IS THE PHILLIPS CURVE A UNICORN?

by

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ABSTRACT

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The new Keynesian wage Phillips curve (NKWPC) is derived from the standard new Keynesian Phillips curve (NKPC) that is examined and verified by many economists. The NKWPC model uses the structural wage equation to present the significant inverse relationship between wage inflation and the unemployment rate in the US economy with the significant assumption of a constant natural rate of unemployment. This study examines the NKWPC model using the generalized method of moments (GMM) and generalized autoregressive conditionally heteroskedastic-M (GARCH-M) to confirm the critical inverse relationship of the Phillips curve. In particular, this study tests the NKWPC separately targeting the official unemployment rate from Komlos (2019)'s real unemployment rate.

The estimated results of this study support the NKWPC re-confirming a significant negative relationship between wage inflation and unemployment, using two different econometric techniques of GMM and GARCH-M. Moreover, it is apparent that they do not distinguish the official unemployment rate from the real unemployment rate.

The Phillips curve is not just a unicorn, or rarity, in the economic world. It is a substantial indicator and still holds merit. This study yields to another lending support to the importance of the Phillips curve.

DEDICATION

Above all, I dedicate my thesis to God and thank Him for everything He has done for me. This manuscript is also dedicated to my family and many friends. A special feeling of gratitude is expressed to my loving parents, Wondae Lee and Taekjoo Song whose words of encouragement and push for tenacity ring in my ears. My elder brother Sangjoon Lee, his wife Youngsook Choi, his daughter Gahyun Lee, my sister Gongjoo Lee, my younger brother Sangeun Lee, his wife Eunsook Kim and his daughter Nayeon Lee have never left my side and are very special to me.

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IS THE PHILLIPS CURVE A UNICORN?

List of Tables ………………………………………………………………..………..…. x

List of Figures ………………………………………………………..……….... xi

1. Introduction ………………………………………………………..……….. 1

2. A Review of the Literature ………………………………………………………… 3

3. The Theoretical Model and Methodology ……………………………………………. 9

(1) Generalized method moments (GMM) ……….…………………………….. 9

1) Calvo's NKPC ……………………………………………………...… 9

2) Galí and Gertler's NKPC ………………………………………….…… 11

3) Galí and Gertler's hybrid NKPC ……………………………...….. 12

4) Galí's NKWPC ……………………………………………………..... 14

(2) Generalized autoregressive conditionally heteroskedastic-M (GARCH-M)

estimation ……………………………………………………….…… 15

(3) Komlos' real unemployment rate ……………..…………………………... 16

(4) Hypotheses ……………………………………………………………..... 17

4. Empirical Analysis ……………………………………………………...………… 19

(1) Descriptive statistics …………………………………………...…… 19

(2) Estimation of the NKWPC ……………………………….…………… 23

1) Test for NKWPC using the official unemployment rate ……..…….. 23

2) Test for NKWPC using the real unemployment rate ……….……. 26

5. Conclusion ……………………………………………...…………………… 29

Appendices …………………………………………………………………….…….. 31

References ……………………………………………………………………… 43

LIST OF TABLES

Table 1. Testing the NKWPC and Econometric Methods of this Study …….……….. 18

Table 2. Basic Statistics for the NKWPC 1994Q1 – 2019Q4 ……………….........…… 19

Table 3. Basic Statistics for Real Unemployment Rate 1994Q1 – 2019Q4 …………… 21

Table 4. The Average Real Unemployment Rate in the US 2019 ………..………..…… 22

Table 5. GMM and GARCH(1,1)-M estimation for the NKWPC using Official
Unemployment Rate 1994Q1 – 2019Q4 ……………………………………..… 24

Table 6. GMM and GARCH(1,1)-M estimation for the NKWPC using Real
Unemployment Rate 1994Q1 – 2019Q4 ……………………………..……… 28

LIST OF FIGURES

Figure 1. Official Unemployment Rate 1994Q1 – 2019Q4 ……………………………. 20

Figure 2. Wage Inflation and Official Unemployment Rate 1994Q1 – 2019Q4 ………. 23

Figure 3. Wage Inflation and Real Unemployment Rate 1994Q1 – 2019Q4 ………..… 25

1. INTRODUCTION

Since the 1980s, the inclination of the debates about the Phillips curve has been unlike the dynamic deliberation of the monetarists during the 1960s and 1970s. Thanks to the higher oil prices during the 1970s, economies had experienced adverse supply shocks. Economists had to work on alternative explanations because they had been confronted with the conflict of the Phillips curve to elucidate the supply shock consequences having a positive correlation. Gordon's (2011) research on the Phillips curve history explained utilizing the two ends of the continuum. One bloc of alternatives concentrated on the rational expectations approach and long-run neutrality of money – a vertical Phillips curve in the long run. The second bloc assumed that prices are sticky and monetary policies are endogenous in response to GDP discrepancies and higher price levels. The two ends of alternatives reached two very opposite destinations on the Phillips curve. One branch concluded "The Phillips curve is dead," but the other branch alleged "The Phillips curve is alive and well." (Reinbold, 2020, p.138).

Recent studies performed, since the 1980s, have provided evidence stressing "jump in expectations in response to anticipated monetary policy changes" by Sargent (1999, pp.130-134) as well as others like Cogley and Sargent (2005), Sargent et al. (2006), Primiceri (2006), Sims (2008), Kydland and Prescott (1977), Phelps (1978), and Gordon (1975, 1984). Sporadic shout-outs claiming "the Phillips curve died" have been continuing by Friedman-Phelps-Lucas legacy supporters such as Roberts (2017, p.64), former secretary of the US Treasury during the Reagan Administration. On the other hand, Krugman (2015) claimed that "the accelerationist" doctrine that has dominated economic discussion of inflation and unemployment for 40 years has fallen flat (p.1). The other branch, conversely, has put much efforts on refining the new Keynesian Phillips curve (NKPC) to claim that the Phillips curve is alive and well. Based on Calvo's (1983) model, rigorous discussions of the NKPC have become a fundamental cornerstone of the New Keynesian economics. Galí and Gertler (1999) have driven the hybrid NKPC model that has been reexamined and modified by numerous economists.

This study scrutinizes whether or not the Phillips curve currently exists. It applies the current quantitative data from 1994Q1 to 2019Q4, but the numerical data of 2020 and 2021 are not deliberated in this study. Secondary to COVID-19, asymmetrical pattern in both price levels and unemployment rates may demonstrate economic crisis consequences. To put it specifically, this study pays attention predominantly to Galí's (2011) new Keynesian wage Phillips curve (NKWPC) which revised Galí and Gertler's (1999) NKPC and hybrid NKPC model to revisit the original Phillips curve. The NKWPC is prudently tested by the general method of moments (GMM) and generalized autoregressive conditionally heteroskedastic-M (GARCH-M) econometric methods. Furthermore, the quantitative econometric models and techniques are applied to compare the variances between the official unemployment rate and the real unemployment rate redefined by Komlos (2019).

2. A REVIEW OF THE LITERATURE

Phillips (1958) discovered a negative nonlinear relation between the rate of change for money wages and the unemployment rate of the UK from 1861 to 1957. Innumerable economists expressed enthusiastic interest in the Phillips' discovery. They searched for feasible ways of exploiting the Phillips model for one of the fundamental macroeconomic theories. Phillips (1958), Samuelson and Solow (1960) have been quoted most in macroeconomic studies for the past century (Sleeman, 2011). Lipsey (1960) applied the Phillips curve further for three time periods of the UK, while Samuelson and Solow (1960) utilized it as an instrument for anti-inflation policy for the US. The economists regarded the Phillips curve as a menu of choices, or a policy prescription providing the foundation of a government to sustain a low unemployment and moderate inflation policy by its fine tuning.

Notwithstanding, Friedman (1975, 1977) entitled the analysis of Phillips (1958) "the error of 1958" and criticized constructively the empirical study (pp.13-16). The Nobel Laureate gave Fisher (1926) higher credit for having studied the same empirical phenomenon earlier than Phillips (1958). Moreover, Friedman (1975, 1977) challenged the Phillips curve model and disclosed the fallacy of it. The main failure of the Phillips curve was that the nominal wage rate should be replaced with the real wage rate and enhanced with the vertical long-run Phillips curve. Along with the economic guru, other economists had contributed with critical and controversial discussions of the Phillips curve. Phelps (1967) also presented an initiation of the money wage dynamics and attempted to explain the role of expectations – the natural rate hypothesis approach. Friedman (1975) strongly acknowledged the criticisms raised by Phelps (1967), Lucas (1969, 1973, 1976) and Lucas and Sargent (1978), as the rational expectations approach. With respect to their contributions, Robert E. Lucas Jr, Edmund S. Phelps, Finn E. Kydland, Edward C. Prescott, Thomas J. Sargent, and Christopher A. Sims were honored and esteemed with Nobel Prize (Fidrmuc and Danišková, 2020).

