Phillips Curve Relation in Pre and Post Covid Malaysia

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Abstract: This paper investigates whether the Phillips curve relation in Malaysia has changed post Covid compared to pre Covid. Monthly data are used to estimate hybrid New Keynesian Phillips curve for Malaysia using Generalized Methods of Moments (GMM) approach. Results suggest that the Phillips curve relation for Malaysia has steepened in the post-Covid period compared to the pre-Covid period. In addition, the Phillips curve relation in Malaysia has become more forward looking with statistically significant coefficients on expected inflation in the post-Covid period.

Keywords: Phillips curve; pre and post Covid; Malaysia

1. Introduction

The Covid-19 pandemic is undoubtedly one of the most significant events of the 21st century. It has caused huge disruptions, negatively impacting economic indicators such as GDP, inflation, unemployment and trade of all the economies in the world. Recently, a number of studies have noted that the Phillips curve relations appear to have steepened post-Covid relative to pre-Covid era in some countries (Benigno and Eggertsson, 2023; Harding et al., 2023; Hobijn et al., 2023). However, all of these studies have focused on the cases of advanced economies, without studying whether the same phenomenon occurs among developing countries. The aim of this paper is to study whether the Phillips curve relation has changed in Malaysia post Covid.

This paper differs from existing studies that investigate Phillips curve relation in Malaysia in two ways. First, it explicitly takes into consideration the role of fuel prices in affecting consumer price inflation rate. While some studies have controlled for the role of international fuel prices in the investigation of consumer price inflation Phillips curves in other countries, the case of Malaysia is different from other countries in that there have been government subsidies for fuel prices in Malaysia which insulate consumers in Malaysia from fluctuations of international fuel prices. This means that international fuel prices or their equivalent in local currency terms will not be the right variables to include for the estimation of Phillips curve relation in Malaysia. Instead, this paper makes use of the data of a retail fuel price index in Malaysia, which takes into consideration the effects of government subsidies on retail fuel prices, which will be more relevant for the estimation of Phillips curve relation in Malaysia.

Second, in contrast to existing studies which make use of either quarterly or annual data, this paper make use of monthly data to estimate the Phillips curve relation in Malaysia. The use of monthly data allows this paper to have enough observations to separate out the post-Covid era to see if the

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Phillips curve relation in Malaysia has changed in the post Covid era as compared to the pre Covid era. Various specifications of the model, including specifications where open economy variables exchange rate and import price are used as control variables, are estimated using Generalized Methods of Moments (GMM) approach. GMM is used as the main estimation method as it allows the paper to investigate the role of expected inflation in inflation dynamics in the absence of direct measure of expected next period month-on-month inflation rate by exploiting moment conditions implied by the assumption of rational expectations, following the seminal contribution of Gali and Gertler (1999).

Estimation results suggest that the Phillips curve relation in Malaysia has indeed changed in the post-Covid era compared to pre-Covid era when headline CPI inflation is used as the measure of inflation. Specifically, the headline CPI inflation Phillips curve in Malaysia has steepened in the post-Covid era, in that the estimated coefficients on output gap or unemployment cycle are larger in magnitude and statistically significant in the post-Covid sample but not statistically significant in the pre-Covid sample. This is consistent with the findings in the literature that for many countries, their Phillips curves have steepened post Covid.

A novel finding in this paper is that expected inflation is statistically significant in the headline CPI inflation Phillips curve in the post-Covid sample, but not statistically significant in the pre-Covid sample. Moreover, this paper finds that fuel and other lubricating equipment price inflation, a measure of retail fuel price inflation in Malaysia is highly statistically significant in all specifications and all samples for Malaysia's headline inflation Phillips curve relation.

The remainder of this paper is organized as follows. Section 2 presents the literature review. Section 3 discusses the methodology and data. Results are discussed in Section 4 followed by the concluding remarks in Section 5.

2. Literature Review

Phillips curve was named after economist William Phillips, who documents a negative relation between nominal wage inflation rate and unemployment rate in the UK (Phillips, 1958). Samuelson and Solow (1960) find that the negative relation also holds between price inflation rate and unemployment rate in the United States and name the relation the Phillips curve. Since then, Phillips curve has become a workhorse model of macroeconomics, and has been estimated for many countries for various periods.

Samuelson and Solow (1960) argue that Phillips curve implies a stable tradeoff between inflation rate and unemployment rate, whereby a country can attain lower unemployment rate if it is willing to accept a higher inflation rate. Nonetheless, the experiences of the 1970s, following the oil shocks, debunked the idea of a stable tradeoff between inflation and unemployment rate. Researchers respond to the breakdown of the Phillips curve by augmenting the original Phillips curve with a term capturing inflation expectations, resulting in what is called "expectations-augmented Phillips curve".

Since the 1980s, a new class of models, called New Keynesian model, combines micro-foundations with nominal rigidities, which gives rise to the New Keynesian Phillips curve (NKPC). In a typical New Keynesian Phillips curve, inflation depends on expected future inflation as well as marginal cost of production. Gali and Gertler (1999) estimate a more general version of NKPC, which allows inflation to depend on its own lag, and call it the hybrid NKPC. They find that the expected future inflation is more important than lagged inflation in NKPC. Gali et al. (2001) find similar results for the case of Euro Area. There are also studies that investigate how other aspects of the economy affect the form of NKPC and how well it describes the data. For example, Lubik and Teo (2012) investigate the role of inventory investment while Lubik and Teo (2014) look at the role of deep habits.

