Crude Oil Price Changes and Inflation: Evidence for Asia and the Pacific Economies

Jiranyakul, Komain

National Institute of Development Administration

June 2021

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

Abstract

This paper examines the influence of crude oil price on inflation in eight Asian and two of the pacific economies, which are oil-importing countries. The period of investigation is from 1987M5 to 2019M12. The results of bounds testing for cointegration reveal that there is a stable positive long-run relationship between the consumer price index and crude oil price in most of these countries during the period of low and less fluctuating oil prices. However, the stable long-run relationship is found in eight countries, but this stable relationship is found only in one country during the period of high and more fluctuating oil prices. The long-run pass-through of crude oil prices to consumer prices is partial. In the short run, the relationship between a crude oil price change and inflation indicates that the short-run pass-through is low in most cases, but this pass-through is more apparent during the period of high and more fluctuating oil prices. Therefore, the structural break seems to matter in the pass-through of crude oil price to consumer prices in both the long and short run. The findings suggest accommodative monetary policy measures to alleviate the inflation rate.

Keywords: Crude oil price, inflation rate, structural break, oil-importing countries

JEL Classification: E31, Q43

1. Introduction

The finding that international oil price exerts a stronger impact on price indexes than domestic oil price does is found by Huang and Chao (2012). On the contrary, Cunado and de Gracia (2005) find that the short-run impact of oil price changes on changes in the price index is more pronounced for domestic oil price than the international oil price. To measure domestic oil price, crude oil price can be converted to domestic oil price by domestic currency. An earlier study by Hamilton (1996) uses world crude oil prices to analyze the impacts of oil shocks on the US output while Cologni and Manera (2009) use the real price of oil to examine the impact of oil price shocks on output growth for the G7 countries. Recently, Askha

and Naveed (2015) find that Pakistan's inflation rate is significantly affected by international oil prices in the long run. In the short run, there is a unidirectional causality running from world oil price to inflation rate. Taking into account asymmetry, Ajmi et al. (2015) find both positive and negative oil price shocks positively cause inflation in South Africa, and the impact of the negative shock is stronger. Olifin and Salisu (2017) examine the oil price-inflation nexus for selected OPEC and EU countries by employing both linear and nonlinear cointegration techniques. One of their main findings indicates that the impact of oil price asymmetry seems to be more pronounced when dealing with oil-exporting countries. However, Choi et al. (2017) find that positive oil price shocks have a larger impact on inflation than negative oil price shocks. Nevertheless, Bala and Chin (2018) use a panel data analysis to investigate the impacts of crude oil price changes on inflation in African OPEC member countries. They find that negative oil price shocks have a stronger impact on inflation than positive oil price shocks. Zakaria et al. (2021) find that world crude oil price shocks have a positive impact on inflation in South Asian countries.

Practically, the domestic oil price should be more reliable because the exchange rate should matter while international oil prices might not signal the overall cost of production in an economy. Nevertheless, international oil price may partially affect some price indices, thus some previous studies still employ world crude oil price to gauge the influence of oil price shocks on inflation and other macroeconomic variables.