Around 1980, the trend of discussion was redirected due to the inapplicability of the original Phillips curve for explaining the adverse supply shock that occurred during the 1970s. One of the issues of this new trend was to build a model to explain price adjustment. Calvo (1983) initiated the new Keynesian Phillips curve (NKPC) and assumed that monopolistic firms changed their prices periodically from expected costs to current costs. The devise of Calvo (1983) relied on the works of Taylor (1980) and Rotemberg (1982). Mankiw (2001) entitled the NKPC as a "dynamic extension of the static new Keynesian models of price adjustment." He recognized the contributions of the NKPC in terms of micro-foundations, a loose impression with the Friedman-Phelps approach and the usefulness for analyzing monetary policies. Still yet, Mankiw criticized the empirical problems of the NKPC. First, actual disinflation resulted in recessions, while credible disinflations instigated inflations in the model. Also, although the inflation rate can jump quickly and persistent, the price level adjusts slowly in the model. Lastly, the model is incompetent to produce "impulse response functions," the core of explaining price adjustment (pp. C45-C61).

The hybrid NKPC by Galí and Gertler (1999) was the reaction to the mis-specification problems of Calvo's (1983) formulation. Later, the hybrid model was amended by Galí et al. (2001, 2005). They assumed that only a fraction of firms set their prices optimally, while the majority of firms will adjust their prices based on the past inflation. Even so, Rudd and Whelan (2005) had pivotal findings of limitations of the NKPC in reduced-form inflation regressions using an alternative approach. They found that the NKPC model was not able to explain the importance of lagged inflation and forward-looking terms that played a very limited role in explaining inflation dynamics. Woodford (2003) added that in the NKPC framework, the changes of prices were associated with real marginal costs and expected future inflation rates were different from the original framework using past inflation rates. Walsh (2003) also differentiated the NKPC from the original Phillips curve and specified expected future inflation rates based on real marginal costs.

More discussions continued about criticisms against the NKPC. Zhang et al. (2009) found a driving variable for the output gap that many others claimed it had no role. They focused on a serial correlation problem in the stylized NKPC and developed an extended model to explain the serial correlation. Mavroeidis et al. (2014) claimed that they reached a limit requiring new identification approaches with new datasets from reviewing the main identification strategies as well as empirical evidence on the role of expectations in the NKPC. They concluded that researchers had faced substantial specification uncertainty while scrutinizing the conflicting results of previous literature in terms of the role of expectations. Mihalache and Bodislav (2019) suggested the First Dynamic Stochastic General Equilibrium model of the NKPC, as an alternative about the criticisms.

The lagged inflation dynamic between backward-looking and forward-looking remained unsettled in the staggered inflation setting of the NKPC models. However, voluminous studies supported advantage of the forward-looking inflation. Cogley and Sbordone (2008) claimed that a purely forward-looking version of the NKPC model fitted the data well with no back-looking components. Lanne and Luoto (2013) estimated the hybrid NKPC with both expected future inflation and lagged inflation, concluding that the forward-looking inflation rate is clearly dominating, and inflation persistence turned out to be intrinsic. Kim (2018) identified the forward-looking NKPC more useful as it heavily relied on firm's forward-looking behavior in the euro area and the US. Chin (2019) used time-varying parameters in the NKPC model and found the time-variation of the trade-off between inflation and economic activity rooted from the degree of price rigidity. This study supported that forward-looking price-setting behavior would play a dominant role in explaining inflation dynamics.

On the other hand, GMM was a crucial econometric technique to study the NKPC and its hybrid model. Nason and Smith (2008) asserted that the NKPC would continue to be a crucial building mass for macroeconomic methods. In their evaluation of the hybrid NKPC model, GMM estimates played an important role to the expected future inflation in explaining current inflation regardless of the lower weight of lagged inflation. Through the GMM, agreeing with foregoing studies, they concluded that marginal costs might be superior to output gaps as a guide to inflation. Hall et al. (2009) follows other previous GMM estimation and found a similar significant effect for lagged inflation. They led with consistent results from using time varying coefficient (TVC) estimation under a variety of sources of misspecification. Kleibergen and Mavroeidis (2009) reexamined the NKPC model using weak instrument robust statistics in GMM and found US postwar data were steady with the previous studies claiming that inflation dynamics are predominantly forward-looking, not backward-looking.

In addition to the GMM, other econometric techniques are employed to examine the NKPC and its hybrid model. Lindé (2005) argued that estimating the model using the full information maximum likelihood (FIML) method was useful to obtain better estimates, while single-equations methods such as the GMM on a simple NKPC model produced inaccurate and biased estimates. Fanelli (2008) presented that the hybrid NKPC did not produce a good first approximation of dynamics in the euro area, which led him to apply vector autoregressive (VAR) systems and likelihood methods. Dees et al. (2009) used a global vector autoregressive (GVAR) model on eight steady industrial countries to estimate the NKPC, while focusing on the weak instrument problem and the characterization of the countries. The GVAR generated global factors as valid instruments and helped to alleviate the weak instrument problem. Fidrmuc and Danišková (2020) reviewed about 200 studies of the NKPC, using the meta-analysis technique. They found a significant publication bias including some top journal publications.

The restitution toward the original Phillips' work was also evident in the discussion of the NKPC. Galí (2011), restructured the New Keynesian Wage Phillips Curve (NKWPC) equation and returned to the original Phillips curve. The NKWPC revealed the equivalent inverse relation that was introduced by Phillips (1958). Galí (2011) derived the structural wage equation to explain the inverse relationship between wage inflation and the unemployment rate of the US economy. The economist added that the standard NKPC model and the hybrid NKPC model had similar theoretical foundations with the original model.

Komlos (2019) also revisited the original Phillips curve, but the economist challenged the official unemployment rate estimated by the Bureau of Labor Statistics (BLS) because the traditional definition of unemployment was appropriate for developing societies a long time before. In a developed country, such as the US, the nature of the labor market has changed noticeably becoming similar with multiple labor markets of a developing country. Along with Komlos (2019), numerous economists raised questions of the official measurement of the unemployment rate (Leonhardt, 2018; Sachs, 2019; Valletta, 2018; Brandolini and Vivano, 2018, 2016; Valetta, 2018; Temin, 2017; Yellen, 2014; Rosengren, 2014; Cajner et al., 2014; Stiglitz, *et al*., 2010; Clogg, 1979; Myrdal, 1968).

The skepticism against the official unemployment rate was mainly on the obscurity of the measurement how to conflate part-time workers with full-time workers as well as involuntary part-time workers who cannot help but work out of necessity, not out of choice. The official unemployment rate embraced both full-time workers and part-time workers in the labor force. However, in the real unemployment rate calculation, Komlos (2019) separated part-time workers into 1) those who were satisfied with working part-time, or voluntary part-time workers and 2) those who had no choice but to work part-time, but longed for working full-time, or involuntary part-time workers. In addition, the real unemployment rate included military, as full-time workers employed by the government.

3. THE THEORTICAL MODEL AND METHODOLOGY

(1) Generalized method moments (GMM)

1) Calvo's NKPC

The initiation of the NKPC model is contributed by Taylor's (1980) principle which is a staggered contracts model. The time dependent price adjustment is clarified by monopolistically competitive firms' profit maximization problem, subject to the constraint of time dependent price adjustment. However, it is burdensome to aggregate individual monopolistic competitive firms' microeconomic-level price adjustment problems. Calvo (1983) considerably simplifies the aggregation problem. He assumes that each firm may adjust its price in any given time with a fixed probability $1-\theta$; in other words, a probability θ must keep its price unchanged.

$$(1-\theta)\sum_{k=0}^{\infty} k\theta^{k-1} = \frac{1}{1-\theta}. \quad (1)$$

The aggregate price level evolves as a convex combination of the lagged price level and the optimal reset price p_t^*. Each firm sets the desired price p_t^* which would maximize profit at that moment in time:

$$p_t = \theta p_{t-1} + (1-\theta)p_t^*, \quad (2)$$

where each variable is a percent deviation from a zero-inflation steady state and the index of prices for firms does not adjust during the period t. Calvo (1983) denotes the nominal marginal cost mc_t^n at t with setting a subjective discount rate β. In his formulation, a firm chooses price at t to maximize expected discounted profits subject to time dependent pricing rules.

$$p_t^* = (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k\{mc_{t+k}^n\}. \quad (3)$$

In the setting above, the firm chooses the expected future pattern of nominal marginal cost by the probability that its price may stay fixed for multiple periods. The future becomes applicable only when there is price rigidity ($\theta > 0$) because the firm simply adjusts its price depending on the current marginal cost (i.e., price perfect flexibility if $\theta = 0$).

