Estimation of New Keynesian Phillips Curve in Malaysia

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Abstract

This paper aims to estimate new Keynesian Phillips curve (NKPC) in Malaysia using the output gap as the proxy for the marginal cost. For this purpose, it employed three econometric methods, namely the ordinary least square (OLS), the two-stage least square (TSLS) and the generalized method of moments (GMM). This paper also estimated two types of the NKPC provisions, namely the baseline NKPC and the hybrid NKPC in its estimation. The empirical findings from the baseline NKPC and the hybrid NKPC offered a consistent conclusion that there is statistically significant price stickiness in Malaysia. In other words, the NKPC model seems to offer a good approximation to estimate the inflation dynamics in Malaysia.

*Keywords***:** new Keynesian Phillips curve, Generalized Method of Moments, Malaysia

1   Introduction

There is an ongoing debate on the existence of trade-off between unemployment rates and inflation rates also known as the "Phillips Curve." This trade-off was introduced by William Phillips in 1958. He observed a negative association between unemployment rates and change of wage rates in United Kingdom for the period of 1861 – 1957. He asserted the change in wage rates can be explained by the unemployment rates, except the wage-price spiral period after the war (Phillips, 1958). However, neoclassical economists denied the existence of the Phillips curve. For example, Robert Lucas (1976) pointed out an important methodological flaw to estimate unemployment-inflation relationship. According to Lucas, a structural model to estimate the Phillips curve needs to include a dependent variable that would be determined by explanatory variables and this variable, at same time, would have impact on a system of these variables. Lucas pointed out, if it not the case, then an empirical estimation of policy change cannot be substantiated.[1] The Phillips curve association between unemployment and inflation can be translated as a relationship between income and price level. The future level of income level (y_{t+1}) can be described as:

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[1] Lucas' critique can be summarized into this paragraph, "Given that structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with change in the structure of series relevant to the decision makers, it follows that any change in policy will systematically alter the structure of econometric model (Lucas, 1976, p. 41).

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$$y_{t+1} = f(y_t, x_t, \theta, \varepsilon_t) \qquad (1)$$

In this equation, the future level of income (y_{t+1}) is the function of the current level of income (y_t), a system of macroeconomic variables (x_t) including price level, a vector of slope coefficients (θ), and random shocks (ε_t). In turn, the current level of income (y_t) would have impact on the system of macroeconomic variables:

$$x_t = f(y_t, \lambda, \eta_t) \qquad (2)$$

In this second equation, a system of macroeconomic variables (x_t) is the function of the current level of income (y_t), a vector of slope coefficients (λ), and random shocks (η_t). There can be an econometric problem in estimating the slope coefficients (θ) in equation (1). For example, a contractionary monetary policy to control inflation will impact coefficients (θ) in equation (1) and concurrently income level. However, changes in income level will alter a system of macroeconomic variables including price level. As such, policymakers will be unable to identify the real effect of the monetary policy. This econometric estimation problem is known as the "Lucas Critique" (Lucas, 1976).

Mankiw (2001) points out that the Phillips curve hypothesis is debatable since some economists doubted the existence of short-run trade-off relationship between unemployment and inflation. He further states that researchers are unable to come up with a good theoretical framework to explain the unemployment-inflation relationship. However, he stressed the unemployment-inflation relationship as an important underlying assumption for economic analysis. Failure to acknowledge the existence of Phillips curve makes it difficult to appreciate the role of monetary policy on inflation and unemployment rates.

Paul Samuelson (2008) clearly spelled out that a negative inflation-unemployment association is a social characteristic in a disequilibrium economy. By contrast, there is no negative relationship in a perfectly competitive economy. In other words, Samuelson claims, Say's law, rather than the Phillips curve, would prevail in the equilibrium economy. Under such idealized system, unemployed person would find a decent employment without any difficulties. Samuelson further pointed out that the U.S. economy could be considered as a disequilibrium economy in the chaotic period between the two world wars and more than three decades after the 1940s. Some of the reasons for disequilibrium economy are international competition, technological breakthrough and strong trade union. In these periods, the Phillips curve was a valid theory to explain the unemployment-inflation relationship. Since the late 1990s, Samuelson asserts, the U.S. economy has become an equilibrium economy in which the Say's law would prevail. In these decades, the outsourcing industries effectively wiped out many element of the disequilibrium economy. He believed the source to

