ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

Master Thesis International Economics

The empirical study on the puzzle of missing Phillips Curve – the evidence from Thailand

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Abstract: The Phillips Curve has become a heart of macroeconomics since the idea of Phillips (1958). In recent times, a number of economists express doubt as to whether this economic theory still exists in the real world, including in Thailand. This thesis investigates the existence of the Philips Curve in a context of the Thai inflation, whether it holds or breaks down and if it does break down, what are causes behind such a result. Thus, the study is carried out on the annual time series ranging from 1990 to 2017 by employing the Least Squares with HAC Consistent Covariance to ensure consistent estimates. Corresponding to continuous evolution of the theoretical frameworks of the Phillips Curve, three main model specifications are studied. First, the traditional Phillips Curve is affirmed to break down also in the Thai economy, which is in line with earlier papers. The New Keynesian Phillips Curve which contains the natural rate and the individual behavior, in contrast, holds true for Thailand. In the same way, the full-form of Phillips Curve which takes the other 3 global factors into account is found to be valid and more realistic for the Thai's economy. Moreover, the structural breakpoint test together with the study of 2 separate sub-samples approves of the presence of the breaks in 1999 and 2000. This means the Phillips Curve is statistically valid for describing the Thai inflation only in some cases and sub-samples. Among them, the most credible case is when the headline CPI inflation is explained by the full-form of Phillips Curve during 2000 to 2017, the period after the Asian financial crisis. Further, the most consistent results obtained from both of the full-sample and the sub-samples are Thai people are backward-looking rather than forward-looking. The oil price growth is a crucial global factor influencing the Thai inflation and a financial crisis is important when it directly affect domestic prices. After all, the most noteworthy result is that my results are sensitive to a choice of inflation measurements and economic-driving variable, e.g. unemployment slack or output gap.

Keywords: Phillips Curve, Thai inflation dynamics, Structural break

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I would like to thank my thesis supervisor, Professor Lorenzo Pozzi for helpful advice and constructive comments. Any errors in this paper are my own responsibility.

1. Introduction

The Phillips Curve is a well-known macroeconomic concept which refers to an inverse relationship between unemployment and inflation in an economy—when unemployment is high, inflation tends to be low, and vice versa. This link has been observed most famously in 1958 from data of the United Kingdom (Nicolini and Fitzqerald, 2013). Since then, the framework lies at the heart of the central banks' models. Nevertheless, this tradeoff broke down in the United States during 1970s to 1980s and even in this decade. The economists have been casting a doubt on the role of Phillips Curve's framework in explaining the inflation dynamics. Even though the puzzle is most apparent in the U.S. where factors such as global force are to be blamed for such an outcome, a similar pattern is observed in Thailand. During these recent years, Thai economy has continuously recovered but the average inflation rates remain below the target level; in 2017 the headline CPI inflation rate is approximately 0.66 percent which is much lower than the target, which is 2.5 percent (Bank of Thailand, 2018). This fact caught my interest in identifying the existence of the Philips Curve in Thailand, whether the framework of Philips Curve holds or breaks down; if it does break down, what are the causes behind such a result. This leads towards the main research question that does the Phillips Curve really disappear and what can explain the deviation of the Phillips Curve in Thailand?

Thailand is the only central focus of the study. Its annual time series data is collected over a period of 1990 to 2017 covering the two major financial crises for a further study into structural breakpoints in the whole sample. To achieve the research aim, the empirical tests are performed on several versions of the Phillips Curve. The principal one is the general full-form of the Phillips Curve which includes all explanatory variables, namely a main economic-driving variable, a natural rate of unemployment or a potential rate of output, individual behavior and such global factors as oil price growth, import price inflation and crisis dummy. Despite being restricted to closed economy for simplicity, the setting of the study allows global economy to have an influence on the Thai domestic economy; in this way, the study setting gets closer to the fact that Thailand is a small open economy. In addition to the full-from of Phillips Curve, the study is extended to the other two special cases. The first one is the traditional Phillips Curve which is the fundamental model originated by Phillips (1958). The other one is the New Keynesian Phillips Curve (henceforth, referred to as the NKPC) which takes the natural rate hypothesis proposed by Friedman (1968) and Phelps (1967, 1968) together with individual behavior towards inflation expectation into consideration. Further, a structural breakpoint test is undergone to determine when and whether there is a significant change in the data. In case a break is discovered, a study into sub-samples is accordingly carried out to re-estimate parameters to be compared with the parameters earned from the full sample. In such a way, a right and logical conclusion could properly be drawn. To that end, the econometric technique called the Least Squares with HAC Consistent Covariance which tackles with heteroskedasticity and autocorrelation of the raw data is employed.

Based upon all Phillips Curve models estimated, this thesis provides explanation of these five specific areas of the underlying research question. First, it empirically examines if each version of the Phillips Curve holds in the Thai economy. Second, it explores the role of the lagged inflation and the expected future inflation in explaining the deviation from the (traditional) Phillips Curve. Third, it investigates to what extent global influential variables conduce to the deviation from the traditional Phillips Curve and the NKPC. Forth, it checks the stability of the estimates by employing a structural breakpoint test and splitting the sample in two sub-samples accordingly. Fifth, it rechecks the consistency of results across choices of inflation measurements, i.e. headline CPI inflation and inflation measured by GDP deflator and economic-driving variables such as unemployment slack and output gap.

The empirical research on the Phillips Curve is worth conducting. At the present time, searching for the Phillips Curve in the reality is a topic of interest among the economists due to the aforementioned evidence from the situation in the U.S. Despite empirical works available on this subject, interestingly, there is shortage of researches in the area of developing countries although the similar circumstantial evidence is found, thereby providing further proof of the Phillips Curve in the developing countries. In terms of practical implication, most importantly, the conclusion of the study will provide viable tools valuable for policymakers. To sum up, the thesis is another piece of evidence to reinforce earlier findings and broaden the research perspectives in this area.

The rest of the thesis paper is organized as follows. Section 2 presents the literature review of the Phillips Curve both in terms of theoretical frameworks and of empirical evidence from earlier papers. Section 3 provides the methodology which comprises model specifications, data and proxies for all variables required in the study and an econometric estimation method. Section 4 discusses the empirical results. Section 5 concludes with some limitations and recommendations for future researches.

2. Literature Review

2.1 Theoretical framework

The Phillips Curve illustrates an unemployment-inflation tradeoff. It first came to be known and owed the name to Phillips (1958) which found the relationship between wage inflation and unemployment in the United Kingdom for a period of almost a century (The Economist, 2017). Since then, this principle has been a heart of Macroeconomics. However, it was due to some failures to fit subsequent data that there is widespread criticism and continuous evolution of this discipline. Until now, the Phillips Curve relationship has been one of the most controversial in macroeconomics (Nason and W. Smith, 2008a). Among a large number of research papers into this area, its different concepts emerge and the most relevant ones to this thesis's empirical tests are described as follows:

2.1.1 Traditional Phillips Curve – A stable relationship

(1) Theoretical argument

The idea that there should be some sort of relationship between inflation and unemployment has been generated since Keynes' General Theory (1936) which postulated that a minimum unemployment level can be maintained with stable prices or rising prices, implying an association between unemployment and prices. In fact, the first statistical investigation of the relationship was originally performed by Fisher (1926) who found a high correlation between the change of employment volume and the rate of price changes for the United States during 1903-1925. Nevertheless, this discipline is attributed to Phillips in 1958 thanks to the stable negative relationship traced in the U.K. over a long period, 1861-1957. The main hypothesis of Phillips (1958) was that wage inflation could be explained by the percentage unemployment (the unemployment rate) and the rate of change of unemployment through 3 channels: price of labor services; rate of change of labor demand; and cost of living adjustments which affect nominal wage rates. His scatter diagram showed the stable downward-sloping non-linear Curve intersecting the horizontal axis at a certain positive unemployment level (Figure 3 – The scatter diagram of the rate of change of wage rates and the percentage unemployment for the years 1861-1957, Appendix). Despite that, the original non-linear functional form tended to drop out of favor in formulating latter empirical tests in this context (Gruen et al, 1999). Instead, the linear relationship generated the greater of interest by the economists when conducting empirical researches. One explanation for the tradeoff is that, for example through price of labor services, when unemployment is high, workers' bargaining power becomes less strong so firms do not need to offer higher nominal wage to hire additional workers. When unemployment is low, meanwhile, firms have to increase nominal wage to attract a worker to work for them. This results in the negative relationship between unemployment and the rate of change of nominal wage rates. With least squares approach and the percentage unemployment or the unemployment rate (U_t) as the economic-driving variable of interest, the original form initiated by Phillips (1958) was described as follows:

$$\pi_t = \alpha_0 + \alpha_1(U_t) \qquad ; \alpha_1 < 0 \tag{1}$$

Reappraising the original paper, Kaldor (1959), Lipsey (1960), Bowen and Berry (1963) as well as Hines (1968) approve this relationship. For instance, Lipsey (1960) reconsidered the same setting as Phillips (1958) but focused particularly on explanations for the negative relationship. Hines (1968) also added that the association was rather weaker overtime than stable. Bowen and Berry (1963), in addition, addressed that the relationship between wage increase and unemployment was stronger if considering the rate of change of unemployment instead of its level. Even though Phillips (1958) explained wage inflation, most of subsequent empirical applications have been formulated in terms of price inflation according to the claim by Gordon (1997) that price inflation is one of the goals of macroeconomic policy (Gruen et al., 1999). Therefore, latter researches found a similar relationship between unemployment and price inflation (Romer, 2011). In combination with Okun's law (1962) that higher output is associated with lower unemployment, the (negative) unemployment-inflation tradeoff implies a positive output-inflation relationship. Supported by theory and many pieces of empirical evidence, this finally leads towards the proposition of the traditional Phillips Curve that the nominal variable, i.e. inflation could negatively affect the percentage unemployment (the unemployment rate) while positively affect the log of real output (in percentage) as illustrated below:

$$\pi_t = \alpha_0 + \alpha_1(U_t) \qquad ; \alpha_1 < 0 \tag{1}$$

$$\pi_t = \alpha_0 + \alpha_1(lnY_t) \qquad ; \alpha_1 > 0 \tag{2}$$

Where $\pi_t$is either wage inflation or price inflation. The percentage unemployment (the unemployment rate) is represented by U_t which is already in percentage. Y_t is the real GDP and then lnY_t is its logarithm form to be interpreted in percentage.

(2) The empirical downfall and criticism

Around the early 1970s, the traditional Phillips Curve started to perform badly to fit the actual data. For example, it could not explain the situation of stagflation in which unemployment increased together with accelerating inflation observed in the U.S. (Motyovszki, 2013). In the theoretical and empirical way, moreover, it was attacked by Samuelson and Solow (1960) who reported that there was no such stability of the negative relationship for the U.S. Following the criticism, the monetarists, Friedman (1968) and Phelps (1967, 1968) made a significant change by exploiting "the Natural Rate hypothesis" to re-specify the model specification of Phillips Curve.

The important idea is that employees work more only if they earn higher wages relative to prices of goods. Similarly, employers produce more only if they earn higher prices relative to wage cost they need to pay. At the end, both of them concern over real purchasing power rather than nominal money earned. The downward-sloping Phillips Curve is concluded to exist only in the short run where money illusion makes the economic agents under- or over-estimate price or wage level. Through time they learn to expect about inflation; therefore, in the long run the Phillips Curve turns vertical at the natural rate of unemployment. In contradiction to the stable relationship claimed in Phillips (1958), this conclusion points out 2 main components needed considering. On one hand, there is a 'natural' rate of unemployment which a monetary policy cannot keep unemployment below forever (Romer, 2001). This is empirically supported by the fact that both inflation and unemployment in 1981 and 1982 were much higher than they were at any time in the 1960s, proving that there might be a minimum rate of unemployment. On the other hand, inflation expectation has an essential role. This is consistent with Mises (1953), Lerner (1949), Lucas Jr. and Rapping (1969) as well as Lucas (1976) all of whom suggested reconciling the Phillips hypothesis with the axiom of anticipated inflation theory.

"Supply shock", in addition, is the other source of the failure of the traditional Phillips Curve and helps explain stagflation through decreasing in aggregate supply. The most compelling evidence in the U.S. is an oil price increase in 1973-74 which caused firms to charge higher prices for any given wages.

Not including supply shock variables creates a potential omitted variables problem because supply shocks, for example a sharp rise in energy prices and a sudden flooding of new labors into the labor force, can create a negative correlation between inflation and the output gap, which implies a downward bias in the estimated coefficient on the output gap (Turner and Seghezza, 1999). For example, an oil price hike might be directly carried into higher consumer prices, but might also lead to lower capacity utilization and higher unemployment; hence, not only unemployment but also capacity utilization have to be entered as explanatory variables in the model to identify the partial effect of the oil price shock on consumer price movement. Controlling for shocks is therefore important in re-specification of the Phillips Curve.

Above all, the permanent tradeoff relationship between inflation and unemployment by Phillips (1958) does not provide an accurate description enough for the inflation dynamics.

2.1.2 The expected-inflation augmented Phillips Curve

(1) Theoretical argument

As the traditional Phillips Curve was unable to explain the inflation dynamics during the late 1960s until the 1980s, the expected-inflation augmented Phillips Curve model was originated. The monetarist's arguments and supply shock were taken into account in modeling the new version of Phillips Curve with 3 main assumptions according to Romer (2011): first, wages and prices are not completely unresponsive to current state of the economy (they are not sticky forever); second, the model allows for supply shock effects; and finally, agents' adjustment to past and expected future inflation comes into action. However, the model ignores microeconomic foundations for a moment.

In the beginning, based on the Friedman-Phelps accelerationist principle the inflation expectation wass simplest adjusted by a fraction of the previous forecast error. This means that expected inflation is adaptive or backward-looking, which is $\pi_t^* = E_t(\pi_{t+1}) = \pi_{t-1}$ (Humphrey, 1985). This model fitted data, for example in the 1980s when there is a combination of high inflation and high unemployment in response to contractionary demand with inflation starting from a high level. At that time, the potential unemployment was 6% to 7%; once unemployment fell below the level, inflation began to increase, which led to the tradeoff as predicted by Phillips Curve theory. When unemployment returned to the potential range, inflation was back to the steady state (Romer, 2011). Nevertheless, inflation expectation based only on previous information is irrational as agents appear to neglect all available information about future. The adaptive inflation expectation thus came across criticism (Motyovszki, 2013). Therefore, the rational expectation theories, including Lucas (1972), Sargent and Wallace (1975), as well as Barro and Fischer (1976) are additional considered in the model. As a result, the typical expected-inflation augmented Phillips Curve is generalized into 2 different forms, depending on a measure of economic-driving variable below with the same prediction of signs as the traditional Phillips Curves:

$$\pi_t = \pi_t^* + \alpha_1(U_t - \widehat{U_t}) + \varepsilon_t \qquad ; \alpha_1 < 0 \qquad (3)$$

Or

$$\pi_t = \pi_t^* + \alpha_1(lnY_t - ln\widehat{Y_t}) + \varepsilon_t \qquad ; \alpha_1 > 0 \qquad (4)$$

Where $\widehat{U_t}$and $ln\widehat{Y_t}$ are the natural rate of unemployment and the potential level output respectively; these represent the level of unemployment or output that would prevailing if prices are fully flexible. The term $\alpha_1(U_t - \widehat{U_t})$ and $\alpha_1(lnY_t - ln\widehat{Y_t})$ implies log-linear relationship for simplicity. Supply shocks are accounted for in ε_t. Particularly, a process of inflation expectation introduced lies through a core inflation,π_t^*, which can be measured in 3 alternatives (Romer, 2011):

(1) The pure backward-looking Phillips Curve, $\pi_t^* = \pi_{t-1}$, where $\pi_{t-1}$is the previous period inflation

$$\pi_t = \pi_{t-1} + \alpha_1(U_t - \widehat{U_t}) + \varepsilon_t \quad ; \alpha_1 < 0 \quad (5)$$

Or

$$\pi_t = \pi_{t-1} + \alpha_1(lnY_t - ln\widehat{Y_t}) + \varepsilon_t \quad ; \alpha_1 > 0 \quad (6)$$

With this formulation, unemployment and output must equal their own natural rates to make inflation steady as a certain level. To decrease inflation, unemployment must be above the natural rate while output must be below the potential level.

(2) The pure forward-looking Phillips Curve: $\pi_t^* = E_t(\pi_{t+1})$ where $E_t(\pi_{t+1})$is expected inflation

$$\pi_t = E_t(\pi_{t+1}) + \alpha_1(U_t - \widehat{U_t}) + \varepsilon_t \quad ; \alpha_1 < 0 \quad (7)$$

Or

$$\pi_t = E_t(\pi_{t+1}) + \alpha_1(lnY_t - ln\widehat{Y_t}) + \varepsilon_t \quad ; \alpha_1 > 0 \quad (8)$$

With this formulation, only if inflation expectations are totally irrational, policy can raise output above the potential level or can decrease unemployment below the natural rate permanently. Otherwise, those two cyclical economic-driving variables eventually are back to the natural/potential level in the long run.

(3) The hybrid Phillips Curve: $\pi_t^* = \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1}$ where $\alpha_2 + \alpha_3 = 1$

$$\pi_t = \alpha_1(U_t - \widehat{U_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \varepsilon_t \quad ; \alpha_1 < 0 \quad (9)$$

Or

$$\pi_t = \alpha_1(lnY_t - ln\widehat{Y_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \varepsilon_t \quad ; \alpha_1 > 0 \quad (10)$$

With this compromise formulation, agents take a weighted average of past inflation and expected inflation when forming their expectation. As long as α_2 and α_3 is strictly less than 1, there is a link between past and future inflation beyond effects operating through expectations. This means there is inertia of inflation (Romer, 2011).

(2) The empirical downfall and criticism

Under the expected-inflations augmented Phillips Curve, the negative relationship between inflation and unemployment holds in the short run. The only point left subjected to criticism is that the model lacks microeconomic foundation; there is no microeconomic analysis of behaviors of the economic agents which underpins a macroeconomic theory (Barro, 1993). This criticism was strongly provoked by rational expectation school of thought in the 1970s led by Robert Lucas and Thomas Sargent.

The principal microeconomic rationale required is nominal rigidities in a sense that nominal prices or nominal wages need some time to completely adjust to the aggregate demand shift. With this assumption, not all the markets can be clearing instantaneously. Hence, unemployment may divert from the level it would be in the long run when price are fully flexible. In conclusion, not only could the money illusion resulting from expectation errors by the economic agents drive the unemployment-inflation tradeoff, but also the nominal rigidities. For example, menu costs, strong negotiation power of labor unions and long-term labor contracts. In conclusion, the modern models of Phillips Curve have featured both rational expectations and additional form of micro-foundation. We know it as the New Keynesian Phillips Curve which is the most influencing structure in conducting research over the past few years and can be viewed as a dynamic extension of the static new Keynesian models of price adjustment (Mankiw, 2001).

2.1.3 New Keynesian Phillips Curve (NKPC)

(1) Theoretical argument

The New Keynesian Phillips Curve (NKPC) was developed in order to close the departure gap of the actual data from what the traditional Phillips Curve predicts. Accepting the criticism, several of researchers applied different approaches to sync the microeconomic idea of nominal rigidities to the expectation-augmented Phillips Curve by introducing a degree of price stickiness (Abbas and Sgro, 2011). Among a large number of papers, Fischer (1977), Phelps (1978), Taylor (1979), Rotemberg (1982) and Calvo (1983) achieve wider recognition. Despite same purpose, they provided empirical tests with different methodologies, model specifications and channels through which nominal rigidities are represented.