It is possible to derive an inflation equation by combining the two equations (2) and (3), after denoting the inflation rate at t as $\pi_t = p_t - p_{t-1}$.

$$\pi_t = \lambda mc_t + \beta E_t\{\pi_{t+1}\}, \quad (4)$$

where $\lambda \equiv (1-\theta)(1-\beta\theta)/\theta$ and the coefficient λ is the rate of arrival for price adjustments. In the formula, θ is the frequency of price adjustment and β is the subject discount factor. In the setting, Calvo (1983) conjectured that inflation should be a discounted process of expected future marginal costs:

$$\pi_t = \lambda\sum_{k=0}^{\infty}\beta^k E_t\{mc_{k+t}\}. \quad (5)$$

In the short-run economy, there is an output gap between the log of actual output y_t and the long-run potential output y_t^* of which price is perfectly flexible. Also, there is an approximate proportionate relationship between marginal cost and output gap:

$$mc_t = \kappa x_t, \quad (6)$$

where $x_t \equiv y_t^* - y_t$ and κ is the output elasticity of marginal cost. Then, the equation of (6) can be combined with the equations (4) and (5):

$$\pi_t = \lambda\kappa x_t + \beta E_t\{\pi_{t+1}\}. \quad (7)$$

$$\pi_t = \lambda\kappa\sum_{k=0}^{\infty}\beta^k E_t\{x_{t+k}\}. \quad (8)$$

A crucial difference between the result above and the traditional Phillips curve is $E_t\{\pi_{t+1}\}$ and π_{t-1}. To put it differently, the consequence above shows that inflation is explained by the discounted sequential process of future output gaps (i.e., forward-looking price adjustment), while the traditional model utilizes a backward-looking price adjustment.

Calvo (1983) assumes the current output gap is an impact on the output gap and the equation (7) with one lagged period has a subjective discount rate of one ($\beta \cong 1$), in order to obtain an empirical equation:

$$\pi_t = -\lambda\kappa x_{t-1} + \pi_{t-1} + \varepsilon_t, \quad (9)$$

where $\varepsilon_t \equiv \pi_t - E_{t-1}\pi_t$.

2) Galí and Gertler's NKPC

Galí and Gertler's NKPC (1999) initiates their new approach with applying real marginal cost MC_t that is the ratio of the wage rate $\frac{W_t}{P_t}$ to the marginal product of labor $\frac{\partial Y_t}{\partial L_t}$.

$$MC_t = \frac{S_t}{\alpha_n}, \quad (10)$$

where $Y_t = A_t K_t^{\alpha_n} L_t^{\alpha_n}$ is a Cobb-Douglas formula and $S_t \equiv \frac{W_t N_t}{P_t Y_t}$ is the labor income share, or real unit labor costs. A percent deviation is applied for the real marginal cost:

$$mc_t = s_t. \quad (11)$$

Combining the equations (11) and (4), the inflation equation is reformed as:

$$\pi_t = \lambda s_t + \beta E_t\{\pi_{t+1}\}, \quad (12)$$

where $\lambda \equiv (1-\theta)(1-\beta\theta)/\theta$ and the coefficient λ is the rate of arrival for price adjustments. The errors of the estimate of π_{t+1} are not related to the variables in the information set of earlier periods. In other words, the covariance between the errors and the variables that are in the information set is zero.

$$E_t\{(\pi_t - \lambda s_t - \beta\pi_{t+1})z_t\} = 0, \tag{13}$$

where z_t is a vector of variables of earlier periods, which presents the orthogonality condition and forms the basic estimating model through GMM. The technique procedure involves transforming the original equations by multiplying the error term by the instrumental variable(s) which are uncorrelated with the error term.

The model obtains an economic non-linear specification in the structural parameters θ and β. To do that, the equation $\lambda \equiv (1-\theta)(1-\beta\theta)/\theta$ is substituted into the equation (13). Moreover, two alternative specifications of the orthogonality conditions are utilized due to the potential sensitivity of nonlinear estimation of small samples using GMM. The first specification is

$$E_t\{(\theta\pi_t - (1-\theta)(1-\beta\theta)s_t - \theta\beta\pi_{t+1})z_t\} = 0, \tag{14}$$

and the second specification is

$$E_t\{(\pi_t - \theta^{-1}(1-\theta)(1-\beta\theta)s_t - \beta\pi_{t+1})z_t\} = 0, \tag{15}$$

where $s_t = mc_t$.

3) Galí and Gertler's hybrid NKPC

Two types of firms with different price strategies are accepted by Galí and Gertler's (1999) hybrid NKPC. The hybrid model accords with the criticism of Rudd and Whelan (2005). They criticized the forward-looking assumption of the previous NKPC because the model did not include inflation inertia. In the hybrid model, one type of firms have forward-looking price setting behavior with probability of $1-\omega$, whereas the other show backward-looking behavior with probability of ω. Applying the lagged inflation, the hybrid NKPC is

$$\pi_t = \lambda mc_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1}, \tag{16}$$

where

$$\lambda = (1-\omega)(1-\theta)(1-\beta\theta)\phi^{-1}, \tag{17}$$

$$\gamma_f = \beta\theta\phi^{-1},$$

$$\gamma_b = \omega\phi^{-1},$$

with $\phi = \theta + \omega[1-\theta(1-\beta)]$. The hybrid NKPC obtain a measure of the residual inertia that Calvo (1983)'s model leaves unexplained, so that it becomes identical to the base model if all firms show forward-looking price setting behavior, $\omega = 0$.

The empirical version of the hybrid Phillips curve is

$$\pi_t = \lambda s_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1}, \tag{18}$$

and the structural model parameters β, θ, and ω can be estimated through a non-linear instrumental variables (GMM) estimator. The instrumental set and the two alternative specifications of the orthogonality conditions are the same as the previous settings. The first specification does not normalize the coefficient on inflation as follows:

$$E_t\{(\phi\pi_t - (1-\omega)(1-\theta)(1-\beta\theta)s_t - \theta\beta\pi_{t+1})z_t\} = 0, \tag{19}$$

while the second specification does as follows:

$$E_t\{(\pi_t - (1-\omega)(1-\theta)(1-\beta\theta)\phi^{-1}s_t - \theta\beta\phi^{-1}\pi_{t+1})z_t\} = 0, \tag{20}$$

where $s_t = mc_t$.

4) Galí's NKWPC

Galí (2011) attempted to return to Phillips' (1958) original work using structural wage inflation and the unemployment rate in the US economy. The researcher introduces NKWPC combining Erceg et al.'s (2000) model with Calvo's (1983) NKPC. As the first step, the baseline wage inflation equation is

$$\pi_t^{\omega} = \beta E_t \pi_{t+1}^{\omega} + \lambda_{\omega}(\mu_t^{\omega} - \mu^{\omega}), \tag{21}$$

where $\pi_t^{\omega} = \omega_t - \omega_{t-1}$ is wage inflation, $\mu_t^{\omega} = \omega_t - p_t - mrs_t$ represents the average wage markup, and mrs_t is the average (log) marginal rate of substitution. Including the unemployment rate, the average wage markup is simplified as

$$\mu_t^{\omega} = \varphi u_t. \tag{22}$$

And the natural rate of unemployment, u_t^n, is assumed with the absence of nominal wage rigidities and follows a constant desired wage markup assumption:

$$u^n = \frac{\mu^{\omega}}{\varphi}, \tag{23}$$

With combining the assumptions, the NKWPC is denoted as

$$\pi_t^{\omega} = \beta E_t\{\pi_{t+1}^{\omega}\} - \lambda_{\omega}\varphi(u_t - u^n). \tag{24}$$

Galí (2011) uses a simple reduced form of the NKWPC, in order to obtain some additional intuition about the joint dynamics for wage inflation and unemployment. The author utilizes the autoregressive process, a stationary time series model, and assumes the unemployment follows a stationary AR(2) process:

$$\hat{u}_t = \phi_1 \hat{u}_{t-1} + \phi_2 \hat{u}_{t-2} + \varepsilon_t, \tag{25}$$

where $\hat{u}_t = u_t - u^n$ and $\{\varepsilon_t\}$ is white noise. Also, he derives the simple reduced form of the NKWPC equation:

$$\pi_t^{\omega} = \alpha + \gamma \bar{\pi}_{t-1}^{p} + \psi_0 \hat{u}_t + \psi_1 \hat{u}_{t-1}, \tag{26}$$

where

$$\psi_0 = -\frac{\lambda_\omega \varphi}{1-\beta(\phi_1+\beta\phi_2)},$$

$$\psi_1 = -\frac{\lambda_\omega \varphi\beta\phi_2}{1-\beta(\phi_1+\beta\phi_2)}.$$

or, evenly,

$$\pi_t^\omega = \alpha' + \gamma\bar{\pi}_{t-1}^p - \delta\hat{u}_t + \psi_1\Delta\hat{u}_t, \tag{27}$$

where $\delta \equiv -(\psi_0 + \psi_1)$. For the empirical analysis, a reduced form of NKWPC described above is utilized as the estimated equation:

$$\pi_t^\omega = \alpha + \gamma\bar{\pi}_{t-1}^p + \psi_0\hat{u}_t + \psi_1\hat{u}_{t-1} + \zeta_t, \tag{28}$$

where ζ_t is a zero mean, possibly an autocorrelated error term. Although Galí (2011) uses the OLS estimation, this study uses the GMM estimation to test the reduced form of NKWPC:

$$E_t\{(\pi_t^\omega - \alpha - \gamma\bar{\pi}_{t-1}^p - \psi_0\hat{u}_t - \psi_1\hat{u}_{t-1})z_t\} = 0. \tag{29}$$

(2) Generalize autoregressive conditionally heteroskedastic-M (GARCH-M) estimation

The GARCH-M model is the extension of the autoregressive conditionally heteroskedastic (ARCH) model, which explicitly recognizes the impact of past errors on the current variance of the error term. It is possible to identify whether large variance come in clusters. The ARCH model is extended allow the conditional mean of a time series to depend on its own conditional variance. If the conditional variance is specified as a function of past conditional variances as well as the squares of past errors, we have a GARCH(1,1)-M model.