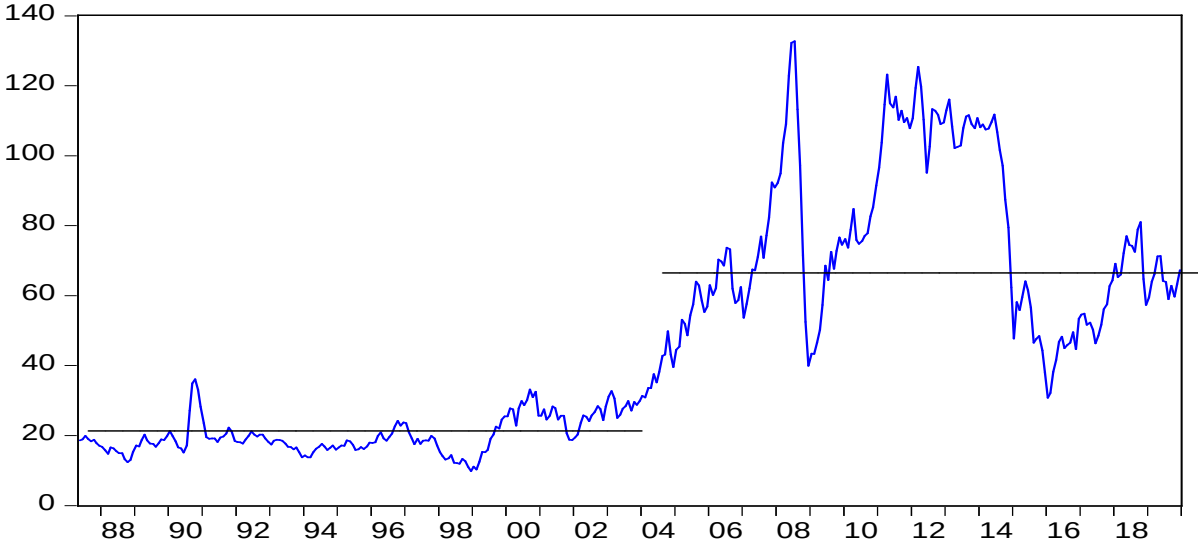

Figure 1. Crude oil price series, 1987M5-2019M12

Figure 1 plots the Brent crude oil price series. The stable period lasted from 1987M5 to 2001M1. The oil price started rising from 2001 with gradual increases and reached the highest point in 2008M6. The price dropped sharply and reached the lowest

point by the end of 2008. This is due to the 2008 oil price shock. The price rose again due to the 2011-2013 oil shock and declined again in 2014M5. After that, the oil price was less fluctuating for the remaining period. As shown in Figure 2, the degree of oil price shock is higher after the 2008 oil shock.

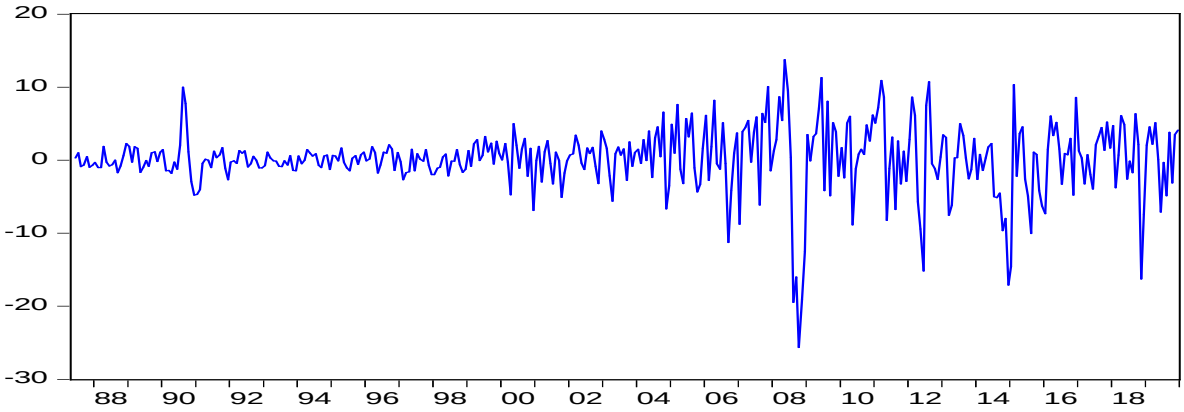

Figure 2. Crude oil price changes, 1987M5-2019M12

This paper evaluates the influence of crude oil price on inflation rate in selected Asia and the Pacific economies, which comprise a group of oil-importing countries. These countries are also oil-producing countries, such as India, Australia, Indonesia, Malaysia, and Thailand while the major crude oil importers are India, Japan, South Korea, the Philippines, Singapore, and Thailand (U.S. Energy Information Administration). New Zealand imports the lowest amount of crude oil. The method used in the analysis is the bound testing for cointegration of Pesaran et al. (2001). Specifically, the paper attempts to evaluate whether a linear cointegration test with symmetric adjustment towards a long-run equilibrium is sufficient to explain the long- and short-run pass-through of crude oil price to consumer prices in these selected countries. This paper contributes to the existing literature in that it provides evidence of the partial pass-through of crude oil price to consumer prices, in the long run, in most economies during the period of low and less fluctuating oil prices. The short-run pass-through seems to be more pronounced during the period of high and more fluctuating oil prices. The main findings seem to support the importance of monetary policy to alleviate the inflation problem in the majority of these countries. The paper is organized as follows. Section 2 explains materials and methods. Section 3 presents empirical results, and the last section gives concluding remarks.