The NKPC has also been extended to incorporate open economy factors. Batini et al. (2005) incorporate relative price of imported inputs, foreign competition pressures and employment adjustment costs to estimate open economy NKPC for the UK. They find that the coefficient on relative price of imported inputs is positive and statistically significant in the open economy NKPC. Mihailov et al. (2011) estimate an open economy NKPC that incorporates terms of trade for 10 OECD countries and find support for 7 of the countries. See Abbas et al. (2016) for more detailed survey of the NKPC literature.

Recently, a few studies have noted that the Phillips curve relations appear to have steepened post-Covid relative to pre-Covid era in some countries, in stark contrast to the literature in the pre-Covid era, which finds that Phillips curve relations have flattened gradually starting around 1975 and continued in the subsequent decades (Kuttner and Robinson, 2010). For example, using quarterly data, Hobijn et al. (2023) document that the absolute values of the estimated coefficients on unemployment gaps in a sample of 29 industrialized countries have become larger in the post-Covid era. Harding et al. (2023) construct a Dynamic Stochastic General Equilibrium (DSGE) model that can generate a nonlinear Phillips curve to explain the flattening of the Phillips curve in the United States during the Great Recession and the steepening of the Phillips curve in the post-Covid era. Similarly, Benigno and Eggertsson (2023) construct a New Keynesian model with search and matching frictions to generate a nonlinear Phillips curve that can explain the recent steepening of Phillips curve in the United States in the post Covid era. The changing slopes of the Phillips curve can have major policy implications for the conduct of monetary policies and hence deserve closer scrutiny.

There are only a handful of published research on estimating a Phillips curve for Malaysia. Furouka (2007) estimates a Vector Error Correction Model (VECM) of inflation and unemployment rate for Malaysia and finds long run relation between the two variables. Tang and Lean (2007) similarly use a Vector Error Correction Model to study the relation between inflation and unemployment rate, with and without additional control variables of output gap and M1 and find long run relations between these variables.

Furouka and Harvey (2015) estimate the hybrid version of NKPC for Malaysia and find that coefficients on expected inflation and lagged inflation to be both positive and statistically significant, with larger coefficient on expected inflation. However, they also find that the coefficient on output gap to be insignificant. Furouka and Munir (2009) use panel cointegration to

study the relation between inflation and unemployment rate in 5 ASEAN countries, including Malaysia, but find no long run relation between these two variables.

Agenor and Bayraktar (2010) estimate open economy NKPC for eight middle income countries, including Malaysia. The open economy variables that they consider are oil prices and real exchange rate. For the case of Malaysia, they find that lagged inflation is more important than expected inflation in the open economy NKPC, but oil price and real exchange rate are not statistically significant. Baharumshah et al. (2021) estimate Markov Switching open economy NKPC model for eight Asian economies, including Malaysia for the period of 1980-2018. The open economy variables that they consider are US dollar exchange rate, global inflation rate and global output gap. They find that their nonlinear Markov Switching model outperform alternative linear models and the three open economy variables are statistically significant for the case of Malaysia. Chong and Ho (2018) investigate how open economy variables, including global slack, commodity prices and exchange rate, affect Phillips curve relation in a panel of 14 Asia Pacific economies including Malaysia using annual data. They find that global slack, commodity prices and exchange rates are important determinants of domestic inflation rates for Asia-Pacific economies.

Out of the 7 published studies on Phillips curve for Malaysia, only 3 studies have explicitly considered open economy factors. Only 1 study has considered non-linear model. Furthermore, all 7 studies make use of either quarterly or annual data and none of the studies have considered the post-Covid era. These reasons motivate this paper to investigate the Phillips curve relation in Malaysia, with special attention to open economy variables such as exchange rate and imported good prices, and whether non-linearities are important features of Phillips curve in Malaysia and use monthly data spanning the pre and post Covid eras, so as to investigate whether the Phillips curve relation has changed in Malaysia in the post Covid era.

3. Methodology and Data

The main research methodology is GMM estimation of the hybrid New Keynesian Phillips curve using monthly data from Malaysia.

A benchmark hybrid NKPC can be expressed as the following:

$$\pi_t = \alpha_0 + \alpha_1 \pi_{t-1} + \alpha_2 E_t \pi_{t+1} + \alpha_3 V_t + \varepsilon_t - eq(1),$$

where π_t is inflation rate in period t, π_{t-1} is lagged one period inflation rate meant to capture inflation persistence, $E_t \pi_{t+1}$ is expected next period inflation rate and V_t is the forcing variable,

which will be explained in more details below. ε_t is the residual term. $\alpha_0, \alpha_1, \alpha_2, \alpha_3$ are coefficients to be estimated[2].

In the canonical closed-economy NKPC model of Gali and Gertler (1999), the forcing variable V_t corresponds to real marginal cost, which is proxied by the labour income share. Some studies use output gap as the forcing variable in estimation (see for example Furouka and Harvey, 2015). Roberts (1995) considers either output gap or unemployment rate as proxy for the forcing variable. Since labour income share data is only available at annual frequency and not at monthly frequency for Malaysia, this paper will use either output gap[3] or "unemployment cycle"[4] as proxies for the forcing variable.