explain inflation is more geared toward microeconomics rather than macroeconomics. Solow, Taylor and Mankiw (2009) argued that it is difficult for someone to make sense of the Phillips curve if one assumes general equilibrium in an economic system. It is more practical to consider the macroeconomic phenomena from a disequilibrium assumption. Based on this view, the change in unemployment rates or inflation rates can be explained from a moment along the Phillips curve or a shift of the Phillips curve itself.

This paper revisits the unemployment-inflation debate by estimating new Keynesian Phillips curve (NKPC) in Malaysia. It aims to add new findings to existing empirical studies which have focused on the estimation of NKPC in developed countries. The inflation dynamics in developed countries can be different in developing countries that that has no well-established financial and monetary system. In this context, estimation of the NKPC in developing countries can be an interesting topic. However, the lack of reliable data on labour share has become a serious methodological problem to estimate the NKPC in developing countries, including Malaysia. Thus, current study uses the output gap, rather than the labour share, as proxy for marginal cost. In other words, the choice of output gap is justified from methodological necessity, rather than theoretical perspective.

This paper consists of five sections. Following the introductory section, section 2 will briefly review the existing literature on the new Keynesian Phillips curve. Section 3 will discuss the data and research methods while the fourth section will report the empirical findings. The final section is the conclusion.

2   A Brief Literature Review on the New Keynesian Phillips Curve (NKPC)

Since Phillips (1958) introduced the trade-off between unemployment rates and inflation rates, various researchers have examined similar relationships. Their empirical findings, however, have been mixed. The results can be divided into two main groups. One that confirmed the existence of Phillips curve while another refuted the existence of the trade-off relationship between these variables.[2]

The New Keynesian Phillips Curve (NKPC) model typically made an assumption that the adjustment of nominal price could be costly and the high cost of price adjustment would cause the "price stickiness". In other words, the NKPC has become an important theoretical pillar of the dynamic stochastic general equilibrium (DSGE) model by linking

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[2] For prominent example, Alogoskoufis and Smith (1991) pointed denied the existence of trade-off relationship in US economy. By contrast, King and Watson (1994) offered an empirical support to the existence of the trade-off relationship in same country. See Furuoka (2007) for detailed discussion about literature review on empirical analysis of the Philips curve.

the nominal price rigidities with inflation rates. (Schorfheide, 2008). It has been said there was a positive correlation between current inflation rate and current marginal costs and there was a negative correlation between current output gap and current marginal cost (Gali and Gertler, 1999). Additionally, the traditional Phillips Curve made an important assumption that there would be a negative correlation between current output gap and current unemployment rate. These three relationships among three variables, such as inflation rate, output gap and unemployment rate, imply that there would be a positive association between current inflation rate and current marginal cost under the NKPC model, which is similar to the trade-off relationship between unemployment rate and unemployment rate in the traditional Phillips Curve model.[3]

In the late 1990s, Gali and Gertler (1999) made a significant contribution towards this discussion. They proposed using the generalized method of moments (GMM) analysis to estimate the Phillips curve. They estimated the new Keynesian Phillips curve (NKPC) in the United States using quarterly data for the period of 1960 to 1997. They used the percentage change in GDP deflator as a proxy of inflation rate. They also used labour income share in non-farm business sector and detrended log GDP as a proxy for marginal cost. Their instrument variables included four lags of the deflator inflation rates, labour income share, detrended log GDP, long-short interest rate spread, wage inflation and commodity price inflation. Gali and Gertler, in both reduced model and structural model, asserted the existence of the NKPC in the United States.