2. Materials and Methods

2.1 Data

This paper analyzes the impact of world crude oil price on inflation in oil-importing Asian and the Pacific economies. Crude oil price is the Brent spot price measured in US dollars per barrel. This series is obtained from the website of the US Energy

Information Administration. The series of the consumer price indexes (CPIs) are obtained from the website of the Bank of International Settlement. All series are seasonally adjusted and transformed into logarithmic series. The crude oil price change is measured as a change in the log of Brent spot price and the inflation rate is measured as a change in CPI for each economy. Since there seem to be many episodes of oil shocks, the whole sample is divided into two periods; (1) the 1987M5-2004M8 period, and (2) the 2004M9-2019M12.[1] The first sub-sample period is the low and less fluctuating oil prices while the second sample period is the high and more fluctuating oil prices (See Figures 1 and 2). The analysis in the present paper will be based on these two sub-periods.

2.2 Estimation Methods

The long-run relationship between CPI and crude oil price is assumed to be linear and can be expressed as:

$$p_t = a_0 + a_1 op_t + \varepsilon_t \tag{1}$$

where p_t is the log of CPI, and op_t is the log of crude oil price.

To test whether the long-run relationship in Equation (1) exist, the bounds testing for cointegration proposed by Pesaran et al (2001) is used. This cointegration test is performed in a bivariate framework with the symmetric auto-regressive distributed lags (ARDL) approach. An unrestricted or conditional error correction model (ECM) is expressed as:

$$\Delta p_t = \alpha + \sum_{i=1}^{k1} \beta_i \Delta p_{t-i} + \sum_{j=1}^{k2} \gamma_j \Delta op_{t-j} + \gamma_0 . \Delta op_t + \delta_1 p_{t-1} + \delta_2 op_{t-1} + e_t \tag{2}$$

where Δp is the change in the log of CPI, Δop is the change in the log of crude oil price. The orders of lagged first differences of CPI and crude oil price are *k1* and *k2*, which might not be the same. The one-period lagged level variables included in Equation (1) are p_{t-1} and op_{t-1}. To obtain the computed F-statistic, the model in Equation (2) needs to be tested against the ARDL(*k1*,*k2*) model. Two hypotheses are tested;

$$H_O : \delta_1 = \delta_2 = 0 \qquad \text{(No cointegration)}$$

and $$H_a : \delta_1 \neq \delta_2 \neq 0 \qquad \text{(Cointegration).}$$

[1] These sub-periods are obtained from the Quant and Andrew structural break tests in the crude oil price series.

If the computed F-statistic is larger than the upper bound critical value at the 1%, 5%, or 10% levels of significance, a cointegrating equation will exist. On the contrary, if the computed F-statistic is smaller than the lower bound critical value, there will be no cointegration. However, if the computed F-statistic lies between the upper bound and lower bound critical value, the result will be inconclusive. When cointegration is found, all first differences will be zero. Therefore, the long-run relationship between CPI and crude oil price will be in the form:

$$p_t = \left(\frac{-\alpha}{\delta_1}\right) + \left(\frac{-\delta_2}{\delta_1}\right) op_t + \varepsilon_t \tag{3}$$

which is the same as Equation (1).

If cointegration exists, the error correction model (ECM) can be estimated to examine whether the long-run relationship between the price level and crude oil price is stable. The ECM is in the form:

$$\Delta p_t = \alpha + \sum_{i=1}^{k1} \beta_i \Delta p_{t-i} + \sum_{j=1}^{k2} \gamma_j \Delta op_{t-j} + \lambda \varepsilon_{t-1} + \nu_t \tag{4}$$

where ε_{t-1} is the error correction term (ECT), and λ is the speed of adjustment towards the long-run equilibrium.

The main advantage of the bounds testing for cointegration is that the test can be performed when variables are not integrated at the same order. However, this procedure cannot be applied if one of the variables is integrated of order 2, or I(2) series. Equation (3) gives room for testing both the long-run pass-through of crude oil price into consumer prices for each economy. The long-run pass-through is defined as a percentage change of consumer prices induced by a percentage change in the price of oil.[2] The coefficient of the short-run pass-through is a measure of the impact of oil price change on inflation at the current period that appears in the estimated conditional ECM expressed in Equation (2).

