that exchange rates and import prices are the two main determinants to domestic price inflation during the post Bretton Woods era. Countries with larger import share tend to experience faster effects of external shocks on domestic inflation. Additionally, Phan (2014) found that output and prices shocks in trading partners are the main contributor to the inflation in Vietnam.

In addition, many studies focus the investigations on the impact of oil price shocks on domestic inflation as historical data/reports show that oil price changes have great influences on the world economic volatility and the oil supply shocks are considered as the source of worldwide macroeconomic volatility and stagflation for that period (Blinder and Rudd, 2012). Historical data also show that the effects of oil prices on inflation were very large in the 1970 and early 1980s, the effect declined to moderate in the late 1980 and 1990s but the effects increase in recent few years. Previous empirical studies also detected significant impacts of oil price changes on inflation. For instance, Kiptui (2009) found that the spike of world oil prices in 2002-2008 was linked to the high inflation in Kenya. Both oil price and exchange rate have contributed to the inflation in Kenya. On the other hand, Misati *et al*. (2013) conducted an investigation on the dynamic linkages between commodity prices and overall inflation and non-food-non-fuel inflation in Kenya. Applying the Granger causality and structural vector autoregressive methods, they reported significant effects of oil and food prices in both measures of inflation.

More recently, Zhao *et al*. (2014) conducted a DSGE mode analysis to study the effects of oil price shock on China's output and inflation. They concluded that crude oil shock contributes to the largest fluctuations in China's output and inflation. Different sources of oil price fluctuations can impose different effects on inflation. They suggested that the policymaker should consider the global economic environment in the policy decision in stabilizing inflation.

Other empirical studies also reported significant effects of oil price on domestic inflation (Kargi, 2014; Abounoori *et al*., 2014; Jiranyakul, 2015). Likewise, Basnet and Upadhyaya (2015) conducted a structural VAR Model to study the impacts of oil price shocks on the economies in ASEAN5 countries. They found that oil price volatility does not explain any macroeconomic variables in ASEAN5 countries but it causes to higher inflation in Thailand.

Apart from these studies that reported significant effect of oil prices on inflation, a number of studies report small or limited effect of oil price on inflation. For instance, Hooker (2002) revealed non-significant effect of oil price changes on US inflation that excluded energy products. Gregorio *et al*. (2007) reported a reduction in the pass-through effect of oil price changes into consumer prices in a sample that included industrialized and emerging countries. Also, Gonzalez *et al*. (2009) investigated the effects of oil price changes on Spanish and Euro area consumer price inflation. They found that oil price changes have limited effect on driving the inflation variability. And the latest study is by Arango *et al*. (2014) who applied a small open macroeconomic model with optimal interest rate rule to study the relationship between commodity prices shocks and inflation process in a country that involved in both exporting and importing of commodities. They found small impact from food international price shocks to inflation. Their results also supported the previous findings that pass-through from oil prices to headline inflation has decreased. They explained this phenomenon is due to effectiveness of monetary policy that includes commodity prices movements in the set of inflation expectations under inflation targeting regime.

Other reasons that can help to explain the decline of inflationary effect of oil price changes include higher energy efficiency of production processes, the price setting due to globalization and also the better conduct of monetary policy that help to reduce the impact of oil price shocks (Gonzalez *et al*., 2009).

Apart from the effect of oil price changes, other external factors that contributed to significant inflationary include money supply (Lim and Sek, 2015), uncertainty and inflationary uncertainty (Jiranyakul and Opiela, 2010), global good and food prices (Loening *et al*., 2009) and supply and demand pull inflation. Many studies show that external shocks have increasingly effects on domestic inflation in the long run and suggest controlling the effect of external influences through monetary policy stabilization (Loening *et al*., 2009; Jiranyakul and Opiela, 2010).

Data: We conduct the analyses based on two groups of countries, i.e., countries with high oil dependency index and countries with low oil dependency index. The selection of countries is based on the top oil importing and oil exporting countries listed on the website of US Energy Information Administration.

Oil importing countries: China, India, Netherlands, Korea, Singapore, Italy, Japan, Germany, Spain, France.