The benchmark hybrid NKPC model is augmented to include various control variables that could affect the Phillips curve relation. The first control variable is fuel price. Fuel receives significant weights in the consumption baskets of most economies, including Malaysia. In Malaysia, fuels and lubricating equipment as a category receives a weight ranging from 7.50% to 8.77% in the consumption basket of Malaysia between 2005 and 2023. Studies such as Roberts (1995) and Agenor and Bayraktar (2010) have included oil price while Chong and Ho (2020) include energy and non-energy commodity prices as control variables in the estimation of NKPC. Considering that retail prices for gasoline, diesel and natural gas have been heavily subsidized by the government in Malaysia, consumers in Malaysia have been insulated from the fluctuations of international energy commodity prices. This means that international energy commodity prices or their equivalents in local currency terms will not be the appropriate variables to include as control variables in the estimation of NKPC for Malaysia. Therefore, this paper instead includes the price index of fuel and lubricating equipment, which is a subcomponent of the CPI index in Malaysia, in percentage change from last period form, as a control variable in the estimation of NKPC for Malaysia. Hence, the NKPC is modified as:

$$\pi_t = \alpha_0 + \alpha_1 \pi_{t-1} + \alpha_2 E_t \pi_{t+1} + \alpha_3 V_t + \alpha_4 \pi_t^{Fuel} + \varepsilon_t - eq(2),$$

where π_t^{Fuel} is the percentage change of the price index of fuel and lubricating equipment from last period, and α_4 is its coefficient to be estimated.

In open economy NKPC, open economy variables such as imported intermediate inputs (Batini et al., 2005) and terms of trade (Mihailov et al., 2011) can affect domestic inflation rates. Since Malaysia is a highly open economy with exports plus imports as a ratio of GDP of over 140%, this paper will include two open economy variables, the dollar-Ringgit exchange rate and an import price index, as control variables in the NKPC:

$$\pi_t = \alpha_0 + \alpha_1 \pi_{t-1} + \alpha_2 E_t \pi_{t+1} + \alpha_3 V_t + \alpha_4 \pi_t^{Fuel} + \alpha_5 \Delta e_t + \varepsilon_t - eq(3),$$

$$\pi_t = \alpha_0 + \alpha_1 \pi_{t-1} + \alpha_2 E_t \pi_{t+1} + \alpha_3 V_t + \alpha_4 \pi_t^{Fuel} + \alpha_5 \Delta e_t + \alpha_6 \pi_t^{Import} + \varepsilon_t - eq(4),$$

[2] See for example Gali and Gertler (1999) for derivation of this equation.

[3] With industrial production index (which is available at monthly frequency) proxying for output and output gap defined as deviations of log industrial production index from its HP-filtered trend.

[4] Constructed as deviation of actual unemployment rate from its HP-filtered trend.

where Δe_t is the percentage change of US dollar-Ringgit exchange rate (expressed as Ringgit per US dollar) from last period; π_t^{Import} is the percentage change of an import price index from last period; α_5 and α_6 are the coefficients associated with the two variables.

To explore whether nonlinearities matter for the NKPC relation for Malaysia, this paper also explores variations to equations (1) to (4) above, where an additional interaction term, $\pi_t V_t$, will be included as additional independent variable. This is designed to capture the idea from Harding et al. (2022) that the responsiveness of inflation to forcing variable may depend on the level of inflation.

Eqs (1) to (4) above will be estimated using GMM methods. In estimating the model, α_i , i=0 to 6, will be treated as reduced form parameters. The equations will be estimated using monthly data from Malaysia, with data from both the pre and post Covid eras. Estimated coefficients from different sample periods will be compared to see if the NKPC relation in Malaysia has changed in the post Covid era. In the GMM estimations, 3 lags of inflation rate as well as 2 lags of the driving force (output gap or unemployment cycle), percentage change of fuel prices, percentage change of exchange rate and percentage change of import price are used as instruments.

The inflation rate is measured as the month-on-month percentage change in the consumer price index. The main focus will be on the headline CPI inflation rate though core CPI inflation rate will also be investigated. Output gap is measured as the deviation of log industrial production index from its HP-filtered trend. The unemployment cycle is computed as the deviation of unemployment rate from its HP-filtered trend. The percentage change of import price index is computed as the percentage change of import unit value index. Data from 2005M4 to 2023M8 are used for the analysis, with 2005M4 to 2020M2 corresponding to pre-Covid subsample, 2020M3 to 2023M8 corresponding to post-Covid subsample[5].

Monthly data of headline CPI index, core CPI index, industrial production index, fuel and lubricating equipment price index, US dollar to Malaysian Ringgit exchange rate and import unit value index are obtained from the CEIC database. Except for the unemployment rate, all the other series are obtained in non-seasonally adjusted forms. Data of CPI index, industrial production index and import unit value index are seasonally adjusted using X13 option in Eviews before further manipulation.