3. Empirical Results

Since the main purpose of the analysis is to investigate both the long-run pass-through of crude oil price into consumer prices and the short-run relationship between a crude oil price change and the inflation rate (the short-run pass-through) in selected Asia and the Pacific region, cointegration tests and conditional ARDL estimates are necessary. First of all, the time series property of variables is

[2] The logarithmic function is convenient to interpret a long-run pass-through.

determined using the augmented Dickey-Fuller (ADF) test for unit root.[3] The ADF tests with constant and a linear trend are performed on the level and first difference of each series to determine whether each series contain more than 1 unit root or not.[4] The test results are shown in Table 1.

Table 1. ADF Test for Unit Root, 1985M05-2019M12.

Panel A: Crude oil price		
	Level of series	First difference
	-2.920 [10]	-4.478***[14]
	(0.158)	(0.002)
Panel B: Consumer price index		
Indonesia	-2.135 [8]	-4.729***[7]
	(0.522)	(0.001)
Malaysia	-0.278 [0]	-9.389***[1]
	(0.978)	(0.000)
Philippines	-1.163 [3]	-6.634***[2]
	(0.713)	(0.000)
Singapore	-0.557 [0]	-15.170***[0]
	(0.980)	(0.000)
Thailand	-0.201 [3]	-6.211***[2]
	(0.000)	(0.003)
India	-1.014 [12]	-3.740**[11]
	(0.938)	(0.022)
South Korea	-1.338 [1]	-11.673***[0]
	(0.876)	(0.000)
Japan	-0.543 [0]	-10.765***[1]
	(0.980)	(0.000)
Australia	-3.516**[0]	-
	(0.000)	
New Zealand	-3.364*[5]	-8.967***[7]
	(0.059)	(0.000)

Note: The number in parenthesis is the p-value, and the number in the bracket is the optimal lag length determined by Akaike Information Criterion (AIC). ***' ** and * indicate significance at the 1%, 5% and 10%, respectively.

The results in Table 1 reveal that the levels of all series are non-stationary, except for consumer prices of Australia. Since the results indicate that all series are first-

[3] Even though the Bound testing of Pesaran et al. (2001) does not require the tests for unit root, this procedure cannot be applied when one or more of the series are integrated of order two, i.e., I(2) series. Therefore, performing testing for a unit root should be necessary to check whether some series are I(2) series.

[4] The ADF tests with a constant and a linear trend is used because each series seems to exhibit a trend.

difference stationary. Therefore, it can conclude that crude oil price and most consumer price indices are integrated of order 1 or they are I(1) series. The bounds testing for cointegration should be suitable because no series contains more than 1 unit root.

3.1 Results of Cointegration Tests

The level relationship between consumer prices and crude oil price expressed in Equation (1) is estimated for the two sub-periods, and the results are reported in Table 2.

Table 2. Level Relationship between Consumer Prices and Crude Oil Price.

	Sub-Period1 (1987M5-2004M8)	Sub-Period 2 (2004M9-2019M12)
Country	Coefficient	Coefficient
Indonesia	1.094***	-0.006
Malaysia	0.244***	-0.014
Philippines	0.629***	0.028
Singapore	0.113***	0.041*
Thailand	0.310	0.046**
India	0.054***	-0.021
South Korea	0.381***	0.024
Japan	0.024**	-0.024**
Australia	0.273***	0.004
New Zealand	0.199***	0.028

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

As shown in Table 2, the level relationship between consumer prices and oil price in sub-period 1 is significantly positive for all countries, except for Thailand. The estimated coefficients range from 1.094 to 0.024. However, the small coefficient of the level relationship in sub-period 2 exists for only Singapore and Thailand while this coefficient is significantly negative in Japan. It should be noted that the long-run coefficients in sub-period 2 are much smaller than those in sub-period 1. This may imply that a 1% change in consumer prices induced by a 1% change in crude oil price is weaker during the period of high and more fluctuating crude oil price.