To lay the microeconomic foundation, Fisher (1977) and Taylor (1979) introduced nominal rigidities by injecting overlapping long-term labor contracts as an element of wage stickiness. Fisher (1977) referred to the rational expectation model of Sargent and Wallace (1975) and argued that a monetary policy could affect real output if there are long-term contracts due to the existence of wage negotiation which provides temporary wage rigidity. Taylor (1979) used his own rational expectation models (1978, 1979) instead to lend the support to the idea that both contract formation and expectations are important components of inflation dynamics. Instead of wage stickiness, Rotemberg (1982) and Calvo (1983) justified price stickiness, mainly for a reason that a price setting is costly. For example, firms must bear subjective costs in a sense that frequent price changes can upset customers and in a particular study setting, firms can change prices only when they receive a price-change signal. The high transaction cost of price adjustment was also supported by Barro (1972) and Sheshinski and Weiss (1977) both of which argued that there are real costs associated with the transmission of price information to consumers and with the decision process itself. Beyond the sticky price model, Domberger (1979) computed speed of price adjustment towards the desire level. Instead of using the standard sticky-price model, in contrast, Mankiw and Reis (2001) explored a dynamic model of price adjustment by proposing the sticky-information model. In this model, prices are always changing, but the decision makers are slow to update their pricing strategies in response to new information. Above all, the researchers suggested 2 important components of explanation for inflation dynamics – nominal rigidities and rational expectation – not be overlooked.

Even though those earlier models already enhanced understanding of the inflation dynamics with well-specified rational settings, successive researchers continued improving the model by applying a variety of data constructions, model specifications, estimation techniques as well as proxies of such variables as inflation and output. Among the number of papers, the models specified in Abbas and Sgro (2011) principally derived from Calvo (1983) is chosen as a main reference for this thesis's empirical models for several reasons. First, many modern models of inflation are derived from Calvo (1983) as it provides analytically-convenient expressions (Fuhrer and Moore, 1995). In addition, it is regarded as a useful reduced-form for capturing the factors that contribute to nominal sluggishness (Christiano, 2005). Second, Abbas and Sgro (2011)'s paper itself deeply studies validity of the NKPC with alternative estimators, namely OLS, 2SLS, and HAC-robust GMM including a variety of instrument variables to show how robust results are. It does not provide only reduced-form coefficient α_x reflecting the overall relationship but also structural estimates, a measure of price rigidity θ, on which the main estimates α_x structurally underlies so that we can see how long prices are fixed on average. Moreover, other than the baseline models addressing the predominance of forward-looking component, the hybrid model is studied to assess the degree to which the NKPC accounts for the inertia in inflation. Lastly, the model is initially based on closed economy which is a good start for conducting research.

In the context of Abbas and Sgro (2011), the NKPC related current inflation to the expected inflation and real economic activities, namely output and real marginal cost. In addition, they particularly offered support for the forward-looking component over the backward-looking one in explaining inflation dynamics; this is in line with the earlier paper of Gali and Gertler (1999), Gali et al. (2001), and Nunes (2010). As a result, they first built a baseline model which was pure forward-looking-based and after that relaxed the model by allowing for a subset of firms to use a backward looking rule-of-thumb into the models. Both models were derived in a monopolistic competition with identical firms producing differentiated products and facing similar restriction in price optimization. Moreover, the price elasticity of demand was assumed to be constant across firms. More importantly, employing the prominent assumption of Calvo (1983) that simplifies profit maximization problem of Taylor (1979), in a given period each firm optimizes prices with probability of$1-\theta$, i.e. equal to the discounted average of marginal cost while remains prices unchanged from the lagged price level with probability of θ. This is simpler in a sense that the adjustment probabilities are independent of the firm's price history (Gali and Gertler, 1999). Also, this assumption was widely adopted by many papers, including King and Wolman (1995), Yun (1996), Woodford (1996) as well as McCallum and Nelson (1998).

In general, the reduced- and structural-form equations of both types of NKPC model specifications are described in 2 different forms, depending on a measure of economic-driving variable with the same prediction as the traditional Phillips Curves and the expected-inflation augmented Phillips Curve:

First, *the baseline model* takes the form:

$$\pi_t = \alpha_1\left(U_t - \widehat{U_t}\right) + \beta E_t(\pi_{t+1}) \qquad ; \alpha_1 < 0 \qquad (11)$$

Or

$$\pi_t = \alpha_1\left(lnY_t - ln\widehat{Y_t}\right) + \beta E_t(\pi_{t+1}) \qquad ; \alpha_1 > 0 \qquad (12)$$

Where $\alpha_1 = \frac{(1-\theta)(1-\beta\theta)}{\theta}$ and $D = \frac{1}{1-\theta}$

Where $\pi_t$is current inflation and $E_t\pi_{t+1}$is its expected inflation. $U_t - \widehat{U_t}$ and $lnY_t - ln\widehat{Y_t}$ represent the deviation of the unemployment and the output from their steady states respectively. Structurally, the reduced-form slope coefficient of the economic activity variable (α_1) is a function of the underlying frequency of price adjustment or so-called price rigidity (θ) that governs the degree of price stickiness (i.e. the average period a price remains fixed, D) and the subjective discount factor (β). θ is the fraction of firms that keep their prices constant (Gali et al., 2001).

The important implications are as follows. First, since α_1 is decreasing in θ, the higher estimates of θ implies a lower estimate of α_1. This means greater price rigidity implies that inflation is less sensitive to movements in real marginal cost (Gali and Gertler, 1999). Second, If β=1, it implies that the long-term Phillips Curve is vertical and thus that the inflation-output relationship will cease to exist in the long run (Masso and Staehr, 2005).

Second, *the hybrid NKPC* takes the form:

$$\pi_t = \alpha_1\left(U_t - \widehat{U_t}\right) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} \qquad ; \alpha_1 < 0 \qquad (13)$$

Or

$$\pi_t = \alpha_1\left(lnY_t - ln\widehat{Y_t}\right) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} \qquad ; \alpha_1 > 0 \qquad (14)$$

Where $\alpha_1 = (1-\omega)(1-\theta)(1-\beta\theta)\emptyset^{-1}$

Where $\begin{bmatrix} \alpha_2 = \beta\theta\emptyset^{-1} \\ \alpha_3 = \omega\emptyset^{-1} \\ \emptyset = \theta + \omega[1 - \theta(1-\beta)] \end{bmatrix}$ and $D = \frac{1}{1-\theta}$

The fraction of $1 - \omega$ of firms is assumed to be forward-looking and set prices using all available information at time t. The remaining firms with fraction ω, in contrast, are backward-looking and instead use a simple rule-of-thumb based on the recent history of aggregate price behavior. In addition, α_2 and α_3 are weights attached to the expected inflation and lagged inflation respectively. If $\omega = 0$, all firms are forward-looking and then the hybrid model converges to the baseline one. The advantage of proceeding this way is that the coefficients of the hybrid Phillips Curve will be a function of two key parameters: the frequency of price adjustment (θ) and the fraction of backward looking price setters (ω). Note that the latter parameter provides a direct measure of the departure from a pure forward looking model needed to account for the persistence in inflation (Gali and Gertler, 1999).[1]

(2) The empirical downfall and criticism

According to Mankiw (2001), there are many appealing features of the New Keynesian Phillips Curve (NKPC). First, it gives some micro-foundations to the idea that the overall price level adjusts slowly to changing economic conditions. Second, it produces an expected-inflation augmented Phillips Curve resembling the model that Friedman and Phelps pioneered in the 1960s. Third, it is simple enough for theoretical policy analysis. As a result, this model has become the workhorse for recent researches in this area. Nevertheless, there are 3 explanations behind the possible failure of the NKPC derived from the Calvo (1983)'s model: First, with the model in which price setters are forward-looking, there exists counter-factual disinflationary booms – the situation that output increases but inflation decreases; this clue was found in Ball (1994). While the theory instead states that inflation increases in output, Ball (1994) demonstrated that with staggered adjustment and credible policy, quick disinflations cause economic booms rather than recessions (Fuhrer and Moore, 1995). Therefore, the staggered price representing nominal rigidity in the NKPC is not sufficient condition to explain the case of disinflation. Second, Fuhrer and Moore (1995) indicated that the model had trouble generating the high degree of inflation persistence while inflation is a highly persistent variable in the real data. Last, the NKPC model delivers an immediate response of inflation to the monetary policy shocks, which contradicts the fact that the response of inflation to monetary shocks is gradual. In detail, The NKPC is incapable of generating empirically plausible impulse response functions – the dynamic path of variables (in this case, inflation and unemployment) in response to some shock (in this case, a shock to monetary policy). The delayed and gradual effect of monetary policy on inflation also shows up in most empirical work and in the reality. For example, Paul Volcker started his historic disinflationary policy in the U.S. in October 1979, but the big declines in inflation came in 1981 and 1982 (Mankiw, 2001).

In sum, the dynamic relationship between inflation and unemployment remains a mystery. The so-called NKPC is appealing from a theoretical standpoint but it is ultimately a failure. Due to the remaining puzzles to be solved, the economist have not yet rejected the short-run relationship between inflation and economic-driving variables but instead tries to explain it with alternatives of samples, data types, models, methodologies and study scope, i.e. closed and open economy. Until now, the NKPC has been in interest and a large number of empirical papers in this area have been published and developed accordingly.

[1] The main implication is that imposing the restriction $\alpha_2 + \alpha_3 = 1$ means no long-run relationship between inflation and a real economic activity (Nason and W. Smith, 2008a). This restricted model with systems estimators was also studied by Linde (2005) and Rudd and Whelan (2006).

2.2 Empirical evidence

As described in the theoretical framework, the original Phillips Curve initiated by Phillips (1958) failed to explain subsequent data, leading to the central issues of the presence and nature of the short-run inflation dynamics which become one of the most heated debated issues. In response to the challenge, the expected-inflation augmented Phillips Curve and the New Keynesian Phillips Curve (NKPC) have emerged as the center pieces of macro-conference of the inflation dynamics and the evolution of monetary policy (Gordon, 2011).

2.2.1 The expected-inflation augmented Phillips Curve

Gruen et al. (1999) studied the expected-inflation augmented Phillips Curve. They estimated non-linear Phillips Curve as actually discovered by Phillips (1958) that the inflation-unemployment was rather convex. Allowing the natural rate of unemployment (NAIRU) to vary overtime and including a role of import prices also for Australia, they concluded that the model achieved success as a framework for monetary policy in the beginning but its prominence declined when excess money growth came to be seen as the root cause of inflation. With the panel data of OECD countries instead of time series, Dinardo and Moore (1999) showed the robust relationship between inflation and unemployment with the claim that the expected inflation and supply shocks mattered a great deal in the estimation; this is in agreement with Gordon (1997) and Turner and Seghezza (1999) which tested for a richer set of supply-shock explanatory variables and for explicit forward-looking expectations of inflation. Their results provided support for regular re-specification of the traditional Phillips Curve across OECD countries and proved that the expected-inflation augmented Phillips Curve did work well in explaining the inflation dynamics during 1970s, the period in which inflation could not be explained by the traditional Phillips Curve. On the contrary, extending Murphy (2014) by allowing its slope to vary overtime, Murphy and Hill (2016) employed Ordinary Least Squares to study the Friedman-Phelps accelerationist Phillips Curve and confirmed that the slope of the Phillips Curve has decreased over recent decades and is close to zero today, implying that the model had become less sensitive to economic activity. To sum up, although this model could perform well in tracking inflation, there was a significant departure from the accelerationist Phillips Curve – the original version by Friedman (1968) and Phelps (1967, 1968) – where the expected inflation is only simplest adjusted by a fraction of the previous forecast error.

2.2.2 The New Keynesian Phillips Curve (NKPC)

In the recent decades, a great number of important advances have focused on re-modeling of the inflation dynamics. Most of them are built on the early prominent work by Fischer (1977), Taylor (1980), and Calvo (1983) that emphasized staggered nominal wage and price setting by individuals who are rather forward-looking than backward-looking. This explicit use of the micro-foundations places additional structure on the Phillips Curve relationship (Gali and Gertler, 1999). With reference to a large number of research papers, however, reconciling this new version of the Phillips Curve with the actual data is not a simple task. Even the claim that there is at least a short-run tradeoff between inflation and unemployment still remains controversial; some readers argue against this principle with a firm belief that the inflation-unemployment tradeoff is just a speculative idea (Mankiw, 2001). In the introduction phase of a simple NKPC model around the ends of 1900s and the early of 2000s several predominant empirical papers were published. For instance, Parkin (1973), Fuhrer and Moore (1995), Fuhrer (1997), Gali and Gertler (1999), Gruen et al. (1999), Dinardo and Moore (1999), Turner and Seghezza (1999), Gali et al. (2001), Mankiw and Reis (2002) and Sbordone (2002).

In the very early stage, Fuhrer and Moore (1995) examined the concept of inflation persistence. The inflation persistence is one aspect of the inflation dynamics. They used a standard dynamic stochastic general equilibrium (DSGE) model to estimate both of reduced-form and structural-form of parameters. Contrary to the theoretical prediction, they concluded that the NKPC did not capture the statistically-significant impact of economic activities on inflation in the U.S. and Europe area. Mankiw and Reis (2001), Gali and Gertler (1999), Gali et al. (2001) and Sbordone (2002), in contrast, commonly concluded that the NKPC provided a good approximation to the inflation dynamics. With the sticky-information model to explain mechanism behind the nominal rigidity, Mankiw and Reis (2001) concluded that the change in inflation was positively correlated with the level of an economic activity. Gali and Gertler (1999) used the generalized method of moments (GMM) to estimate both baseline and hybrid NKPC and drew the conclusion that the NKPC well-explained the inflation dynamics for the U.S. during 1960 and 1997. More importantly, they showed stronger support for forward-looking behavior than backward-looking in description of inflation dynamics. In-depth, the backward-looking component was important but limited in quantitative perspective while the forward-looking component was important in both statistical and economic aspects. They found also that the average duration of fixed prices representing the degree of price stickiness was about one year; this number viewed considerable enough to be regarded as rigidity and it is in line with the results of the survey. Using the GMM estimates with alternative instrument variables, this finding is subsequently approved by Sbordone (2002) which tested on the U.S. data of 1960 to 1997 and Gali et al. (2001) on the European data over 1970 to 1998. Based on several papers, the NKPC in fact explained the European inflation better than the U.S. inflation. In-depth, most papers found that the inflation dynamics in Europe appeared to have stronger forward-looking component. Moreover, the empirical model of Gali et al. (2001) successfully captured the phenomenon of high inflation of the 1970s, of disinflation of the 1980s, and of the low inflation currently. Conversely, Fuhrer (1997) suggested the forward-looking behavior be unimportant because the role of the future inflation in estimating the inflation-output gap relationship for the U.S. during 1966 and 1993 was negligible.

In comparison with earlier papers focusing on the short-run relationship, Parkin (1973) focused specifically on the long-run tradeoff between inflation and unemployment for Australia and confirmed what proposed in the Phelps-Friedman hypothesis that there is no relationship in the long run. In the short run, however, only weak Phillips Curve relationship existed. If demand management policies were able to maintain a steady state of inflation, the unemployment level would be lower when the chosen inflation was higher. In details, in the short run the inflation may be reduced by allowing unemployment to stand above its natural rate. Meanwhile, there is an unemployment rate at which the inflation turns to be steady in the long run. This is also in line with Jonson et al. (1973) which examined the determinants of average weekly earnings in Australia and pointed out that there was no long-run tradeoff between the rate of inflation and the state of the labor market in Australia.

(1) Developed countries

In the simple closed economy, employing the widely-used GMM techniques with instrument variables, Masso and Staehr (2005) did research to uncover the determinants and dynamics of the inflation process in the Baltic countries: Estonia, Latvia and Lithuania. With panel data estimations, they found satisfactory results statistically and economically in support of the New Keynesian Phillips Curve (NKPC). In particular, they concluded that both forward- and backward-dynamics played a role in explaining the inflation dynamics, which is consistent with Hansen and Pancs (2001) for Latvia and Bardsen et al. (2004) for the U.S. data. Moreover, they lent support to (industrial) output gaps as a better proxy of economic-driving variables than the unemployment gaps. In the same way, Jondeau and Le Bihan (2005) showed importance of both forward- and backward-looking components. Moreover, they stated that in most cases of the European countries, the hybrid NKPC worked better when introducing extra lags and leads. From studying the hybrid NKPC which included both backward- and forward-looking components, many papers clearly determined which type of individual behavior is more important in determining the inflation movement. Following Gali and Gertler (1999), both Linde (2005) and Rudd and Whelan (2005b) are examples of backward-looking supporters. In contrast, relatively-newer papers followed Fuhrer (1997) which claimed that the forward-looking component was more dominant, e.g. Paloviita (2006), Kuttner and Robinson (2010), Gordon (2011) and Abbas and Sgro (2011). For instance, Paloviita (2006) which applied both OLS and GMM techniques showed that the baseline pure forward-looking was sufficient to understand inflation behavior in economies. Likewise, Abbas and Sgro (2011) showed that the pure forward-looking NKPC better explained the Australian inflation dynamics. They added that neither output gap nor marginal cost was found to be a key economic-driving force of the inflationary dynamics. Similarly, Jean-Baptiste (2011) found that survey-based inflation forecasts made the Phillips Curve predominantly forward-looking for France.

Extending closed economy to open economy, Leu (2011) estimated the Structural Vector Autoregression (SVAR) model for Australia. In conversion to the global Phillips Curve, foreign prices become crucial factors. This is consistent with Batini et al. (2005) and Masso and Staehr (2005) showing that imported inflation drove a large part of inflation. Leu (2011) pointed to two main conclusions that a large fraction of firms was backward-looking in setting prices in one hand and output gap was a significant economic-driving variable in the other hand. Instead of a single country, Medel et al. (2014) studied the global inflation dynamics for the prediction of national inflation rates in 31 countries. Their findings indicated that the international inflation measure had a predictive value. Compared between closed-economy and the open-economy setting, Rumler (2007) employed the GMM method for 9 European countries and found that the open-economy NKPC outperformed the closed-economy one. The outperformance of the open economy framework was later confirmed by Abbas et al. (2016) which also investigated the relationship between 'globalization' and 'inflation' for Australia, Canada, New Zealand and UK. They concluded that the NKPC incorporating intermediate imports prices as production inputs in the marginal cost had higher explanatory power for the inflation process compared to the terms of trade and the real exchange rate specifications.

In case of the U.S., Neiss and Nelson (2005), Dufour et al. (2006) and Nunes (2010) showed that the hybrid NKPC was the best model to explain the U.S. inflation dynamics. However, they confirmed the dominant role of the expected inflation as claimed by Gali and Gertler (1999). In contrast, Zhang et al. (2008), Zhang et al. (2009) and Castle et al. (2010) used structural breaks to check the stability of the estimates obtained. All of them showed that the coefficient on expected inflation is not stronger than lagged inflation; this is also in line with Adam and Padula (2011).

(2) Developing countries

In the simple closed economy, with the stationary test Al-zeaud (2015) examined the inflation-unemployment relationship for Jordanian economy over the period of 1976 to 2013. The study confirmed that the negative relationship was present with the minimum limits of inflation and unemployment, proving that there was the potential level of unemployment as suggested by Friedman (1968) and Phelps (1967, 1968). This result is consistent with Furuoka et al. (2003) and Furuoka (2007) which discovered the relationship for Philippines and Malaysia respectively. Zhang and Murasawa (2011) employed the GMM instead to investigate the NKPC. They concluded that the new output gap measure was a valid driving-force for Chinese inflation. Mehrotra et al (2010) tested the validity of the NKPC with the probit analysis and regional data instead and suggested the forward-looking component and the output gap be important inflation drivers. The earlier paper, Du Plassis and Burger (2006), likewise approved of the merits of the NKPC in describing the inflation dynamic in South Africa.

Extending closed economy to open economy, Prasad-Sahu (2013) examined the short-run inflation dynamics in India by estimating an open-economy version of the hybrid NKPC and found that this version of the NKPC provided a robust explanation of the dynamics of both wholesale price index inflation and manufacturing sector inflation over the sample period. Therefore, economic agents were guided by both backward- and forward-looking behaviors. Moreover, the output gap and the foreign inflation were underlying determinants of the inflation in India. This is confirmed by the finding of Mostafa Kamal (2013) that Indian firms followed both backward- and forward-looking behavior. The difference is he claimed that the real marginal cost and the exchange rate pass-through played an important role in inflation dynamics. Cheng et al. (2009) also achieved the result that globalization were important causes in leading to the flattening NKPC in Taiwan.