4. Results

4.1 Hybrid New Keynesian Phillips Curve

Table 1 shows the results of GMM estimations of eq(1) and eq(2) with headline CPI inflation as the measure of inflation and output gap as the driving force variable. Panel A shows the results for eq(1), the standard close economy NKPC without other control variables. For the full sample (2005M4 to 2023M8), lag inflation and expected inflation are both statistically significant, with

[5] To address the concern that there may be structural break in the immediate post Covid data sample, a later start date of 2021M1 has also been tried for the post-Covid sample, results are mostly the same.

the estimated coefficient on expected inflation more than twice the value of the estimated coefficient on lag inflation. The estimated coefficient on output gap is negative but statistically insignificant. When the sample is divided into pre and post Covid, lag inflation is statistically significant in the pre-Covid sample, but not in the post Covid sample, while expected inflation is statistically significant in the post Covid sample, but not in the pre sample. The output gap is not statistically significant in the pre Covid sample, but is positive and statistically significant in the post Covid sample. Moreover, the magnitude of the estimated coefficient on output gap is 10 times larger in the post Covid sample than in the pre Covid sample. The results on output gap are consistent with the findings for other countries in the literature, where the pre Covid period corresponds to a flattening of the Phillips curve while the post Covid period corresponds to a steepening of the Phillips curve (Benigno and Eggertsson, 2023; Harding et al., 2023; Hobijn et al., 2023).

Table 1: GMM Estimation of Eq (1) and Eq(2) with Headline CPI Inflation as the Inflation Measure and Output Gap as the Driving Force Variable

	Panel A			Panel B		
Sample period	2005M4-2023M8	2005M4-2020M2	2020M3 -2023M8	2005M4-2023M8	2005M4-2020M2	2020M3 -2023M8
π_{t-1}	0.317***	0.278***	-0.212	0.156***	0.149***	-0.019
	(0.064)	(0.043)	(0.127)	(0.048)	(0.033)	(0.095)
$E_t\pi_{t+1}$	0.702***	0.158	0.754***	0.363*	0.174	0.510***
	(0.245)	(0.277)	(0.146)	(0.188)	(0.129)	(0.110)
Output gap	-0.002	0.008	0.080***	0.008	0.003	0.038***
	(0.014)	(0.011)	(0.012)	(0.008)	(0.008)	(0.009)
π_t^{Fuel}				0.066***	0.081***	0.043***
				(0.013)	(0.013)	(0.006)
Constant	-0.007	0.092*	0.092*	0.072*	0.107***	0.092**
	(0.046)	(0.052)	(0.052)	(0.038)	(0.028)	(0.040)
Prob(J-statistics)	0.434	0.605	0.911	0.195	0.156	0.671

Notes: Robust standard errors in parenthesis. ***, ** and * denote statistically significant at 1%, 5% and 10% levels, respectively. Prob(J-statistics) refers to the p-value for the Sargan-Hansen test of overidentifying restrictions.

Panel B of Table 1 shows the results for eq(2), where fuel and lubricating equipment price inflation is added as a control variable. Fuel and lubricating equipment price inflation is positive and statistically significant at 1% level in the full sample as well as the two subsamples. The estimated coefficients on lag inflation, expected inflation and output gap in Panel B have the same patterns as those in Panel A, though the magnitude of the estimated coefficients in Panel B are smaller than those of Panel A.

Table 2: GMM Estimation of Eq (3) and Eq(4) with Headline CPI Inflation as the Inflation Measure and Output Gap as the Driving Force Variable

	Panel A			Panel B		
Sample period	2005M4-2023M8	2005M4-2020M2	2020M3-2023M8	2005M4-2023M8	2005M4-2020M2	2020M3-2023M4
π_{t-1}	0.135**	0.138***	-0.025	0.051	0.116***	-0.032
	(0.062)	(0.042)	(0.092)	(0.108)	(0.054)	(0.126)
$E_t\pi_{t+1}$	0.485**	0.267*	0.485***	0.441	0.348	0.437***
	(0.214)	(0.174)	(0.113)	(0.283)	(0.247)	(0.163)
Output gap	0.011	0.002	0.036***	0.013	0.003	0.034***
	(0.012)	(0.009)	(0.010)	(0.017)	(0.011)	(0.009)
π_t^{Fuel}	0.072***	0.087***	0.046***	0.072***	0.081***	0.048***
	(0.015)	(0.016)	(0.007)	(0.016)	(0.021)	(0.008)
Δe_t	0.042	0.026	0.031	0.045	0.026	0.026
	(0.026)	(0.032)	(0.026)	(0.034)	(0.038)	(0.028)
π_t^{Import}				0.156	0.062	0.026
				(0.113)	(0.055)	(0.047)
Constant	0.050	0.091***	0.087**	0.041	0.069	0.083
	(0.040)	(0.031)	(0.035)	(0.052)	(0.045)	(0.051)
Prob(J-statistics)	0.292	0.147	0.542	0.788	0.250	0.417

Notes: Robust standard errors in parenthesis. ***, ** and * denote statistically significant at 1%, 5% and 10% levels, respectively. Prob(J-statistics) refers to the p-value for the Sargan-Hansen test of overidentifying restrictions.

Table 2 shows the results for eq(3) and eq(4). The percentage change in US Dollar-Ringgit exchange rate is positive (indicating a depreciation of Ringgit is associated with higher inflation rate in Malaysia) but not statistically significant in Panel A for the full sample as well as the two subsamples. The estimated coefficients on lag inflation, expected inflation, output gap and fuel and lubricating equipment price inflation have almost completely identical patterns as the results in Panel B of Table 1, except that expected inflation is positive and marginally significant in the pre-Covid sample when percentage change of US Dollar-Ringgit exchange rate is added as a control variable.

