THE IMPACT OF EXCHANGE RATE AND OIL PRICE SHOCKS ON DISAGGREGATED CONSUMER PRICE INDEXES IN MALAYSIA

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ABSTRACT

This study explores influence of exchange rate and oil price shocks on total and disaggregated consumer prices in Malaysia in the long run and short run. Moreover, this study examines asymmetric effect of exchange rate and oil price shocks on total and disaggregated consumer prices in Malaysia in the long run and short run. This study uses annual data over the period from 1980 to 2020. The results of the linear autoregressive distributed lags (ARDL) model and nonlinear autoregressive distributed lags (NARDL) model show the impact of exchange rate and oil price differs across different categories of consumer prices and in the long run and short run. An implication is that weak currency or high oil price results higher consumer prices and hence leads to higher inflation in Malaysia. Moreover, there is asymmetric effect of exchange rate and oil price shocks on total and disaggregated consumer prices in Malaysia. Domestic demand, money supply, interest rate and the Asian financial crisis are important in affecting many consumer prices.

Keywords: Exchange Rate, Oil Price, Disaggregated Consumer Prices, Asymmetric Effect, Malaysia
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1. INTRODUCTION

Consumer price index (CPI) is a measure of the average change over time in the prices paid by a representative consumer for a common basket of goods and services. CPI attempts to quantify and measure the average cost of living in a given country by estimating the purchasing power of a single unit of currency. It is an indicator for measuring inflation a plethora of market dynamics (Barkan et al, 2022). Total and disaggregated consumer prices in Malaysia increase rapidly since 1999. Exchange rate decrease rapidly since 1985 (Figure 1). The correlation between consumer price index (CPI) total and exchange rate was negative and statistically significant at -0.8579. The correlations between CPI 1 (food), CPI 3 (gross rent, fuel and power), CPI 4 (furniture, furnishings and household equipment and operation), CPI 5 (medical), CPI 6 (transport), CPI 7 (recreation) and CPI 8 (miscellaneous) and exchange rate were negative and statistically significant at -0.6558, -0.6903, -0.6649, -0.6804, -0.6746, -0.6024, -0.6792, respectively, except the correlation between CPI 2 (clothing) and exchange rate was positive and statistically significant at 0.4906. Overall, the relationship between CPIs and exchange rate is negative, that is, depreciation of exchange rate would lead to higher inflation in Malaysia. Inflation would increase due to conflict in Ukraine, high oil price, pandemic of COVID-19 and so forth. In a world of integrated trade in goods and services, sovereign nations have become increasingly interdependent. High inflation in an economy would have a significant impact on other economy through its influence on international relative prices (Zhao, 2022).Oil price fluctuated rapidly for the period 1999-2020 (Figure 2). The correlation between CPI total and oil price was positive and statistically significant at 0.5722. The correlations between CPI 1, CPI 3, CPI 4, CPI 5, CPI 6, CPI 7 and CPI 8 and oil price were positive and statistically significant at 0.5654, 0.4530 0.5290 0.5156 0.7293 0.4992 0.5709, respectively, except the correlation between CPI 2 and oil price was negative and statistically significant at -0.6521. Generally, the relationship between CPIs and oil price is positive, that is, an

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increase in oil price would lead to higher prices in Malaysia. Although Malaysia is a net oil exporter but an increase in oil price in the world market would lead to higher cost of production in Malaysia.

Generally, exchange rate depreciation or an increase in oil price would result higher inflation (Sek, 2017; Husaini et al., 2019). Understanding the behaviour of price in reaction to exchange rate and oil price fluctuation is crucial for policymakers to implement a sound policy for price stability in the country, which is important for sustainable economic growth in an economy. Economies are now more integrated than before and external shocks such as exchange rate and oil price shocks influence domestic economies through price changes (Valogo et al., 2023). Numerous studies have concluded that the relationship between the oil price, exchange rate and inflation is based on linear assumption (Wu and Ni, 2011; Chen et al., 2014; Akçelik and Oegunç, 2016; Castro et al., 2016; Husaini et al., 2019). A linear relationship assumes symmetric behavior between the dependent and independent variables, that is, the behaviour of the independent variable on the dependent variable is fixed to the same behaviour in the long run. Pal and Mitra (2019) argue that symmetric behaviour is not suitable in the real world. With the nonlinear autoregressive distributed lags (NARDL) approach, we can justify whether a symmetric or an asymmetric model is suitable for exploring the impact of the independent variable on the dependent variable. Ibrahim (2015), Pal and Mitra (2019) and Zhu and Chen (2019) argue that the effect of oil price and exchange rate on the price level is asymmetric in nature in that while the price level may increase when oil price (or exchange rate) increases, a decrease in oil price (or exchange rate) might not cause the price level to decrease as there are several factors that still force the price level to increase. Therefore, a decrease in oil price (or exchange rate) might fail (or less) to cause the price level to decrease (Ibrahim, 2015).

This study examines influence of exchange rate and oil price shocks on total and disaggregated consumer prices in Malaysia in the long run and short run. Moreover, this study examines asymmetric effect of exchange rate and oil price shocks on total and disaggregated consumer prices in Malaysia in the long run and short run. The majority of studies in the literature focuses on CPI total, many policy makers from economic and financial institutions are interested in disaggregated components of CPI total (Barkan et al, 2022). Malaysia is a small open economy. Its economy is strongly influence by external shock including imported inflation. A weak currency would cause import becoming more expensive and then a high inflation. This study uses annual data over the period from 1980 to 2020. The results of the linear autoregressive distributed lags (ARDL) model and NARDL model show the impact of exchange rate and oil price differs across different categories of consumer prices and in the long run and short run. An implication is that weak currency or high oil price results higher consumer prices and hence leads to higher inflation in Malaysia. Moreover, there is asymmetric effect of exchange rate and oil price shocks on total and disaggregated consumer prices in Malaysia. A high inflation is a detriment to real economic growth in the long run (Hayat, Balli and Rehman, 2017).

2. LITERATURE REVIEW

Husaini and Lean (2021) examine the asymmetric impact of both oil price and exchange rate on the disaggregate price inflation in Indonesia, Malaysia, and Thailand. An increase in oil price has a greater impact on producer price index (PPI) than consumer price index (CPI) in all countries. A decrease in oil price would lead to only a decrease in CPI and PPI in Thailand. An increase in exchange rate (currency depreciation) is significantly increases in CPI and PPI in all countries but, a decrease in exchange rate (currency appreciation) is not reduces CPI and PPI in all countries. Maintaining price stability is vital for sustainable economic growth.