In case of Thailand, distinct results about the individual behavior in forming inflation expectation are found. Bhanthumnavin (2002) results strongly supported the backward-looking behavior. On the contrary, recent papers including Sakurai (2016) stated that the NKPC in Thailand was relatively forward-looking. Manopimoke and Direkudomsak (2015) studied the impact both of domestic factors and global factors in driving the Thai inflation by extending the closed-economy NKPC of Kim et al. (2014) to an open economy framework. They discovered that the Thai inflation dynamics has undergone structural shifts in 2001 and 2007 since global oil prices played a greater role in determining the overall price movement. The importance of oil prices are also confirmed by Direckudomsak (2016) which concluded that the inflation variability was worldwide phenomenon that coincided with accelerating globalization. In particular, global factors such as Dubai oil prices and exchange rates change the inflation dynamics in Thailand. More importantly, the global output gap was claimed to be more important than domestic one. In addition, the paper published by IMF in 2017 addressed importance of import price inflation even though Bhanthumnavin (2002) showed that this factor did not attach considerable significance to the inflation dynamics. Bhanthumnavin (2002) showed that the Phillips Curve relationship emerged in Thailand only after the Asian financial crisis, suggesting the potential structural break at time of the Asian financial crisis. In brief, all of these place emphasis of inclusion of the oil prices, the import price inflation and the crisis dummy as explanatory variables in the models of inflationary dynamics, especially of Thai setting which is the main focus of the thesis.

(3) Result sensitivity to proxies

The different results of the validity of the NKPC model are partly due to a chosen proxy of the main cyclical economic-driving variable to explain the inflation dynamics by researchers. Some papers worked with unemployment gap in the labor market such as Parkin (1973), Gruen et al. (1999), Dinardo and Moore (1999), Gordon (2008), Friedrich (2014), Chletsos et al. (2016) and Murphy and Hill (2016). For example, Murphy and Hill (2016) explained that the less sensitivity of inflation to economic activity was partly due to an inappropriate measure of economic activity used in the models.

Instead of the gap in the labor market, another group of researchers resorts to gaps in the goods market as a measure of economic-driving variables. Two major candidate measures are output gap and real marginal cost gap. Neiss and Nelson (2005), Zhang et al. (2009), Kuttner and Robinson (2010), Zhang and Murasawa (2011), Kumar Tiwari et al. (2013) and Valadkhani (2014) showed clear preference for output gap. Kumar et al. (2013), for example, determined that the output gap was able to predict the inflation dynamics. Further, Zhang and Murasawa (2011) which exploited the empirical success of the NKPC in explaining China's inflation dynamics with a new measure of the output gap – using the Bayesian multivariate Beveridge-Nelson decomposition method – showed that the new output gap was likely to be superior in the NKPC model. On the contrary, Gali and Gertler (1999), Gali et al. (2001), Woodford, 2001, Sbordone (2002), Guerrieri et al. (2010) and Reid and Rand (2014) are examples of papers showing that the real marginal cost is quantitatively important determinant of the inflation. They showed that the slope coefficient on the real marginal cost was positive and significant which is consistent with the theory while the one of the output gap is negative which is at odds with the theory. More specifically, most of them used unit labor cost calculated by wage share to GDP although Gali and Gertler (1999) mentioned that the degree of price rigidity was prone to be upward biased because the labor share was unlikely to be an accurate measure of real marginal cost. In the latter times, as a result, the unit labor cost becomes frequently-used. Abbas and Sgro (2011) gave the conclusion also that neither the output gap nor the real marginal cost were a key driving-force variable of the inflation across different set of instruments. It was due to strengths and weaknesses of each proxy for an economic-driving variable that searching for the most suitable one is still on-going.

Another central challenge to the NKPC approach is to find a good proxy for another essential component, inflation expectation term. Surprisingly, there is little discussion in the literature of this aspect (Gordon, 2011). As in the era of the expected-inflation augmented Phillips Curve, to remain a simple estimation, several papers such as Fuhrer and Moore (1995), Dinardo and Moore (1999) and Turner and Seghezza (1999) used lagged inflation as a proxy for it. Instead, Roberts (1997, 1998) argued that the NKPC fit reasonably well when using survey measures of inflation expectation instead of the traditional way earlier to estimate inflation expectation. This is in accordance with Jean-Baptiste (2011) which indicated that the survey forecasts did not improve only estimates of the NKPC but also the forecasting performance of inflation. In other words, the survey approach yields better both of in-sample and out-sample fit of the model. Similarly, Coibion and Gorodnichenko (2013) suggested household inflation expectations be good proxies for inflation forecasts by small firms. Therefore, most of recent papers prefer referring to the survey as a measure of inflation expectation than to the traditional method, i.e. lags of inflation alone.

3. Methodology

3.1 Model

3.1.1 The general full-form of the model

There are 2 general model specifications for each of main variables of interest which are output gap and unemployment slack. This is because of different expected sign of each variable predicted by the Phillips Curve principle. As described in the theoretical framework, the original paper by Phillips (1958) studied the relationship between (wage) inflation and the percentage unemployment or the unemployment rate (U_t); however, the relationship was later extended to take the natural rate of unemployment ($\widehat{U}_t$) into account according to the Natural Rate hypothesis by Friedman (1968) and Phelps (1967, 1968). Therefore, the deviation of the percentage unemployment from its deviation $\left(U_t - \widehat{U_t}\right)$ is considered as the main explanatory variable instead. When Okun's law holds, in the other way, the Phillips Curve implies a relationship between inflation and output; this relationship has also been widely studied by the economists. Therefore, the deviation of the log of output from its steady state $(y_t - \widehat{y_t})$ is the other measure of economic-driving variable considered. In sum, the 2 general model specifications of output gap and unemployment slack are derived as follows:

(a) The unemployment slack $\left(\boldsymbol{U_t} - \widehat{\boldsymbol{U_t}}\right)$

$$\pi_t = \alpha_0 + \alpha_1\left(U_t - \widehat{U_t}\right) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \alpha_z(Z_t) + \varepsilon_t$$

Or more specifically,

$$\pi_t = \alpha_0 + \alpha_1\left(U_t - \widehat{U_t}\right) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \alpha_4(D_t^{CRISIS}) + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \qquad (1)$$

(b) The output gap $(\boldsymbol{y_t} - \widehat{\boldsymbol{y_t}})$

$$\pi_t = \alpha_0 + \alpha_1(y_t - \widehat{y_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \alpha_z(Z_t) + \varepsilon_t$$

Or more specifically,

$$\pi_t = \alpha_0 + \alpha_1(y_t - \widehat{y_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \alpha_4(D_t^{CRISIS}) + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \qquad (2)$$

For the first specification in which unemployment slack is considered as a measure of an economic-driving variable, $U_t$is unemployment rate (%) and $\widehat{U}_t$is the natural rate of unemployment or so-called NAIRU. For the second specification in which output gap is considered as a measure of an economic-driving variable, $ln(Y_t)$ is defined as y_t to interpret it as percentage whereas Y_t is real GDP level and $\widehat{y}_t$ is the potential output level. In brief, the main variables of interest are $(U_t - \widehat{U_t})$ and $(y_t - \widehat{y_t})$ which represent their deviation from own steady state.

Moreover, $\pi_t$is current (price) inflation at time t, $E_t(\pi_{t+1})$ is its expected inflation, and π_{t-1} is first-lagged inflation. Z_t is a vector of control variables containing imported price inflation (π_t^{IMP}), oil prices ($Oilprice_t$), and a crisis binary dummy (D_t^{CRISIS}). As Thailand is a small open economy, Thai inflation dynamics have been influenced by globalization. Thus, taking imported price inflation and oil prices into account is necessary as both of them represent channels through which globalization could affect commodity price levels in Thailand based on the fact that Thailand is a net energy importer and exchange rate pass-through also directly affects domestic inflation through oil prices (Direkudomsak, 2016). The crisis dummy is also supposed to be important in capturing impact of structural shocks, i.e. a period of financial crisis. More specifically, in Thai data, the binary dummy is equal to 1 for 1997 to 1998 in which the Asian financial crisis was in effect and for 2007 to 2009 during which the Global financial crisis was in effect; it is 0 otherwise. Unobservable supply shock and measurement error are both captured by ε_t.

The reduced-form estimate is represented by α_1. According to the theory's prediction described in the literature review, α_1 is expected to be statistically-significantly negative in (1) and is expected to be statistically-significantly positive in (2). In order to further study into individual behavior, the magnitudes of α_2 and α_3 are compared to give an indication whether they are forward- or backward-looking, implying the inertia in inflation. The $\alpha_z$accounts for the coefficients of other control variables assumed to help explain inflation dynamics. Lastly, the constant term,α_0, captures time-invariant factors.[2]

3.1.2 Traditional Phillips Curve

The traditional Phillips Curve originated by Phillips (1958) is the first special case to study in this paper. On one hand, it is the original form which was a reasonable approximation of the historical record (Parkin, 1973). On the other hand, it subsequently motivates the use of the new specification, for example, the inflation-expectation augmented Phillips Curve and the New Keynesian Phillips Curve (Gali et al., 2001).

The traditional Phillips Curve relates the inflation rate with a measure of economic-driving variables, including a constant. As illustrated earlier in the literature review and in this section, this original form was studied either on the percentage unemployment or the unemployment rate (U_t) or on the log of output (y_t) because the Natural Rate hypothesis had not yet received recognition. In conclusion, the 2 distinct specifications of the traditional Phillip Curve can be derived subject to the assumption that all other explanatory variables except unemployment and output do not influence inflation movement ($\alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = 0$) as defined below:

(a) The unemployment rate (U_t)

$$\pi_t = \alpha_0 + \alpha_1(U_t) + \varepsilon_t \quad (3)$$

(b) The log of output (y_t)

$$\pi_t = \alpha_0 + \alpha_1(y_t) + \varepsilon_t \quad (4)$$

For the first specification, the percentage unemployment or the unemployment rate (U_t) is a measure of an economic-driving variable and then it is replaced with the log of output or the log real GDP (y_t) in the second specification. The reduced-form estimate of the main variable of interest is represented by α_1. Similarly, according to the theory's prediction described in the literature review, α_1 is expected to be statistically-significantly negative in (3) and is expected to be statistically-significantly positive in (4).

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[2] Further, the additional restriction that $\alpha_2 + \alpha_3 = 1$ can also be imposed, which implies that there is no long-run relation between inflation and real activity levels (Nason and W. Smith, 2008a).

3.1.3 The New Keynesian Phillips Curve (NKPC)

The New Keynesian Phillips Curve (NKPC) is the other special case to study in this paper. This form of the model is worth studying because it takes more perspectives into consideration. First, it is developed from the idea of the Natural Rate hypothesis, so it also includes the potential output and the natural rate of unemployment in the model. Second, the rational expectations and micro-economic foundation which is the nominal rigidity are considered. Among a few versions of the NKPC, the hybrid NKPC including both backward- and forward-looking components are focused in this study to directly investigate the relative important roles between them which implies the behavior of economic-agents in explaining the inflation dynamics.

The NKPC relates the inflation rate with a measure of economic-driving variables including the other two important components to capture the inertia of inflation – the lagged inflation and the expected inflation. As illustrated earlier in the literature review and in this section, the NKPC was studied based either on the unemployment slack $\left(U_t - \widehat{U_t}\right)$ or on the output gap $(y_t - \widehat{y_t})$ because the Natural Rate hypothesis is already widely approved and acknowledged. With the assumption that apart from unemployment slack and output gap, individual behavior becomes important determinant of inflation dynamics while the vector of three control variables are ignored for a moment ($\alpha_4 = \alpha_5 = \alpha_6 = 0$). In conclusion, the 2 distinct specifications in reduced-form of the hybrid NKPC are defined below:

(a) The unemployment slack $\left(\boldsymbol{U_t - \widehat{U_t}}\right)$

$$\pi_t = \alpha_0 + \alpha_1\left(U_t - \widehat{U_t}\right) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 \pi_{t-1} + \varepsilon_t \quad (5)$$

(b) The output gap $(\boldsymbol{y_t - \widehat{y_t}})$

$$\pi_t = \alpha_0 + \alpha_1(y_t - \widehat{y_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 \pi_{t-1} + \varepsilon_t \quad (6)$$

For the first specification, the unemployment slack $\left(U_t - \widehat{U_t}\right)$ is a measure of an economic-driving variable and then it is replaced with the output gap $(y_t - \widehat{y_t})$ in the second specification. The reduced-form estimate of main variable of interest is represented by α_1. Similarly, according to the theory's prediction described in the literature review, α_1 is expected to be statistically-significantly negative in (5) and is expected to be statistically-significantly positive in (6).[3]

3.1.4 Structural break

The exercise of structural break test is important for diving insights into the main objective of the thesis as it helps determine when and whether there is a significant change in the whole data. The Chow breakpoint test is applied to the 2 predetermined financial crises. In addition, the study covers both the during-crisis and the earliest two post-crisis years as follows:

Crisis (1) The Asian financial crisis

- During-crisis years : 1997, 1998
- Post-crisis years : 1999, 2000

[3] Further, the restriction $\alpha_2 + \alpha_3 = 1$ can also be imposed, implying no long-run relationship between the inflation and the real activity levels as suggested by a number of authors including Linde (2005), Rudd and Whelan (2006) as well as Nason and W. Smith (2008a).

Crisis (2) The Global financial crisis

- During-crisis years : 2007, 2008, 2009
- Post-crisis years : 2010, 2011

3.1.5 Sub-samples

The entire sample period, 1990 to 2017, will be split accordingly at the structural break points found in the Chow's break test to re-estimate the reduced-form parameters of the full-form of Phillips Curve which includes all explanatory variables except for the crisis dummy to avoid the duplicate of crises accounted.

3.2 Data and Proxy

The study of this thesis focuses on Thailand of which annual time-series ranges from 1990 to 2017, 28 years in total. For Thai data, the annual observations for most series are used thanks to the availability for a long time span. Meanwhile, monthly and quarterly data series are more difficult to obtain as the methodology of data collection has not fully been developed until the 1990s. All the variables used in this paper are described below:

3.2.1 Dependent variable

The main study of this thesis focuses on the rate of change of price index or so-called price inflation (π_t) instead of wage inflation because the use of prices in the context of policy interest is more common than wage; the price inflation is clearly one of the ultimate targets of macro policy (Gordon, 1997). The 2 proxies for price inflation are applied to figure out possible different results sensitive to the inflation measurements: log difference of Consumer Price Index (CPI); and log difference of GDP deflator. The type of CPI used is the headline CPI which is not adjusted for seasonality and the often-volatile elements of food and energy prices both of which are removed from the core CPI. The headline CPI inflation thus accounts for any inflationary spikes caused by highly volatile goods. With the headline CPI inflation, the total inflation within a country can entirely explained.

The data of the headline CPI is obtained from Bank of Thailand. Meanwhile, the GDP deflator is obtained from IMF – World Economic Outlook (WEO).

3.2.2 Independent variable

(a) Main independent variable of interest (the cyclical economic-driving variable)

The choice of capacity gap measure must be considered carefully. It pertains to 2 different markets, namely the labor market; and the output market. Therefore, the paper focuses on both the unemployment rate (U_t) which is a representative of the labor market and the log of output or log real GDP (y_t) which is a representative of the good market.

The data for the percentage unemployment (the unemployment rate) is obtained from Bank of Thailand; it is calculated by the unemployed percent of total labor force which covers persons with the age of 15 years and over. The data for the real GDP is obtained from the office of the National Economic and Social Development Board (NESDB); it is calculated based on chain volume measures. To account for the natural rate of unemployment in the labor market, unemployment slack $\left(U_t - \widehat{U_t}\right)$ is calculated by using Hodrick-Prescott filter to eliminate trend (which is the natural rate of unemployment) in the percentage unemployment to obtain only its cyclical component (which is the unemployment slack).

To account for the potential output, in the good market, the output gap $(y_t - \widehat{y_t})$ is calculated in 2 ways: first, use Hodrick-Prescott filter to eliminate trend (which is potential output) in the log real GDP to obtain only its cyclical component (which is output gap); and second, data of output gap is estimated by Oxford Economics by deducting potential output from real GDP and then multiply with 100. These 2 different proxies of the output gap allow for examining possible different results due to the sensitivity of the proxies.

(b) The additional explanatory variables accounting for individual behavior

In order to study individual behavior, I include both forward-looking and backward-looking behavior of individuals. The data for expected inflation is obtained from the IFO World Economic Survey (WES); the survey questionnaire focuses on qualitative information: assessments of a country's general economic situation and expectations regarding key economic indicators. Meanwhile, the first lag of inflation is calculated using command @lag (inflation, 1) in Eviews.

(c) The additional control variables accounting for global factors

To consider also the effect of globalization, I include import price inflation, percentage growth of oil price and crisis dummy. Import price inflation is calculated by log differencing of import price deflator of which data is obtained from Oxford Economics which tracks the change in the price for all goods and services imports. The percentage growth of oil price is also calculated by log differencing of Dubai crude oil price (USD/Barrel) of which data is at current prices (nominal rates) obtained from IMF – World Economic Outlook (WEO). Lastly, the dummy of crisis is generated to account for 2 major crises which either directly or indirectly affect Thai economy during the whole sample period: the 1997-98 Asian financial crisis; and the 2007-09 Global financial crisis.

3.3 Estimation method

The Ordinary Least Squares (OLS) with Heteroskedasticity and Autocorrelation Consistent (HAC) Covariance (Newey-West) is employed to estimates the reduced-form parameters. It is due to time constraint and high complexity of estimation, the structural-form parameters are left for future researches. This econometrics method is proposed by Newey and West (1987) to address the problem of the presence of both heteroskedasticity and autocorrelation under the assumption that the autocorrelations between distant observations die out. They use kernel methods to form an estimate of the log-run variance. Moreover, Eviews is a program used to run all the statistical results.

4. Empirical results

(1) The traditional Phillips Curve

The study is conducted on 4 different combinations of the traditional Phillips Curve based on 2 inflation measurements and 2 measures of economic-driving variables. The reduced-form estimates of these 4 traditional Phillips Curves are reported in Table 1 and Table 2. Regardless of a choice of inflation measurement, neither the unemployment rate nor the log real output yields the signs predicted by the theory. The estimates of the unemployment rate are statistically insignificantly positive opposite to the traditional Phillip Curve framework which suggests the (negative) tradeoff between inflation and the unemployment rate. In the same way, the log real output is either statistically significantly or insignificantly negative which contradicts the positive relation between inflation and the log real output predicted by the theory. Indeed, this can be suspected from Table 19 where the positive correlation between inflation and the unemployment rate and the negative correlation between inflation and the log real GDP are seen. For instance, the correlation of the headline CPI inflation with the unemployment rate and with the log real GDP are 0.1721 and -0.3292 respectively. Evidently, the signs are completely opposite to the theoretical prediction.

In conclusion, the traditional Phillips Curve does not hold for the Thai data over the full sample period – 1990 to 2017. The result is consistent across different proxies both for the dependent variable and for the explanatory variable. Hence, this finding is another piece of evidence for the failure of the Phillips (1958)'s idea and accordingly sides with Friedman (1968) and Phelps (1967, 1968) which proposed the natural rate hypothesis and addressed importance of individual's expectation of inflation.

(2) The New Keynesian Phillips Curve (NKPC)

As described in the literature reviews, the traditional Phillips Curve struggles to demonstrate the inflation dynamics since the early 1970s. The failure is also indisputable in this thesis, leading to a study further into the New Keynesian Phillips Curve (NKPC). Among 3 versions of the NKPC, the hybrid one is concentrated on because both forward- and backward-component are included at once; in this way the inflation inertia can also be examined. The study is conducted on 6 distinct models based on the 2 inflation measurements and the 3 proxies for an economic-driving variable: detrended percentage unemployment as unemployment gap, output gap calculated by detrended log real GDP with Hodrick-Prescott filter (HP filter) and output gap estimated by Oxford Economics. The reduced-form estimates of the NKPC are reported in Table 3 and Table 4.