Oil exporting countries: Norway, Canada, UK, Saudi Arabia, Kuwait, Russia, Iraq, Qatar, Nigeria, Kazakhstan. We apply the annual data ranging from 1980-2013. The data are collected from the World Bank, Federal Reserve Bank of St. Louis FRED) and Bank for International Settlements. These data include gross domestic product, GDP (US$), consumer price index, CPI (%), real effective exchange rate (REER, index) and producer price index for US (PPI_US, index) and world oil price or OIL (US$ per barrel). All variables are transformed into natural log form so that they are given in percentage.

MATERIALS AND METHODS

We apply panel data approach based on the data of two groups of countries, each group consists of 10 countries. The analysis involves several steps. In the first step, conduct the preliminary tests (panel unit-root tests and panel cointegration tests) for the checking of stationarity and cointegration of variables. Then in the second step, we perform the optimal lag length criterion on model specification. Third, we construct our pass-through equation into ARDL (Autoregressive Distributed Lag) format for each group of countries. This step is followed by MG (Mean Group) and PMG (Pooled Mean Group) estimations. Finally, we perform the Hausman test to decide on the preference between MG and PMG estimations.

At data variables checking stage, we apply panel unit-root tests (Levin, Lin and Chu (LLC) test, Im, Pesaran and Shin (IPS) test and Fisher ADF test) for the checking of stationary. We then proceed for the checking of long-run relationship among variables based on cointegration tests (Pedroni residual test and Kao residual test). This step is crucial because the pre-condition to apply ARDL models is the existence of the long-run relationship between dependent and independent variables.

ARDL Model: The ARDL (p, q) Model with number of lag p on dependent variable and lag q of independent variables can be written as stated (Pesaran and Shin, 1999):

$$Y_{it} = \sum_{j=1}^{p} \lambda_{ij} Y_{it-j} + \sum_{j=0}^{q} \delta_{ij}' x_{it-j} + \varepsilon_{it} \quad (3)$$

where, i = 1, 2, ..., N as number of countries; t = 1, 2, ..., T indicates number of periods; Y_{it} is the dependent variable; x_{it} is a k×1 vector of independent variables; δ^* is$_{ij}$ k×1 coefficient vectors; λ_{ij} is the vector of scalars and ε_{it} is a disturbance term that assume to be distributed with a zero mean and a finite variance. This equation can be reparameterized into an error correction format as:

$$\Delta Y_{it} = \phi_i Y_{it-1} + \beta_i' x_{it} + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta Y_{it-j} + \sum_{j=0}^{q-1} \delta_{ij}^{*'} \Delta x_{it-j} + \varepsilon_{it} \quad (4)$$

Where:

$$\phi_i = -1\left(1 - \sum_{j=1}^{p} \lambda_{ij}\right); \beta_i = \sum_{j=0}^{q} \delta_{ij}$$

$$\lambda_{ij}^* = \sum_{m=j+1}^{p} \lambda_{im}, j = 1, 2, ..., p-1, \delta_{ij}^* = \sum_{m=j+1}^{p} \delta_{im}, j = 1, 2, ..., q-1$$

By regrouping, an error correction Eq. 4 can be summarized as:

$$\Delta y_{it} = j_i \left(y_{it-1} - \theta_i' x_{it}\right) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{it-j} + \sum_{j=0}^{q-1} \delta_{ij}^{*'} \Delta x_{it-j} + \varepsilon_{it} \quad (5)$$

$\theta_i = (\beta_i/\phi_i)$ is the indicator for the long-run or equilibrium relationship among Y_{it} and x_{it}. λ^*_{ij} and δ^*_{ij} are the short-run coefficients which show the short run effects of independent variables on the dependent variables. ϕ_i is the error-correction coefficient to measure the speed of adjustment of Y_{it} in attaining its long-run equilibrium as x_{it} changes. This parameter should be always negative so that there is a convergence or stability in the long-run relationship. θ_i indicates the pass-through rate of shocks from independent variables into dependent variable.