The model of the hybrid NKPC can be formulated as

$$\pi_t = \lambda mc_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} + \theta\sigma_t^2 + \eta_t, \tag{30}$$

$$\eta_t \mid \Omega_{t-1} \sim N(0, \sigma_t^2),$$

$$\sigma_t^2 = \phi_0 + \phi_1 \eta_{t-1}^2 + \psi_1 \sigma_{t-1}^2 + v_t.$$

Also, the model of the NKWPC can be formulated as

$$\pi_t^{\omega} = \alpha + \gamma \bar{\pi}_{t-1}^{p} + \varphi_0 \hat{u}_t + \varphi_1 \hat{u}_{t-1} + \theta\sigma_t^2 + \eta_t, \tag{31}$$

$$\eta_t \mid \Omega_{t-1} \sim N(0, \sigma_t^2),$$

$$\sigma_t^2 = \phi_0 + \phi_1 \eta_{t-1}^2 + \psi_1 \sigma_{t-1}^2 + v_t.$$

(3) Komlos' real unemployment rate

Most mainstream economists, including specifically researchers of the NKPC, embrace the official unemployment rate that US Bureau of Labor Statistics releases. Nonetheless, Komlos (2019) challenges the commonly accepted index and conducts a dialectic calculation. The voluntary part-time workers are considered as employed, which are 62.5% of the full-time workers of the labor force. On the other hand, the involuntary part-time workers are the rest of the full-time workers of the labor force, or 37.5%. Moreover, the actual unemployment rate includes the military within the labor force, of using data are from US Department of Defense. In his estimation, the military is added to the actual labor force and a total effective labor force becomes 4.2 million above the official estimate.

Following from Komlos (2019), the estimate of the real unemployment rate utilizes quantitative data, except for the military data, from the Federal Reserve Bank of St. Louis. Unlike the traditional official unemployment statistic, Komlos' (2019) measurement including military in the total effective labor force embraces the idea of voluntary part-time employees. Moreover, the real unemployment measurement contains both involuntary part-time workers and the workers who want jobs but do not look for them. The total effective labor force is restructured from the base of the civilian full-time labor force combined with voluntary part-time workers, military, and really unemployed workers. Also, the really unemployed workers are estimated by the sum of the official unemployed workers, involuntary part-time employees, and unemployed workers who want jobs but do not look for them.

$$Real\ Unempolyment\ Rate = \frac{RU}{TELF} \times 100, \tag{31}$$

where $TELF = FLF + VPTW + MIL + RU$ and $RU = OU + IVPTW + WJBDNL$; TELF = number of total *effective* labor force; RU = number of really unemployed workers; FLF = number of full-time civilian labor force; VPTW = number of voluntary part-time workers; MIL = number of military; OU = number of officially unemployment workers; IVPTW = number of involuntary part-time workers; WJBDNL = number of unemployed who want a job but do not look for a job.

(4) Hypotheses

Galí (2011) analyzes the data from the time period between 1994Q1 and 2009Q3, using the traditional robust OLS method. The study presents some theoretical foundations of a Phillips-like relationship between wage inflation and unemployment to the NKWPC framework. Also, it proves that the NKWPC equation can explain the strong negative co-movement between wage inflation and unemployment during this time period. Moreover, Komlos (2019) replaces official unemployment rate with the real unemployment rate in the study. This current study analyzes the data of wage inflation and the real unemployment rate within the time period between 1994Q1 and 2019Q4. As Table 1 presents, this analysis uses the reduced NKWPC model of equation (28) by applying two different analytical methods of GMM and GARCH(1,1)-M. In order to test the NKWPC model using the data with the analytical methods, two hypotheses are generated:

> Hypothesis 1. The NKWPC equation can explain a Philips-like negative relationship between wage inflation and the official unemployment rate in between 1994Q1 and 2019Q4.
>
> Hypothesis 2. The NKWPC equation can explain a Philips-like negative relationship between wage inflation and the real unemployment rate in between 1994Q1 and 2019Q4.

Table 1. Testing the NKWPC and Econometric Methods of this Study

GMM estimation	
Model 1	$E_t\{(\pi_t^\omega - \alpha - \gamma\bar{\pi}_{t-1}^p)z_t\} = 0.$
Model 2	$E_t\{(\pi_t^\omega - \alpha - \gamma\bar{\pi}_{t-1}^p - \delta\hat{u}_t)z_t\} = 0.$
Model 3	$E_t\{(\pi_t^\omega - \alpha - \gamma\bar{\pi}_{t-1}^p - \psi_0\hat{u}_t - \psi_1\hat{u}_{t-1})z_t\} = 0.$
GARCH(1,1)-M estimation	
Model 1	$\pi_t^\omega = \alpha + \gamma\bar{\pi}_{t-1}^p + \theta\sigma_t^2 + \eta_t,$ $\eta_t \mid \Omega_{t-1} \sim N(0,\, \sigma_t^2),$ $\sigma_t^2 = \phi_0 + \phi_1\eta_{t-1}^2 + \psi_1\sigma_{t-1}^2 + v_t.$
Model 2	$\pi_t^\omega = \alpha + \gamma\bar{\pi}_{t-1}^p + \delta\hat{u}_t + \theta\sigma_t^2 + \eta_t,$ $\eta_t \mid \Omega_{t-1} \sim N(0,\, \sigma_t^2),$ $\sigma_t^2 = \phi_0 + \phi_1\eta_{t-1}^2 + \psi_1\sigma_{t-1}^2 + v_t.$
Model 3	$\pi_t^\omega = \alpha + \gamma\bar{\pi}_{t-1}^p + \varphi_0\hat{u}_t + \varphi_1\hat{u}_{t-1} + \theta\sigma_t^2 + \eta_t,$ $\eta_t \mid \Omega_{t-1} \sim N(0,\, \sigma_t^2),$ $\sigma_t^2 = \phi_0 + \phi_1\eta_{t-1}^2 + \psi_1\sigma_{t-1}^2 + v_t.$

4. EMPIRICAL ANALYSIS

(1) Descriptive statistics

This study analyzes the NKWPC model using the quarterly data from 1994Q1 to 2019Q4. Table 2 discloses basic descriptive statistics for the variables used in this study. The basic variables for the NKWPC are nominal wage, wage inflation, and official unemployment.

Table 2. Basic Statistics for the NKWPC 1994Q1 – 2019Q4

Variable	Obs.	Mean	Std. Dev.	Min	Max
Nominal Wage	104	17.13	3.63	11.23	23.81
Wage inflation rate	100	48.7	12.6	27.3	83.7
Official unemployment rate	104	5.7	1.7	3.6	9.9

The data of nominal wage are derived from the Average Hourly Wages of All Employees, Total Private of the Bureau of Labor Statistics and the Federal Reserve Bank of St. Louis. The number of observations of the data from 1994Q1 to 2019Q4 is 104, the mean score is 17.13, and the standard deviation is 3.63. Also, the range of the nominal wage is between 11.23 and 23.81.

Wage inflation is measured as the centered four-quarter difference of the log nominal wage in percentage form, used by Galí (2011). The difference between nominal wage of *t + 2* and nominal wage of *t – 2* is multiplied by 100. By the computation, the number of observations becomes 100.