The conditional ECM expressed in Equation (2) is estimated for countries with the significance of the possible long-run coefficients in both sub-periods. The lag orders, *k1* and *k2*, are set up to 6 as the maximum, and an appropriate and parsimonious

ARDL model is selected to perform cointegration tests[5]. The results are reported in Table 3.

Table 3. ARDL Testing for Cointegration.

Panel A: Cointegration Tests

	Sub-Period 1 (1987M5-2004M8)			Sub-Period 2 (2004M9-2019M12)		
Country	ARDL Model	$\chi^2_{(2)}$	Computed F-statistic	ARDL Model	$\chi^2_{(2)}$	Computed F-statistic
Indonesia	[1,1]	2.576 (0.276)	0.621			na
Malaysia	[3,2]	0.299 (0.861)	4.849*			na
Philippines	[2,1]	1.605 (0.448)	9.562***			na
Singapore	[1,2]	2.538 (0.281)	11.640***	[3,1]	4.037 (0.133)	7.866***
Thailand	[3,1]	2.428 (0.297)	2.768	[4,1]	1.163 (0.440)	7.416**
India	[3,2]	0.912 (0.639)	8.290***			na
South Korea	[2,2]	1.811 (0.404)	10.354***			na
Japan	[1,1]	3.619 (0.164)	6.167**	[1,1]	2.415 (0.299)	3.382
Australia	[3,2]	0.054 (0.974)	5.702*			na
New Zealand	[3,2]	1.435 (0.489)	6.389**			na

Panel B: Bounds Critical Values

Critical Value	Upper Bound	Lower Bound
1% level	7.84	6.84
5% level	5.73	4.94
10% level	4.78	4.04

Criteria:

Above the Upper Bound	Cointegrated
Below the Lower Bound	Not cointegrated
Between the Upper and Lower Bound	Inconclusive

Note: The number in the bracket is the lag order of an ARDL model, and the number in parenthesis is the p-value. ***, **, and * indicate significance at the 1%, 5%, and 10%, respectively. The critical values are adapted from Table CI (iii) Case III of Pesaran et al. (2001). The abbreviation, 'na', stands for not applicable.

[5] This method is referred to as the grid-search approach. In addition, the bounds testing for cointegration is performed if the long-run coefficient is statistically significant.

The estimated ARDL models are free of serial correlation since the Chi-square statistics show that the null hypothesis of no serial correlation is accepted in all cases. The relationship between consumer prices and crude oil price seems to be different between the two sub-periods. In the first sub-period, the long-run relationship between consumer prices and oil price is found in 8 out of 10 countries. In the second period, this long-run relationship is found in only 2 out of 10 countries. Therefore, structural breaks seem to matter in most countries. In Indonesia, cointegration cannot be found in both sub-periods. In eight countries, the long-run relationship is found in the first sub-period, but not in the second sub-period. These countries are Malaysia, the Philippines, Singapore, India, South Korea, Japan, Australia, and New Zealand. For Thailand, the level relationship between oil price and consumer prices is not found in the first sub-period, but it is found in the second sub-period. For Singapore, even though the long-run relationship is found in both sub-periods, but the relationship is significant at only 10% in the second period.

Table 4. Estimated Coefficients of the Error Correction Term.

	Sub-Period 1 (1987M5-2004M8)		Sub-Period 2 (2004M9-2019M12)	
Country	λ Coefficient	t-statistic	λ Coefficient	t-statistic
Indonesia	—	—	—	—
Malaysia	-0.003**	-2.016 (0.045)	—	—
Philippines	-0.006***	-4.301 (0.000)	—	—
Singapore	-0.011***	-4.862 (0.000)	-0.004	-1.455 (0.148)
Thailand	—	—	-0.010***	3.073 (0.003)
India	-0.004***	-3.261 (0.001)	—	—
South Korea	-0.006***	-4.547 (0.000)	—	—
Japan	-0.014**	-3.492 (0.001)	—	—
Australia	-0.008***	-3.339 (0.001)	—	—
New Zealand	-0.009***	-3.572 (0.000)	—	—

Note: The number in parenthesis is the p-value. ***, **, and * indicate significance at the 1%, 5%, and 10%, respectively.