Since the publication of their seminal paper, the estimation of the NKPC became a popular topic among empirical economists. There were a large number of empirical inquiries that were devoted to find out the existence of the NKPC. For example, Gali, Gerther and Lopez-Sahido (2001) applied the GMM analysis to estimate the NKPS in the Euro area for the period of 1970 – 1998. They employed same inflation and marginal cost variables approach as in Gali and Gertler (1999). In their estimations, instrument variables are five lags of deflator inflation rates and two lags of real unit labour cost, detrended log GDP and wage inflation. They pointed out the existence of the NKPS in the Euro zone. Furthermore, Gali, Gertler and Lopez-Sahido (2005) used the output gap as proxy for the marginal cost to estimate the structural model of NKPC in the United States for the period of 1960Q1 – 1997Q4. They used the same sets of marginal cost variables that were used in Gali and Gertler (1999). Regarding instruments, they decreased the number of instrument in order to avoid over-identification problem. Thus, they included only four lags of deflator inflation and two lags of labour income share, detrended GDP and wage inflation as instrument variables. They pointed out that, when output gap is used, the slope coefficient for the variable is negative and not significant.

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[3] We are grateful to an anonymous reviewer for providing the detailed theoretical background of the NKPC approach.

Jondeaua and Bihan (2005) estimated for the NKPS in the United States, the Euro area and four E.U. member countries, namely Germany, France, Italy and United Kingdom, for the period of 1970Q1 – 1999Q4. They used the percentage change in GDP deflator as proxy for inflation. They also used the detrended log GDP with a Hodrick-Prescott (HP) filter and real unit labour cost (ULC) as proxy for marginal cost. Their instrument variables consisted of four lags of deflation inflation rates, detrended log GDP, real unit labour cost and three-month money-market interest rates. Their finding from the output gap confirmed the existence of the NKPS in the case of Germany only. Sanchez (2006) estimated the NKPC in Japan for the period of 1973Q1 – 2005Q2. In her model, the inflation rates were measured by the quarter log difference of the GDP deflation and the consumer price index (CPI) and the marginal costs were measured by the wage share of GDP, the hourly wage share of GDP and the detrended log GDP with a HP filter. The wage share of GDP is equal to the average wage per person times the total number of employment divided by GDP. On the other hand, the hourly wage share of GDP is the wage share of GDP divided by the average work-hour in a quarter. Instrument variables consist of one and two lags of GDP, CPI inflation, wage inflation, detrended GDP, and interest rate spread. She pointed out that there is a positive relationship between inflation rates and output gap in the country.

In addition, Abbas and Sgro (2011) estimated the NKPC for Australia using quarterly data for the period of 1953 – 2009. They used the percentage change in GDP deflator as proxy of inflation, detrended log GDP, the wage share as percentage of GDP, and the nonfarm wage share as percentage of nonfarm GDP which act as the proxy of marginal cost. They used three sets of instrument variables. The first set of instrument variables consists of same variables that were suggested by Gali and Gertler (1999). The second set of instruments was suggested by Gali et al. (2001). The third set of instruments was suggested by Gali et al. (2005). In the most of cases, they found out the existence of the baseline NKPC and the hybrid NKPC in Australia by using labour share as proxy for marginal cost. However, they failed to confirm the existence of the NKPC when they used the de-trended GDP as proxy for the marginal costs. Furthermore and importantly, Abbas and Sgro (2011) found that the baseline NKPC model is a better model specification to explain the inflation dynamics than the hybrid NKPC model.

Previous researchers mainly estimated the NKPC in the developed countries. There is still lacking of the systematic estimations of the NKPC in developing countries, including Malaysia. Notable exception is Lai (2013) estimated the NKPC in nine developing countries, including Malaysia, for the period of 1970Q2 – 2011Q1. She utilized the percentage change in GDP deflator, the consumer price index (CPI) as the proxy for inflation and the GDP deflator as proxy for marginal cost. In her model, the instrument variables include deflator inflation, CPI deflation and output gap. She

pointed out the existence of the NKPC in all nine developing countries including Malaysia. Saman and Pauna (2013) used the multivariate approach to estimate the NKPC in Romania for the period of 2000Q1 – 2011Q4. They decomposed variables into the permanent components and the cyclical component. Saman and Pauna pointed out the existence of the NKPC in the country by detecting a significant positive relationship between inflation rate and output gap.