Ha et al. (2020) investigate exchange rate pass-through into consumer prices using structural factor-augmented vector autoregression models for 55 countries. Monetary policy shocks are found with higher exchange rate pass-through measures compared to other domestic shocks whilst global shocks have different impact across countries.

Arghyrou and Pourpouride (2016) suggest a theoretical explanation on asymmetric exchange rate shocks. If monetary authorities have larger aversion to negative rather than positive output gap values (and / or to inflation rates below the target level) as suggested by a substantial theoretical and empirical literature on asymmetric monetary policy preferences, they will stand ready to reduce nominal interest rates more aggressively when nominal interest rates must be reduced to meet a credible inflation target rather than to increase them when interest rates need to be increased to meet the same inflation target. Rational markets anticipating the difference in the speed of adjustment of nominal interest rates and by extension real returns, will then stand ready to sell higher volumes of the domestic currency under negative inflation surprises rather than the volumes they will be willing to buy under positive ones. This difference causes asymmetric exchange rate responses to inflation surprises differently.

Prasertnukul and Kakinaka (2010) show that inflation targeting would achieve price stability through a decline in exchange rate pass-through or volatility, complementing expected reduction in inflation. There is no evidence that adopting inflation targeting increases nominal exchange rate volatility. The adoption of inflation targeting would tend to offset any increase in exchange rate volatility associated with the adoption of a floating regime. A commitment made by a central bank to lower or control inflation is an important factor in determining exchange rate pass-through and volatility. To preserve the credibility of an inflation-targeting regime, inflation-targeting central banks should make their monetary policies more accountable and transparent. Moreover, the central banks should resort to foreign exchange intervention and capital control in response to exchange rate shocks to mitigate the impact of pass-through effects on inflation as well as to reduce exchange rate volatility.

Exchange rate is volatile. They are many studies in the literature argued that the relationship between exchange rate, oil price and exchange rate is in linear (Wu and Ni, 2011; Nazlioglu and Soytas, 2012; Chen et al., 2014; Akçelik and Oegunç, 2016; Castro et al., 2016; Lean and Smyth, 2010). Conversely, Ibrahim (2015), Sek (2017), and Lacheheb and Sirag (2019), among others, use a nonlinear model to capture the asymmetric impact of oil price on inflation. Ibrahim (2015) and Lacheheb and Sirag (2019) report that the pass-through of the asymmetric impact on inflation is incomplete. Ghosh (2014) use a panel dataset and find that currency depreciation increases the inflation rate significantly in advanced economies, emerging markets, and low-income counties. On the other hand, Salisu et al. (2017) uses a panel dataset of net oil exporting countries and net importing countries. They find that the impact of an increase in oil price on inflation is stronger than the impact of a decrease in oil prices in the net oil importing countries. However, the pass-through impact of oil price on inflation is incomplete in the net oil exporting countries where only the increase in oil price significantly causes inflation. Choi et al. (2018) conclude that the pass-through impact of oil price on inflation is complete in the advanced economies and developing economies.

Yilmazkuday (2022) investigates the drivers of Turkish inflation by using a structural vector autoregression model using monthly data over the period from January, 2005 to August, 2021. The results demonstrate that Turkish inflation increases following a negative policy rate shock, a positive exchange rate shock or a positive global oil price shock. The volatility of Turkish inflation is mostly explained by global oil prices and exchange rate movements in the long run. The contribution of exchange rate shocks to Turkish inflation has continuously increased over time. Exchange rate depreciation can be reduced by positive policy rate shocks, it is implied that a conventional monetary policy increasing policy rates following an increase in inflation or a depreciation of Turkish lira would be optimal to achieve and maintain price stability in Turkey.

Citci and Kaya (2023) examine the connectedness of exchange rate uncertainty and inflation. The study analyses the impact of exchange rate uncertainty on inflation by using panel data from 149 countries over the period 1980–2017. The results point that the uncertainty of the exchange rate has a significant and positive effect on inflation. Moreover, the effect of exchange rate uncertainty on inflation is nonlinear. As the exchange rate uncertainty increases, the size of its effect on inflation decreases. The degree of exchange rate pass-through and the effect of exchange rate uncertainty on inflation differ amomg country groups and their effects on inflation have decreased through time.

Valogo et al (2023) investigate the threshold effect of exchange rate pass-through (ERPT) on inflation in Ghana using a monthly data from January 2002 to December 2018. The results of the ERPT model revealed that exchange rate depreciation beyond a monthly threshold of 0.70% has a significant positive pass-through effect on inflation, which gives credence to the relevance of threshold level. The results of the monetary policy rule model also showed that regardless of the threshold level of 0.51%, the exchange rate significantly influences the monetary policy rate positively. It is suggested that monetary regulators should view the exchange rate at any level essential to adjust the policy rate.

Exchange rate can influence domestic economy as poor exchange rate performance could translate into price instability (Valogo et al, 2023). Predicting the future price is not simple. There are many determinants of inflation. Nonetheless, exchange rate and oil price are among the important determinants. The relationship between exchange rate and oil price with inflation may not be in linear. Most of studies in the literature of inflation focus on CPI total. However, less attention is given on disaggregated components of CPI total, which they are important to many policy makers in economic and financial institutions. NARDL model is widely used in the literature to examine the asymmetric impact of a variable. A stable inflation is a pivotal situation for sustainable economic growth in an economy.

3. DATA AND METHODOLOGY

Consumer price index (CPI_{kt}) is consumer price index of *i* (k = t, 1, 2 , … , 8, 2010 = 100) where *t* is total consumer price and 1, 2 , … , 8 are consumer prices of (1) food, (2) clothing, (3) gross rent, fuel and power, (4) furniture, furnishings and household equipment and operation, (5) medical, (6) transport, (7) recreation and (8) miscellaneous, respectively. Exchange rate (ER_t) is expressed as real effective exchange rate (2010 = 100). An increase in ER implies depreciation of domestic currency whereas a decrease in ER implies appreciation of domestic currency. Domestic demand (Y_t) is expressed as GDP of Malaysia (RM million, 2010 = 100). Oil price (O_t) is expressed as average crude oil price (USD / barrel, 2010 = 100). Interest rate (R_t) is expressed as lending interest rate in Malaysia. Money supply (MS_t) is expressed as broad money (RM million). A dummy variable (D_t) is used to capture the Asian financial crisis, 1997-1998, that is, 1 for the years 1980-1998 and 0 for the rest of the years.