The Figure 1 presents the graphic pattern of official US unemployment rates from 1994Q1 to 2019Q4, which is quoted from the Federal Reserve Bank of St. Louis. The number of observations of the data is 104, the mean score is 5.7%, and the standard deviation is 1.7%. Also, the range of the variable is between 3.6% and 9.9%. The estimated mean score of the official unemployment rate (5.7%) is used as the natural rate of the official unemployment rate in the estimation. ($\hat{u}_t \equiv u_t - u_n$)

Figure 1. Official Unemployment Rate 1994Q1 – 2019Q4

Table 3 describe the basic statistics of Komlos' (2019) real unemployment rate that combines military and voluntary part-time employees to the official unemployment rate computation. The number of observations is 104, the mean score is 11.9%, and the standard deviation is 2.4%. Also, the range of the data is between 8.8% and 17.1%.

Table 3 also provides the basic statistics of variables for the real unemployment rate. The range of the latter rate is 5% to 8% higher than that of the official unemployment rate. Also, in the formula, the total number of really unemployed workers increases more than 10 million workers than the total number of officially unemployed workers. In other words, the real unemployment rate is about twice the official rate, which matches with Komlos (2019). While the author emphasizes the accuracy of economic data in the empirical studies, he concludes that the official unemployment rate delivers a misleading impression of the labor market, which situates a major challenge for policy makers and researchers.

Table 3. Basic Statistics for Real Unemployment Rate 1994Q1 – 2019Q4

Real unemployment rate (%) = (RU / TELF) x 100						
Variable (Million)		Obs.	Mean	Std. Dev.	Min	Max
RU	OU	104	8.5	2.6	5.6	15.4
	VPTW	104	15.9	1.2	14.2	17.4
	WJBDNL	104	5.4	0.7	4.4	6.8
	RU	104	19.3	4.9	13.2	30.2
TELF	FLF	104	124.0	7.7	107.0	137.0
	IVPTW	104	5.4	1.8	3.2	9.1
	MIL	104	2.5	0.4	2.1	3.1
	TELF	104	161.0	11.7	143.0	177.0
Real unemployment rate		104	11.9	2.4	8.8	17.1

*RU = number of really unemployed workers = OU + IVPTW + WJBDNL; OU = number of officially unemployed workers; IVPTW = number of involuntary part-time workers; WJDNL = number of unemployed who want a job but do not look for a job
**TELF = number of total effectively labor force = FLF + VPTW + MIL + RU; FLF = number of full-time civilian labor force; VPTW = number of voluntary part-time workers; MIL = number of military

Accepting the official unemployment rate, most traditional mainstream economists believe that US economy has been experiencing full employment recently for about four years. Komlos (2019) argues that the estimate of the natural rate of unemployment is imprecise, and the labor market is not far from tight by the inflationary output gap, or away from the full employment. Table 4 shows the official unemployment rate averaged from 2019Q1 to 2019Q4, at 3.5%, is below 4.0%, which is less than half of the real unemployment rate of 9.0%. It is a nonnegligible misleading percentage, even if the official rate can be used as a minimum guide to trends in the labor market.

Table 4. The Average Real Unemployment Rate in the US 2019

Variable		Number (Million)	Percent
Total effective labor force (TELF)		171.9	
	Civilian labor force full time (FLF)	163.5	95.1%
	Part-time voluntary (VPTW)*	16.8	9.8%
	Military (MIL)	2.9	0.6%
Total really unemployed workers (RU)		15.5	
	Official unemployed (OU)	6.0	38.7%
	Part-time involuntary (IVPTW)**	4.5	29.0%
	Want job, did not look (WJBDNL)	5.0	32.3%
Real unemployment rate		15.5 / 171.9	9.0%

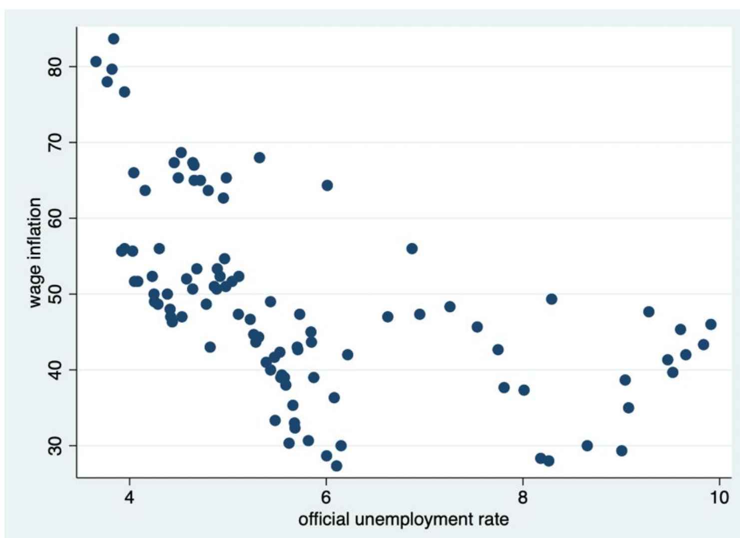
*According to 2018 data, this study uses 62.5% of part-time workers as voluntary part-time employees.
** 37.5% of part-time workers is considered as involuntary part-time employees.

(2) Estimation of the NKWPC

1) Test for NKWPC using the official unemployment rate

The NKWPC derived above implies an inverse relationship between wage inflation and the unemployment rate. The Figure 2 presents a scatterplot of wage inflation and the US official unemployment rate. The scatterplot pattern discloses a modest negative correlation (*r* = – 0.54) between the two variables. The result is parallel with Galí's (2011) examination of the mid-1980s data, the so-called "Great Moderation era," (p.449). During the time, it presents a relatively strong inverse relationship (*r* = – 0.76).

Figure 2. Wage Inflation and Official Unemployment Rate 1994Q1 – 2019Q4



Prior to the further study, the significant lag of unemployment rate can be examined by the good fit of an AR(2) process for the unemployment rate. Using data 1994Q1 – 2019Q4, the results estimate the following equation (25) model:

$$u_t = 0.12 + 1.70\, u_{t-1} - 0.72 u_{t-2} + \varepsilon_t$$

S.E. (0.072) (0.069) (0.069)

As the estimated equation reflects almost identical results to Galí's (2011), we can also assume that the unemployment of the two lags are independent. Moreover, the two lagged variables are significant, even though the second lag of the unemployment is not significant in Galí's (2011) estimation.

Table 5 reports GMM and GARCH(1,1)-M estimates of the NKWPC model of equation (28) including one-lagged variables. Estimates are based on quarterly data and cover the sample of 1994Q1 – 2019Q4. Table 5 presents the comparison of equations with instruments – official unemployment rate, one lag of official unemployment rate, and one lag of wage inflation. With adding each instrument, the results reveal the alteration of the coefficient and statistical significance of each variable in the equation.

Table 5. GMM and GARCH(1,1)-M estimation for the NKWPC using the Official Unemployment Rate 1994Q1 – 2019Q4

(1) $\pi_t^{\omega} = \alpha + \gamma\bar{\pi}_{t-1}^{p} + \zeta_t$ (2) $\pi_t^{\omega} = \alpha + \gamma\bar{\pi}_{t-1}^{p} + \delta\hat{u}_t + \zeta_t$ (3) $\pi_t^{\omega} = \alpha + \gamma\bar{\pi}_{t-1}^{p} + \psi_0\hat{u}_t + \psi_1\hat{u}_{t-1} + \zeta_t$						
	GMM			GARCH(1,1)-M		
	(1)	(2)	(3)	(1)	(2)	(3)
ψ_0 ($\hat{u}_t$)			– 4.969** (0.000)			– 4.308** (0.000)
δ ($\hat{u}_t$)		– 0.811** (0.000)			– 0.626* (0.035)	
ψ_1 ($\hat{u}_{t-1}$)			4.408** (0.000)			3.968** (0.001)
γ (π_{t-1})	0.978** (0.000)	0.924** (0.000)	0.966** (0.000)	0.932** (0.000)	0.898** (0.000)	0.922** (0.000)
Wald test (F or χ^2)			52.28** (0.000)			1249.35** (0.000)

*Statistical significance at the 5% level
**Statistical significance at the 1% level

Table 5 states the estimates of the three equations by both GMM and GARCH(1,1)-M methods. I have first estimated the traditional Phillips curve model only with the official unemployment rate (together with lagged inflation rate) as an explanatory variable (Model 2). The GMM estimation results show that the coefficient of the unemployment rate ($\hat{u}_t$) is – 0.811 as well as highly significant. Also, the estimated coefficient of the unemployment rate ($\hat{u}_t$) by GARCH(1,1)-M method is – 0.626 as well as highly significant. Thus, the results confirm the traditional Phillips curve conclusion.

Next, I have estimated Galí's NKWPC model with the one-period lagged unemployment rate ($\hat{u}_{t-1}$) added to the model (Model 3). The GMM estimation results show that the coefficient of $\hat{u}_t$ is – 4.969 as well as highly significant, and the coefficient of $\hat{u}_{t-1}$ is 4.408 as well as highly significant. The estimated coefficient of $\hat{u}_t$ by GARCH(1,1)-M is – 4.308 as well as highly significant, and the coefficient of $\hat{u}_{t-1}$ is 3.968 as well as highly significant.