In Panel B of Table 2, the estimated coefficients on percentage change of US Dollar-Ringgit exchange rate and percentage change of imported goods price are positive but not statistically significant in all samples. The estimated coefficients on percentage change of imported goods price may be statistically insignificant because the data used for imported goods price is import unit

value index, which also reflect prices of imported intermediate inputs and imported capital goods, rather than only prices of imported consumption goods, the later will be more relevant for CPI inflation rate. The estimated coefficients on lag inflation, expected inflation, output gap and fuel and lubricating equipment price inflation have almost completely identical patterns as the results in Panel B of Table 1, except that lag inflation is positive but not statistically significant in the full sample in Panel B of Table 2. In all specifications and all samples in Table 1 and Table 2, the validity of overidentifying restrictions cannot be rejected as indicated by p-values of J-statistics above 0.1 in all cases.

Overall, the results in Tables 1 and 2 are consistent with the findings for other countries in the literature of flattening of the Phillips curve pre Covid and steepening of the Phillips curve in the post Covid era (Benigno and Eggertsson, 2023; Harding et al., 2023; Hobijn et al., 2023). However, this paper also finds a novel result that has not been documented in the literature, which is that lag inflation is statistically significant in the Phillips curve for Malaysia only in the pre-Covid sample, while expected next period inflation is positive and statistically significant in the Phillips curve for Malaysia in the post-Covid sample. The results thus suggest that expected inflation has become more important in the Phillips curve relation for Malaysia post-Covid. Interestingly, the two open economy control variables, percentage change of US Dollar -Ringgit exchange rate and percentage change of import price are all statistically insignificant in all samples. In contrast, the estimated coefficients on fuel and lubricating equipment price inflation are positive and highly significant in all specifications and all samples. The version of NKPC with fuel and lubricating equipment price inflation as a control variable emerges as the preferred specification for Malaysia.

4.2 Nonlinear Hybrid New Keynesian Phillips Curve

The results above show that the NKPC for Malaysia has steepened post-Covid compared to the pre-Covid period. Harding et al. (2023) show that a nonlinear Phillips curve where the coefficient on output gap depends on the inflation rate can explain flattening of the Phillips curve pre-Covid and steepening of the Phillips curve post-Covid in the United States. To investigate this possibility for Malaysia, an interaction term $\pi_t V_t$, is added to eq(1) to eq(4) and estimated with data from the full sample, to see whether a nonlinear Phillips curve where the slope depends on the level of inflation can better explain inflation dynamics in Malaysia.

Table 3: Results for the Case of Non-linear Phillips Curve Where Interaction Term, π_t ∗Output Gap Is Added

	2005M4-2023M8	2005M4-2023M8	2005M4-2023M8	2005M4-2023M8
π_{t-1}	0.299***	0.150***	0.130**	0.049
	(0.070)	(0.048)	(0.054)	(0.103)
$E_t\pi_{t+1}$	0.726***	0.253	0.343*	0.383
	(0.250)	(0.188)	(0.220)	(0.35)
Output gap	-0.004	0.013	0.014*	0.012
	(0.013)	(0.010)	(0.011)	(0.016)
π_t ∗Output gap	-0.028	0.029	0.022	0.006
	(0.017)	(0.021)	(0.019)	(0.024)
π_t^{Fuel}		0.085***	0.088***	0.073***
		(0.020)	(0.021)	(0.023)
Δe_t			0.037*	0.042
			(0.024)	(0.034)
π_t^{Import}				0.162
				(0.120)
Constant	0.008	0.074**	0.062*	0.048
	(0.051)	(0.034)	(0.037)	(0.056)
Prob(J-statistics)	0.284	0.201	0.277	0.765

Notes: Robust standard errors in parenthesis. ***, ** and * denote statistically significant at 1%, 5% and 10% levels, respectively. Prob(J-statistics) refers to the p-value for the Sargan-Hansen test of overidentifying restrictions.

As can be seen from Table 3, the interaction term turns out to be statistically insignificant in all specifications. Thus, the simple modification of adding an interaction term between inflation rate and output gap to generate non-linearities does not seem to work for the case of Malaysia.

4.3 Purely Backward-Looking Phillips Curve

Tables 4 and 5 below show the results for eq(1) to eq(4) when the coefficients on expected inflation are set at zero, to explore the cases of purely backward looking Phillips curve. The equations are estimated using ordinary least squares. Overall, the results are broadly similar compared to the version with expected inflation, with coefficients on output gap being larger in the post-Covid sample, suggesting a steepening of the Phillips curve and the coefficients on fuel price inflation

positive and highly significant while the coefficients on the two open economy variables being insignificant.