Consumer price index data were obtained from *Time Series Data*, Department of Statistic, Malaysia. Exchange rate and domestic demand data were obtained from World Development Index. Oil price data were obtained from *The Pink Sheet*, World Bank Commodity Price Data. The data is yearly from 1980 to 2020.

This study begins with the unit root test. The Phillips and Perron (PP) unit root test statistic is used to examine the stationary of the data. The ARDL approach is used to examine the long-run relationship of the variables in the FDI models. This study estimates the following CPI model:

$$CPI_{kt} = \beta_{11}\, ER_t + \beta_{12}\, O_t + \beta_{13}\, Y_t + \beta_{14}\, MS_t + \beta_{15}\, R_t + u_{1,t} \quad (1)$$
$$CPI_{kt} = \beta_{21}\, ER_t^+ + \beta_{22}\, ER_t^- + \beta_{23}\, O_t^+ + \beta_{24}\, O_t^- + \beta_{25}\, Y_t + \beta_{26}\, MS_t + \beta_{27}\, R_t + u_{2,t} \quad (2)$$

where CPI_{kt} is consumer price index, k = 1, 2 , 3 , 4, 5, 6, 7 and 8, ER_t is exchange rate at time t, O_t is oil price at time t, Y_t is domestic demand at time t, MS_t broad money supply at time t, R_t is interest rate in Malaysia at time t, $ER_t^+ = \sum_{j=1}^{t} \Delta\ ER_j^+$, $\Delta \ln ER_j^+$ = max (Δ ER, 0), $ER_t^- = \sum_{j=1}^{t} \Delta\ ER_j^-$, $\Delta \ln ER_j^-$ = min (Δ ER, 0) and $u_{i,t}$ (i = 1, 2) *is* a disturbance term, respectively. ER_t^+ and ER_t^- are partial sum process of positive and negative changes in ER_t, respectively. The coefficient of domestic income is expected to be positive whilst the coefficient of exchange rate, money supply and oil price are expected to be negative (Cheikh and Zaied, 2020). Model (2) is used to explore the asymmetric impact of exchange rate on consumer price index as exchange rate depreciation can lead to more or less in consumer price index (Cheikh and Zaied, 2020). The coefficients estimated are said to be the long-run coefficients.

The error correction models of the import price models (1) and (2), respectively are as follows:

$$\Delta\, CPI_{kt} = \beta_{30} + \beta_{31} D_t + \sum_{i=0}^{p} \beta_{32i}\, \beta_{32i}\, \Delta\, ER_{t-i} + \sum_{i=0}^{q} \beta_{33i}\, \Delta\, O_{t-i} + \sum_{i=0}^{r} \beta_{34ii}\, \Delta\, Y_{t-i} + \sum_{i=0}^{s} \beta_{35i}\ \Delta\, MS_{t-i} + \sum_{i=0}^{v} \beta_{36i}\ \Delta\, R_{t-i} + \sum_{i=1}^{w} \beta_{37i}\, \Delta\, CPI_{kt-i} + \beta_{38} ec_{t-1} + u_{3,t} \quad (3)$$

$$\Delta\, CPI_{kt} = \beta_{40} + \beta_{41} D_t + \sum_{i=0}^{p} \beta_{42i}\, \Delta\, ER_{t-i}^+ + \sum_{i=0}^{q} \beta_{43i}\ \Delta\, ER_{t-i}^- + \sum_{i=0}^{r} \beta_{44i}\, \Delta\, O_{t-i}^+ + \sum_{i=0}^{s} \beta_{45i}\, \Delta\, O_{t-i}^- + \sum_{i=0}^{v} \beta_{46i}\ \Delta\, Y_{t-i} + \sum_{i=0}^{w} \beta_{47i}\ \Delta\, MS_{t-i} + \sum_{i=0}^{w} \beta_{48i}\ \Delta\, R_{t-i} + \sum_{i=1}^{z} \beta_{49i}\, \Delta\, CPI_{kt-i} + \beta_{410} ec_{t-1} + u_{4,t} \quad (4)$$

where Δ is the first difference operator, D_t is the dummy variable used to capture the Asian financial crisis, 1997-1998, that is, 1 for the years 1980-1998 and 0 for the rest of the years and $u_{i,t}$ (i = 3, 4) is a disturbance term. The sum of the coefficients of $\sum_{i=0}^{p} \beta_{42i}\, \Delta\, ER_{t-i}^+$ and sum of the coefficients of $\sum_{i=0}^{q} \beta_{43i}\, \Delta\, ER_{t-i}^-$ are not the same implies the asymmetric impact of exchange rate in the short run. This can be tested using the Wald-statistic. Also, the sum of the coefficients of $\sum_{i=0}^{r} \beta_{44i}\, \Delta\, O_{t-i}^+$ and sum of the coefficients of $\sum_{i=0}^{s} \beta_{45i}\, \Delta\, O_{t-i}^-$ are not the same implies the asymmetric impact of oil price in the short run. This can be tested using the Wald-statistic. The ordinary least squares (OLS) estimator with Newey-West standard error (Huber-White standard error) is used when there is autocorrelation (heteroscedasticity) in the disturbance.

4. EMPIRICAL RESULTS AND DISCUSSIONS

Table 1 displays the results of the Phillips-Perron (PP) unit root test statistic. The lag length used to estimate the PP unit root test statistic is mainly based on Newey West Bartlett Kernel automatic bandwidth. On the whole, the PP unit root test statistic shows all variables are non-stationary in levels and become stationary after taking the first differences.