For the Thai inflation dynamics during 1990 and 2017, all of the 3 economic-driving variables turn to be correctly signed as predicted by the theory, i.e. Phillips (1958)'s traditional Phillips Curve, Friedman (1968) and Phelps (1967, 1968) as well as Calvo (1983). In general, unemployment slack and output gap are found highly statistically significant at 1% in explaining the headline CPI inflation but lesser at 10% in describing the inflation dynamics measured by GDP deflator. This proves that the natural rate hypothesis is undeniable. In detail, the unemployment gap has statistically significantly negative effect on inflation both measured by headline CPI in Table 3 and by GDP deflator in Table 4 despite lesser significance when the inflation is measured by GDP deflator, i.e. at 90% confidence level. With the similar pattern as the regression on the unemployment slack, both of the detrended log real GDP and the output gap measured by Oxford Economics have statistically significant positive effect on the inflation dynamics both measured by headline CPI in Table 3 and by GDP deflator in Table 4. Once again, the lesser degree of statistical significance obtained when the inflation is measured by GDP deflator. All of these imply that the results are sensitive to the measures of inflation although both types of inflation appear to track each other closely on Figure 4.

The other key components of the hybrid NKPC model are expected inflation and lagged inflation both of which represent manner of individuals. They are highly statistically significant in explaining Thai inflation dynamics at least at 95% confidence level, indicating the essential role of agents' behavior as suggested by the expected-inflation augmented model and the NKPC. More specifically, the estimates of the expected inflation are highly statistically significantly positive at 1% significance level. Similarly, the estimates of the lagged inflation are statistically significant but at lesser extent, i.e. at least at 5% significance level. The backward component instead shows the negative sign. In comparison with the expected inflation, the (absolute) magnitude of the lagged inflation estimates is larger than expected inflation for all the 6 models in the study. This demonstrates that Thai people are more backward-looking in forming the expectation for future inflation; this is in line with several papers, namely Bhanthumnavin (2002), Khemangkorn et al. (2008) and Puzon (2009) claiming that for Thailand, past inflation influences people's expectations on future inflation. In addition, this appears to be realistic in that Thai people are typically influenced by religion, beliefs, and traditions; as a result, they are likely to anticipate changes in inflation based on the inflation history they have perceived rather than current economic climate and performance actually used in the survey, e.g. expectations regarding key economic indicators. The puzzling point is it is always that the expectation of inflation has a positive effect and the lagged inflation has a negative effect; there is no apparent explanation for this moment. In sum, by comparison with the traditional Phillips Curve, including 2 components reflecting behavior of individuals turn the estimated signs of the main variables to be consistent with the theory. Furthermore, it improves in-sample fit of the models measured by R-squared, adjusted R-squared and Standard Error of regression (see Table 16).

In conclusion, to explain the inflation dynamics of Thailand, the NKPC holds true at least during 1990 to 2017. Nonetheless, as a small open country with continuous-rising degree of trade openness since the 1990s, it is reasonable assumption that the global factors make contribution to explanation of Thai domestic inflation (Direkudomsak, 2016). Taking financial crisis, import prices, and oil prices as proxies for the global factors into account is assumed to improve the in-sample fit of the NKPC.

(3) The general full-form of Phillips Curve

As mentioned before, the additional control variables through which globalization influence incline to also help explain the Thai inflation dynamics. This assumption brings the dummy for financial crises, the import price inflation, and the growth of oil prices into the focus of the study. The study covers 21 models each of which is a combination varying across the 2 inflation measurements, the 3 proxies for an economic-driving variable, and the additional 3 controls variables. All possible cases which are one control added, two controls added and all three controls added are studies to examine how different each model performs. The reduced-form estimates of the full-form of Phillips Curve are reported in Table 5 to Table 12.

For the Thai inflation dynamics during 1990 and 2017, adding the 3 control variables remains statistical significance of the main variables, i.e. unemployment slack and output gap. Also, their signs maintain the same as predicted by the theory with a few exceptions and with the fact that the degree of the statistical significance varies from one proxy to another; this is slight different points compared to the results of the NKPC. For the unemployment slack displayed in Table 7 and Table 10, most of the estimates are statistically significant. For all different combinations of the 3 control variables, the unemployment slack highly explains the headline CPI inflation at 99% confidence level. Conversely, the inflation dynamics measured by GDP deflator cannot be well-explained by the unemployment slack; some estimates are mildly significant at only 10% significance level and some are insignificant even at 10% significance level. For output gap both measured by the detrended log real GDP shown in Table 8 and Table 11 and by Oxford Economics shown in Table 9 and Table 12, all estimates show statistically significantly positive sign. Similar to the case of the unemployment slack, the lesser degree of the significance obtained when the inflation dynamics is measured by GDP deflator: the output gap highly demonstrates the headline CPI inflation at 1% significance level but is able to explain the inflation measured by GDP deflator at least at 10% significance level. The results are again proved to be sensitive to measurement of the inflation.

Another two components of the full-form model are the expected inflation and the lagged inflation, representing manner of individuals. In most cases, both components keep playing a crucial role in explaining the Thai inflation dynamics. Similar to the NKPC, the expected inflation maintains statistically significant positive at 1% significance level. The lagged inflation also remains statistically significantly at least at 10% significance level in some case. It becomes insignificant in some cases, nevertheless. The latter case is widely observed in the regression of the inflation measured by GDP deflator on the detrended log real GDP. Consistent with the NKPC, the magnitude of the lagged inflation estimates are steadily (in absolute) larger than the ones of the expected inflation regardless of whether lagged inflation is statistical significant. This reaches the same conclusion and explanation as the findings of the NKPC that Thais are backward-looking as the overwhelming majority of them are conventional in their ways of life. The consistent signs of both components still remain puzzling.

Focusing on the 3 additional controls, the significance degree of each variable is dramatically sensitive to a choice of the inflation measurement and of a proxy of an economic-driving variable. At a superficial level, the growth of oil prices is the chief factor of all three added. This is in line with Puzon (2009) which pointed out that oil price shocks also influenced Thai inflation substantially from 1980 to 2005. The estimates of the oil price growth are not only statistically significant at least at 5%

significance level but also the significant estimates of it are founded in more cases compared to the other two control variables. In detail, the growth of oil prices are statistically significant at 1% significance level in explaining the headline CPI inflation but it turns insignificant even at 10% significance level when explaining the inflation measured by GDP deflator. For import price inflation, in contrast, the estimates show statistical significance in fewer cases; apparently seen when the headline CPI inflation is explained by the detrended log real GDP. This outcome supports the finding of Bhanthumnavin (2002) that the import price inflation was surprisingly small for such a small open economy, Thailand. The relatively-greater significance of the oil price growth and the relatively-smaller significance of the import price deflation is also discovered by Jongwanich and Park (2008), Manopimoke and Direkudomsak (2015), and Direkudomsak (2016) all of which pointed out that the main effect of global commodity prices are through oil prices as Thailand is a net energy importer with the real figure that the weight of the energy in the consumer price index basket account for 11.4% approximately. The situation is worse with the crisis dummy; its estimates barely show statistical significance. One possible reason is that the dummy is assumed to be 1 in years during which either the Asian financial crisis or the global financial crisis is in effect. The reality is, however, the latter event did not directly impact Thai inflation but rather influenced through oil prices (cost push factors) and interest rate (demand pull factors). Therefore, the effect of the 2008 crisis was relatively minor compared with that of 1997 (Sakurai, 2016). As a result, the insignificance of the crisis dummy in the statistical aspect is probably attributed to the relatively small effect of the 2008 global financial crisis on the Thai economy. As a matter of that fact, the indirect effect of the 2008 global crisis via cost push and demand pull factors simultaneously attaches more importance to the oil price growth as a control variable and simultaneously suggests including interest rate as another explanatory variable in further researches. Moreover, these 3 controls are found to explain the headline CPI inflation better than the inflation measured by GDP deflator, showing that the results are sensitive to the inflation measurement. This is not surprising as it is consistent with what learned from the NKPC. Another interesting point is related to their signs. Irrespective of statistical significance, the growth of oil prices and the import inflation are all positive as supposed to be: the higher global commodity prices and oil prices increase the domestic prices given an exchange rate. For the crisis dummy, on the contrary, its signs vary greatly from case to case, contradicting the expectation of positive sign as the crisis dummy also serves as supply shock (Puzon, 2009). As explained before, the credible explanation is the Asian financial crisis directly affects the domestic price levels while the global crisis does not.

Although the 3 additional variables do not consistently show statistical significance in all the models studied, it does not mean that these controls are not important in explaining Thai inflation dynamics and should be immediately removed from the model. In this thesis, there are valid reasons for including these control variables. First of all, adding at least one of the 3 controls improves the in-sample fit of the model measured by R-squared, adjusted R-squared and SE of regression (see Table 16), implying that the full-form of Phillips Curve fits the actual data of Thai inflation better than the prior two models. In addition, adding them maintains the statistical significance of the unemployment slack and the output gap with correct signs as theoretically predicted. This suggests the Phillips Curve is robust with these 3 control variables. Last of all, now that these controls are included, the setting of the study become more realistic as Thailand is an open economy relying on international trade, for example import of crude oil.

In conclusion, the full-form of Phillips Curve is a successful in explaining the Thai inflation dynamics with the improvement on the model in-sample fit compared to the NKPC. At least, this is verifiable for the Thai data of 1990 to 2017. After all, the major implication is that the Natural Rate hypothesis stays irrefutable, behavior of individuals are approved significant and the far-reaching one is that the global factors, especially global oil prices are good addition to the Phillips Curve models.

(4) Structural break

As illustrated earlier, the entire period of Thai data contains the years in which 2 deep financial crises had arisen. The first crisis is the Asian financial crisis of 1997. The second crisis is the global financial crisis of 2008. Under this circumstance, a structural break test makes good sense to conduct an in-depth study for 3 reasons. Firstly, when examining the visual look of inflation rates in Figure 4, the period during and after the 2 crises mentioned incline to be structural breakpoints of the whole period. The first remarkable point is that all the (core CPI, headline CPI, GDP deflator) inflation rates rose to the record high of the full sample period in 1998 when Thailand was in the financial crisis. In the recovery period, the inflation slumped to a record low in 1999 and surged up in the following year. This signals potential structural breaks somewhere around the 1997 financial crisis. The other striking moment is in 2009 in which all the inflation rates plunged to a new low, following the global trend hit by the global financial crisis and an upsurge noticed in the year after. This makes another sign of other potential breaks supposed to be somewhere around the 2008 global financial crisis. Moreover, the inflation rates of those possible structural breaks hardly reached the threshold set by the central bank of Thailand (BOT). Effective before 2015, BOT used core inflation as a monetary policy target by virtue of highly-volatile items excluded in order to avoid frequently adjusting policies. Despite that, the inflation measured by headline CPI and by GDP deflator closely follows the same pattern as the core inflation year over year as exhibited in Figure 4. In detail, the core inflation on target was 0 to 3.5 percent in the 1990s but the actual rates were barely in the desired interval, for example the core inflation rate of 1998 was up to 6.9 percent. Later in the late 2000s, the core inflation rate was narrowed to 0.5 to 3 percent and likewise the actual one in 2009 was only 0.2 percent which fell short of the target. Lastly, in the economic sense, the image of Thai economy was quite stable over the whole sample period except for the 2 financial crisis points. The financial crisis inevitably impact on economic indicators such as GDP growth and exchange rate; this points towards potential break points at the time of crises. Manopimoke (2015) indicated in the same way that the Thai inflation dynamics had undergone shifts in 2001 and 2007. Above all, it is noteworthy to examine stability of the obtained estimates from the full-form of Phillips Curve. The main question is whether the 2 financial crises are significant break points in statistical way; by doing so it is not imposing a structural break but merely allowing one to happen.

Since the structural break points are predetermined, the Chow's breakpoint test is employed. To delve into other hidden break points, the Quandt-Andrews breakpoint test proper for unknown breaks is thought of. Unfortunately, it cannot be applied even at the minimum 5 trimming percentage due to the limited number of observations in this time series. The full-form of Phillips Curve with all the explanatory variables except the dummy crisis is chosen for this study for 2 supportive arguments. First, the full-form of Phillips Curve is maintained to be the best in-sample fit and most realistic. Second, the crisis dummy is excluded to avoid duplicate consideration of crisis years. Testing the structural break provides different perspectives from the inclusion of crisis dummy in the model as done in Sub-section (3) in that it specifically investigates if each single crisis has a significant impact on inflationary dynamics instead of assuming the dummy to be 1 for both crises at a time.

The study is conducted on 6 cases of the selected full-form of Phillips Curve based on the 2 inflation measurements and the 3 proxies of an economic-driving variable. Both during-crisis year and post-crisis years are focused. According to Friedrich (2014), it is also vital to study consequence following the crisis: while the pattern of inflation during a crisis may behave as expected, their subsequent post-crisis evolution is harder to align with economic theory. Thus, the upcoming study covers both of the during-crisis and the post-crisis periods. For the Asian financial crisis, the during-crisis years are 1997 and 1998 while its post-crisis years are 1999 and 2000. The onset of this crisis is pinpointed on 2 July 1997 when Thai baht (THB) devalued more than 10% after massive speculative attack since 1996. Its impact kept spreading over other regions in 1998. After the crisis, Thai economy recovered by 2001. For the global financial crisis, the during-crisis years are 2007, 2008, and 2009 while its post-crisis years are 2010 and 2011. It began in 2007 when a housing crisis deepened in the US subprime mortgage market and triggered global panic when Lehman Brothers bankrupted in 2008. The recession ended by 2009 according to the US National Bureau of Economic Research (NBER) and the markets were finally stabilized in 2011.

Alongside the 95 percent confidence bands, the result of Chow's breakpoint test in Table 13 suggests 1999 and 2000 (post-Asian financial crisis) be common break points found for *nearly* all the 6 models considered. The tests reject the null hypothesis of no structural breaks within the entire sample period 1990 to 2017 at 5% significance level. In Table 13, for example, in the model with the headline CPI inflation and the unemployment slack (cycle unemployment), p-value of F-statistic is 0.0015 and 0.0108 in 1999 and 2000 respectively. Similarly, in the model with the inflation measured by GDP deflator and the detrended log real GDP p-value of F-statistic is 0.0511 and 0.0074 in 1999 and 2000 respectively. For some inexplicable reasons, the period during and after the 2007 global crisis is regarded as structural break points only in the model which is a combination of the headline CPI inflation and the output gap estimated by Oxford Economics. Clearly, this statistical result is consistent with the earlier examination of Figure 4. The result that only 1999 and 2000 (post 1997 financial crisis period) are statistical significant break points does make sense. Carefully reexamining Figure 4, the most noticeable points are indeed 1999 and 2000 in which both of the headline CPI and the GDP deflator inflation fell to the low level of the history in 1999 and surged up in 2000. This result is not a surprising when exploring what happened in the real world. The 1997 Asian financial crisis has more adverse impact on the Thai domestic price level compared to the 2007 global financial crisis due to the fact that the Asian crisis originated from Thailand but the global crisis did not. In depth, the inflation rates 'stably' remained high many years before the Asian financial crisis; this increased interest rates to be accordingly so the short-term foreign capital flooded in for speculative purpose which eventually precipitated the crisis (the Strait Times, 2007). At that time, the inflation rates of 1998 soared caused by higher material cost (cost-push factor) due to devalued THB. This increase is not statistically significant enough as the inflation had normally remained high before the crisis. Instead, the statistically significant structural break is in 1999 when the inflation sharply decreased because people are aware of spending (demand-pull factor). 2000 is the other break point when inflation climbed up again. This rise partly resulted from the low inflation in 1999 which boosted Thai economy and partly was because of rising global oil price which is another supply shock. All above are probable explanations for why the structural break points are 1999 and 2000. In case of the global financial crisis emerging in the U.S., on the contrary, Thai economy was only indirectly affected through a decline in export as the U.S. is a major importer of Thailand. This slowed down Thai economy but the effect on inflation is small through interest rate adjustment as a policy to boost the economy.

In conclusion, there exist the structural shifts of the relationship between inflation and an economic-driving variable in 1999 and 2000. This suggests the whole samples be split at the estimated break to recheck the stability of the estimates obtained in the Phillips Curve models in Sub-section (3).

(5) Sub-samples

In the previous sub-section, the period of 1999 and 2000 are claimed to be statistically significant structural break points. In this exercise, the entire sample of 1990 to 2017 is divided into 2 sub-samples: 1990 to 1999; and 2000 to 2017 accordingly in order to re-estimate reduced-form parameters and test reliability of the estimates having been earned in Sub-section (3). For the same reason as given before in Sub-section (4), this exercise of sub-samples is based upon the full-form of Phillips Curve model with all explanatory variables except the crisis dummy. All the empirical results are displayed in Table 14 and Table 15.

In overall, estimated results of 2 sub-samples confirm the presence of the structural break points in the full period. The estimates of most variables are generally distinct between the first and the second sub-sample in that statistical significance of the estimates change and/or their magnitude changes significantly. The results of the main economic-driving variables i.e. unemployment slack and output gap quite vary according to an inflation measurement and a proxy for an economic-driving variable of choice. In brief, the headline CPI inflation on Table 14 can be well-explained by the unemployment slack and by the detrended log real GDP in the sub-sample (2) – 2000 to 2017. Conversely, the inflation measured by GDP deflator on Table 15 can be well-described by all three economic-driving variables in the sub-sample (1) – 1990 to 1999. Moreover, all estimates give correct signs as theoretical predicted.

In particular, the fairly similar pattern of results is discovered between the following two cases: the models with the unemployment slack as an economic-driving variable; and the models with the detrended log real GDP as an economic-driving variable. In explaining the headline CPI inflation on Table 14, the insignificant estimates during 1990 to 1999 turn significant during 2000 to 2017. This means that the full-form of Phillips Curve holds true only after 1999. The finding is in accordance with Bhanthumnavin (2002) which also used headline CPI to measure inflation and then stated that the underlying Phillips relationship always existed in Thailand. However, no variation in such driving variables as the import price inflation due to fixed exchange rate regime caused the relationship to be invisible during the financial crisis (1997 and 1998). Rather, the relationship became apparent after the Asian crisis had made large variations of those driving variables, i.e. once Thai Baht was devalued, import prices turned dynamic. Pointing the opposite way, in explaining the inflation measured by GDP deflator on Table 15, the estimates are significant in sub-sample (1) – 1990 to 1999, but become insignificant in sub-sample (2) – 2000 to 2017. This means that the full-form of Phillips Curve holds true only before 2000 which covers the period of 1997 Asian financial crisis. This is quite a puzzle as the finding totally contradicts Sakurai (2016) which also referred to the growth of GDP deflator as inflation but explained that the Phillips Curve hardly holds during 1993Q3 to 1997Q2 because of the bubble economy during the financial crisis. At that time, the Thai economy thus did not meet the assumptions of the model: sticky prices and incomplete competition. Rather, the relationship was clearly observed after 2009 thanks to the stable economic condition. However, one reason behind this puzzle could be thought of is that there might be some significant variables omitted from the model because if thoroughly looking at the results, the estimate of the import price inflation is also highly significant despite the fact that calculation of the inflation measured by GDP deflator does not include import price movements. For the remaining two regressions of inflation on the output gap estimated by Oxford Economics, their results are absolutely different from the results above. In detail, in case of the headline CPI inflation on Table 14, the parameters maintain insignificant across the 2 sub-samples. This is probably because 1999 and 2000 are just common structural break points, i.e. found in most models studied. Precisely, those two years are not the structural break points in the regression of the headline CPI inflation on the output gap estimated by Oxford Economics but its structural break is in fact 2008. In case of the inflation measured by GDP deflator on Table 15, conversely, the parameters keep significant across 2 sub-samples; the full-form of Phillips Curve always holds true throughout the full sample but become flatter after 1999.