3   Methods and Data

This paper used the Gali-Gertler (GG) method to estimate the new Keynesian Phillips curve (Gali & Gertler, 1999) in Malaysia by using quarterly data for the period of 1991Q1 – 2012Q4. Lai (2013) estimated the baseline NKPC in 9 developing countries including Malaysia, without estimating the hybrid NKPC. This paper will estimate both baseline and hybrid NKPC in Malaysia. The number of observation is 88. This paper used the quarter change in the GDP deflator as proxy for the inflation and the HP filtered output gap as the proxy for the marginal cost. The data on GDP deflator and real GDP are obtained from International Monetary Fund (2014). The data were transformed into natural logarithms.

Figure 1 depicts the relationship between natural log of real GDP and HP-filtered trend from 1991Q1 to 2012Q4 while Figure 2 depicts the nature log of the GDP deflator in the same period. As Figure 1 clearly indicates, Malaysia's economic development has not suffered from the high level of the under-production or the over-production, except the period of 1998 – 2002 when the Asian financial crisis made a negative impact on the Malaysia's economy. In the end of the 1990s, due to the regional economic downturn, Malaysia experienced high level of under-production. By contrast, in the beginning of the 2000s, Malaysia's economy produced excessive amount of goods and service to compensate the under-production during its economic crisis. On the other hand, Figure 2 revealed that Malaysia tends to have a stable change of price level, except the end of the 1990s and the end of 2000s. The price level in the country increased rapidly after the Asian economic crisis in the end of the 1990s when the Malaysian current suffered from a serious depreciation again the US current. By contrast, the price level increased relatively slowly in the end of the 2000s when the prices of crude oil and other commodities decreases due to the global economic downturn.
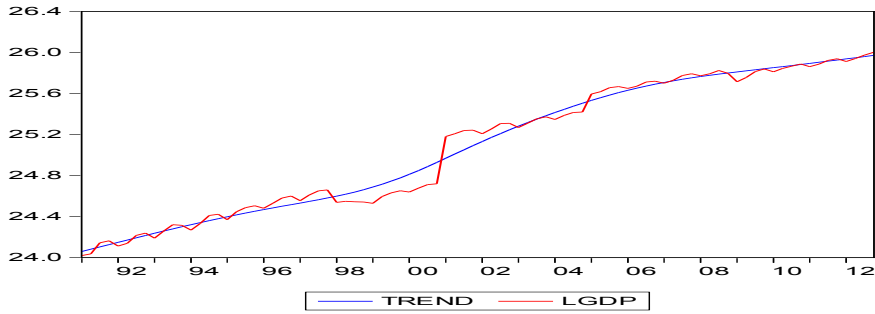
Source: IMF (2014)

Figure 1   Log of GDP and Trend
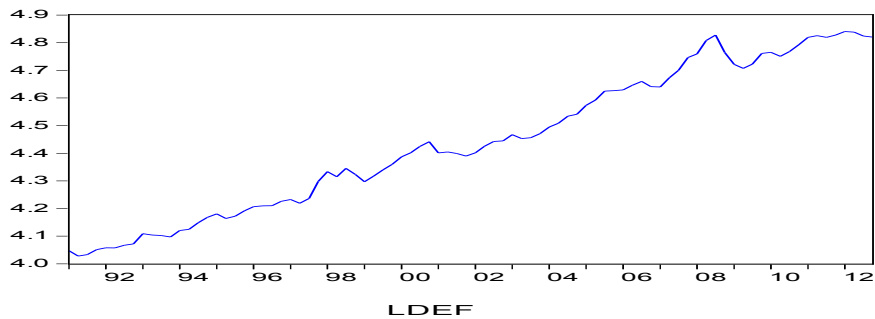
Source: IMF (2014)