<Insert Table 1 about here>

The ARDL bounds testing approach and the long run coefficients of the ARDL approach are given in Table 2 whereas the ARDL bounds testing approach and the long run coefficients of the ARDL approach with asymmetric impact of exchange rate are given in Table 3. The optimal lag length is selected by the used Schwarz information criteria (SIC). The F statistic for testing long-run cointegration are all found to be statistically significant. Therefore, there are long-run relationships between import prices and their determinants. The coefficients of exchange rate are found to be negative and statistically significant for CPI total, CPI 5 and CPI 7. An appreciation of exchange rate would reduce inflation. The coefficients of oil price are found to be positive and statistically significant for CPI total, CPI 1 and CPI 6. An increase in oil price would increase many prices of goods. The coefficients of domestic demand are found to be positive and statistically significant for CPI 1, CPI 5 and CPI 6. This implies that domestic demand can lead to higher prices. The coefficients of money supply are found to be positive and statistically significant for CPI total, CPI 5 and CPI 7. An increase in money supply lead to an increase in prices. The coefficients of interest rate are found to be positive and statistically significant for CPI total, CPI 1, CPI 3, CPI 6 and CPI 7. An increase in interest rate would imply higher cost which in turns lead to higher prices. Overall, an increase in exchange rate, an increase in oil price, an increase in money supply or an increase in interest rate would lead to an increase in inflation.

<Insert Table 2 about here>

The results of the ARDL approach with asymmetric impact of exchange rate exhibit about the same conclusion as the results of the ARDL approach without asymmetric impact of exchange rate. The F statistic for testing long-run cointegration are all found to be statistically significant. The coefficient of positive or negative exchange rate is found to be negative and statistically significant for CPI total. Conversely, the coefficients of negative exchange rate are found to be negative and statistically significant for CPI 1, CPI 2, CPI 3, CPI 4, CPI 5 and CPI 7. The impact of exchange rate varies across different prices. The asymmetric impact of exchange rate is found to be significant for CPI total, CPI 2, CPI 4, CPI 5, CPI 6 and CPI 7. This implies an appreciation or a depreciation of exchange rate has different impact on prices. The coefficient of positive or negative oil price is found to be positive and statistically significant for CPI total. On the other hand, the coefficients of positive oil price are found to be positive and statistically significant for CPI 1, CPI 4, CPI 6 and CPI 7. An increase in oil price likely would lead to an increase in prices. The asymmetric impact of oil price is found to be significant for CPI total, CPI 1, CPI 3, CPI 4 and CPI 6. Hence, the impact of an oil price increase or a decrease is not the same. The coefficients of income demand are found to be negative and statistically significant for CPI total, CPI 2 and CPI 5 whereas the coefficients of income demand are found to be positive and statistically significant for CPI 6 and CPI 7. The coefficients of money supply are found to be positive and statistically significant for CPI total, CPI 2, CPI 3and CPI 5. Generally, the coefficients of interest rate are mostly found to be positive and statistically significant.

<Insert Table 3 about here>

The results of the error correction models are reported in Table 4 whilst the results of the error correction models with asymmetric impact of exchange rate are disclosed in Table 5. The coefficients of the one lag of error correction terms are found to be less than one and to have the expected negative signs and statistically significant for the error correction models and the error correction models with asymmetric impact of exchange rate. This implies the validity of an equilibrium relationship among the variables in the estimated model. The estimated models mostly fulfil the diagnostic tests of no autocorrelation, no-autocorrelation, homoscedasticity of disturbance terms, no-functional form and the estimated models are found to be stable. For the error correction models with asymmetric impact of exchange rate, all estimated models fulfil the diagnostic tests of no-autocorrelation, homoscedasticity of disturbance terms, no-functional form and stability of estimated models, except CPI 7 where autocorrelation is found in the disturbance term and the ordinary least squares (OLS) estimator with Newey-West standard error is used. For CPI 6 and CPI 8 where there is heteroscedasticity problem in the disturbance term and autocorrelation problem in the disturbance term and the OLS estimator with Huber-White standard error is used. For CPI 5, CUSUMSQ is found to be unstable. The asymmetric impact of exchange rate in the short run is found on CPI total, CPI 1, CPI 2, CPI 3, CPI 6, CPI 7 and CPI 8. Conversely, the asymmetric impact of oil price in the short run is found on CPI total, CPI 2, CPI 5 and CPI 8. Generally, the coefficients of exchange rate or positive exchange rate and negative exchange rate, oil price or positive oil price and negative oil price, domestic demand, money supply, interest rate and the Asian financial crisis are found to be statistically significant for inflation.

<Insert Table 4 about here>

<Insert Table 5 about here>

CPI is influenced by many factors such as exchange rate, oil price, domestic demand, money supply, interest rate and the Asian financial crisis (Hayat et al. 2017).

Yilmazkuday (2022) reports that inflation in Turkey is influenced by a negative policy rate shock, a positive exchange rate shock or a positive global oil price shock. CPI varies according to products. The impact of exchange rate and oil price on CPI are not the same. Moreover, CPI differ across different categories of prices in the long run. The long run impact of exchange rate on prices is negative, which implies that appreciation of exchange rate would lead to a cheaper import price and therefore lower inflation (Jalil et al. 2014). Positive or negative exchange rate or oil price has significant impact on prices. Husaini and Lean (2021) also report depreciation of exchange rate and an increase in oil price contribute to an increase in inflation in Malaysia. Domestic demand, money supply and interest rate are important in influencing CPI. Inflation is a monetary phenomenon (Friedman, 1956). An increase in money supply is positively linked with inflation (Jalil et al. 2014).

A disaggregated CPI forecast gives a more accurate picture of the sources and features of inflation pressures in economy. This can improve policymakers' response efficiency. Analysis disaggregated CPI would improve the optimization problem faced by the central bank (Barkan et al, 2022). Furthermore, inflation in an economy can be transmitted into another economy through its impact on international relative prices (Zhao, 2022).

5. CONCLUDING REMARKS

This study explores change of exchange rate and oil price on total and disaggregated consumer prices in Malaysia in the long run and short run. Moreover, this study examines asymmetric effect of exchange rate and oil price shocks on total and disaggregated consumer prices in Malaysia in the long run and short run. This study uses annual data over the period from 1980 to 2020. There are not many empirical studies on the changes of exchange rate and oil price and their asymmetry impact on different categories of consumer prices in Malaysia. The results of the linear autoregressive distributed lags (ARDL) model and NARDL model show the impact of exchange rate and oil price differs across different categories of consumer prices and in the long run and short run. An implication is that weak currency or high oil price results higher consumer prices and hence leads to higher inflation in Malaysia. The estimated NARDLmodel shows that there is asymmetric impact of exchange rate and oil price but differ across different categories of consumer prices in the short run and long run. The asymmetric impact of exchange rate in the long run is found on CPI total, CPI 2, CPI 4, CPI 5, CPI 6 and CPI 7. On the other hand, the asymmetric impact of oil price in the long run is found on CPI total, CPI 1, CPI 3, CPI 4 and CPI 6. This implies that exchange rate or oil price increase or decrease its impact on consumer prices are not the same. Domestic demand, money supply, interest rate and the Asian financial crisis are important in affecting many consumer prices. An increase in interest rate would lead to an increase in consumer prices in Malaysia. The cost of borrowing capital, which is commonly known as interest rate is one of important source of inflation from cost push side (Jalil et al. 2014; Husaini and Lean, 2021). There are many factors contribute inflation in Malaysia. The asymmetric impact of exchange rate in the long run and in the short run are found on CPI total and many disaggregated price levels. The asymmetric impact of oil price in the long run and in the short run are found in CPI total and many disaggregated price levels. Strengthen exchange rate, control money supply and, maintain cost of production, among others can help to maintain inflation in Malaysia.