In order to investigate whether the AR process of the unemployment rate has a negative relationship with the inflation rate, I have unsophisticatedly summed the two coefficients. The sum of these two coefficients by GMM is – 0.561, while the sum of them by GARCH(1,1)-M is – 0.340. More specifically, in order to test whether the sum of the coefficients is statistically significant, I have concluded the Wald test. The unrestricted and restricted models are as follows:

Unrestricted model: $\pi_t^{\omega} = \alpha + \gamma\bar{\pi}_{t-1}^{p} + \psi_0\hat{u}_t + \psi_1\hat{u}_{t-1} + \zeta_t$

Restricted model: $\pi_t^{\omega} = \alpha + \gamma\bar{\pi}_{t-1}^{p} + \zeta_t$

In terms of GMM method, the Wald statistic is 52.28 and the critical F value for the Wald test is 1.40. Instead, in terms of GARCH(1,1)-M, the Wald statistic is 1249.35 and the critical χ^2 value for the test is 135.81. According to the results, we are able to reject the null hypothesis that $\psi_0 = \psi_1 = 0$ and conclude that the sum of the coefficients is highly significant. Therefore, this finding lends support to the Phillips curve trade-off implied by

Gali's NKWPC model. This result is in parallel with the simple Phillips curve model with only the current unemployment rate. (The coefficient of $\hat{u}_t$ in Model 2 is – 0.811 by GMM and – 0.626 by GARCH(1,1)-M.)

2) Test for NKWPC using the real unemployment

The estimated results using the real unemployment are very similar with the estimation using the official unemployment. Figure 3 displays a similar negative-relationship pattern of a scatterplot of wage inflation and the US official unemployment rate. The scatterplot graph discloses a modest but slightly higher negative correlation (r = – 0.55) between the two variables.

Figure 3. Wage Inflation and Real Unemployment Rate 1994Q1 – 2019Q4

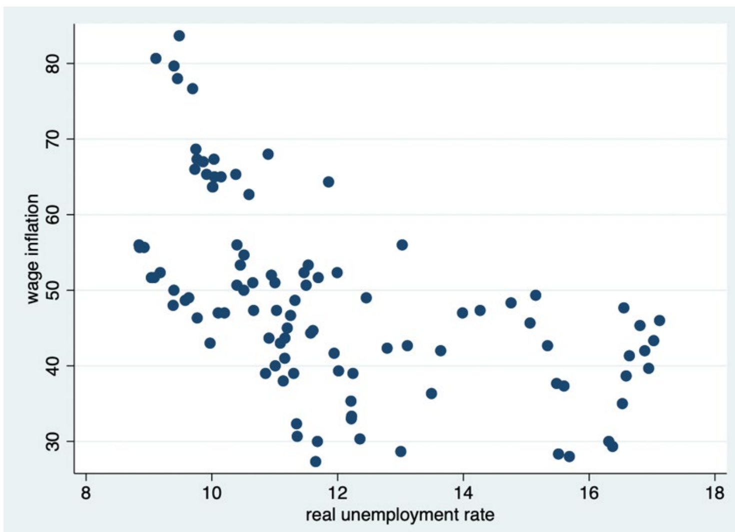


Table 6 correspondingly states the estimates of the three equations using the real unemployment by both GMM and GARCH(1,1)-M methods. The estimated results also confirm the traditional Phillips curve conclusion. Identical to the previous examination using the official unemployment rate, I have first estimated the traditional Phillips curve model only with the real unemployment rate (together with lagged inflation rate) as an explanatory variable (Model 2). The estimated coefficient of the unemployment rate ($\hat{u}_t$) by GMM is – 0.458 as well as highly significant. Also, the estimated coefficient of the unemployment rate ($\hat{u}_t$) by GARCH(1,1)-M is – 0.626 and significant at the 5% level.

Afterward, similar to the previous estimation, I have estimated Galí's NKWPC model with the one-period lagged unemployment rate ($\hat{u}_{t-1}$) added to the model (Model 3). The GMM estimation result shows that the coefficient of $\hat{u}_t$ is – 3.407 as well as highly significant, and the coefficient of $\hat{u}_{t-1}$ is 3.100 as well as highly significant. On the other hand, the estimated coefficient of $\hat{u}_t$ by GARCH(1,1)-M is – 2.184 as well as significant at the 5% level, while the estimated coefficient of $\hat{u}_{t-1}$ is 1.629 that is insignificant. In order to investigate whether the AR process of the unemployment rate has a negative relationship with the inflation rate, I have plainly summed the two coefficients like beforehand. The sum of these two coefficients by GMM is – 0.307, while the sum of them by GARCH(1,1)-M is – 0.555.

In terms of testing Hypothesis 2, the NKWPC lucratively explains the inverse relationship between inflation and unemployment in both econometric techniques. The estimates using real unemployment rate have the theoretically-presumed negative directions, and most of the estimated coefficients are statistically significant. In order to examine it, like before, I have concluded the Wald test to test whether the sum of the coefficients is statistically significant. The Wald statistic by GMM is 62.25 and the critical F value for the Wald test is 1.40. On the other hand, the Wald statistic by GARCH(1,1)-M is 874.9 and the critical χ^2 value for the Wald test is 135.81. As a result, we are able to reject the null hypothesis that $\psi_0 = \psi_1 = 0$ and conclude that the sum of the coefficients is highly significant. Thus, this finding also backs up the Phillips curve trade-off implied by Gali's NKWPC model. This result is also in parallel with the simple Phillips curve model with only the real unemployment rate. (The coefficient of $\hat{u}_t$ in Model 2 is – 0.458 by GMM and – 0.626 by GARCH(1,1)-M.)

Table 6. GMM and GARCH(1,1)-M estimation for the NKWPC using the Real Unemployment Rate 1994Q1 – 2019Q4

(1) $\pi_t^{\omega} = \alpha + \gamma\bar{\pi}_{t-1}^{p} + \zeta_t$
(2) $\pi_t^{\omega} = \alpha + \gamma\bar{\pi}_{t-1}^{p} + \delta\hat{u}_t + \zeta_t$
(3) $\pi_t^{\omega} = \alpha + \gamma\bar{\pi}_{t-1}^{p} + \psi_0\hat{u}_t + \psi_1\hat{u}_{t-1} + \zeta_t$

	GMM			GARCH(1,1)-M		
	(1)	(2)	(3)	(1)	(2)	(3)
ψ_0 ($\hat{u}_t$)			– 3.407** (0.000)			–2.184* (0.038)
δ ($\hat{u}_t$)		– 0 .458** (0.001)			– 0.626* (0.035)	
ψ_1 ($\hat{u}_{t-1}$)			3.100** (0.000)			1.629 (0.162)
γ (π_{t-1})	0.980** (0.000)	0.932** (0.000)	0.966** (0.000)	0.933** (0.000)	0.898** (0.000)	0.872** (0.000)
Wald test (F or χ^2)			62.25** (0.000)			874.9** (0.000)

*Statistical significance at the 5% level
**Statistical significance at the 1% level

5. CONCLUSION

At times, the Phillips curve model is controversial or disregarded. Nonetheless, numerous articles testing the model such as the NKPC prove that the Phillips curve is real and constructive for policy makers. This study also is consistent with the preceding efforts and finds that it is erroneous to conclude that the Phillips curve is just a unicorn. The tight negative relationship between inflation and unemployment is examined by the test of the rate of change of the nominal wage and unemployment.

The scrutiny of this study supports the NKWPC model through two econometric techniques – GMM and GARCH(1,1)-M. Galí's (2011) NKWPC returns to the original Phillips (1958) model based on the achievements of the Galí et al. (2001, 2005) NKPC model and its following studies. Galí et al. (2001, 2005) and many other studies of the NKPC model mostly utilizes the GMM method. Also, Galí (2011) uses the simple OLS method to examine the NKWPC. Thus, it is evocative to employ both GMM and GARCH(1,1)-M to test the NKWPC model. The GARCH method investigates the heteroskedastic term directly into the equation that is introduced to measure the response of the dependent variable to the volatility of time series data.

Moreover, this study is supported by Komlos (2019)'s thought-provoking real unemployment rate. Numerous economists challenge the official unemployment rate released by the BLS. The skepticism highlights the obscurity of the measurement and how it combines voluntary and involuntary part-time workers with full-time workers. The official unemployment rate considers both full-time and part-time workers as employed, whether the employment is either voluntary or involuntary. Moreover, the official unemployment rate does not define military in the labor force. However, the real unemployment rate separates voluntary part-time workers from involuntary workers and includes the military in the calculation.