Figure 2   Log of GDP Deflator

Following the methods suggested by Gali and Gertler (1999), the baseline NKPC is based in the equation (3a) and the hybrid NKPC is based on the equation (3b) (Gali & Gertler, 1999):

$$\pi_t = \lambda_1 mc_t + \lambda_2 E_t\{\pi_{t+1}\} \tag{3a}$$
$$\pi_t = \lambda_1 mc_t + \lambda_2 E_t\{\pi_{t+1}\} + \lambda_3 \pi_{t-1} \tag{3b}$$

where π_t is the current level of inflation rate, mc_t is the marginal cost, $E_t\{\pi_{t+1}\}$ is expected inflation rate, π_{t-1} is the lagged inflation rate and λ_1, λ_2 and λ_3 are slope coefficients. The baseline NKPC incorporates only one direction of the inflation dynamics (λ_2) which is an indicator for the influence of expected inflation rates in the future. The hybrid NKPC model incorporates not only future inflation dynamics (λ_2) but also the past inflation dynamics (λ_3) which is an indicator of the influence of the lagged inflation rate in the past.

In other word, the NKPC model made an assumption that current inflation rate, π_t, would have a positive association with current marginal costs, mc_t. Additionally,

NKPC also made another assumption that the current inflation rate would be determined by the expected future inflation rate, $E_t\{\pi_{t+1}\}$. Furthermore, the "hybrid" NKPC model made an assumption that the current inflation rate would be determined jointly by the expected future inflation rate and the lagged inflation rate, π_{t-1}. In this hybrid model, the slope coefficient for the lagged inflation rate, λ_3, could be called the "backward" adjustment parameter and the slope coefficient for the expected future inflation rate, λ_2, could be called the "forward" adjustment parameter. The slope coefficient for marginal cost, λ_1, would measure what extend change of marginal cost would have an impact on the inflation rate. Furthermore, in the NKPC model, the relationship between marginal cost and inflation rate could be estimated by using a log-linear regression method because the variables in the NKPC model could be measured in logarithms. For example, current inflation rate could be expressed as the difference between natural log of current GDP deflator and natural log of lagged GDP deflator.[4]

This paper uses the output gap as the proxy for marginal cost. In other words, the current study assumes that the marginal cost is equal to the gap between actual level of output and the potential output level:

$$mc_t = \kappa(y_t - y^*) \tag{4}$$

where y_t is output level, y^* is steady state level of output, κ is the output elasticity of marginal cost. The trend component of output level, which was estimated by the Hodrick-Prescott (HP) filter, is used as a proxy of the steady state level of output. Furthermore, this study assumes that output elasticity of marginal cost is approximately one ($\kappa \cong 1$). Under this assumption, the baseline NKPC and the hybrid NKPC are expressed as:

$$\pi_t = \lambda_1(y_t - y^*) + \lambda_2 E_t\{\pi_{t+1}\} \tag{5a}$$
$$\pi_t = \lambda_1(y_t - y^*) + \lambda_2 E_t\{\pi_{t+1}\} + \lambda_3 \pi_{t-1} \tag{5b}$$

In this paper, we will estimate both the reduced form model and the structural model of baseline NKPC and the hybrid NKPC. Estimation of the reduced form is based on the equations (5a) and equation (5b). The reduced formed coefficients in the baseline NKPC can be expressed by two structural parameters, α and β:

$$\lambda_1 = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha} \tag{6a}$$
$$\lambda_2 = \beta \tag{6b}$$

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[4] We are also indebted from the constructive criticism from an anonymous reviewer to improve and deepen the explanations and discussions on the research methods.

Similarly, the reduced formed coefficients in the hybrid NKPC can be expressed by three structural parameters, α, β and γ:

$$\lambda_1 = \frac{(1-\gamma)(1-\alpha)(1-\alpha\beta)}{\alpha} \tag{7a}$$

$$\lambda_2 = \beta \tag{7b}$$

$$\lambda_3 = \frac{\gamma}{\alpha} \tag{7c}$$

For the estimation of the structural model of the baseline NKPC, $E_t\{\pi_{t+1}\}$ is replaced by π_{t+1} and η_t in equation (5a) and equation (5b) where η_t is the expectational error.