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Table 1: The Results of the Phillips and Perron (PP) Unit Root Test Statistics

	PP		PP
$P_{t,t}$	1.1891(4)	$\Delta P_{t,t}$	-4.3847***(4)
$P_{1,t}$	1.4124(4)	$\Delta P_{1,t}$	-5.3041***(4)
$P_{2,t}$	-0.2339(3)	$\Delta P_{2,t}$	-5.9738***(2)
$P_{3,t}$	3.1369(3)	$\Delta P_{3,t}$	-3.7512***(3)
$P_{4,t}$	2.1733(3)	$\Delta P_{4,t}$	-5.4600***(4)
$P_{5,t}$	1.8138(3)	$\Delta P_{5,t}$	-7.2925***(4)
$P_{6,t}$	-0.5070(4)	$\Delta P_{6,t}$	-6.7290***(6)
$P_{7,t}$	0.7218(2)	$\Delta P_{7,t}$	-4.7110***(3)
$P_{8,t}$	1.2029(2)	$\Delta P_{8,t}$	-6.5205***(3)
ER_t	-1.1837(4)	ΔER_t	-4.6273***(7)
Y_t	1.7797(2)	ΔY_t	-4.5431***(2)
MS_t	4.5837(2)	ΔMS_t	-2.8761*(3)
O_t	-1.4916(1)	ΔO_t	-6.4671***(1)
r_t	-0.4015(7)	Δr_t	-0.4015***(20)

The PP unit root statistics are estimated based on the model including an intercept. Values in the parentheses are the lags for the number of bandwidths in Bartlett Kernel used in estimating the PP unit root test. *** (**, *) denotes significance at the 1% (5%, 10%) level.

Table 2: The Results of Bounds Testing Approach for Cointegration and the Long Run Coefficients of the ARDL Approach

	$P_{t,t}$	$P_{1,t}$	$P_{2,t}$	$P_{3,t}$	$P_{4,t}$
ER_t	-0.2895*	-0.9411	-0.6507	0.2413	-1.0313
	(-1.9393)	(-1.5083)	(-0.5721)	(1.4184)	(-0.8074)
O_t	0.4859***	0.8615*	-0.1021		0.5918
	(4.3682)	(0.8615)	(-0.3304)	0.0341 (0.4671)	(0.9782)
Y_t	1.30E-10	1.75E-10**	-3.54E-11	4.34E-11	1.95E-10
	(6.1742)	(2.3536)	(-0.1835)	(1.4563)	(1.6390)
MS_t	6.1742***	-6.10E-11	3.51E-11	3.01E-11	-7.53E-11
	(-2.9342)	(-1.2640)	(0.2848)	(1.2715)	(-1.0752)
r_t	6.7126***	11.3059**		4.6598**	15.1317
	(4.9486)	(2.3122)	19.8437 (1.1988)	(2.3625)	(1.2585)
F1	13.0234***	18.8698***	2.9021***	22.5500***	8.1865***
	$P_{5,t}$	$P_{6,t}$	$P_{7,t}$	$P_{8,t}$	
ER_t	0.5505*	-0.3628	-0.1372**	-0.6611	
	(2.0110)	(-1.1554)	(-2.1037)	(-0.7993)	
O_t	0.0815	0.4322***	0.0299	1.1673	
	(0.8176)	(-2.2856)	(1.1917)	(1.2932)	
Y_t	1.35E-10***	7.63E-11**	-7.02E-12	3.79E-10	
	(3.8490)	(2.1260)	(-0.8271)	(1.6651)	
MS_t	-5.15E-11*	-2.64E-11	1.85E-11***	-2.29E-10	
	(-2.1132)	(-1.1916)	(3.5430)	(-1.4136)	
r_t	-1.8912	8.0122**	1.9181***	5.3319	
	(-0.7014)	(2.4813)	(3.7169)	(1.0647)	
F1	5.1202***	6.4171***	13.0503***	6.2702***	

F1 is the Wald statistic for the ARDL bounds testing approach of cointegration. *** (**, *) denotes significance of at the 1% (5%, 10%) level. For $P_{7,t}$, the long-run cointegrating equation is estimated with restricted constant and no trend.

Table 3: The Results of Bounds Testing Approach for Cointegration and the Long Run Coefficients of the ARDL Approach – Asymmetric Impact of Exchange Rate and Oil Price