As a result, the quantitative analyses of this study accept the two hypotheses assuming that there is a significant negative relationship between inflation and unemployment. Both methods produce the same results using the two different estimation techniques, GMM and GARCH-M to test for the NKWPC. Moreover, the application of both unemployment rates for the model confirms that there is no significant different outcome, except for the descriptive statistical variances.

APPENDICES

Appendix A. Data Collection References

Appendix B. Quantitative Data

Appendix A. Data Collection References

Variable	Data Sources
Official Labor Force (OLF)	LNS11000000*
Full-Time Labor Forces (FLF)	LNS11000000* – LNS12600000*
Part-Time Voluntary Workers (VPTW)**	LNS12600000*
Part-Time Involuntary Workers (IVPTW)	LNS12032194*
Military (MIL)	U.S. Department of Defense***
Officially Unemployed (OU)	UNEMPLOY*
Want job, did not look (WJBDNL)	NILFWJN*
Nominal Wage	CES0500000003*
Consumer Price Index	CPALTT01USQ661S*

*Federal Reserve Bank of St. Louis.
**Part-time workers worked 62.5% as many hours as full-time workers in 2018.
***Department of Defense (2020). DoD Personnel, Workforce Reports & Publications. https://dwp.dmdc.osd.mil/dwp/app/dod-data-reports/workforce-reports

Appendix B. Quantitative Data

QDATE	OLF	PTW	VPTW	MIL	OU	IVPW
1994q1	130555000	23538666.7	14711666.7	2626282	8561000	4857000
1994q2	130653667	23136666.7	14460416.7	2626282	8057666.67	4773000
1994q3	131116000	23048333.3	14405208.3	2580423.67	7871000	4719000
1994q4	131862000	23464666.7	14665416.7	2488707	7412333.33	4387666.67
1995q1	132087000	23417666.7	14636041.7	2488707	7238333.33	4486000
1995q2	132130000	23147000	14466875	2488707	7500666.67	4425333.33
1995q3	132430000	23271333.3	14544583.3	2448452.67	7496333.33	4479333.33
1995q4	132613667	23064333.3	14415208.3	2367944	7392333.33	4518333.33
1996q1	132916000	23126666.7	14454166.7	2367944	7374000	4315000
1996q2	133591000	23138333.3	14461458.3	2367944	7311000	4437666.67
1996q3	134284333	23295333.3	14559583.3	2335193	7066000	4332333.33
1996q4	135013667	23151666.7	14469791.7	2269691	7173333.33	4381666.67
1997q1	135582333	23348666.7	14592916.7	2269691	7086666.67	4193000
1997q2	136115333	23247000	14529375	2269691	6775666.67	4250000
1997q3	136590000	23021666.7	14388541.7	2242356	6639666.67	4023333.33
1997q4	136916333	23292666.7	14557916.7	2187686	6412666.67	4008666.67
1998q1	137147667	23273666.7	14546041.7	2187686	6365333.33	3910666.67
1998q2	137325667	23357333.3	14598333.3	2187686	6066666.67	3833333.33
1998q3	137814667	23155333.3	14472083.3	2166686.67	6246000	3763000
1998q4	138431333	23263666.7	14539791.7	2124688	6137333.33	3472666.67
1999q1	138900000	23117000	14448125	2124688	5956666.67	3402666.67
1999q2	139131667	23267333.3	14542083.3	2124688	5917000	3472666.67
1999q3	139497000	23372000	14607500	2107841.67	5926000	3384666.67
1999q4	139991000	23010333.3	14381458.3	2074149	5715666.67	3239333.33

QDATE	OLF	PTW	VPTW	MIL	OU	IVPW
2000q1	142385667	23226000	14516250	2074149	5766333.33	3238666.67
2000q2	142576667	22848333.3	14280208.3	2074149	5630000	3194666.67
2000q3	142436667	22735000	14209375	2069260	5741666.67	3212000
2000q4	142944000	23340333.3	14587708.3	2059482	5602333.33	3202333.33
2001q1	143808333	23412666.7	14632916.7	2059482	6084333.33	3347333.33
2001q2	143414667	23064666.7	14415416.7	2059482	6327000	3288333.33
2001q3	143642333	23241000	14525625	2063644.67	6922333.33	3595666.67
2001q4	144210333	23693666.7	14808541.7	2071970	7985000	4016666.67
2002q1	144339000	23495333.3	14684583.3	2071970	8233666.67	4274000
2002q2	144823667	23958666.7	14974166.7	2071970	8463666.67	4196333.33
2002q3	145121333	23938000	14961250	2078242	8315000	4098666.67
2002q4	145140333	23754666.7	14846666.7	2090786	8489000	4314666.67
2003q1	146019667	24275333.3	15172083.3	2090786	8575333.33	4419000
2003q2	146676667	24568333.3	15355208.3	2090786	9021666.67	4764666.67
2003q3	146486667	24455333.3	15284583.3	2094515.33	8942666.67	4603333.33
2003q4	146815000	24346000	15216250	2101974	8541666.67	4704666.67
2004q1	146831667	24361000	15225625	2101974	8342666.67	4772333.33
2004q2	147125000	24744000	15465000	2101974	8222666.67	4619666.67
2004q3	147557000	25000666.7	15625416.7	2099007.33	8017666.67	4493333.33
2004q4	148004667	24846333.3	15528958.3	2093074	7975666.67	4593666.67
2005q1	148261333	24573000	15358125	2093074	7833666.67	4454333.33
2005q2	149141667	24494333.3	15308958.3	2093074	7615666.67	4305333.33
2005q3	149721667	24904666.7	15565416.7	2081306.33	7434666.67	4382333.33
2005q4	150032000	24887666.7	15554791.7	2057771	7432666.67	4478333.33
2006q1	150556000	24719000	15449375	2057771	7106666.67	4152333.33

QDATE	OLF	PTW	VPTW	MIL	OU	IVPW
2006q2	151101333	24696000	15435000	2057771	7033666.67	4015333.33
2006q3	151585000	24551666.7	15344791.7	2059052	7037666.67	4244000
2006q4	152393000	24989333.3	15618333.3	2061614	6787000	4220666.67
2007q1	153059333	25048666.7	15655416.7	2061614	6924666.67	4218666.67
2007q2	152715333	25170000	15731250	2061614	6865000	4262000
2007q3	153072333	24882000	15551250	2361317.33	7128666.67	4408333.33
2007q4	153645333	24727666.7	15454791.7	2960724	7374000	4474000
2008q1	153874667	24824666.7	15515416.7	2960724	7668000	4652666.67
2008q2	154128333	25277000	15798125	2960724	8202333.33	5008666.67
2008q3	154560000	25403333.3	15877083.3	2960724	9289666.67	5585333.33
2008q4	154723333	25835666.7	16147291.7	3026638	10632666.7	6229666.67
2009q1	154293667	26722666.7	16701666.7	3026638	12794000	7795333.33
2009q2	154657333	27325666.7	17078541.7	3026638	14353000	8949666.67
2009q3	154212000	27506333.3	17191458.3	3026638	14808000	9009333.33
2009q4	153591000	27422666.7	17139166.7	3077125	15223000	8951666.67
2010q1	153710667	27655333.3	17284583.3	3077125	15120333.3	8914000
2010q2	154109667	26912000	16820000	3077125	14882666.7	9115666.67
2010q3	153917333	27384333.3	17115208.3	3077125	14579666.7	8640666.67
2010q4	153803333	27444333.3	17152708.3	3076561	14648333.3	8961000
2011q1	153284333	27047000	16904375	3076561	13856666.7	8759333.33
2011q2	153456000	27394333.3	17121458.3	3076561	13924666.7	8587000
2011q3	153726333	27457333.3	17160833.3	3076561	13843000	8428000
2011q4	154028000	27358666.7	17099166.7	3033825	13329666.7	8870333.33
2012q1	154600333	27479666.7	17174791.7	3033825	12774333.3	8307666.67
2012q2	154831333	27745333.3	17340833.3	3033825	12666000	7975333.33