In this study, we convert Eq. 2 into ARDL format and in order to investigate the impact of oil price on inflation, a new variable OIL is added into estimation so that our model to be estimated is:

$$\begin{aligned} \Delta CPI_{it} = C + j_i (CPI_{it-1} - \theta_{1i}' \ln GDP_{it} - \theta_{1i}' \ln REER_{it} - \\ \theta_{3i}' \ln PPI\_US_{it} - \theta_{4i}' \ln OIL_{it}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta CPI_{it-j} + \\ \sum_{j=0}^{q-1} \delta_{1ij}^{*'} \Delta \ln GDP_{it-j} + \sum_{j=0}^{q-1} \delta_{2ij}^{*'} \Delta \ln REER_{it-j} + \\ \sum_{j=0}^{q-1} \delta_{3ij}^{*'} \Delta \ln PPI\_US_{it-j} + \sum_{j=0}^{q-1} \delta_{4ij}^{*'} \ln OIL_{it-j} + \varepsilon_{it} \end{aligned} \quad (6)$$

where all coefficients are as interpreted in Eq. 3-5. Equation 6 is estimated using Mean Group (MG) and

Pooled Mean Group (PMG) methods. MG imposes no restriction on cross-country and allows for heterogeneity of all parameters. The MG estimator provides estimates on separate regressions for each country and provides averages of the country-specific coefficients which are consistent estimates of the long-run coefficients (Evans, 1997). On the other hand, PMG restricts the long-run parameters to be constant over all countries but allows the intercepts, short-run coefficients and error variances to be different across countries.

RESULTS AND DISCUSSION

Our unit-root tests (Levin, Lin and Chu (LLC) test, Im, Pesaran and Shin (IPS) test and Breitung test) show that most of the variables are not able to reject the null hypothesis of unit-root at 5% level. However, all variables become stationary after first differenced transformation, indicating that these variables are integrated with order one or I(1).

Next, testing with panel cointegration tests (Pedroni residual test and Kao residual test), our results show some evidences to reject the null hypothesis of no cointegration, indicating the detection of long-run relationship between dependent and independent variables for the two groups of data. Therefore, we fulfil the requirement of ARDL Model and it is appropriate to apply the ARDL Model in our study.

For the good specification of the ARDL Model, we perform the optimal lag length criterion by limiting the comparisons of multiple combinations of ARDL (p, q, r, s, u) to lag one due to the small sample size. Akaika Info Criterion (AIC) suggests ARDL (1,1,0,0,1) while Bayes info criterion (BIC) suggests ARDL (1,1,0,0,0) for oil exporting countries. Meanwhile both AIC and BIC suggest the same specification, i.e., ARDL (1,0,0,0,0) for oil importing countries. We first compare the estimation results using PMG technique using specifications from both AIC (Table 1). After identifying the better specification, we then compare the estimation results of PMG with MG approach (Table 2).

Table 1 summarizes the results of PMG estimation using specifications suggested by AIC and BIC criterion for the two groups of countries. Two different specifications give us very similar results. Therefore, we will select the specification that shows the larger maximum log likelihood value. We have selected ARDL (1,0,0,0,0) for oil importing group and ARDL (1,1,0,0,1) for oil exporting group. We then proceed to compare the results of MG and PMG estimations which are summarized in Table 2.

From Table 2, we observe that MG estimations give quite different results compared to PMG estimation. Most of the coefficients under MG estimations are not significant. Also, Hausman test is not significant and fails to reject the null hypothesis that PMG is more efficient. Since PMG technique is more efficient, our discussion will base on the PMG estimation in Table 2.

The results of PMG estimation in Table 2 show that the four variables (exchange rate, GDP, foreign producer cost and oil price) have no significant effect on determining the domestic CPI inflation in the short run. However, the effects are significant in the long run. The results hold in two groups of countries.

Higher GDP and oil price lead to higher domestic inflation in both oil importing and exporting countries. This is because higher, GDP implies higher demand and production, hence higher consumption and higher price levels. Also, higher oil price leads to higher inflation on domestic goods as oil is the main input used in productions of many goods. The oil price pass-through is higher in oil importing countries as these countries very depend on oil in their productions. On the other hand, the impact of oil price is lower in oil exporting countries as these countries produce oil and they are low oil dependence.