Since finding cointegration between the two variables is necessary for detecting a long-run relationship between consumer prices and oil price, it will be sufficient when Equation (4) is estimated to examine whether the long-run equilibrium will be corrected when there is any deviation from the equilibrium. The estimated coefficients of ETCs are reported in Table 4. The results reveal that the stable long-run pass-through from crude oil price to consumer prices is found in 8 out of 10 countries during sub-period 1. There is no long-run pass-through in Indonesia, which is also an oil-producing country. Also, the net oil-importing country, Thailand, does not have a long-run pass-through either. For the second sub-period, cointegration exists only in the cases of Singapore and Thailand. The estimated coefficient of the ECT is statistically significant for Thailand. Therefore, a stable partial long-run pass-through is found for 1 out of 10 countries during the period of high and more fluctuating oil prices. The short-run impact of crude oil price change on inflation is analyzed using the estimated conditional ECM model of Equation (2). The results of the short-run pass-through of crude oil price to consumer prices are shown in Table 5.

Table 5. Relationship between an Oil Price Change and Inflation.

	Sub-Period 1 (1987M5-2004M8)		Sub-Period 2 (2004M9-2019M12)	
Country	Coefficient	t-statistic	Coefficient	t-statistic
Indonesia	-0.016**	-2.041	-0.003	-0.529
		(0.043)		(0.597)
Malaysia	-0.003	-1.363	-0.003	- 1.551
		(0.175)		(0.122)
Philippines	-0.008	-1.391	0.009***	3.919
		(0.166)		(0.000)
Singapore	-0.001	-0.507	0.009***	2.706
		(0.613)		(0.008)
Thailand	-0.001	-0.311	0.023***	7.023
		(0.755)		(0.000)
India	-0.015***	-3.736	0.014***	3.366
		(0.000)		(0.001)
South Korea	-0.005	-1.417	0.004*	1.888
		(0.158)		(0.061)
Japan	-0.002	0.279	0.005**	2.330
		(0.369)		(0.021)
Australia	0.002	0.685	0.006***	3.614
		(0.494)		(0.000)
New Zealand	0.002	0.835	0.007**	2.282
		(0.405)		(0.024)

Note: The number in parenthesis is the p-value. ***, **, and * indicate significance at the 1%, 5%, and 10%, respectively.

The results reported in Table 5 are the coefficients of the aforementioned short-run pass-through, which is an impact of crude oil price change on inflation at the current period. The short-run pass-through is significantly negative in Indonesia during the period of low and less fluctuating oil prices. This might be possible since Indonesia is an oil-producing country in Southeast Asia. However, the significant and negative short-run pass-through in India does not seem to be surprising since India is the second largest oil producers in Asia. For the remaining countries, the coefficients of the pass-through are not statistically significant. In the period of high and more fluctuating oil prices, the coefficients of the pass-through are statistically significant for all cases, except for Indonesia and Malaysia.

The findings in this paper suggest that world crude oil prices can exert a positive impact on the consumer price index as evidenced in Huang and Chao (2012) and Zakaria et al. (2021). Olifin and Salisu (2017) employ some dummy variables to investigate the impacts of structural breaks. However, this paper finds that the types of pass-through both in the long run and the short run depend on a structural break defined by sub-periods in the analysis.

4. Concluding Remarks

This study examines the degree of crude oil price pass-through to inflation in selected Asia and the Pacific countries, which are mainly oil-importing. A linear cointegration test with symmetric adjustment towards the long-run equilibrium is used to investigate the long-run impact of world crude price on consumer prices. The results show that the long-run impact of crude oil price on the consumer price index is moderate in most cases. The results support the partial long-run pass-through during the period of low and less fluctuating world oil prices. In the short run, the impact of an oil price change on inflation is significant in most of these economies during the period of high and more fluctuating oil price. In theory, several factors can influence consumer prices and thus the inflation rate. The oil price change is one of the crucial factors that can cause inflation such that policymakers should take into account when formulating policy measures to alleviate the high inflation rate.

This paper concludes that a structural break might play an important role in both the long- and short-run pass-through of crude oil prices into consumer prices. The drawback of this paper is that the paper does not examine whether positive and negative crude oil price changes asymmetrically influence inflation. Nevertheless, there is evidence showing that the oil price asymmetry seems to be more important for oil-exporting countries.

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