	$P_{t,t}$	$P_{1,t}$	$P_{2,t}$	$P_{3,t}$	$P_{4,t}$
ER_t^+	-0.6134***	-0.0439	1.4731***	0.1229 (0.3254)	0.3996
	(-3.6372)	(-0.1100)	(4.5492)		(1.2582)
ER_t^-	-0.9695***	-0.3723***	-0.6799***	-0.2744*	-0.3681***
	(-7.9534)	(-3.0206)	(-6.1749)	(-1.8864)	(-3.7261)
O_t^+	0.2591***	0.5611***	0.0894	-0.4114*	0.4646***
	(3.7973)	(7.1127)	(1.1395)	(-1.9897)	(6.4293)
O_t^-	0.4765***	0.0896	0.0089	0.7616**	-0.0207
	(4.8056)	(1.2680)	(0.2118)	(2.5262)	(-0.4484)
Y_t	-6.34E-11**	-4.17E-11	-2.15E-10***	2.00E-11	-3.61E-11
	(-2.3282)	(-1.0893)	(-6.8931)	(0.3623)	(-1.0761)
MS_t	6.91E-11***	2.24E-11	8.67E-11***	1.46E-10***	-7.60E-12
	(3.6818)	(1.1069)	(4.2994)	(2.9748)	(-0.3780)
r_t	7.6937***	6.6567***	9.1105***	8.6109***	6.5860***
	(21.1042)	(19.6442)	(19.9103)	(10.1169)	(17.4113)
F1	38.3750***	20.4806***	7.8182***	15.0706***	21.2988***
F2	7.2968**	0.9895	28.3776***	1.2884	8.2982**
F3	4.3810*	8.5402**	0.5894	13.6409***	20.2439***
	$P_{5,t}$	$P_{6,t}$	$P_{7,t}$	$P_{8,t}$	
ER_t^+	1.4188	-0.1715	-0.5342	-0.4444	
	(1.5417)	(-0.4224)	(-1.3613)	(-0.3608)	
ER_t^-	-0.9575**	-0.1435	-0.4313***	-0.3944	
	(-2.7040)	(-0.8362)	(-3.3563)	(-0.7523)	
O_t^+	0.0799	0.3901**	0.7147***	0.9534	
	(0.4709)	(2.5561)	(5.2281)	(1.2433)	
O_t^-	0.2884	0.1765	0.0312	-0.0909	
	(1.3714)	(1.8424)	(0.4814)	(-0.3066)	
Y_t	-3.26E-10***	9.09E-11*	1.47E-10**	-3.63E-11	
	(-3.2154)	(1.8424)	(2.2749)	(-0.3117)	
MS_t	1.97E-10***	-4.20E-11	-1.32E-10**	-3.09E-11	
	(3.3092)	(-1.4321)	(-3.0222)	(-0.4276)	
r_t	6.4409***	6.5813***	4.9106***	8.5593***	
	(6.7939)	(9.2518)	(4.8787)	(3.2341)	
F1	10.3531***	4.3816***	11.333***	1.7980*	
F2	10.5823***	3.0754**	8.0986**	5.39E-05	
F3	0.4814	3.7211**	2.8904	1.5608	

F1 is the Wald statistic for the ARDL bounds testing approach of cointegration. F2 is the Wald statistic to test the asymmetric impact of exchange rate. F3 is the Wald statistic to test the asymmetric impact of oil price. *** (**, *) denotes significance of at the 1% (5%, 10%) level.

Table 4: The Results of the Error-Correction Models

	$\Delta P_{t,t}$	$\Delta P_{1,t}$	$\Delta P_{2,t}$	$\Delta P_{3,t}$	$\Delta P_{4,t}$
constant	0.8795**	1.8114***	0.2489	-	0.7476
	(2.4573)	(2.8117)	(0.6272)		(1.4003)
D_t	-3.7280***	-2.9354**	-0.9604	-2.8247***	-2.7437***
	(-5.3733)	(-2.4267)	(-0.9380)	(-4.4873)	(-2.9308)
ΔER_t	-0.0565**	-	-	-0.0493**	-0.0238
	(-2.3471)			(-2.4481)	(-0.8088)
ΔER_{t-1}	-	-	-	-	-
ΔER_{t-2}	0.0389*	-	-0.0730**	-	-
	(1.8523)		(-2.1005)		
ΔER_{t-3}	-0.1045***	-0.0737*	-	-	-0.0434*
	(-4.3160)	(-1.8154)			(-1.7582)
ΔO_t	0.0557***	0.0377**	-0.0407***	0.0245**	-
	(5.9914)	(2.4795)	(-2.8061)	(2.2704)	
ΔO_{t-2}	-0.0595***	-0.0786***	-	-	-0.0306*
	(-4.7787)	(-3.4024)			(-1.8761)
ΔO_{t-3}	0.0279***	-	-	-	-
	(2.9217)				
ΔY_t	-	-	-	-1.58E-11***	-
				(-3.9600)	
ΔY_{t-1}	-	-	-2.23E-11*	-	-
			(-1.9795)		
ΔY_{t-2}	3.38E-11***	3.92E-11***	-	-	2.60E-11***
	(4.4407)	(2.9820)			(2.7940)
ΔMS_t			2.06E-11***		
	-	-	(2.7849)	-	-
ΔMS_{t-1}	7.16E-12*	0.0818			
	(1.8553)	(0.1246)	-	-	-
ΔMS_{t-3}		3.15E-11***			2.19E-11**
	-	(4.4561)	-	-	(4.1272)
Δr_t	0.6810***	0.8245**	1.1125***		0.6163**
	(4.2223)	(2.5128)	(3.8564)	-	(2.5329)
Δr_{t-2}	0.6866***	0.6191	0.6460**		
	(3.7781)	(1.7462)	(2.2025)	-	-
ΔP_{i-1}		0.3020**			
	-	(2.6898)	-	-	-
ec_{t-1}		-0.0601***	-0.0210**	-0.0971***	-0.0302***
	-0.0451***	(-4.7070)	(-2.6551)	(-12.564)	(-2.6518)
	(-4.2577)	-	-		

Table 4 (Continued)

Adj. R^2	0.8030	0.7057	0.3771	0.7709	0.4693
LM	0.0206	2.5145	0.4641	1.0318	1.2386
HETERO	0.8412	1.7589	0.8163	1.6432	1.2952
RESET	0.6070	3.9532*	0.2960	2.5909	4.9363**
CUSUM	S	S	S	S	S
CUSUMSQ	S	S	S	S	S

	$\Delta P_{5,t}$	$\Delta P_{6,t}$	$\Delta P_{7,t}$	$\Delta P_{8,t}$
constant	-	0.6019 (0.5906)	-0.8390*** (-2.8361)	1.2625* (1.7687)
D_t	-3.9658*** (-4.8402)	-6.3555*** (-2.9824)	-1.9396** (-2.6837)	0.6337 (0.3357)
ΔER_t	-0.1359*** (-4.8826)	-0.1825** (-2.6543)	-	-
ΔER_{t-1}	-	-	-	-0.01424 (-0.5617)
ΔER_{t-3}	-0.0785*** (-2.9167)	-	-0.0780*** (-3.3621)	-
ΔO_t	-0.0134 (-1.0537)	0.1602*** (4.8182)	-	-
ΔO_{t-1}	-	-	-0.0449*** (-3.4547)	-
ΔO_{t-3}	-	-	-	0.0155 (1.1546)
ΔY_t	8.07E-12 (1.5071)	5.90E-11*** (3.8247)	-	-1.04E-11* (-1.8081)
ΔY_{t-1}	-	6.24E-11** (2.2858)	1.77E-11** (2.2858)	-
ΔY_{t-2}	-	9.74E-11*** (4.1825)	-	-
ΔY_{t-3}	-	4.03E-11** (2.3992)	-	-
ΔMS_t	1.24E-11** (2.4877)	-	1.01E-11 (1.6598)	-
ΔMS_{t-2}	1.49E-11*** (3.3412)	-	-	-
ΔMS_{t-3}	1.17E-11** (2.1830)	-	1.92E-11*** (5.1536)	1.71E-11* (1.9320)
Δr_t	0.3414* (1.9734)	1.1674** (2.1729)	-	-
Δr_{t-1}	0.5509*** (3.1402)	-	0.5186*** (2.8167)	-