Table 1: PMG estimation

	Oil importing	Oil exporting	
Variables	ARDL (1,0,0,0,0)	ARDL (1,1,0,0,0)	ARDL (1,1,0,0,1)
Long-run parameter			
ln GDP_{it-1}	0.1990***	0.3462***	0.3354***
ln $REEP_{it-1}$	-0.3841***	-0.2068**	-0.2308***
ln PPI_US_{it-1}	-0.4745**	-0.4498**	-0.4795**
ln OIL_{it-1}	0.1980***	0.0899**	0.1118**
C	0.2571***	-0.2670***	-0.1713***
Speed of adjustment ϕ_i	-0.0969***	-0.2013***	-0.2036***Short-run parameter
Δln GDP_{it-1}	-	-	-
$\Delta REER_{it-1}$	-	0.1502	-0.0882
Δln PPI_US_{it-1}_	-	-	-
Δln OIL_{it-1}	-	-	0.1784
Maximized log-likelihood	870.8553	615.4688	625.6368

Table 2: PMG versus MG estimation

	Oil importing		Oil exporting	
Variables	MG	PMG	MG	PMG
Long-run parameter				
ln GDP_{it-1}	0.3121***	0.1990***	5.6474	0.3354***
ln $REER_{it-1}$	-0.8396***	-0.3841***	12.6377	-0.2308***
ln PPI_US_{it-1}	-0.2630	-0.4745**	-13.962	-0.4795**
ln OIL_{it-1}	0. 7956	0.1980***	-4.5188	0.1118**
C	-0.1804	0.2571***	-4.5554*	-0.1713***
Speed of adjustment ϕ_i	-0.2026***	-0.0969***	-0.1827***	-0.2036***
Short-run parameter				
Δln GDP_{it-1}	-	-	-	-
Δln $REER_{it-1}$	-	-	0.1134*	-0.0882
Δln PPI_US_{it-1}	-	-	-	-
Δln OIL_{it-1}	-	-	0.027	0.1784
Specification	ARDL(1, 0, 0, 0, 0)		ARDL(1, 1, 0, 0, 1)	
Hausman test	χ^2 (4) = 3.66		χ^2 (4) = 0.99	
	Prob. = 0.4544		Prob. = 0.9112	
	Prefer PMG		Prefer PMG	

The results also reveal opposite relationship between real exchange rate and domestic inflation. Higher REER implies appreciation of domestic currency or lower trade competition power in the international market as domestic goods are more expensive. This will reduce the volume of trade and induces to the drop in domestic price/inflation. Foreign producer cost (PPI of US) has a positive long run significant impact on inflation in both groups of countries as higher foreign production cost leads to lower domestic inflation. When foreign production cost increases, domestic production cost and the price of final goods also increase. This leads to lower demand and producers reduce productions, hence lower inflation.

Comparing the results across two groups of countries, we observe that although oil price has significant effect on domestic inflation in two groups of countries, its impact is relatively smaller than the other variables (GDP, exchange rate and foreign producer cost). Foreign production cost and real exchange rate appear to be the main determinants to domestic inflation in oil importing group. On the other hand, the main determinants to domestic inflation in oil exporting countries are foreign production cost and domestic GDP. The speed of adjustment indicates the convergence rate for the domestic inflation towards its equilibrium level. The convergence rate is higher in oil exporting countries, i.e., inflation in oil exporting countries take shorter time to recover/converge to its equilibrium level relative to oil importing countries.

CONCLUSION

In this study, empirical analyses are performed to investigate the effects of oil price on domestic inflation in two groups of countries, namely the oil importing and oil exporting countries. Each group consists of 10 countries which are selected based on the world top oil importing and exporting ranking. In addition, we also compare the relative effect of oil price with other types of shocks such as real exchange rate, domestic output and foreign production cost. We model the pass-through equation in ARDL format and estimate the model using mean group and pooled mean group methods. Our results show evidences on the significance impact of oil price on determining the domestic CPI inflation in both groups of countries. Higher oil price leads to higher inflation. However, the impact of oil price on inflation is relatively smaller compared to the effects from other shocks on inflation. The main determinants to domestic inflation are exchange rate and foreign production cost (oil importing countries); GDP output and foreign producer cost (oil exporting countries). All these variables have long run impacts on domestic inflation but impose no significant short run impact on domestic inflation.

In conclusion, exchange rate, oil price, domestic output and foreign production cost are important factors that can influence the domestic inflation in oil importing and oil exporting countries. Therefore, the policymaker should concern on the effects of these shocks and seeks to accommodate the effects of these shocks on economy through monetary tools/actions.

ACKNOWLEDGEMENT

This research was supported in part by FRGS under Grant No. 203/PMATHS/6711431.

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