A methodical problem in the estimation of the NKPC is that expected future inflation, $E_t\{\pi_{t+1}\}$, is not observable. Researchers need to find a proxy for the expected future inflation. Mazumder (2011) pointed out that the prevailing conventional method was to replace the expected inflation rates with the actual level of future inflation. This traditional method is based on the theory of the rational expectations. The expected level of inflation would be equal to the actual level of inflation if the inflation expectations would be formed rationally (Palley, 2015). On the other hand, there is a new method which would use a survey measure of expected future inflation. In the case of United States, survey measure of expected future inflation could be obtained from the Survey of Professional Forecasters (Mazumder, 2011). However, in the case of Malaysia, there is no readily available survey measure of the expected future inflation. So, this paper employed the traditional method, rather than new method, for the measure of the expected inflation. Furthermore, the estimation of the NKPC in the traditional method by employing the ordinary least squares (OLS) could yield inconsistent estimates of the parameters because the actual level of future inflation is correlated with the error term. To overcome this methodological problem, the two-stage least square (TSLS) could be employed for the estimation of the NKPC. The TSLS could be considered as the special case of the generalized method of moments (GMM) (Nason & Smith, 2008; Schmitt-Grohe & Uribe, 2008). This is the reason why Gali and Gertler (1999) used the GMM method for their estimation of the NKPC in the United States. Following the Gali-Gertler method, the current paper used the framework of GMM method for estimation of the NKPC in Malaysia.

Furthermore, the baseline NKPC equation and hybrid NKPC equation could be reformulated by bring all items in the RHS of the equations to the LHS of the equation, except the expectational error. In other words, the equations (5a) and (5b) are transformed into:

$$\eta_t = \pi_t - \lambda_1(y_t - y)^* - \lambda_2\pi_{t+1} \tag{8a}$$

$$\eta_t = \pi_t - \lambda_1(y_t - y)^* - \lambda_2\pi_{t+1} - \lambda_3\pi_{t-1} \tag{8b}$$

Furthermore, the reduced formed slope coefficients, λ_1, λ_2 and λ_3, are also replaced by relationships in equations (6a) and (6b). The moment conditions are that the expectational error and instrumental variable (z_t) would be orthogonal. In other words, the moment conditions in the baseline NKPC and the hybrid NKPC can be expressed as:

$$E_t\{(\pi_t - \lambda_1(y_t - y^*) - \lambda_2\pi_{t+1})z_t\} = 0 \tag{9a}$$

$$E_t\{(\pi_t - \lambda_1(y_t - y^*) - \lambda_2\pi_{t+1} - \lambda_3\pi_{t-1})z_t\} = 0 \tag{9b}$$

Furthermore, the relationships in equation (6a) and equation (6b) can be incorporated into the moment condition for the baseline NKPC model in equation (9a). Thus, for the estimation of the baseline NKPC model, the following two orthogonal conditions can be used:

$$E_t\{(\alpha\pi_t - (1-\alpha)(1-\alpha\beta)(y_t - y^*) - \alpha\beta\pi_{t+1})z_t\} = 0 \tag{10a}$$

$$E_t\{(\pi_t - \frac{(1-\alpha)(1-\alpha\beta)(y_t - y^*)}{\alpha} - \beta\pi_{t+1})z_t\} = 0 \tag{10b}$$

where α and β are structural parameter. More precisely, α is the rigidity parameter and β is the discount parameter which is equal to the slope coefficient of expected inflation (λ_2). The instrument variables are one lags of the deflator inflation, the log GDP and the HP filtered trend of the log GDP. Furthermore, the relationships in equation (7a), equation (7b) and equation (7c) can be incorporated into the moment condition for the hybrid NKPC model in equation (9b). For the estimation of the hybrid NKPC model,[5] the following two orthogonal conditions can be used:

$$E_t\{(\alpha\pi_t - (1-\alpha)(1-\alpha\beta)(y_t - y^*) - \alpha\beta\pi_{t+1} - \gamma\pi_{t-1})z_t\} = 0 \tag{11a}$$

$$E_t\{(\pi_t - \frac{(1-\alpha)(1-\alpha\beta)(y_t - y^*)}{\alpha} - \beta\pi_{t+1} - \frac{\gamma}{\alpha}\pi_{t-1})z_t\} = 0 \tag{11b}$$

where γ is a structural parameter that indicate the "backwardness" of firms' price setting behaviour Calvo model. The "backwardness" parameter divided by the rigid parameter (γ/α) is equal to the slope coefficient of the lagged inflation rate (λ_3).