Table 4 (Continued)

$\Delta\ r_{t-2}$	0.3647*			
	(1.9294)	-		-
$\Delta\ P_{i-1}$		-0.3245**		
	-	(-2.5390)		-
$\Delta\ P_{i-2}$		-0.6012***		
	-	(-5.0870)		-
$\Delta\ P_{i-3}$	-0.2398***			
	(-3.0608)	-		-
ec_{t-1}	-0.0157*	-0.1795***	-0.0840**	-0.0179*
	(-2.0507)	(-4.4069)	(-2.5903)	(-1.8841)
Adj. R^2	0.7395	0.7636	0.5360	0.3263
LM	1.6943	0.9739	2.5436***	0.8811
HETERO	0.8647	3.0196**	1.6514	5.3332***
RESET	0.9654	2.8309	0.1295	0.5316
CUSUM	S	S	S	S
CUSUMSQ	S	U	S	S

Notes: See also Table 2 for explanations. F2 is the Wald statistic to test the asymmetric impact of exchange rate in the short run. F3 is the Wald statistic to test the asymmetric impact of oil price in the short run.

Adj. R^2 is the adjusted R^2. LM is the Lagrange multiplier test of disturbance serial correlation. HETERO is the test of heteroscedasticity. RESET is the test of functional form. CUSUM denotes the cumulative sum test of stability. CUSUMSQ denotes the cumulative sum of squares test of stability. S denotes stable. U denotes unstable. The OLS estimator with Newey-West standard error is used when the Lagrange Multiplier test of disturbance serial correlation is found to be statistically significant. The OLS estimator with Huber-White standard error is used when the test of heteroscedasticity is found to be statistically significant. *** (**, *) denotes significance of the t-statistic at the 1% (5%, 10%) level.

Table 5: The Results of the Errorr-Correction Models – Asymmetric Impact of Exchange Rate and Oil Price

	$\Delta P_{t,t}$	$\Delta P_{1,t}$	$\Delta P_{2,t}$	$\Delta P_{3,t}$	$\Delta P_{4,t}$
constant	-2.8717***	-2.4995***	9.6571***	-0.6545	-0.7394
	(-8.4542)	(-4.8443)	(5.9803)	(-1.5384)	(-1.6083)
D_t	-3.7382***	-4.0507***	-2.1225***	-1.4097*	-2.1150**
	(-8.8143)	(-3.9774)	(-4.1095)	(-1.9466)	(-2.3378)
ΔER_t^+	0.3128***	-	-1.0701***	-	-
	(5.3994)		(-5.4208)		
ΔER_{t-1}^+	0.1291***	-	-	-	-
	(3.1843)				
ΔER_{t-2}^+	0.2464***	0.2331***	-0.9727***	0.2037***	-
	(5.2933)	(3.0867)	(-5.1437)	(2.9620)	
ΔER_{t-3}^+	-	-	-0.4337***	-	-0.0458
			(-5.0986)		(-0.6282)
ΔER_t^-	-	0.1986***	-	-	-
		(3.3903)			
ΔER_{t-1}^-	-0.2388***	-0.1603***	0.23899***	-0.1333***	-0.1636***
	(-7.6490)	(-2.9840)	(3.4196)	(-3.4831)	(-2.7412)
ΔER_{t-2}^-	-	-	0.3494***	-	-
			(4.1660)		
ΔER_{t-3}^-	-0.1555***	-	0.3083***	-0.0967**	-
	(-5.5944)		(3.4408)	(-2.5227)	
ΔO_t^+	0.0984***	0.1197***	-	3.0666***	-
	(7.8413)	(4.1069)		(5.5522)	
ΔO_{t-1}^+	-	-0.1302***	-	-	-
		(-3.8577)			
ΔO_{t-2}^+	-0.0640***	-0.1783***	0.1946***	-	-
	(-3.8018)	(-5.1173)	(3.2705)		
ΔO_{t-3}^+	-	-	-	0.0489**	-
				(2.3993)	
ΔO_t^-	-	-0.0779***	-	-	-2.7412
		(-2.8858)			(-1.9802)
ΔO_{t-1}^-	0.0463***	0.4732**	0.0444**	-	0.0391*
	(3.8414)	(2.5988)	(2.2858)		(1.8037)
ΔO_{t-2}^-	-0.0899***	-0.0937***	-	-	-
	(-8.8423)	(-4.4250)			
ΔO_{t-3}^-	0.0817***	-	-0.1213***	0.0453**	-
	(5.2873)		(-3.4083)	(2.5288)	
ΔY_t	-	-	-2.31E-11***	-1.24E-11***	-
			(-3.1294)	(-2.6722)	
ΔY_{t-1}	-	-	-4.57E-11***	-	-
			(-4.1587)		

Table 5 (Continued)