For the other 2 components accounting for the individual behavior, the expected inflation remains highly statistically significant in most cases in both sub-samples while the lagged inflation also keeps statistically significant, especially in the sub-sample (1). Also, the (absolute) size of the backward-looking component is still larger than the forward-looking component. All of these prove that the individual behavior is still important in explaining Thai inflationary dynamics and most Thais are backward-looking; this is consistent with the result obtained in the study into the full-sample.

For the other 2 control variables accounting for the global impact, the growth of oil prices maintains statistically significant in most cases, especially in explaining the headline CPI inflation. In contrast, the import price inflation is hardly statistically significant in most cases. This confirms the results of the study of the full sample that the oil price movement is the most important global factor in explaining the Thai inflation. Moreover, the structural breakpoint test and the study into 2 separate sub-samples make a good point about the financial crisis. In the full-sample, the crisis dummy is rarely statistically significant as assuming both the 1997 Asian financial crisis and the 2007 global financial crisis as 1. Quite contrary, the different results between estimates of the 2 sub-samples prove that 1999 and 2000 (post-period of the 1997 Asian crisis) is important breakpoints. The financial crisis, specifically the 1997 Asian financial crisis indeed produces a substantial effect on the Thai inflation dynamics.

Furthermore, most of the models have a pretty good fit with the actual data (see Table 16). Both of R-squared and adjusted R-square are up to 90 percent on average. In the meantime, the Standard Error of the models is just approximately 1 percent. Considering also the plots of the residuals on Figure 2, errors are random, capturing unpredictable measurement errors and unobservable supply shocks.

In conclusion, the results of the separate regressions for each sub-sample are quite different from the end result of the study on the full sample. The estimates are generally distinct between the first and the second sub-sample in that the statistical significance of the estimates change and/or their magnitude changes substantially. This proves that the consideration for a structural break point in the sample is imperative in drawing the logical conclusion of the Phillips Curve relationship in Thailand. Even though the full-form of Phillips Curve can hold true in the Thai economy for only some cases, one noteworthy remark is that results are sensitive to how inflation is measured.

(6) Result sensitivity to proxies

According to the results shown in all the former sub-sections, most of the results of whether the Phillips Curve is hold in Thailand are markedly sensitive to a choice of inflation measurements and to a proxy for cyclical economic-driving variables which is the main explanatory variable of interest.

On one hand, the results are sensitive to the inflation measurement. To illustrate, in both of the NKPC and the full-form of Phillips Curve, the unemployment slack and the output gap have an impact on the headline CPI inflation with higher statistical significance (i.e. highly significant at 1% for all cases) than on the inflation measured by GDP deflator (i.e. in some cases, the estimates are not even significant at 10%). It is thus interesting to consider what differences between inflation measured by headline CPI and by GDP deflator are so that we can understand reasons behind the sensitivity of the results. At first glance at Figure 4, both inflation measurements track each other well, in particular that they show the same pattern overtime, seemingly oblivious to narrow divergence between them. Literally, there are subtle differences between the two inflation measurements. They reflect different sets of prices. The GDP deflator includes only goods produced domestically so it does not include price changes of imported goods. In contrast, the headline CPI includes all goods bought by domestic consumers including imported goods (Quickonomics, 2018). This could be one of logical reasons why, for instance, the unemployment slack and the output gap can better describe the growth of headline CPI in Table 5 than describing the growth of GDP deflator in Table 6. As mentioned before, moreover, in some models e.g. the full-form of Phillips Curve regressing on the unemployment slack with oil price as a sole additional control variable (Table 10, Appendix), the inflation measured by GDP *cannot at all* be explained statistically either by unemployment slack or by output gap. A simple reason is probably that in fact the GDP deflator has a specific purpose; it is used to deflate nominal GDP to obtain real GDP so it is not appropriate measurement of household inflation.

On the other hand, when splitting the entire sample into the 2 sub-samples, the results are sensitive to proxies for the economic-driving variables. For instance, the findings in Table 14 and Table 15 show the different patterns between results of the output gap estimated by detrended log real GDP and ones of the output gap estimated by Oxford Economics. This is probably due to different approaches to removing short-run fluctuation, i.e. potential output from the real GDP to reveal the cyclical component. In brief, the HP filter is a technique used to determine the long term trend of a time series by discounting the importance of short-term fluctuation by minimizing sum of the squared deviations which penalizes the cyclical component and a multiple of the sum of the squares of the trend component's second differences. In the meantime, Oxford Economics subtracts the log potential output from the log real GDP and then multiplies with 100. Therefore, both measures have different scales which results in different sizes of their estimates. Conducting a careful inspection of this distinction could be another interesting for further researches.

This issue is consistent with what is described in the literature review. The results change from paper to paper partly because of different proxies for the main dependent variable and explanatory variables both of which are the primary focuses. In spite of being re-modified in a number of ways, as a result, there is no firm conclusion of the fundamental research question of whether the Phillips Curve holds in the real world. Finally, this topic of the Phillips Curve is controversial in discussion until now.

5. Conclusions

In the recent years, the concept of the Phillips Curve has come into question. The researchers and economists cast doubt on whether this theory still exists in the real world, including in Thailand. The Thai economic growth has continuously accelerated while the inflation remains low and even lower than the inflation target set by the bank of Thailand. This thesis then aims to identify the existence of the Phillips Curve in Thailand based on the main research question that whether Phillips Curve holds or breaks down and if it does break down, what are the causes behind such a result.

This thesis provides the empirical test of the validity of Phillips Curve models in several forms. Begin with the traditional Phillips Curve originated by Phillips (1958), the results both of the unemployment rate and the log real GDP consistently indicate that the traditional Phillips Curve does not hold for the Thai data over the full sample – 1990 to 2017. Both of the estimates are not correctly signed and/or statistically significant. The New Keynesian Phillips Curve (NKPC) which includes the idea of the Friedman-Phelps Natural Rate hypothesis which consists largely of the potential/natural minimum rate and the individual behavior is then studied. Accordingly, the fundamental change is the unemployment slack and the output gap are referred to as economic-driving variables instead of the unemployment rate and the log real GDP respectively. The results illustrate that the NKPC does hold in the Thai economy during the entire sample. Consistent with the theoretical prediction, the estimates of the unemployment slack show statistically significant negative while the output gap both measured by the detrended log real GDP and estimated by Oxford Economics show statistically significant positive. Moreover, both of the expected inflation and the lagged inflation are statistically significant. This is another proof that Phillips (1958) fails to hold in the real economy and takes a stand on the Natural Rate hypothesis proposed by Friedman (1968) and Phelps (1967, 1968). Moreover, Thai people are revealed to be backward-looking when the size of the estimates between the expected inflation and the lagged inflation are compared; this finding is credible in the Thai society. As a small open economy dependent on international trade, it is sensible assumptions that the global factors have influence on the domestic price movement in Thailand. The general full-form of the Phillips Curve which incorporates 3 additional control variables, namely oil prices, import price inflation, and consequences of crisis is finally studied. The overall results demonstrate that the full-form of Phillips Curve is a successful model in explaining the Thai inflation during the whole sample with the improvement on in-sample fit and more realistic setting than the NKPC. The estimates on the unemployment slack and the output gap maintain statistically significant. Similar to the results of the NKPC, Thai people are approved to be backward-looking. With respect to the 3 controls reflecting the global force, the results point out that the growth of oil prices is the determining factor. In contrast, the import price inflation and the crisis dummy are less important. Although these additional variables do not consistently show the statistical significance in the statistical analysis of all models, the inclusion of these controls still makes good sense, inasmuch as it is not only realistic but also fit the actual data better than the prior two models. After all, the profound implication is that the Natural Rate hypothesis makes outstanding contribution and the individual behavior is confirmed significant. The far-reaching one is the global factors, especially oil prices are good addition to the Phillips Curve models.

From the structural break point test, furthermore, there exist the structural shifts of the Phillips Curve relationship in 1999 and 2000 which are the post-Asian financial period. To recheck the validity of the study of the full-sample earlier, the entire period is suggest to be split at the estimated break points into 2 sub-samples: 1990 to 1999; and 2000 to 2017. It is quite a different story when considering the sub-samples instead of the full-samples. The estimates are generally distinct between the first sub-sample and the second sub-sample in that the statistical significance of the estimates change and/or their magnitude changes significantly. This proves that the consideration for a structural breakpoint is imperative in drawing the logical conclusion of the Phillips Curve relationship of Thailand. Focusing on the estimates of the unemployment gap and the output gap both measured by the detrended log real GDP and estimated by Oxford Economics, the full-form of Phillips Curve appears to hold true only in some cases. In other words, their statistical significance pretty varies according to an inflation measurements and a proxy for an economic-driving variable of choice. As a result, it is more difficult to arrive at an obvious and firm conclusion of the main research question of this thesis. Nevertheless, the most convincing case is that the full-form of Phillips Curve hold true after 1999 which is the post-Asian financial crisis when all the explanatory variables are used to explain the headline CPI inflation; this is incompliance with earlier research papers namely Bhanthumnavin (2002) and Sakurai (2016). The simplest reason is the headline CPI inflation is a more suitable proxy in the context of inflation dynamics. Similar to the research findings on the full sample, the two components of individual behavior are decisive factors in explaining the Thai inflationary dynamics and Thais on average have backward-looking manner since most estimates of the expected inflation and the lagged inflation keep statistically significant in both sub-samples and larger magnitude of the backward looking obtained. Also, the results of the control variables which are representatives of for the global impact, the results confirm that the global oil prices are the determining factor in explaining the Thai inflation dynamics. In part of the financial crisis, although the crisis dummy is not very significant in the full sample study, the presence of the structural breakpoints in 1999 and 2000 indicates that a financial crisis could produce a substantial effect on the Thai inflation dynamics when a crisis directly impacts on domestic price movements.

In brief, this thesis is another piece of evidence to confirm that the traditional Phillips Curve alone cannot hold true in the economy, more particularly in the Thai economy. Instead, it holds true when additional explanatory variables are taken into account. The Natural Rate hypothesis together with the individual behavior is a fundamental theoretical concept. The global factors are good addition to the Phillips Curve model, especially the growth of oil prices. A financial crisis could also serves as a supply shock when it has directly marked effect on domestic prices. The most noteworthy one, however, is that the results are sensitive to an inflation measurement and a proxy for the economic-driving variables. To a certain extent, above all, the results give explanation for the five specific areas of the main research question: whether each version of the Phillips Curve holds in the Thai economy, whether there is a role of the lagged inflation and the expected future, to what extent global factors conduce to the deviation from the traditional Phillips Curve and the NKPC, whether there is significant structural breakpoints needed considering, and whether the results are consistent across an inflation measurement and a proxy for the cyclical economic-driving variable of choice.

The results are subject to a few limitations. The sample covers only 27 years although the duration contains other important economic events worth studying in the structural breakpoint test such as the 9/11 attack in 2001 and the oil price hikes in 2011. Owing to the limited number of observations, the Quandt-Andrew breakpoint test cannot be performed to identify all possible structural breakpoints in the entire sample period. Hence, any future research would be conducted on quarterly data or on longer years. Moreover, to account for some instrument variables such as interest rates and extra lags of inflation which possibly influence the expected inflation, the other econometric techniques, namely Two-Stage Least Squares (2SLS) and generalized method of moments (GMM) could be employed in future researches. As a noteworthy remark from the study of this thesis, furthermore, the results are generally sensitive to an inflation measurement and a proxy for the economic-driving variables of choice, future researches could also be done by using another types of inflation, another proxy for an economic-driving variable, or another method to calculate the potential output, the natural rate of unemployment, and the expected inflation all of which are the most difficult variables to be estimated as they are unobservable. Lastly, a further study could be extended to include a discussion about potential policy implications so that the implication of the context of the Phillips Curve becomes more practical.

References

Abbas, Sankar Bhattacharya, Sgro, 2016. International Review of Economics and Finance 43, 378-403.

Abbas and Sgro, 2011. New Keynesian Phillips Curve and inflation dynamics in Australia. Economic Modelling 28, 2022-2033.

Alichi, 2015. A New Methodology for Estimating the Output Gap in the United States. IMF Working Papers 15/144, International Monetary Fund.

Al-zeaud and Al-hosban, 2015. Does Phillips Curve really exist? An empirical evidence from Jordan. European Scientific Journal 11 (10), 1957-7881.

Angel Garcia and Wu, 2017. Thailand Inflation. International Monetary Fund Country Report 17/137.

Ball, 1990. Credible Disinflation with Staggered Price Setting, NBER Working Papers 3555, National Bureau of Economic Research, Inc.

Bhanthumnavin, 2002. The Phillips Curve for Thailand, EcoMod2002 330800009, EcoMod.

Bhattarai, 2016. Unemployment-inflation trade-offs in OECD countries. Economic Modelling 58, 93-103.

Calvo, 1983. Staggered prices in a utility-maximizing framework. Journal of Monetary Economics, Elsevier 12(3), 383-398.

Chletsos, Drosou, Roupakias, 2016. Can Phillips Curve explain the recent behavior of inflation? Further evidence from USA and Canada. The Journal of Economic Asymmetries 14, 20-28.

Christiano, Eichenbaum, Evans, 2005. Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. Journal of Political Economy 113 (1), 1-45.

Coibion and Gorodnichenko, 2015. Is the Phillips Curve Alive and Well after All? Inflation Expectations and the Missing Disinflation. American Economic Journal: Macroeconomics, American Economic Association 7(1), 197-232.

Dinardo and Moore, 1999. The Phillips Curve is back? Using panel data to analyze the relationship between unemployment and inflation in an open economy. Working Papers from California Irvine – School of Social Sciences.

Direkudomsak, 2016. Inflation dynamics and inflation expectations in Thailand. A chapter in Inflation mechanisms, expectations and monetary policy, vol. 89, 349-360 from Bank for International Settlements.

Dritsaki and Dritsaki, 2013. Phillips Curve inflation and unemployment: and empirical research for Greece. International Journal of Computational Economics and Econometrics 3 (1/2), 27-42.

Fisher, 1973. I Discovered the Phillips Curve: "A Statistical Relation between Unemployment and price Changes". Journal of Political Economy 81 (2), 496-502.

Fisher, 1977. Long-Term Contracts, Rational Expectations, and the Optimal Money Supply Rule. Journal of Political Economy 85 (1), 191-205.

Friedman, 1968. The Role of Monetary Policy. The American Economic Review 58 (1), 1-17.

Friedrich, 2016. Global inflation dynamics in the post-crisis period: What explains the puzzles? Economics Letters vol. 142 issue C, 31-34.

Fuhrer, 1997. Inflation/Output Variance Trade-Offs and Optimal Monetary Policy. Journal of Money, Credit and Banking 29 (2), 214-234.

Fuhrer and Moore, 1995. Inflation Persistence. The Quarterly Journal of Economics 110 (1), 127-159.

Furuoka, 2007. Does the “Phillips Curve” really exist? New Empirical Evidence from Malaysia. Economics Bulletin vol. 5 No. 16, 1-14.

Gali, Jordi & Gertler, Mark, 1999. Inflation dynamics: A structural econometric analysis. The Journal of Monetary Economics, Elsevier, vol. 44(2), 195-222, October.

Gali, Jordi, Gertler, Mark, Lopez-Salido, J.David, 2001. European inflation dynamics. European Economic Review, Elsevier vol. 45(7), 1237-1270.

Gordon, 1976. Recent developments in the theory of inflation and unemployment. Journal of Monetary Economics 2, 185-219.

Gordon, 2011. The history of the Phillips Curve: Consensus and Bifurcation. Economica 78, 10-50.

Gruen, Pagan, Thompson, 1999. The Phillips Curve in Australia. Journal of Monetary Economics 44, 223-258.

Hines, 1968. Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom 1862-1963: A Reappraisal. The Review of Economics and Statistics 50 (1), 60-67.

Jondeau and Le Bihan, 2003. Testing for the New Keynesian Phillips Curve. Additional international evidence. Economic Modelling 22, 521-550.

Jonson, Mahar, Thompson, 1974. Earnings and award wages in Australia. Australian Economic Papers 13 (22), 80-98.

Karanassou and Sala, 2010. The US inflation-unemployment trade-off revisited: New evidence for policy-making. Journal of Policy Modeling 32, 758-777.

Kuttner and Robinson, 2010. Understanding the flattening Phillips Curve. North American Journal of Economics and Finance 21, 110-125.

Leu, 2011. A New Keynesian SVAR model of the Australian economy. Economic Modelling 28, 157-168.

Lipsey, 1960. The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1862-1957: A Further Analysis. Economica 27 (105), 1-31.

Mankiw, 2001. The inexorable and mysterious tradeoff between inflation and unemployment. The Economic Journal 111, C45-C61.

Mankiw and Reis, 2001. Sticky Information Versus Sticky Prices: A Proposal to Replace the New Keynesian Phillips Curve. NBER Working Paper No. w8290.

Manopimoke and Direkudomsak, 2015. Thai Inflation Dynamics in a Globalized Economy. PIER Discussion Papers 11., Puey Ungphakorn Institute for Economic Research, revised Nov 2015.

Masso and Staehr, 2005. Inflation dynamics and nominal adjustment in the Baltic States. University of Tartu - Faculty of Economics and Business Administration Working Paper Series 35, Faculty of Economics and Business Administration, University of Tartu (Estonia).

Motyovszki, 2013. The Evolution of Phillips Curve Concepts and Their Implications for Economic Policy. Central European University.

Nakornthab, 2009. Thailand's monetary policy since the 1997 crisis. Kobe University Economic Review 55.

Nason and Smith, 2008. Identifying the New Keynesian Phillips Curve. Journal of Applied Econometrics 23, 525-551.

Parkin, 1973. The short-run and long-run trade-offs between inflation and unemployment in Australia. Research Discussion Paper 31.

Phelps, 1967. Money-Wage Dynamics and Labor-Market Equilibrium. Journal of Political Economy 76 (4), 678-711.

Phelps, 1967. Phillips Curves, Expectations of Inflation and Optimal Unemployment over Time. Economica 34 (135), 254-281.

Phelps, 1978. Disinflation without recession: Adaptive guideposts and monetary policy. Review of World Economics (Weltwirtschaftliches Archiv), Springer;Institut für Weltwirtschaft (Kiel Institute for the World Economy) 114(4), 783-809.

Phillips, 1958. The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957. Economica 25 (100), 283-299.

Puzon, 2009. The Inflation Dynamics of the ASEAN-4: A Case Study of the Phillips Curve Relationship. Journal of American Science 5(1), 55-57.

Roberts, 1995. New Keynesian Economics and the Phillips Curve. Journal of Money, Credit and Banking, Blackwell Publishing 27(4), 975-984.

Robert and Murphy, 2016. Why Has Inflation Been So Unresponsive to Economic Activity in Recent Years? Boston College Working Papers in Economics 920, Boston College Department of Economics.

Rotemberg, 1982. Sticky Prices in the United States. Journal of Political Economy 90 (6), 1187-1211.

Rudebush and Svensson, 2001. Policy rules for inflation targeting. A chapter from the National Bureau of Economic Research, 203-262.

Sachisida, Divino, Cajueiro, 2011. Inflation, unemployment, and the time consistency of the US monetary policy. Structural Change and Economic Dynamics 22, 173-179.

Sakurai, 2016. The New Keynesian Phillips Curve in Thailand through two financial crises. The Asian Economic and Financial Review 6(4), 190-195.

Sbordone, 2002. Prices and unit labor costs: a new test of price stickiness. Journal of Monetary Economics 49, 265-292.

St-Amant and Van Norden, 1997. Measurement of the Output gap: A Discussion of Recent Research at the Bank of Canada.

Taylor, 1979. Staggered Wage Setting in a Macro Model. American Economic Review, American Economic Association 69(2), 108-113.

Turner and Seghezza, 1999. Testing for a Common OECD Phillips Curve. OECD Economics Department Working Papers, No. 219, OECD Publishing, Paris.