Table 4: OLS Estimation of Purely Backward Looking Versions of Eq (1) and Eq(2) and Headline CPI Inflation as the Inflation Measure

	Panel A			Panel B		
Sample period	2005M4-2023M8	2005M4-2020M2	2020M3 - 2023M8	2005M4-2023M8	2005M4-2020M2	2020M3 - 2023M8
π_{t-1}	0.150*	0.236***	-0.437*	0.083**	0.106***	-0.150
	(0.088)	(0.056)	(0.234)	(0.038)	(0.038)	(0.108)
Output gap	0.045***	0.028**	0.091***	0.012***	0.012**	0.036***
	(0.011)	(0.013)	(0.013)	(0.004)	(0.006)	(0.008)
π_t^{Fuel}				0.080***	0.083***	0.064***
				(0.006)	(0.006)	(0.006)
Constant	0.161***	0.142***	0.326***	0.148***	0.143***	0.211***
	(0.033)	(0.032)	(0.083)	(0.015)	(0.016)	(0.043)
Adjusted R^2	0.189	0.089	0.621	0.811	0.797	0.871

Notes**:** Robust standard errors in parenthesis. ***, ** and * denote statistically significant at 1%, 5% and 10% levels, respectively.

Panel A of Table 4 shows the case where no control variable is added. In contrast to the case with expected inflation in Panel A of Table 1 where output gap is only statistically significant in the post-Covid sample, output gap is positive and statistically significant in all samples in the purely backward-looking version of the Phillips curve. However, the estimated coefficient on output gap in the post-Covid sample is more than 3 times that of the pre-Covid sample, which is consistent with the findings for other countries with regard to the steepening of the Phillips curve. The estimated coefficient on lag inflation is positive and significant for the full sample and pre-Covid sample in Panel A of Table 4, consistent with the results in Panel A of Table 1. However, the estimated coefficient on lag inflation is paradoxically negative and marginally significant for the post-Covid sample in Panel A of Table 4, unlike the case of Panel A of Table 1, where the estimated coefficient is negative but statistically insignificant.

Panel B of Table 4 shows the results where fuel and lubricating equipment price inflation is added as a control variable. The estimated coefficient for fuel and lubricating equipment price inflation is positive and statistically significant for all samples, similar to the results in Panel B of Table 1. The estimated coefficient for output gap is positive and statistically significant in all samples, similar to the results in Panel A of Table 4. The estimated coefficient on output gap is three times as large in the post-Covid sample compared to the pre-Covid sample and hence is also consistent with steepening of the Phillips curve. The estimated coefficient on lag inflation is positive and

statistically significant for the full sample and the pre-Covid sample, negative but statistically insignificant for the post-Covid sample.

Table 5 shows the results for the purely backward-looking Phillips curve, when percentage change of exchange rate and percentage change of import price are added as control variables. The two open economy control variables are statistically insignificant in all samples. The estimated coefficients on lag inflation, output gap and fuel and lubricating equipment price inflation in Table 5 have the same patterns as the results in Panel B of Table 4.

Table 5: OLS Estimation of Purely Backward-Looking Versions of Eq (3) and Eq(4) and Headline CPI Inflation as the Inflation Measure

	Panel A			Panel B		
Sample period	2005M4-2023M8	2005M4-2020M2	2020M3 - 2023M8	2005M4-2023M8	2005M4-2020M2	2020M3 - 2023M8
π_{t-1}	0.083**	0.106***	-0.149	0.082**	0.108***	-0.157
	(0.038)	(0.038)	(0.109)	(0.039)	(0.039)	(0.112)
Output gap	0.012***	0.012**	0.035***	0.012***	0.012**	0.034***
	(0.004)	(0.006)	(0.008)	(0.004)	(0.006)	(0.007)
π_t^{Fuel}	0.081***	0.083***	0.064***	0.081***	0.083***	0.063***
	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)
Δe_t	0.003	0.000	0.005	0.003	0.001	-0.007
	(0.008)	(0.008)	(0.023)	(0.008)	(0.008)	(0.020)
π_t^{Import}				0.001	-0.004	0.043
				(0.001)	(0.009)	(0.033)
Constant	0.148***	0.143***	0.209***	0.148***	0.144***	0.204***
	(0.015)	(0.016)	(0.042)	(0.015)	(0.016)	(0.042)
AdjustedR^2	0.811	0.796	0.868	0.810	0.795	0.869

Notes**:** Robust standard errors in parenthesis. ***, ** and * denote statistically significant at 1%, 5% and 10% levels, respectively.

4.4 Core Inflation

Tables 6 and 7 show the results of eq(1) to eq(4) when core CPI inflation is used as the measure of inflation rate. The results differ quite substantially compared to the benchmark specification where headline inflation is used as the measure of inflation. The coefficients on fuel price inflation are only significant in the pre-Covid sample while steepening of the Phillips curve is only observed in the specifications with control variables.

First, the estimated coefficients for fuel and lubricating equipment price inflation are only significant for pre-Covid sample. Since core CPI by definition has removed fuel price from its index, this means that fuel and lubricating equipment price inflation only have pass through effects on the components of core CPI during the pre-Covid period, but not during the post-Covid period.

A possible reason for this is that between 2014 and June 2018 the government of Malaysia removed most of the fuel subsidies, making fuel price in that period more volatile. In contrast, after July 2018 until present, the government reintroduced fuel subsidies for RON95 and Diesel, making the fuel and lubricating price index less volatile during the post-Covid period. As the Malaysian government plans to gradually move towards a targeted subsidy mechanism for fuel items starting in year 2024, retail fuel prices may become more volatile and have pass through effects to components of core CPI again, potentially bringing back the pre-Covid pattern where fuel price inflation has statistically significant effect on core CPI inflation.