4   Empirical Findings

This paper estimates both the reduced form model and the structural model. The empirical findings from the reduced form model of the baseline NKPC are reported in Table 1. This estimation is based on equation (3a). The findings from the ordinary

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[5] Gali and Gertler (1999) employed more complex orthogonality conditions. However, some researchers reported problem of singular matrix when these orthogonality conditions applied to estimate the hybrid NKPC based on the Gali-Gertler method (Oreng, 2003; Rao and Paradiso, 2011). Rao and Paradiso (2011) pointed out that there can be a singular matrix problem when the expected inflation rate ($E_t\{\pi_t+1\}$) is replaced with the actual level of inflation rate (π_{t+1}).

least squares (OLS) estimation indicated the slope coefficient for the output gap is negative but not statistically significant. Furthermore, empirical findings from the two stage least squares (2SLS) and the GMM indicated that coefficient is positive and not significant. On the other hand, the slope coefficient for the expected inflation is positive and significant. This means that the current inflation is not determined by the output gap, but is determined by the expected level of inflation.

Table 1 Reduced form model of the baseline NKPC

	Ordinary least square (OLS)	Two stage least square (2SLS)	Generalized method of moments (GMM)
Constant	0.068 (0.002) [2.894]***	0.002 (0.004) [0.564]	0.001 (0.002) [0.697]
λ_1	−0.018 (0.027) [−0.657]	0.017 (0.073) [0.232]	0.016 (0.054) [0.296]
λ_2	0.239 (0.107) [2.218]**	0.721 (0.379) [1.903]*	0.755 (0.212) [3.551]***

Notes: The number in parentheses indicated the standard errors and the numbers in the bracket indicate the *t*-statistics. For the GMM methods, the instrument variables are one lags of the deflator inflation, the log GDP and the HP filtered trend of the log GDP.
*** indicates significant at the 1 per cent level.
** indicates significant at the 5 per cent level.
* indicates significant at the 10 per cent level.

Table 2 shows the empirical results from the structural model of the baseline NKPC. The orthogonality condition 1 is based on the Equation (10.a) while the orthogonality condition 2 is based on the Equation (10.b). The findings indicated that the rigidity parameter (α) was positive and statistically significant. On the other hand, the discount parameter (β) is also positive and statistically significant. In other words, these findings seem to indicate that there is statistically significant price stickiness in Malaysia.

Table 2 Structural model of the baseline NKPC

	Generalized method of moments (GMM) based on orthogonality condition1 (Equation 10.a)	Generalized method of moments (GMM) based on orthogonality condition 2 (Equation 10.b)
A	*0.913* *(0.161)* *[5.650]****	*0.929* *(0.187)* *[4.960]****
B	*0.881* *(0.121)* *[7.264]****	*0.887* *(0.169)* *[7.449]****

Notes: The number in parentheses indicated the standard errors and the numbers in the bracket indicate the *t*-statistics. The instrument variables are one lags of the deflator inflation, the log GDP and the HP filtered trend of the log GDP. *** indicates significant at the 1 per cent level.

Empirical findings from the reduced form model of the hybrid NKPC are found in Table 3. Estimation of hybrid model is based on the equation (3b). Despite minor differences, these three different estimation methods generate consistent findings. The empirical findings from the OLS estimation indicated the slope coefficient for the output gap is negative but not statistically significant. However, empirical results from the 2SLS and the GMM indicated that coefficient is positive and not significant. By contrast, the slope coefficient for the expected inflation rates and the slope coefficient for the lagged inflation rates are positive and significant. These findings indicate that the current inflation is determined by the expected level of inflation in the future and the lagged level of inflation in the past.