Zhang, 2013. Inflation Dynamics and an Extended New Keynesian Phillips Curve for China. Emerging Market Finance & Trade Vol. 49 (5), 85-102.

Zhang, Osborn, Kim, 2009. Observed Inflation Forecasts and the New Keynesian Phillips Curve. Oxford Bulletin of Economics and Statistics 71 (3), 0305-9049.

Appendix

Table 1

The traditional Phillips Curve

: the regression of the headline CPI inflation

Headline CPI inflation		
Constant term	0.021262*** (0.009503)	0.725905* (0.445544)
Unemployment rate (U_t)	0.003730 (0.004228)	
Log real GDP (y_t)		-0.023660 (0.015066)

Note: The table reports the estimates of the traditional Phillips Curve in which the headline CPI inflation is a dependent variable according to specifications below:

$\pi_t = \alpha_0 + \alpha_1(U_t) + \varepsilon_t$ (3)

$\pi_t = \alpha_0 + \alpha_1(y_t) + \varepsilon_t$ (4)

Where $U_t$is the unemployment rate and $y_t$is the log real GDP. The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses.

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 2

The traditional Phillips Curve

: the regression of the inflation measured by GDP deflator

Inflation measured by GDP deflator		
Constant term	0.029291*** (0.008837)	0.695228 (0.245942)
Unemployment rate (U_t)	0.000891 (0.004882)	
Log real GDP (y_t)		-0.022536 (0.008285)

Note: The table reports the estimates of the traditional Phillips Curve in which the inflation measured by GDP deflator is a dependent variable according to specifications below:

$\pi_t = \alpha_0 + \alpha_1(U_t) + \varepsilon_t$ (3)

$\pi_t = \alpha_0 + \alpha_1(y_t) + \varepsilon_t$ (4)

Where $U_t$is the unemployment rate and $y_t$is the log real GDP. The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses.

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 3

The New Keynesian Phillips Curve (NKPC)

: *the regression of the headline CPI inflation*

Headline CPI inflation			
Constant	-0.005490* (0.003140)	-0.003405 (0.003873)	0.000922 (0.005050)
Survey forecast inflation	0.010796*** (0.000891)	0.010217*** (0.000891)	0.010251*** (0.000855)
Lagged inflation	-0.237965*** (0.082599)	-0.253045*** (0.089357)	-0.191958** (0.088383)
Unemployment slack $(U_t - \widehat{U_t})$	-0.011148*** (0.001761)		
Detrended log real GDP $(y_t - \widehat{y}_t)$		0.163048*** (0.023560)	
Output gap $(y_t - \widehat{y}_t)$ (Oxford Economics)			0.001976*** (0.000326)

Note: The table reports the estimates of the NKPC in which the headline CPI inflation is a dependent variable according to specifications below:

$$\pi_t = \alpha_0 + \alpha_1\left(U_t - \widehat{U_t}\right) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 \pi_{t-1} + \varepsilon_t \qquad (5)$$

$$\pi_t = \alpha_0 + \alpha_1(y_t - \widehat{y}_t) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 \pi_{t-1} + \varepsilon_t \qquad (6)$$

Where $U_t - \widehat{U_t}$ is the unemployment slack and $y_t - \widehat{y}_t$ is the output gap. There are 2 proxies for the output gap: the detrended log real GDP by the Hodrick-Prescott filter; and output gap estimated by Oxford Economics. The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses.

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 4

The New Keynesian Phillips Curve (NKPC)

: *the regression of inflation measured by GDP deflator*

Inflation measured by GDP deflator			
Constant	0.007948 (0.004951)	0.009902** (0.004461)	0.016858*** (0.004796)
Survey forecast inflation	0.008813*** (0.001374)	0.008258*** (0.001343)	0.008477*** (0.001215)
Lagged inflation	-0.393808** (0.160535)	-0.405249** (0.180785)	-0.396542*** (0.134387)
Unemployment slack $\left(U_t - \widehat{U_t}\right)$	-0.010686* (0.006083)		
Detrended log real GDP $(y_t - \hat{y}_t)$		0.151476* (0.077781)	
Output gap $(y_t - \hat{y}_t)$ (Oxford Economics)			0.002637*** (0.000920)

Note: The table reports the estimates of NKPC in which the inflation measured by GDP deflator is a dependent variable according to specifications below:

$$\pi_t = \alpha_0 + \alpha_1\left(U_t - \widehat{U_t}\right) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \varepsilon_t \qquad (5)$$

$$\pi_t = \alpha_0 + \alpha_1(y_t - \hat{y}_t) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \varepsilon_t \qquad (6)$$

Where $U_t - \widehat{U_t}$ is the unemployment slack and $y_t - \hat{y}_t$ is the output gap. There are 2 proxies for the output gap: the detrended log real GDP by the Hodrick-Prescott filter; and output gap estimated by Oxford Economics. The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses.

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 5

The full-form of Phillips Curve with all the 3 controls included simultaneously

: the regression of the headline CPI inflation

Headline CPI inflation			
Constant	-0.004474** (0.001696)	-0.001387 (0.002741)	0.002168 (0.003927)
Survey forecast inflation	0.009900*** (0.000638)	0.008657*** (0.026555)	0.009019*** (0.000575)
Lagged inflation	-0.215338*** (0.067268)	-0.212357*** (0.069849)	-0.125173* (0.068218)
Crisis dummy	0.002255 (0.003094)	0.002251 (0.002382)	-0.003562 (0.002270)
Import price inflation	0.015206 (0.046244)	0.064986* (0.035176)	0.056616 (0.036820)
Growth of oil prices	0.021573*** (0.005747)	0.017678** (0.005534)	0.016791*** (0.004970)
Unemployment slack $(U_t - \widehat{U_t})$	-0.011396*** (0.001929)		
Detrended log real GDP $(y_t - \hat{y}_t)$		0.168297*** (0.026555)	
Output gap $(y_t - \hat{y}_t)$ (Oxford Economics)			0.001952*** (0.000341)

Note: The table reports the estimates of the full-form of Phillips Curve in which the headline CPI inflation is a dependent variable according to specifications below:

$$\pi_t = \alpha_0 + \alpha_1(U_t - \widehat{U_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 \pi_{t-1} + \alpha_4(D_t^{CRISIS}) + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \quad (1)$$

$$\pi_t = \alpha_0 + \alpha_1(y_t - \hat{y}_t) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 \pi_{t-1} + \alpha_4(D_t^{CRISIS}) + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \quad (2)$$

Where $U_t - \widehat{U_t}$is the unemployment slack and $y_t - \hat{y}_t$is the output gap. There are 2 proxies for the output gap: the detrended log real GDP by the Hodrick-Prescott filter; and output gap estimated by Oxford Economics. The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses. This table shows estimates of the models in which *all the control variables* (i.e. the crisis dummy, the import price inflation, and the growth of oil prices) are added only.

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 6

The full-form of Phillips Curve with all the 3 controls included simultaneously

: the regression of the inflation measured by GDP deflator

Inflation measured by GDP deflator			
Constant	0.008329 (0.005331)	0.011088** (0.004663)	0.016977*** (0.004859)
Survey forecast inflation	0.007966*** (0.001818)	0.006597*** (0.001702)	0.007778*** (0.001939)
Lagged inflation	-0.353157* (0.197663)	-0.324096 (0.196664)	-0.346354* (0.192670)
Crisis dummy	0.004470 (0.004833)	0.004099 (0.004710)	0.000192 (0.004524)
Import price inflation	0.008431 (0.078159)	0.062753 (0.088469)	0.015356 (0.085268)
Growth of oil prices	0.013108 (0.015707)	0.009402 (0.017144)	0.010823 (0.012945)
Unemployment slack $(U_t - \widehat{U_t})$	-0.010800* (0.006150)		
Detrended log real GDP $(y_t - \widehat{y_t})$		0.153851* (0.081335)	
Output gap $(y_t - \widehat{y_t})$ (Oxford Economics)			0.002598** (0.000932)

Note: The table reports the estimates of the full-form of Phillips Curve in which the inflation measured by GDP deflator is a dependent variable according to specifications below:

$$\pi_t = \alpha_0 + \alpha_1(U_t - \widehat{U_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 \pi_{t-1} + \alpha_4(D_t^{CRISIS}) + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \qquad (1)$$

$$\pi_t = \alpha_0 + \alpha_1(y_t - \widehat{y_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 \pi_{t-1} + \alpha_4(D_t^{CRISIS}) + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \qquad (2)$$

Where $U_t - \widehat{U_t}$is the unemployment slack and $y_t - \widehat{y_t}$is the output gap. There are 2 proxies for the output gap: the detrended log real GDP by the Hodrick-Prescott filter; and output gap estimated by Oxford Economics. The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses. This table shows estimates of the models in which *all the control variables* (i.e. the crisis dummy, the import price inflation, and the growth of oil prices) are added only.

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 7-9

The full-form of Phillips Curve with *all the possible combinations* of 3 controls

: the regression of the headline CPI inflation

Table 7

The regression of the headline CPI inflation on the unemployment slack $\left(U_t - \widehat{U_t}\right)$

Headline CPI inflation							
Constant	-0.004474** (0.001696)	-0.004411** (0.001708)	-0.004715** (0.001705)	-0.003825 (0.002755)	-0.004949*** (0.001738)	-0.003846 (0.002738)	-0.005394 (0.003192)
Survey forecast inflation	0.009900*** (0.000638)	0.009801*** (0.000598)	0.010086*** (0.000444)	0.009498*** (0.000943)	0.010184*** (0.000537)	0.009570*** (0.000930)	0.010760*** (0.000894)
Lagged inflation	-0.215338*** (0.067268)	-0.198569*** (0.061664)	-0.225357*** (0.059573)	-0.0181984** (0.082021)	-0.210974*** (0.064249)	-0.196461** (0.078545)	-0.244659*** (0.084122)
Crisis dummy	0.002255 (0.003094)		0.002916 (0.002585)	-0.001964 (0.004270)			0.001287 (0.002966)
Import price inflation	0.015206 (0.046244)	0.027902 (0.038157)		0.086225* (0.048515)		0.078194 (0.045793)	
Growth of oil prices	0.021573*** (0.005747)	0.020179*** (0.005083)	0.022795*** (0.003571)		0.022153*** (0.003480)		
Unemployment slack $\left(U_t - \widehat{U_t}\right)$	-0.011396*** (0.001929)	-0.011125*** (0.001833)	-0.011643*** (0.002032)	-0.009929*** (0.002202)	-0.011532*** (0.002005)	-0.010103*** (0.001875)	-0.011192*** (0.001844)

Note: The table reports the estimates of the full-form of Phillips Curve in which the headline CPI inflation is a dependent variable according to specifications below:

$$\pi_t = \alpha_0 + \alpha_1\left(U_t - \widehat{U_t}\right) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \alpha_4(D_t^{CRISIS}) + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \qquad (1)$$

Where $U_t - \widehat{U_t}$ is the unemployment slack. The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses. This table shows estimates of all 7 possible models which include *at least one of control variables* (i.e. the crisis dummy, the import price inflation, and the growth of oil prices).

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 8

The regression of the headline CPI inflation on the detrended log real GDP $(y_t - \widehat{y_t})$

Headline CPI inflation							
Constant	-0.001387 (0.002741)	-0.001394 (0.002673)	-0.002333 (0.002645)	-0.001079 (0.003417)	-0.002822 (0.002563)	-0.001063 (0.003366)	-0.003093 (0.003973)
Survey forecast inflation	0.008657*** (0.000515)	0.008587*** (0.026157)	0.009414*** (0.000398)	0.008451*** (0.000715)	0.009602*** (0.000601)	0.008480*** (0.000687)	0.010114*** (0.000849)
Lagged inflation	-0.212357*** (0.069849)	-0.195780*** (0.058163)	-0.253652*** (0.081791)	-0.189347** (0.072734)	-0.226697** (0.082527)	-0.197368** (0.064973)	-0.271848*** (0.092705)
Crisis dummy	0.002251 (0.002382)		0.005084* (0.002512)	-0.001081 (0.003112)			0.003372 (0.003082)
Import price inflation	0.064986* (0.035176)	0.076465** (0.029213)		0.118166*** (0.040572)		0.114083*** (0.035582)	
Growth of oil prices	0.017678*** (0.005534)	0.016381*** (0.005299)	0.022783*** (0.004302)		0.021638*** (0.004301)		
Detrended log real GDP $(y_t - \widehat{y_t})$	0.168297*** (0.026555)	0.164557*** (0.026151)	0.174700*** (0.028654)	0.159046*** (0.025871)	0.167123*** (0.029586)	0.160696*** (0.022139)	0.167930*** (0.023690)

Note: The table reports the estimates of the full-form of Phillips Curve in which the headline CPI inflation is a dependent variable according to specifications below:

$$\pi_t = \alpha_0 + \alpha_1(y_t - \widehat{y_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \alpha_4(D_t^{CRISIS}) + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \quad (2)$$

Where $y_t - \widehat{y_t}$ is the detrended log real GDP. The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses. This table shows estimates of all 7 possible models which include *at least one of control variables* (i.e. the crisis dummy, the import price inflation, and the growth of oil prices).

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 9

The regression of the headline CPI inflation on the output gap estimated by Oxford Economics $(y_t - \hat{y}_t)$

Headline CPI inflation							
Constant	0.002168 (0.003927)	0.002067 (0.003907)	0.001542 (0.003848)	0.002312 (0.004558)	0.001585 (0.003778)	0.002144 (0.004637)	0.000851 (0.005126)
Survey forecast inflation	0.009019*** (0.000575)	0.009129*** (0.000601)	0.009686*** (0.000481)	0.008807*** (0.000354)	0.009642*** (0.000448)	0.008978*** (0.000289)	0.010326*** (0.000892)
Lagged inflation	-0.125173* (0.068218)	-0.149155** (0.060833)	-0.157879* (0.077047)	-0.107830 (0.081704)	-0.164320** (0.067952)	-0.151691* (0.079761)	-0.177779* (0.097259)
Crisis dummy	-0.003562 (0.002270)		-0.001330 (0.001795)	-0.006443** (0.002858)			-0.002776 (0.002173)
Import price inflation	0.056616 (0.036820)	0.039212 (0.039212)		0.107499** (0.043578)		0.084520* (0.044021)	
Growth of oil prices	0.016791*** (0.004970)	0.018735*** (0.004485)	0.021193*** (0.003621)		0.021467*** (0.003528)		
Output gap (Oxford Economics) $(y_t - \hat{y}_t)$	0.001952*** (0.000341)	0.001933*** (0.000328)	0.002039*** (0.000366)	0.001863*** (0.000354)	0.021467*** (0.003528)	0.001806*** (0.000289)	0.002020*** (0.000345)

Note: The table reports the estimates of the full-form of Phillips Curve in which the headline CPI inflation is a dependent variable according to specifications below:

$$\pi_t = \alpha_0 + \alpha_1(y_t - \hat{y}_t) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \alpha_4(D_t^{CRISIS}) + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \quad (2)$$

Where $y_t - \hat{y}_t$is the output gap estimated by Oxford Economics. The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses. This table shows estimates of all 7 possible models which include *at least one of control variables* (i.e. the crisis dummy, the import price inflation, and the growth of oil prices).

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 10-12

The full-form of Phillips Curve with *all the possible combinations* of 3 controls

: The regression of the inflation measured by GDP deflator

Table 10

The regression of the inflation measured by GDP deflator on the unemployment slack $\left(U_t - \widehat{U_t}\right)$

Inflation measured by GDP deflator							
Constant	0.008329 (0.005331)	0.008481 (0.005186)	0.008221 (0.005229)	0.008785 (0.005246)	0.007963 (0.005298)	0.008821* (0.005118)	0.008155 (0.004790)
Survey forecast inflation	0.007966*** (0.001818)	0.007769*** (0.001722)	0.008086*** (0.001530)	0.007832*** (0.006405)	0.008336*** (0.001786)	0.007736*** (0.001712)	0.008647*** (0.001121)
Lagged inflation	-0.353157* (0.197663)	-0.324123* (0.185340)	-0.360740* (0.179260)	-0.349480* (0.194054)	-0.353755* (0.189255)	-0.333590* (0.174433)	-0.402387** (0.155917)
Crisis dummy	0.004470 (0.004833)		0.004784 (0.004936)	0.002268 (0.005965)			0.003853 (0.005227)
Import price inflation	0.008431 (0.078159)	0.035068 (0.072149)		0.048264 (0.078229)		0.058860 (0.067151)	
Growth of oil prices	0.013108 (0.015707)	0.010556 (0.015510)	0.013652 (0.013847)		0.012506 (0.013576)		
Unemployment slack $\left(U_t - \widehat{U_t}\right)$	-0.010800* (0.006150)	-0.010275* (0.005962)	-0.010939 (0.006613)	-0.010015 (0.006405)	-0.010820 (0.006448)	-0.009806 (0.006045)	-0.010772* (0.006232)

Note: The table reports the estimates of the full-form of Phillips Curve in which the inflation measured by GDP deflator is a dependent variable according to specifications below:

$$\pi_t = \alpha_0 + \alpha_1\left(U_t - \widehat{U_t}\right) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \alpha_4(D_t^{CRISIS}) + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \qquad (1)$$

Where $U_t - \widehat{U_t}$ is the unemployment slack. The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses. This table shows estimates of all 7 possible models which include *at least one of control variables* (i.e. the crisis dummy, the import price inflation, and the growth of oil prices).

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 11

The regression of the inflation measured by GDP deflator on the detrended log real GDP $(y_t - \hat{y}_t)$

Inflation measured by GDP deflator							
Constant	0.011088** (0.004663)	0.011112** (0.004577)	0.010372** (0.004607)	0.011325** (0.004634)	0.009926** (0.004626)	0.011304** (0.004588)	0.010281** (0.004302)
Survey forecast inflation	0.006597*** (0.001702)	0.006477* (0.001663)	0.007448*** (0.007448)	0.006576*** (0.001730)	0.007802*** (0.001764)	0.006496*** (0.001646)	0.008007*** (0.001018)
Lagged inflation	-0.324096 (0.196664)	-0.299003 (0.181198)	-0.378799* (0.201519)	-0.325547 (0.190617)	-0.367152 (0.214421)	-0.307945* (0.169766)	-0.419499** (0.175163)
Crisis dummy	0.004099 (0.004710)		0.006459 (0.005461)	0.002597 (0.005582)			0.005528 (0.005635)
Import price inflation	0.062753 (0.088469)	0.084772 (0.085491)		0.088290 (0.077462)		0.099438 (0.071593)	
Growth of oil prices	0.009402 (0.088469)	0.007225 (0.016858)	0.013368 (0.014997)		0.011816 (0.014813)		
Detrended log real GDP $(y_t - \hat{y}_t)$	0.152851* (0.081335)	0.147733* (0.079466)	0.160024* (0.085740)	0.150201* (0.079757)	0.152220* (0.083759)	0.146551* (0.076300)	0.158072* (0.079256)

Note: The table reports the estimates of the full-form of Phillips Curve in which the inflation measured by GDP deflator is a dependent variable according to specifications below:

$$\pi_t = \alpha_0 + \alpha_1(y_t - \hat{y}_t) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \alpha_4(D_t^{CRISIS}) + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \qquad (2)$$

Where $y_t - \hat{y}_t$ is the detrended log real GDP. The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses. This table shows estimates of all 7 possible models which include *at least one of control variables* (i.e. the crisis dummy, the import price inflation, and the growth of oil prices).