A second interesting finding is that lagged inflation and expected inflation are both positive and statistically significant in the post-Covid sample in all specifications, with the estimated coefficients on expected inflation larger than those of lagged inflation. In contrast, for pre-Covid sample, lagged and expected inflation are only statistically significant in the specification without control variables, but are statistically insignificant when control variables such as fuel and lubricating equipment price inflation, percentage change of US Dollar-Ringgit exchange rate and percentage change of import price are added. This suggests that core inflation has become both more persistent and more forward looking in the post-Covid period, with the forward-looking component exerting larger influences.

Table 6: GMM Estimation of Eq (1) and Eq(2) with Core CPI Inflation as the Inflation Measure and Output Gap as the Driving Force Variable

	Panel A			Panel B		
Sample period	2005M4-2023M8	2005M4-2020M2	2020M3-2023M8	2005M4-2023M8	2005M4-2020M2	2020M3-2023M8
π_{t-1}	0.100**	0.089***	0.337***	0.093**	0.034	0.297***
	(0.040)	(0.034)	(0.080)	(0.046)	(0.043)	(0.080)
$E_t\pi_{t+1}$	0.705***	0.548**	0.609***	0.718***	0.589	0.615***
	(0.207)	(0.280)	(0.117)	(0.208)	(0.384)	(0.118)
Output gap	0.007**	0.009**	0.002	0.005*	0.007	0.003*
	(0.003)	(0.004)	(0.002)	(0.003)	(0.006)	(0.002)
π_t^{Fuel}				0.002	0.025**	-0.004
				(0.006)	(0.012)	(0.003)
Constant	0.029	0.058	0.006	0.031	0.056	0.016
	(0.032)	(0.045)	(0.014)	(0.032)	(0.058)	(0.014)
Prob(J-statistics)	0.523	0.575	0.950	0.476	0.688	0.915

Notes: Robust standard errors in parenthesis. ***, ** and * denote statistically significant at 1%, 5% and 10% levels, respectively. Prob(J-statistics) refers to the p-value for the Sargan-Hansen test of overidentifying restrictions.

Table 7: GMM Estimation of Eq (3) and Eq(4) with Core CPI Inflation as the Inflation Measure and Output Gap as the Driving Force Variable

	Panel A			Panel B		
Sample period	2005M4-2023M8	2005M4-2020M2	2020M3-2023M8	2005M4-2023M8	2005M4-2020M2	2020M3-2023M4
π_{t-1}	0.072	0.029	0.277**	0.043	0.012	0.253**
	(0.044)	(0.045)	(0.116)	(0.054)	(0.054)	(0.113)
$E_t\pi_{t+1}$	0.689***	0.539	0.610***	0.627**	0.563	0.636***
	(0.240)	(0.383)	(0.163)	(0.248)	(0.379)	(0.154)
Output gap	0.005**	0.008	0.003	0.005	0.007	0.004*
	(0.003)	(0.006)	(0.002)	(0.004)	(0.006)	(0.002)
π_t^{Fuel}	0.005	0.025**	-0.001	0.003	0.022*	-0.000
	(0.008)	(0.012)	(0.003)	(0.008)	(0.013)	(0.003)
Δe_t	0.013	0.016	0.020	0.016	0.017	0.023*
	(0.021)	(0.023)	(0.012)	(0.024)	(0.024)	(0.013)
π_t^{Import}				0.043	0.019	-0.014
				(0.050)	(0.036)	(0.015)
Constant	0.039	0.068	0.017	0.044	0.064	0.019
	(0.037)	(0.059)	(0.017)	0.037	(0.058)	(0.015)
Prob(J-statistics)	0.346	0.622	0.972	0.236	0.446	0.992

Notes: Robust standard errors in parenthesis. ***, ** and * denote statistically significant at 1%, 5% and 10% levels, respectively. Prob(J-statistics) refers to the p-value for the Sargan-Hansen test of overidentifying restrictions.

Third, the percentage change of US Dollar-Ringgit exchange rate is only marginally significant in the version where percentage change of import price is also added as a control variable for the post-Covid sample, but insignificant otherwise. The percentage change of import price, on the other hand, is statistically insignificant for all samples.

Fourth, output gap is positive and only statistically significant in the full sample and pre-Covid sample when no control variable is added. However, when fuel and lubricating equipment price inflation is added as a control variable, output gap is positive and only statistically significant in the full sample and post-Covid sample. Hence, when core inflation is used as the measure of inflation rate, steepening of the Phillips curve is only observed when fuel and lubricating equipment price inflation is added as a control variable.

4.5 Unemployment Cycle as the Measure of Driving Force

Tables 8 and 9 show the results when the unemployment cycle is used as the measure of driving force. Overall, the results are consistent with the steepening of the Phillips curve and expected inflation becoming more important post-Covid.

The unemployment cycle is negative and statistically significant in the full sample and post-Covid sample in specifications where control variables are added, but not statistically significant when no control variable is added. This result is consistent with the steepening of the Phillips curve post Covid. Expected inflation is positive and statistically significant in the post-Covid sample, except for the specification where percentage change of import price is added as a control variable, but not significant in all specifications pre-Covid. This result is consistent with the result in section 4.1 where output gap is used as the driving force. It suggests that expected inflation has become more important in inflation dynamics in Malaysia post Covid.