Table 3 Reduced form model of the hybrid NKPC

	Ordinary least square (OLS)	Two stage least square (2SLS)	Generalized method of moments (GMM)
Constant	*0.004* *(0.002)* *[1.739]**	*−0.001* *(0.003)* *[−0.370]*	*−0.001* *(0.001)* *[−0.761]*
λ_1	*−0.016* *(0.026)* *[−0.605]*	*0.053* *(0.054)* *[0.981]*	*0.040* *(0.037)* *[1.233]*
λ_2	*0.273* *(0.105)* *[2.603]****	*0.788* *(0.268)* *[2.937]****	*0.759* *(0.115)* *[6.598]****
λ_3	*0.259* *(0.104)* *[2.438]***	*0.374* *(0.130)* *[2.859]****	*0.384* *(0.085)* *[4.481]****

Notes: the number in parentheses indicated the standard errors and the numbers in the bracket indicate the *t*-statistics. For the GMM methods, the instrument variables are one lags and two lags of the deflator inflation, the log GDP and the HP filtered trend of the log GDP.
*** indicates significant at the 1 per cent level.
** indicates significant at the 5 per cent level.
* indicates significant at the 10 per cent level.

Finally, Table 4 report the empirical results from the structural model of the hybrid NKPC. The orthogonality condition 1 is based on the Equation (11.a) and the orthogonality condition 2 is based on the Equation (11.b). The findings from the hybrid NKPC model confirmed the findings from the baseline NKPC model. The findings from the hybrid NKPC indicated that the rigidity parameter (α) and discount parameter (β) are positive and statistically significant. On the other hand, the backwardness parameter (γ) is also positive and statistically significant. These findings also seem to indicate that there is statistically significant price stickiness in Malaysia.

Table 4 Structural model of the hybrid NKPC

	Generalized method of moments (GMM) based on Orthogonality Condition 1 (Equation 11.a)	Generalized method of moments (GMM) based on Orthogonality Condition 2 (Equation 11.b)
α	0.913 (0.057) [15.775]***	0.926 (0.060) [15.363]***
β	0.701 (0.071) [9.596]***	0.701 (0.072) [9.684]***
γ	0.312 (0.082) [3.807]***	0.319 (0.084) [3.740]***

Notes: The number in parentheses indicated the standard errors and the numbers in the bracket indicate the *t*-statistics. The instrument variables are one lags and two lags of the deflator inflation, the log GDP and the HP filtered trend of the log GDP.
*** indicates significant at the 1 per cent level.

In short, the empirical findings from the baseline NKPC and the hybrid NKPC offered a consistent conclusion that there is statistically significant price stickiness in Malaysia. The estimated price stickiness parameter is approximately 0.9. It means that the price level in the country will be fully adjusted in 10 quarters. More importantly, empirical findings indicated that the NKPC model seems to offer a good approximation to estimate the inflation dynamics in Malaysia.

5   Conclusion

There is an ongoing debate about an existence of Phillips curve relationship. The current study revisited this important macroeconomic topic by employing the generalized method of moments (GMM) analysis to estimate the new Keynesian Phillips curve (NKPC) in Malaysia. The usage of the GMM for the estimation of the NKPC is suggested by Gali and Gertler (1999, 2005). The findings from the baseline NKPC and the hybrid NKPC offered a consistent conclusion that there is statistical evidence for the price stickiness in Malaysia. These findings implied there is statistically significant price stickiness in Malaysia. In other words, the NKPC can be considered as a good approximation to estimate and evaluate the dynamic nature of inflation rates in Malaysia.

This study aims to serve a preliminary empirical inquiry to examine the inflation dynamics in Malaysia. However, there is two major limitations in the current study. First of all, the estimation of the NKPC could be more efficient if the researcher is able to use a survey measure of the expected inflation rate. However, there is no readily available data on the survey measure of the future inflation rates. Thus, the current study uses the traditional method to replace the expected level of inflation rate with the actual level of future inflation rate. This option of research method may put the findings on a shaky ground. The future research may use the survey measure of the expected inflation rate for its analysis of the NKPC.

Another limitation of current study is lack of reliable data. The future research may use the better dataset, namely labour share, wage inflation rates and interest spread, for the estimation of the NKPC in Malaysia and other developing countries. The output gap-based estimation of the NKPC can be applied for other developing countries. The findings from these empirical inquiries would offer a better insight for this inexorable and mysterious NKPC relationship in developing countries.

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