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 12

The regression of the inflation measured by GDP deflator on the output gap estimated by Oxford Economics $(y_t - \hat{y}_t)$

Inflation measured by GDP deflator							
Constant	0.016977*** (0.004859)	0.016982*** (0.004700)	0.0016886*** (0.004564)	0.017134*** (0.005038)	0.016883*** (0.004494)	0.017105*** (0.004829)	0.016857*** (0.004902)
Survey forecast inflation	0.007778*** (0.001939)	0.007772*** (0.001838)	0.007992*** (0.001452)	0.007729*** (0.001880)	0.008029*** (0.001512)	0.007769*** (0.001732)	0.008481*** (0.001169)
Lagged inflation	-0.346354* (0.192670)	-0.345317* (0.174891)	-0.359670** (0.161575)	-0.348059* (0.186115)	-0.358892** (0.158613)	-0.356567** (0.164131)	-0.396358** (0.140939)
Crisis dummy	0.000192 (0.004524)		0.000707 (0.003932)	-0.001431 (0.004618)			-0.000090 (0.004059)
Import price inflation	0.015356 (0.085268)	0.016351 (0.074282)		0.045537 (0.079236)		0.039733 (0.071714)	
Growth of oil prices	0.010823 (0.012945)	0.010724 (0.012659)	0.011777 (0.011190)		0.011619 (0.0011124)		
Output gap (Oxford Economics) $(y_t - \hat{y}_t)$	0.002598** (0.000932)	0.002598*** (0.000908)	0.002630** (0.001012)	0.002542** (0.000905)	0.002640** (0.000999)	0.002536*** (0.000869)	0.002638*** (0.000935)

Note: The table reports the estimates of the full-form of Phillips Curve in which the inflation measured by GDP deflator is a dependent variable according to specifications below:

$$\pi_t = \alpha_0 + \alpha_1(y_t - \hat{y}_t) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \alpha_4(D_t^{CRISIS}) + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \qquad (2)$$

Where $y_t - \hat{y}_t$ is the output gap estimated by Oxford Economics. The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses. This table shows estimates of all 7 possible models which include *at least one of control variables* (i.e. the crisis dummy, the import price inflation, and the growth of oil prices).

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 13 – The Chow's structural breakpoint test

The Chow's breakpoint test is conducted based on the full-form of Phillips Curve which includes *all explanatory variables except the crisis dummy* as specified below:

$$\pi_t = \alpha_0 + \alpha_1(U_t - \widehat{U_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \quad (1)$$

$$\pi_t = \alpha_0 + \alpha_1(y_t - \widehat{y_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3\pi_{t-1} + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t \quad (2)$$

	Inflation measurement		(a) Headline CPI inflation			(b) Inflation measured by GDP deflator		
	Economic-driving variable		Unemployment slack $(U_t - \widehat{U_t})$	Detrended log real GDP $(y_t - \widehat{y_t})$	Output gap (Oxford Economics) $(y_t - \widehat{y_t})$	Unemployment slack $(U_t - \widehat{U_t})$	Detrended log real GDP $(y_t - \widehat{y_t})$	Output gap (Oxford Economics) $(y_t - \widehat{y_t})$
Asian financial crisis	During-crisis	1997	1.073285 (0.4206)	0.758095 (0.6134)	1.115071 (0.3992)	0.435908 (0.8436)	0.695027 (0.6576)	0.719628 (0.6402)
		1998	6.207442** (0.0019)	1.853955 (0.1555)	1.639455 (0.2043)	2.025014 (0.1254)	1.628205 (0.2073)	1.855012 (0.1553)
	Post-crisis	1999	6.537028** (0.0015)	1.877937 (0.1509)	1.683814 (0.1930)	4.505771** (0.0084)	2.771672 (0.0511)	3.780886** (0.0170)
		2000	4.237555** (0.0108)	3.321846** (0.0276)	2.664915 (0.0578)	5.192377** (0.0045)	4.643174** (0.0074)	5.364278** (0.0039)
Global financial crisis	During-crisis	2007	0.632434 (0.7027)	1.793730 (0.1678)	2.436795 (0.0758)	0.408422 (0.8621)	0.179395 (0.9783)	0.433821 (0.8450)
		2008	0.376193 (0.8829)	1.610279 (0.2121)	2.968381** (0.0408)	0.332582 (0.9092)	0.219130 (0.9646)	0.433884 (0.8450)
	Post-crisis	2009	0.348167 (0.9001)	1.894608 (0.1477)	2.774924 (0.0509)	0.508008 (0.7931)	0.285611 (0.9348)	0.382581 (0.8788)
		2010	0.297919 (0.9284)	1.783425 (0.1700)	2.765417 (0.0515)	0.364323 (0.8903)	0.237314 (0.9573)	0.290366 (0.9323)
		2011	0.216913 (0.9654)	1.544127 (0.2308)	2.230157 (0.0973)	0.404762 (0.8645)	0.306489 (0.9238)	0.449870 (0.8341)

Note: The Chow's breakpoint test for the null hypothesis that no breaks at specified breakpoints. The table shows F-statistic and its P-value (in parentheses) from the Chow's breakpoint test. (**) indicates 5% significance level.

Table 14-15

Sub-sample stability reduced-form estimates of the full-form of Phillips Curve which includes *all explanatory variables except the crisis dummy*

Table 14

The regression of the headline CPI inflation

Headline CPI inflation	Sub-sample (1) 1990-1999			Sub-sample (2) 2000-2017		
Constant	0.060389* (0.023557)	0.030491 (0.035893)	0.067091* (0.026175)	-0.007413** (0.002899)	-0.008096 (0.005090)	-0.007923 (0.006526)
Survey forecast inflation	0.002647 (0.003270)	0.005692 (0.004328)	0.001515 (0.003764)	0.010096*** (0.001106)	0.010432*** (0.001739)	0.011039*** (0.001888)
Lagged inflation	-0.795134** (0.178676)	-0.577647* (0.239033)	-0.755962* (0.259527)	-0.083402* (0.040690)	-0.061386* (0.029515)	-0.046382 (0.041007)
Crisis dummy						
Import price inflation	0.121867 (0.067780)	0.110137 (0.060537)	0.147210 (0.088839)	0.068498* (0.036610)	0.052983 (0.034295)	0.029890 (0.005703)
Growth of oil prices	0.111639*** (0.018615)	0.070897 (0.033316)	0.103674** (0.030368)	0.015877*** (0.004224)	0.015301*** (0.004718)	0.017179** (0.005703)
Unemployment slack $(U_t - \widehat{U_t})$	-0.005218 (0.004080)			-0.012185*** (0.003550)		
Detrended log real GDP $(y_t - \widehat{y_t})$		0.122733 (0.073643)			0.125179* (0.059145)	
Output gap $(y_t - \widehat{y_t})$ (Oxford Economics)			0.000798 (0.001013)			0.000886 (0.006526)

Note: The table reports the sub-sample estimates of the full-form of Phillips Curve in which the headline CPI inflation is a dependent variable according to specifications below:

$$\pi_t = \alpha_0 + \alpha_1(U_t - \widehat{U_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 \pi_{t-1} + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t$$

$$\pi_t = \alpha_0 + \alpha_1(y_t - \widehat{y_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 \pi_{t-1} + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t$$

Where $U_t - \widehat{U_t}$ is the unemployment slack and $y_t - \widehat{y_t}$ is the output gap. There are 2 proxies for the output gap: the detrended log real GDP by the Hodrick-Prescott filter; and output gap estimated by Oxford Economics. This table shows estimates of the models in which *all explanatory variables included except the crisis dummy*.

The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses.

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 15

The regression of the inflation measured by GDP deflator

Inflation measured by GDP deflator	Sub-sample (1) 1990-1999			Sub-sample (2) 2000-2017		
Constant	-0.067642** (0.016610)	-0.067689* (0.028074)	-0.027112 (0.014954)	0.006975 (0.006773)	0.009967 (0.006908)	0.019231*** (0.006190)
Survey forecast inflation	0.028489*** (0.002292)	0.022828** (0.070342)	0.022505*** (0.002669)	0.006154 (0.002338)	0.005330** (0.002044)	0.004583** (0.001806)
Lagged inflation	-1.046443*** (0.169712)	-0.674491** (0.191752)	-0.929423** (0.123144)	0.009420 (0.151515)	-0.000291 (0.142815)	-0.047108 (0.121928)
Crisis dummy						
Import price inflation	-0.452983*** (0.056778)	-0.176033 (0.077395)	0.089658** (0.089658)	0.016664 (0.064747)	0.034147 (0.055156)	0.037571 (0.044610)
Growth of oil prices	0.003080 (0.021194)	-0.027893 (0.022064)	-0.010044 (0.012804)	0.018610* (0.009698)	0.017249* (0.009435)	0.019907* (0.009455)
Unemployment slack $(U_t - \widehat{U_t})$	-0.026011*** (0.002708)			-0.009322 (0.008347)		
Detrended log real GDP $(y_t - \widehat{y_t})$		0.320581** (0.070342)			0.170936 (0.104766)	
Output gap $(y_t - \widehat{y_t})$ (Oxford Economics)			0.004423** (0.000949)			0.002529** (0.009455)

Note: The table reports the sub-sample estimates of the full-form of Phillips Curve in which the inflation measured by GDP deflator is a dependent variable according to specifications below:

$$\pi_t = \alpha_0 + \alpha_1(U_t - \widehat{U_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 \pi_{t-1} + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t$$

$$\pi_t = \alpha_0 + \alpha_1(y_t - \widehat{y_t}) + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 \pi_{t-1} + \alpha_5(\pi_t^{IMP}) + \alpha_6(Oilprice_t) + \varepsilon_t$$

Where $U_t - \widehat{U_t}$ is the unemployment slack and $y_t - \widehat{y_t}$ is the output gap. There are 2 proxies for the output gap: the detrended log real GDP by the Hodrick-Prescott filter; and output gap estimated by Oxford Economics. This table shows estimates of the models in which *all explanatory variables included except the crisis dummy*.

The Bartlett kernel, fixed Newey-West, HAC is used. The robust Standard Error is reported in parentheses.

*** denotes statistical significance at 1% level

** denotes statistical significance at 5% level

* denotes statistical significance at 10% level

Table 16

The measures of fit of the models of Table 1-15

(A) The Traditional Phillips Curve

Inflation measurement	Economic-driving variable	R-squared	Adjusted R-squared	Standard Error of the model
Headline CPI inflation (Table 1)	Unemployment rate	0.029620	-0.007703	0.022847
	Log real GDP	0.108340	0.074045	0.021901
Inflation measured by GDP (Table 2)	Unemployment rate	0.002015	-0.036370	0.021219
	Log real GDP	0.117196	0.083243	0.019957

(B) The NKPC

Inflation measurement	Economic-driving variable	R-squared	Adjusted R-squared	Standard Error of the model
Headline CPI inflation (Table 3)	Unemployment slack	0.903855	0.891314	0.007331
	Detrended Log real GDP	0.900762	0.887818	0.007448
	Output gap (Oxford Economics)	0.902347	0.889610	0.007388
Inflation measured by GDP (Table 4)	Unemployment slack	0.639192	0.592131	0.013202
	Detrended Log real GDP	0.630041	0.581785	0.013368
	Output gap (Oxford Economics)	0.731450	0.696422	0.011390

(C) The full-form of Phillips Curve with *all the 3 controls included simultaneously*

Inflation measurement	Economic-driving variable	R-squared	Adjusted R-squared	Standard Error of the model
Headline CPI inflation (Table 5)	Unemployment slack	0.949262	0.934041	0.005711
	Detrended Log real GDP	0.955536	0.942196	0.005346
	Output gap (Oxford Economics)	0.948479	0.933023	0.005755
Inflation measured by GDP (Table 6)	Unemployment slack	0.661562	0.560030	0.013712
	Detrended Log real GDP	0.663704	0.562815	0.013668
	Output gap (Oxford Economics)	0.744772	0.668203	0.011907

(D) The full-form of Phillips Curve with *all the possible combinations* of 3 controls

Case (1) Import price inflation and growth of oil prices

Inflation measurement	Economic-driving variable	R-squared	Adjusted R-squared	Standard Error of the model
Headline CPI inflation (Table 7)	Unemployment slack	0.948247	0.935925	0.005629
	Detrended Log real GDP	0.954521	0.943692	0.005277
	Output gap (Oxford Economics)	0.945823	0.932923	0.005759
Inflation measured by GDP (Table 8)	Unemployment slack	0.656487	0.574698	0.013481
	Detrended Log real GDP	0.659400	0.578305	0.013424
	Output gap (Oxford Economics)	0.744762	0.683991	0.011621

Case (2) Crisis dummy and growth of oil prices

Inflation measurement	Economic-driving variable	R-squared	Adjusted R-squared	Standard Error of the model
Headline CPI inflation (Table 7)	Unemployment slack	0.948906	0.936741	0.005593
	Detrended Log real GDP	0.948305	0.935996	0.005626
	Output gap (Oxford Economics)	0.943064	0.929507	0.005904
Inflation measured by GDP (Table 8)	Unemployment slack	0.661449	0.580841	0.013383
	Detrended Log real GDP	0.656642	0.574891	0.013478
	Output gap (Oxford Economics)	0.744367	0.683502	0.011630

Case (3) Crisis dummy and import price inflation

Inflation measurement	Economic-driving variable	R-squared	Adjusted R-squared	Standard Error of the model
Headline CPI inflation (Table 7)	Unemployment slack	0.919870	0.900792	0.007004
	Detrended Log real GDP	0.935049	0.919584	0.006306
	Output gap (Oxford Economics)	0.929917	0.913231	0.006550
Inflation measured by GDP (Table 8)	Unemployment slack	0.648718	0.565079	0.013633
	Detrended Log real GDP	0.656891	0.575199	0.013473
	Output gap (Oxford Economics)	0.735755	0.672839	0.011824

Case (4) Growth of oil prices

Inflation measurement	Economic-driving variable	R-squared	Adjusted R-squared	Standard Error of the model
Headline CPI inflation (Table 7)	Unemployment slack	0.946659	0.936961	0.005583
	Detrended Log real GDP	0.941648	0.931039	0.005839
	Output gap (Oxford Economics)	0.942605	0.932170	0.005791
Inflation measured by GDP (Table 8)	Unemployment slack	0.653978	0.591065	0.013219
	Detrended Log real GDP	0.643252	0.578389	0.013422
	Output gap (Oxford Economics)	0.744207	0.697699	0.011366

Case (5) Import price inflation

Inflation measurement	Economic-driving variable	R-squared	Adjusted R-squared	Standard Error of the model
Headline CPI inflation (Table 7)	Unemployment slack	0.918994	0.904266	0.006880
	Detrended Log real GDP	0.934786	0.922929	0.006173
	Output gap (Oxford Economics)	0.920324	0.905838	0.006824
Inflation measured by GDP (Table 8)	Unemployment slack	0.647273	0.583141	0.013347
	Detrended Log real GDP	0.655005	0.592278	0.013200
	Output gap (Oxford Economics)	0.735166	0.687014	0.011565

Case (6) Crisis dummy

Inflation measurement	Economic-driving variable	R-squared	Adjusted R-squared	Standard Error of the model
Headline CPI inflation (Table 7)	Unemployment slack	0.904300	0.886900	0.007478
	Detrended Log real GDP	0.903741	0.886239	0.007500
	Output gap (Oxford Economics)	0.904374	0.886988	0.007475
Inflation measured by GDP (Table 8)	Unemployment slack	0.644118	0.579413	0.013406
	Detrended Log real GDP	0.640017	0.574566	0.013483
	Output gap (Oxford Economics)	0.731454	0.682627	0.011646

(E) Sub-sample stability reduced-form estimates of the full-form of Phillips Curve which includes *all explanatory variables except the crisis dummy*

Sub-sample (1)

Inflation measurement	Economic-driving variable	R-squared	Adjusted R-squared	Standard Error of the model
Headline CPI inflation (Table 14)	Unemployment slack	0.969421	0.918456	0.005887
	Detrended Log real GDP	0.977292	0.939444	0.005073
	Output gap (Oxford Economics)	0.963060	0.901493	0.006471
Inflation measured by GDP (Table 15)	Unemployment slack	0.971495	0.923986	0.007857
	Detrended Log real GDP	0.943913	0.850433	0.011021
	Output gap (Oxford Economics)	0.970975	0.922599	0.007928

Sub-sample (2)

Inflation measurement	Economic-driving variable	R-squared	Adjusted R-squared	Standard Error of the model
Headline CPI inflation (Table 14)	Unemployment slack	0.973285	0.962154	0.003451
	Detrended Log real GDP	0.967497	0.953954	0.003806
	Output gap (Oxford Economics)	0.960455	0.943978	0.004199
Inflation measured by GDP (Table 15)	Unemployment slack	0.705011	0.582098	0.009377
	Detrended Log real GDP	0.731615	0.619788	0.008944
	Output gap (Oxford Economics)	0.800697	0.717655	0.007708

Table 17

A summary of variables

Type of variable			Variable in Eviews	Variable	Description	Source of data
Dependent variable		π_t	inflation_headline_cpi	Inflation CPI (%)	Inflation rate measured by Headline Consumer Price Index (CPI)	The headline CPI is obtained from Bank of Thailand (BOT)
			inflation_gdp_deflator	Inflation GDP deflator (%)	Inflation rate measured by GDP deflator	The GDP deflator is obtained from World Economic Outlook (WEO) under IMF
Independent variable (Explanatory variable)	Main variable of interest	U_t	unemployment_rate	Percentage unemployment (%)	Percentage of unemployment rate	The percentage of unemploymenr rate is obtained from Bank of Thailand (BOT)
		$lnY_t = y_t$	log_realgdp	Log real GDP (%)	Log of real GDP	The real GDP is obtained from the office of the National Economic and Social Development Board (NESDB)
		$U_t - \widehat{U}_t$	cycle_unemployment	Unemployment slack (%)	Cycle component of the percentage of unemployment rate as unemployment slack	Detrended percentage of unemployment rate employing the Hodrick-Prescott filter in Eviews to eliminate the trend component which is the natural rate of unemployment rate
		$lny_t - ln\hat{y}_t$ $y_t - \hat{y}_t$	cycle_log_realgdp	Output gap1 (%)	Output gap calculated by detrended log real GDP	Detrended log real GDP employing the Hodrick-Prescott filter in Eviews to eliminate the trend component which is the potential rate of output
			output_gap_2	Output gap2 (%)	Output gap calculated by Oxford Economics	The output gap is estimated by Oxford Economics
	Control variables	$E_t(\pi_{t+1})$	survey_forecast_inflation	Expected inflation (survey) (%)	The survey of the expectation of inflation	The survey questionnaires is conduced by IFO World Economic Survey (WES)
		D_t^{CRISIS}	crisis_dummy	Crisis dummy	A dummy of financial crises	The dummy = 1 for years in which a financial crisis arises and has an effect. The dummy = 0 otherwise
		π_t^{IMP}	growth_import_deflator	Import price inflation (%)	Import price inflation	The import price inflation is calculated by log-differencing import price deflator (index) and the import price deflator is obtained from Oxford Economics
		$Oilprice_t$	growth_oilprice	Growth of oil price (%)	Growth of Dubai oil prices	The growth of oil prices is calculated by log-differencing Dubai oil prices and the Dubai oil prices (USD/Barrel) is obtained from World Economic Outlook (WEO) under IMF