Table 8: GMM Estimation of Eq (1) and Eq(2) with Headline CPI Inflation as the Inflation Measure and Unemployment Cycle as the Driving Force Variable

	Panel A			Panel B		
Sample period	2010M3-2023M8	2010M3-2020M2	2020M3-2023M8	2010M3-2023M8	2010M3-2020M2	2020M3-2023M8
π_{t-1}	0.346***	0.212**	0.437***	0.138***	0.068	0.063
	(0.056)	(0.082)	(0.092)	(0.042)	(0.067)	(0.050)
$E_t\pi_{t+1}$	0.562***	0.021	0.717***	0.182	-0.173	0.207**
	(0.191)	(0.329)	(0.118)	(0.135)	(0.166)	(0.092)
Unemployment Cycle	-0.001	0.001	-0.001	-0.002*	0.002	-0.004***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
π_t^{Fuel}				0.082***	0.083***	0.076***
				(0.008)	(0.013)	(0.007)
Constant	0.019	0.118*	-0.029*	0.099**	0.172***	0.152**
	(0.036)	(0.065)	(0.036)	(0.030)	(0.037)	(0.030)
Prob(J-statistics)	0.307	0.455	0.628	0.268	0.356	0.345

Notes: Robust standard errors in parenthesis. ***, ** and * denote statistically significant at 1%, 5% and 10% levels, respectively. Prob(J-statistics) refers to the p-value for the Sargan-Hansen test of overidentifying restrictions.

Table 9: GMM Estimation of Eq (3) and Eq(4) with Headline CPI Inflation as the Inflation Measure and Unemployment Cycle as the Driving Force Variable

	Panel A			Panel B		
Sample period	2010M3-2023M8	2010M3-2020M2	2020M3 - 2023M8	2010M3-2023M8	2010M3-2020M2	2020M3 - 2023M8
π_{t-1}	0.133***	0.070	0.054	0.089*	0.060	-0.050
	(0.051)	(0.072)	(0.057)	(0.062)	(0.075)	(0.077)
$E_t\pi_{t+1}$	0.200	-0.197	0.192*	0.197	-0.156	0.059
	(0.148)	(0.227)	(0.107)	(0.147)	(0.228)	(0.100)
Unemployment cycle	-0.002**	0.002	-0.004***	-0.003**	0.002	-0.004***
	(0.001)	(0.002)	(0.007)	(0.001)	(0.002)	(0.001)
π_t^{Fuel}	0.091***	0.083***	0.077***	0.084***	0.090***	0.078***
	(0.012)	(0.015)	(0.007)	(0.011)	(0.015)	(0.005)
Δe_t	0.032	-0.003	0.001	0.020	-0.035	-0.040*
	(0.021)	(0.019)	(0.018)	(0.025)	(0.033)	(0.021)
π_t^{Import}				0.126**	0.117	0.144***
				(0.069)	(0.076)	(0.037)
Constant	0.092***	0.176***	0.157***	0.093***	0.175***	0.184***
	(0.032)	(0.051)	(0.031)	(0.034)	(0.058)	(0.033)
Prob(J-statistics)	0.322	0.272	0.262	0.506	0.678	0.858

Notes: Robust standard errors in parenthesis. ***, ** and * denote statistically significant at 1%, 5% and 10% levels, respectively. Prob(J-statistics) refers to the p-value for the Sargan-Hansen test of overidentifying restrictions.

5. Concluding Remarks

This paper investigates whether Phillips curve relation in Malaysia has changed in the post-Covid period relative to the pre-Covid period. Various specifications of the hybrid New Keynesian Phillips curve are estimated using GMM methods using monthly data from Malaysia spanning the pre and post Covid periods. The results suggest that the headline CPI inflation Phillips curve in Malaysia has steepened in the post-Covid period, consistent with the results documented in the literature for several advanced countries. In addition, this paper finds that expected inflation plays a more significant role in the Phillips curve relation for Malaysia in the post Covid period. The results hold regardless of whether output gap or unemployment cycle is used as the forcing variable. When core inflation is used as the measure of inflation, steepening of the Phillips curve is only observed in the specifications with control variables.

The results that expected inflation has become more significant in the Phillips curve relation for Malaysia in the post Covid period have more policy implications. It suggests that it has become

more important for the central bank of Malaysia to make sure that inflation expectations in Malaysia is well-anchored to ensure stable inflation dynamics.

This paper has a few limitations. First, the lack of subjective expected next period month-on-month inflation rate data[6] for Malaysia that can be used to investigate the roles of expected inflation further. In the absence of subjective expected next period month-on-month inflation rate data, the paper can only rely on GMM methods and the assumption of rational expectations to estimate the coefficient on expected inflation. Considering the potential importance of expected inflation rate, it will be good if the Department of Statistics Malaysia or other research organisations can start collect the subjective expected next period month-on-month inflation data. Second, the paper has only attempted to capture the steepening of the Phillips curve in the post-Covid era by investigating whether a non-linear Phillips curve with interaction term of output gap and inflation rate can capture the phenomenon. Future research can explore alternative modelling methods that may be able to capture the change in the slope of the Phillips curve in Malaysia.

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[6] Monthly data of 12 month ahead analyst forecast is available, but for estimation of the hybrid NKPC model at monthly frequency, the expected inflation variable requires monthly data of next period month-on-month inflation rate, which is not available.

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