	2.73E-11***	3.02E-11***	-4.40E-11***	-	1.73E-11
Δ Y_{t-2}	(6.0707)	(3.0331)	(-3.6232)		(1.6188)
Δ Y_{t-3}	-2.62E-11***	-2.21E-11**	-4.48E-11***	-	-
	(-4.6467)	(-2.4566)	(-3.8345)		
Δ MS_t		-2.08E-11***			
	-	(-2.8824)	-	-	-
Δ MS_{t-1}	8.40E-12**		-5.04E-11***	5.99E-12	-5.29E-12
	(2.3263)	-	(-3.8746)	(1.1789)	(-0.7010)
Δ MS_{t-2}	2.52E-11***				
	(6.2476)	-	-	-	-
Δ MS_{t-3}	2.62E-11***				
	(7.9464)	-	-	-	-
Δ r_t	1.7145***	3.0920***	1.9468***	1.2755***	1.1763***
	(10.5944)	(7.4796)	(5.4740)	(5.0160)	(3.437146)
Δ r_{t-1}		-0.6138**	-1.0628**		-0.5594*
	-	(-2.3848)	(-1.0628)	-	(-1.9262)
Δ r_{t-2}	1.0628***		0.7953**	0.5159**	
	(7.0093)	-	(2.3376)	(2.4413)	-
Δ r_{t-3}	-0.6866***		2.3368***		
	(-4.9017)	-	(4.1035)	-	-
Δ P_{i-1}		-0.5675***			
		(-5.1372)	-	-	-
					-
Δ P_{i-2}			1.0155***	0.4873***	
		-	(4.0564)	(3.1815)	-
ec_{t-1}	-0.0318***	-0.3471***	-0.0460**	0.0085***	-0.0271*
	(-3.6670)	(-9.7525)	(-2.5862)	(3.2384)	(-1.7393)
Adj. R^2	0.9357	0.8541	0.6183	0.7646	0.4183
LM	1.7006	0.7460	2.2088	0.7577	1.5768
HETERO	0.9925	1.4475	2.1157*	5.8484	0.4660
RESET	0.3596	0.0249	0.0294	0.0133	1.9180
CUSUM	S	S	S	S	S
CUSUMSQ	S	S	S	S	S
F2	77.3737***	3.7751*	30.0996***	14.7787***	2.0533
F3	0.0210***	0.0522	14.8343***	0.0141	0.7666

Table 5 (Continued)

	$\Delta P_{5,t}$	$\Delta P_{6,t}$	$\Delta P_{7,t}$	$\Delta P_{8,t}$
constant	-2.0136*** (-4.0678)	0.6717 (0.4395)	-	-1.0002* (-1.7582)
D_t	-3.3785*** (-8.2756)	-3.3631 (-1.6344)	-1.3491** (-2.7818)	-0.1109 (-0.1116)
ΔER_t^+	-0.0490 (-1.0480)	-	0.0737* (1.8955)	0.5223*** (2.7934)
ΔER_{t-1}^+	-	-	0.2361*** (5.2239)	-0.3280*** (-4.2811)
ΔER_{t-2}^+	-	0.2791 (1.5303)	0.3350*** (6.4930)	0.4308*** (4.9052)
ΔER_{t-3}^+	-	-	-	-0.1061* (-1.9887)
ΔER_t^-	-	-	0.0141 (0.6005)	0.0760** (2.5750)
ΔER_{t-1}^-	-0.0966*** (-3.6230)	-	-0.2416*** (-9.4021)	0.0771** (2.2861)
ΔER_{t-2}^-	-	-	-0.1766*** (-6.8275)	-
ΔER_{t-3}^-	-	-0.2803*** (-3.0971)	-	-
ΔO_t^+	-	0.2152*** (3.2704)	-0.0390** (-2.9073)	-
ΔO_{t-1}^+	-0.0431*** (-3.9482)	-0.1502** (-2.1417)	-0.1860*** (-10.217)	-
ΔO_{t-2}^+	-	-	-0.0779*** (-5.4009)	-
ΔO_t^-	-0.0593*** (-6.0591)	0.1258** (2.7049)	-0.0279** (-2.6912)	-0.0748*** (-3.7368)
ΔO_{t-1}^-	-	-	-	0.0969** (2.8418)
ΔO_{t-2}^-	-0.0600*** (-8.5569)	-0.1427*** (-3.3320)	-	-0.1462*** (-4.3132)
ΔO_{t-3}^-	-	-	-	0.0808*** (2.8091)
ΔY_t	-	4.73E-11*** (2.6732)	1.17E-11*** (3.5308)	-
ΔY_{t-1}	-	6.78E-11** (2.4921)	-	-
ΔY_{t-2}	-	7.02E-11*** (3.6355)	-	-
ΔY_{t-3}	-1.99E-11*** (-3.0791)	4.91E-11** (2.3012)	-	-4.84E-11*** (-3.7086)

Table 5 (Continued)

ΔMS_t	-	-	-1.35E-11*** (-4.0323)	-2.50E-11** (-2.3424)
ΔMS_{t-1}	-		6.50E-12* (2.0008)	-
ΔMS_{t-2}	1.87E-11*** (5.7144)	-	-	3.66E-11*** (2.8749)
ΔMS_{t-3}	-	2.61E-11* (1.7499)	-	-
Δr_t	1.4215*** (5.8038)	1.1203* (2.0294)	1.7899*** (8.6532)	1.3020*** (3.5652)
Δr_{t-1}	0.2861*** (2.8162)	-	-0.5367*** (-3.3762)	-2.2390*** (-4.4859)
Δr_{t-2}	0.3740** (2.2068)	-	-1.0589*** (-7.5211)	1.9355*** (4.4255)
Δr_{t-3}	-	-1.3737*** (0.4566)	-	-0.6727** (-2.5016)
ΔP_{i-1}	-	-	-0.2167** (-2.5400)	-
ΔP_{i-2}	-	-	-0.4350*** (-5.4693)	
ΔP_{i-3}	-	-	-	-0.6322*** (-3.5387)
ec_{t-1}	-0.0450*** (-7.1837)	-0.4182*** (-4.6125)	-0.1926*** (-12.4149)	-0.0349*** (-2.8220)
Adj. R^2	0.8223	0.7427	0.8985	0.6672
LM	2.8426*	0.2939	6.5732**	0.8124
HETERO	2.3215**	0.8822	0.6723	1.3325
RESET	0.2660	0.7779	0.6234	0.0502
CUSUM	S	S	S	S
CUSUMSQ	S	S	S	S
F2	0.6284	5.9297**	21.7257***	6.2547**
F3	34.9096***	0.5803	0.7082	6.7401**

Figure 1: The Plots of CPIs and Real Effective Exchange Rate, 1980-2020

Notes: PT denotes CPI total. P1 is CPI 1. P2 is CPI 2. P3 is CPI 3. P4 is CPI 4. P5 is CPI 5. P6 is CPI 6. P7 is CPI 7. P8 is CPI 8.

Figure 2: The Plots of CPIs and Oil Price, 1980-2020