Table 18

The descriptive data

Sample:
1990 - 2017

	INFLATION GDP DEFLATOR (%)	INFLATION HEADLINE CPI (%)	LOG REAL GDP (%)	UNEMPLOYMENT RATE (%)	OUTPUT GAP1 (%)	UNEMPLOYMENT SLACK (%)	OUTPUT GAP2 (%)	CRISIS DUMMY	IMPORT PRICE INFLATION (%)	GROWTH OF OIL PRICE (%)	EXPECTED INFLATION (SURVEY) (%)
Mean	0.0310	0.0286	29.4726	1.9629	0.0025	-0.0242	-2.8636	0.1786	0.0259	0.0561	4.0250
Median	0.0298	0.0290	29.4835	1.6250	0.0034	-0.0979	-2.4300	0.0000	0.0152	0.0734	3.6500
Maximum	0.0775	0.0770	29.9541	4.3500	0.1050	1.5508	4.0900	1.0000	0.1388	0.4311	10.0000
Minimum	-0.0261	-0.0091	28.8470	0.6600	-0.0743	-1.2504	-11.0700	0.0000	-0.0510	-0.6358	1.2000
Std. Dev.	0.0208	0.0228	0.3166	1.0502	0.0429	0.6259	3.4242	0.3900	0.0452	0.2147	2.1251
Skewness	-0.3266	0.0718	-0.1947	0.7362	0.3958	0.4936	-0.3610	1.6785	0.5007	-1.0698	0.7479
Kurtosis	3.6656	2.1619	1.9736	2.6463	3.1261	3.9912	3.0666	3.8174	3.1813	5.1984	3.3178
Jarque-Bera	1.0146	0.8436	1.4058	2.6755	0.7496	2.2829	0.6134	13.9273	1.2082	10.9791	2.7281
Probability	0.6021	0.6559	0.4951	0.2624	0.6874	0.3194	0.7359	0.0009	0.5466	0.0041	0.2556
Sum	0.8691	0.8003	825.2335	54.9600	0.0695	-0.6786	-80.1800	5.0000	0.7247	1.5706	112.7000
Sum Sq. Dev.	0.0117	0.0140	2.7068	29.7792	0.0497	10.5770	316.5726	4.1071	0.0552	1.2450	121.9325
Observations	28	28	28	28	28	28	28	28	28	28	28

Table 19

The correlation between the inflation and the economic-driving variables
(i.e. the unemployment rate and the log real GDP)

	INFLATION HEADLINE CPI	INFLATION GDP DEFLATOR	UNEMPLOYMENT RATE	LOG REAL GDP
INFLATION HEADLINE CPI	1.0000	0.7533	0.1721	-0.3292
INFLATION GDP DEFLATOR	0.7533	1.0000	0.0449	-0.3423
UNEMPLOYMENT RATE	0.1721	0.0449	1.0000	-0.7456
LOG REAL GDP	-0.3292	-0.3423	-0.7456	1.0000

Table 20

The correlation between the inflation and the economic-driving variables
(i.e. the unemployment slack and the output gap)

	INFLATION HEADLINE CPI	INFLATION GDP DEFLATOR	UNEMPLOYMENT SLACK (CYCLE UNEMPLOYMENT)	OUTPUT GAP1 (CYCLE LOG REAL GDP)	OUTPUT GAP2 (OXFORD ECONOMICS)
INFLATION HEADLINE CPI	1.0000	0.7533	-0.1845	0.4355	0.3511
INFLATION GDP DEFLATOR	0.7533	1.0000	-0.2846	0.2947	0.4214
UNEMPLOYMENT SLACK (CYCLE UNEMPLOYMENT)	-0.1845	-0.2846	1.0000	-0.7810	-0.8276
OUTPUT GAP1 (CYCLE LOG REAL GDP)	0.4355	0.2947	-0.7810	1.0000	0.8467
OUTPUT GAP2 (OXFORD ECONOMICS)	0.3511	0.4214	-0.8276	0.8467	1.0000

Figure 1

The pattern of inflation overtime

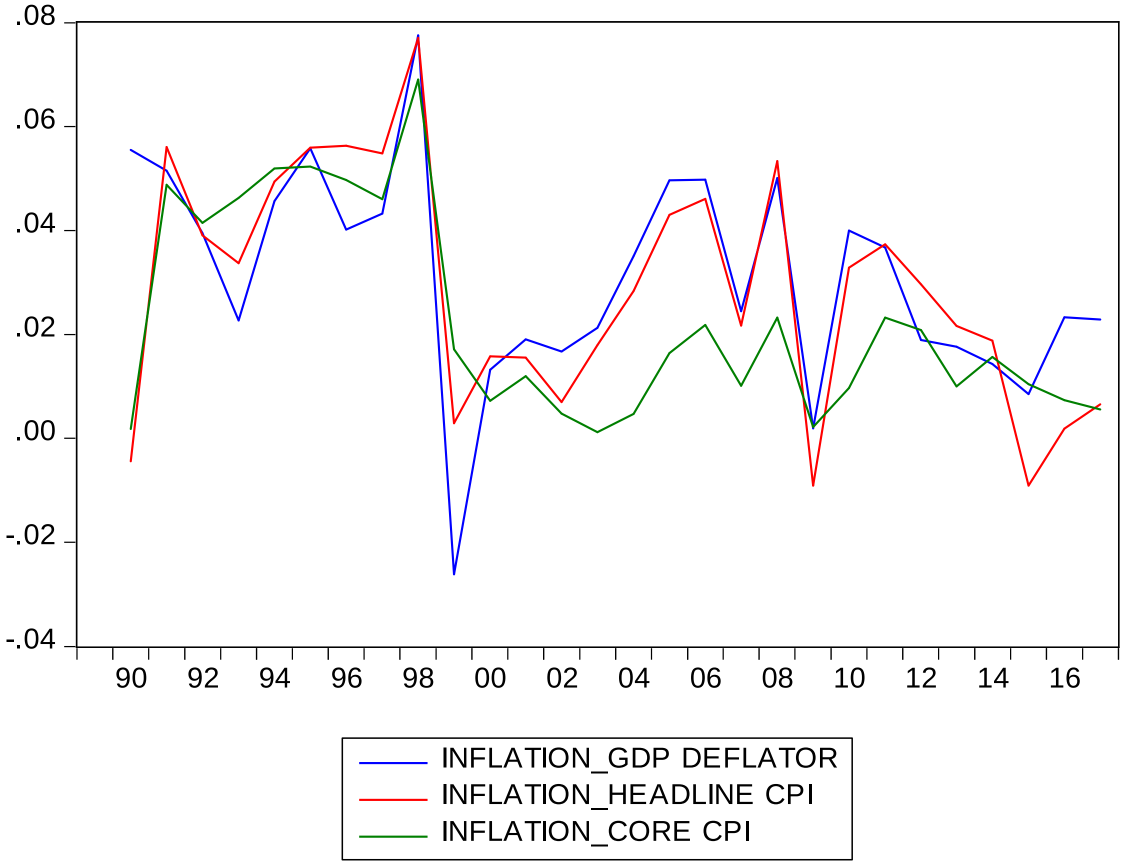
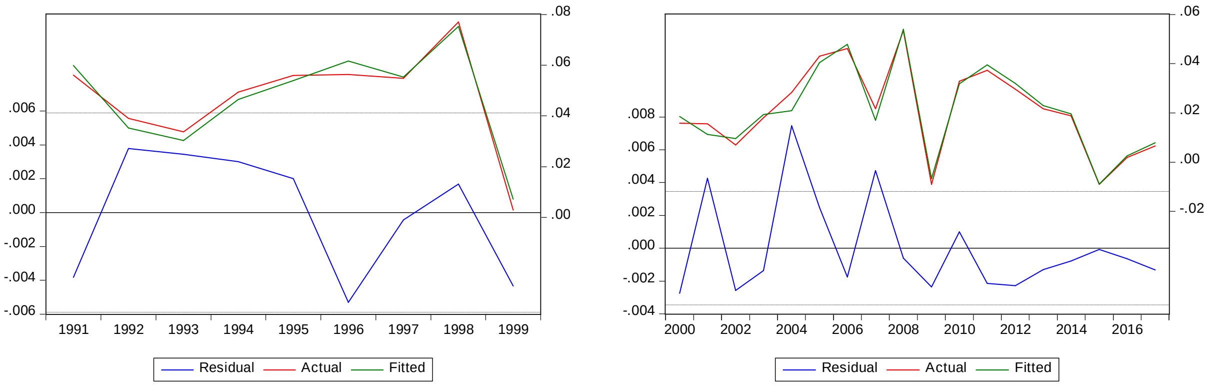


Figure 2

The plots of residuals of Table 14-15

Sub-sample (1) 1990-1997

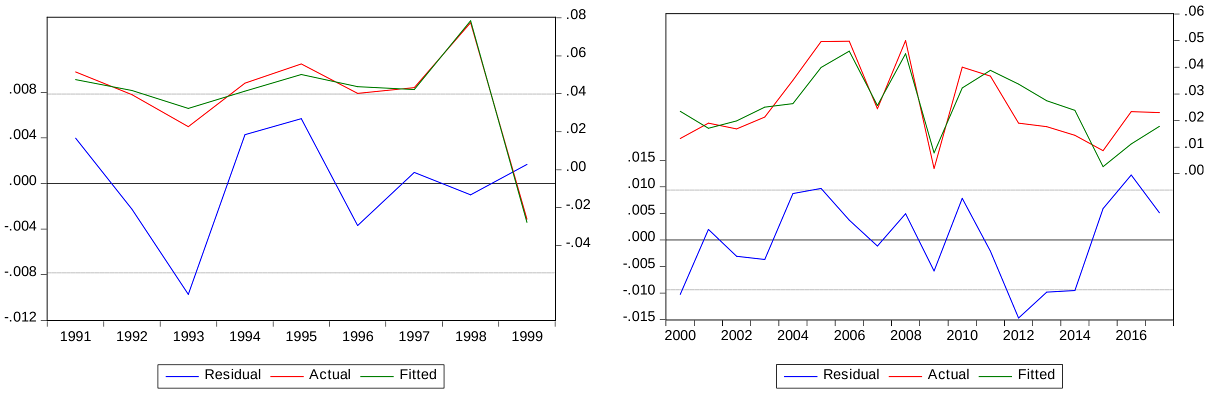
Sub-sample (2) 2000-2017



(A) The residual of the regression of the headline CPI inflation on the unemployment gap

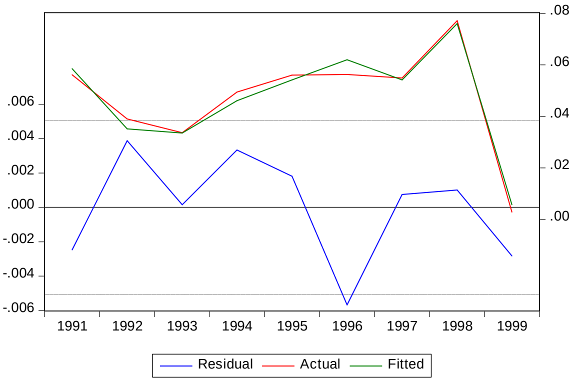
Sub-sample (1) 1990-1997

Sub-sample (2) 2000-2017

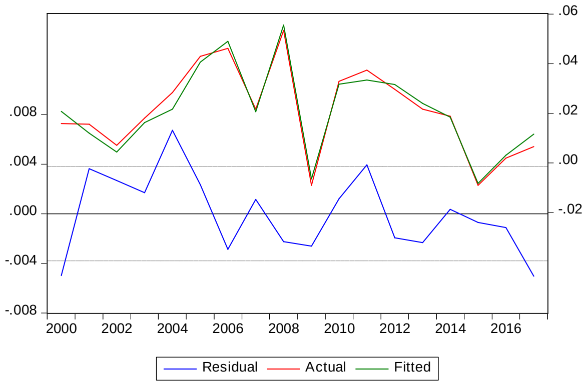


(B) The residual of the regression of the inflation measured by GDP deflator on the unemployment gap

Sub-sample (1) 1990-1997

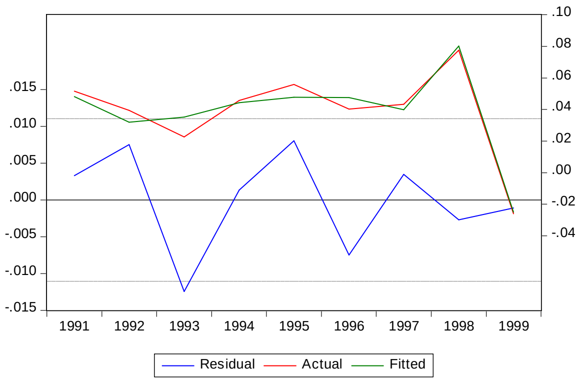


Sub-sample (2) 2000-2017

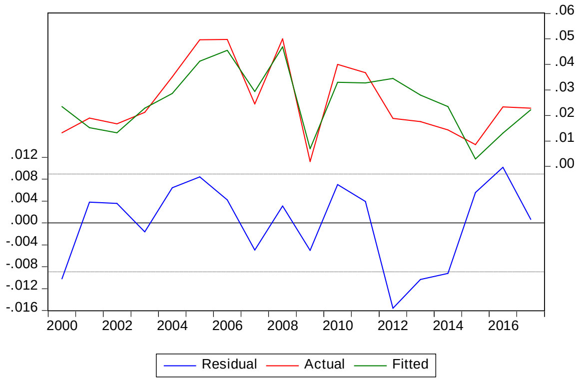


(C) The residual of the regression of the headline CPI inflation on the detrended log real GDP

Sub-sample (1) 1990-1997



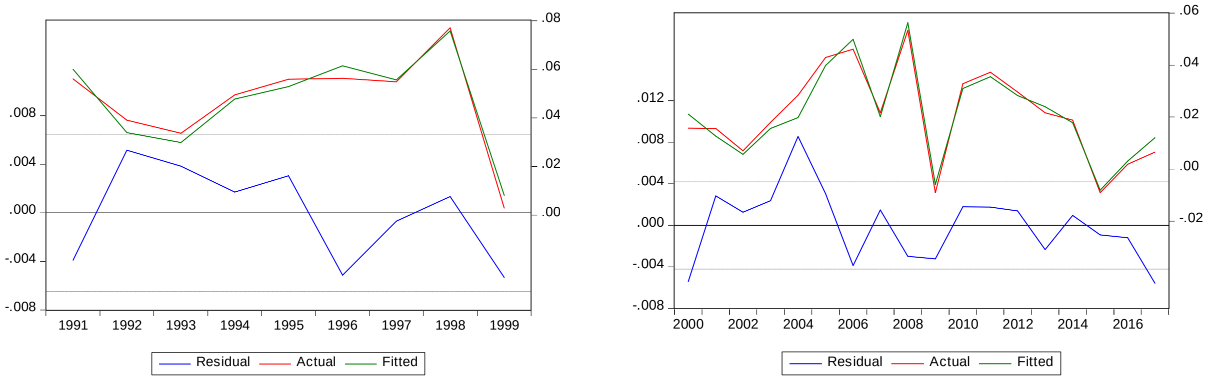
Sub-sample (2) 2000-2017



(D) The residual of the regression of the inflation measured by GDP deflator on the detrended log real GDP

Sub-sample (1) 1990-1997

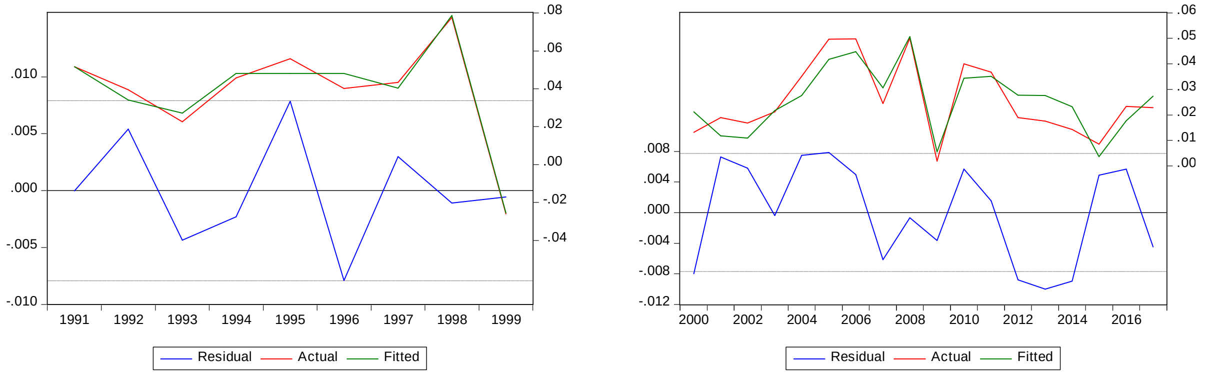
Sub-sample (2) 2000-2017



(E) The residual of the regression of the headline CPI inflation on the output gap estimated by Oxford Economics

Sub-sample (1) 1990-1997

Sub-sample (2) 2000-2017

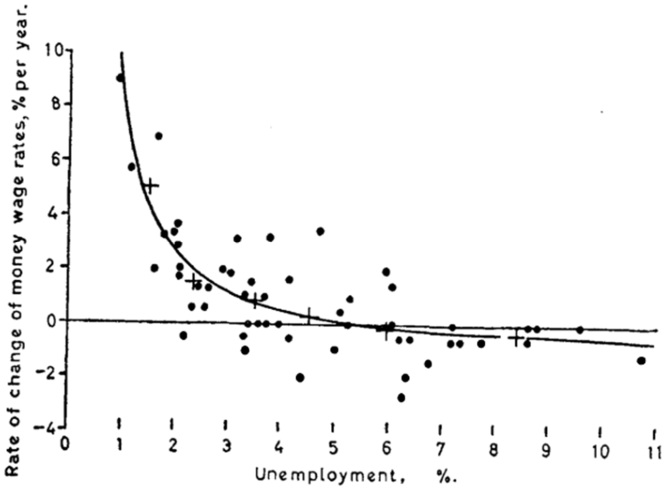


(F) The residual of the regression of the inflation measured by GDP deflator on the output gap estimated by Oxford Economics

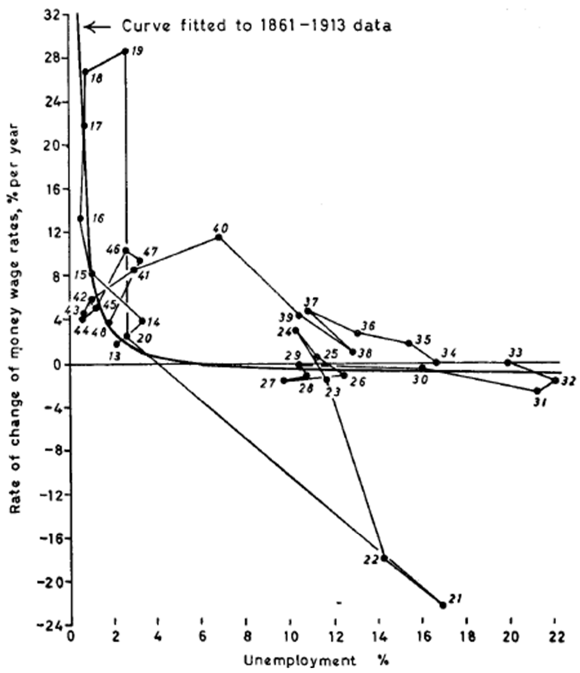
Figure 3

The scatter diagram of the rate of change of wage rates and the percentage unemployment
The entire period of 1961-1957 are split into 1961-1913, 1913-1948 and 1948-1957

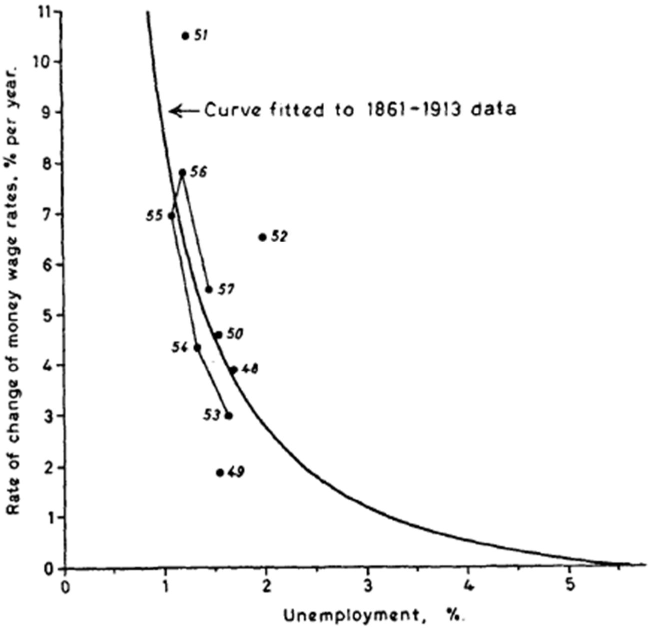
(a) 1861-1913



(b) 1913-1948



(c) 1948-1957



Source: Phillips (1958)