QDATE	OLF	PTW	VPTW	MIL	OU	IVPW
2012q3	154957000	27718666.7	17324166.7	3033825	12414000	8085000
2012q4	155506667	27700000	17312500	2981291	12142333.3	8282666.67
2013q1	155360000	27523000	17201875	2981291	12036666.7	8086666.67
2013q2	155559667	27720666.7	17325416.7	2981291	11721666.7	7954666.67
2013q3	155630333	27864333.3	17415208.3	2981291	11294666.7	8046333.33
2013q4	155040000	27373333.3	17108333.3	2957975	10775666.7	7838666.67
2014q1	155621000	27524333.3	17202708.3	2946274	10310333.3	7613666.67
2014q2	155586667	27432666.7	17145416.7	2931976	9673666.67	7414333.33
2014q3	156059000	27767666.7	17354791.7	2913842	9489666.67	7359333.33
2014q4	156414333	27647000	17279375	2893947	8932333.33	7074000
2015q1	156772333	27358000	17098750	2888306	8666333.33	6854000
2015q2	157257667	27592666.7	17245416.7	2889443	8543666.67	6636333.33
2015q3	156967333	27102666.7	16939166.7	2885215	8022000	6425000
2015q4	157555000	27305666.7	17066041.7	2883978	7943000	6091000
2016q1	158699667	27668000	17292500	2883750	7763333.33	6060666.67
2016q2	158964000	27783333.3	17364583.3	2883578	7821000	6002000
2016q3	159490000	27438333.3	17148958.3	2880491	7792666.67	6076333.33
2016q4	159596333	27819333.3	17387083.3	2870032	7628333.33	5954666.67
2017q1	159858000	27461666.7	17163541.7	2870032	7320333.33	5686000
2017q2	160241000	27289333.3	17055833.3	2866826	7025666.67	5451666.67
2017q3	160738000	27546333.3	17216458.3	2877622	6914666.67	5276666.67
2017q4	160434000	27184333.3	16990208.3	2867667	6670333.33	5095666.67
2018q1	161507000	27564000	17227500	2864053	6528333.33	4929000
2018q2	162003667	27139333.3	16962083.3	2869822	6397333.33	5033666.67
2018q3	162012000	26961000	16850625	2887588	6111333.33	4759333.33

QDATE	OLF	PTW	VPTW	MIL	OU	IVPW
2018q4	162769333	27090333.3	16931458.3	2881687	6219333.33	4526666.67
2019q1	163036333	26856000	16785000	2889691	6257000	4850000
2019q2	162877000	26923000	16826875	2906876	5958000	4534333.33
2019q3	163801667	26965666.7	16853541.7	2929645	5899000	4204666.67
2019q4	164434667	27019333.3	16887083.3	2921107	5891000	4352333.33

QDATE	WJBDNL	NW	FLF	OUR	CPI	
1994q1	6475000	11.23333	107016333	6.55736	61.8943	
1994q2	6360333.33	11.29	107517000	6.16723	62.2459	
1994q3	6103666.67	11.36333	108067667	6.00325	62.8225	
1994q4	5897666.67	11.45	108397333	5.62137	63.1882	
1995q1	5791000	11.52	108669333	5.47999	63.6523	
1995q2	5601666.67	11.59333	108983000	5.67658	64.1726	
1995q3	5573000	11.69667	109158667	5.66061	64.4961	
1995q4	5714333.33	11.78	109549333	5.57436	64.8477	
1996q1	5601000	11.87333	109789333	5.54798	65.4243	
1996q2	5515666.67	11.98333	110452667	5.47274	65.9868	
1996q3	5395333.33	12.09	110989000	5.26194	66.3665	
1996q4	5274000	12.19667	111862000	5.31301	66.9432	
1997q1	5086666.67	12.32	112233667	5.22692	67.351	
1997q2	5005333.33	12.42667	112868333	4.9779	67.5057	
1997q3	4856333.33	12.55667	113568333	4.86102	67.8432	
1997q4	4796666.67	12.70667	113623667	4.68365	68.2089	
1998q1	4880666.67	12.83	113874000	4.64121	68.3495	
1998q2	4791333.33	12.96	113968333	4.41765	68.5745	
1998q3	4906000	13.06333	114659333	4.53213	68.9261	
1998q4	4660000	13.17667	115167667	4.43356	69.2496	
1999q1	4658333.33	13.3	115783000	4.28839	69.5027	
1999q2	4736666.67	13.42333	115864333	4.25282	70.0231	
1999q3	4466666.67	13.55	116125000	4.24812	70.5435	
1999q4	4377333.33	13.66667	116980667	4.08293	71.0638	
1994q1	6475000	11.23333	107016333	6.55736	61.8943	

QDATE	WJBDNL	NW	FLF	OUR	CPI	
2000q1	4483000	13.8	119159667	4.04978	71.767	
2000q2	4375333.33	13.94	119728333	3.94884	72.3296	
2000q3	4369666.67	14.06667	119701667	4.03104	72.9905	
2000q4	4425333.33	14.22667	119603667	3.91921	73.5109	
2001q1	4423000	14.35667	120395667	4.23085	74.2141	
2001q2	4554000	14.49667	120350000	4.4117	74.7344	
2001q3	4655333.33	14.59	120401333	4.81912	74.9454	
2001q4	4726333.33	14.70667	120516667	5.53695	74.8891	
2002q1	4653333.33	14.78667	120843667	5.70438	75.1282	
2002q2	4733333.33	14.88667	120865000	5.84415	75.7189	
2002q3	4720333.33	15.02	121183333	5.72979	76.1267	
2002q4	4576333.33	15.15667	121385667	5.8489	76.5768	
2003q1	4716000	15.26	121744333	5.87271	77.3643	
2003q2	4667000	15.32333	122108333	6.15052	77.2378	
2003q3	4839000	15.41	122031333	6.10476	77.8144	
2003q4	4663000	15.45667	122469000	5.81797	78.1097	
2004q1	4778333.33	15.53333	122470667	5.68173	78.7707	
2004q2	4693000	15.63	122381000	5.58886	79.3895	
2004q3	4841333.33	15.73333	122556333	5.43357	79.8958	
2004q4	5113000	15.83667	123158333	5.38884	80.7537	
2005q1	4992666.67	15.93333	123688333	5.28367	81.1615	
2005q2	5035666.67	16.04	124647333	5.10636	81.71	
2005q3	4916666.67	16.17	124817000	4.96562	82.9476	
2005q4	4998000	16.31	125144333	4.95405	83.7211	
2006q1	4927666.67	16.48	125837000	4.72028	84.1571	

QDATE	WJBDNL	NW	FLF	OUR	CPI	
2006q2	4693333.33	16.66667	126405333	4.65498	84.9165	
2006q3	4826333.33	16.82	127033333	4.64278	85.7182	
2006q4	4692000	16.98	127403667	4.45361	85.3666	
2007q1	4592333.33	17.15333	128010667	4.52415	86.2035	
2007q2	4873000	17.34	127545333	4.49524	87.1798	
2007q3	4771333.33	17.50667	128190333	4.65702	87.7317	
2007q4	4552333.33	17.63333	128917667	4.79923	88.8078	
2008q1	4767666.67	17.80333	129050000	4.98322	89.7698	
2008q2	4837666.67	17.97667	128851333	5.32134	90.9376	
2008q3	5032666.67	18.16	129156667	6.01033	92.3398	
2008q4	5315333.33	18.31333	128887667	6.87222	90.225	
2009q1	5710666.67	18.44667	127571000	8.29201	89.6044	
2009q2	5940333.33	18.53667	127331667	9.28037	90.0809	
2009q3	5867000	18.65333	126705667	9.60259	90.8559	
2009q4	6062000	18.79	126168333	9.91132	91.5673	
2010q1	6011000	18.9	126055333	9.83684	91.7124	
2010q2	5882000	18.99667	127197667	9.65666	91.6801	
2010q3	6067333.33	19.08667	126533000	9.47237	91.9488	
2010q4	6300666.67	19.21	126359000	9.5238	92.6934	
2011q1	6463000	19.31333	126237333	9.03986	93.6826	
2011q2	6448333.33	19.39333	126061667	9.07405	94.7478	
2011q3	6412666.67	19.47333	126269000	9.0049	95.3656	
2011q4	6415000	19.56	126669333	8.65407	95.7937	
2012q1	6326666.67	19.60667	127120667	8.26284	96.3332	
2012q2	6433000	19.69333	127086000	8.18051	96.5365	

QDATE	WJBDNL	NW	FLF	OUR	CPI	
2012q3	6781333.33	19.75333	127238333	8.01137	96.9724	
2012q4	6704000	19.84333	127806667	7.80819	97.6172	
2013q1	6693000	19.98	127837000	7.74721	98.0096	
2013q2	6589333.33	20.07	127839000	7.53516	97.9023	
2013q3	6309666.67	20.18	127766000	7.25737	98.4318	
2013q4	5968000	20.3	127666667	6.95052	98.7957	
2014q1	6181666.67	20.46333	128096667	6.62524	99.411	
2014q2	6322333.33	20.54333	128154000	6.21757	99.939	
2014q3	6322000	20.65	128291333	6.08081	100.195	
2014q4	6465000	20.72	128767333	5.71065	99.9457	
2015q1	6386000	20.82667	129414333	5.52787	99.2988	
2015q2	6134000	20.97	129665000	5.4327	99.976	
2015q3	5951666.67	21.07333	129864667	5.11059	100.354	
2015q4	5851666.67	21.21	130249333	5.04146	100.346	
2016q1	5887666.67	21.35	131031667	4.89166	100.284	
2016q2	5788000	21.48667	131180667	4.91989	101.086	
2016q3	5891666.67	21.60667	132051667	4.88589	101.515	
2016q4	5826666.67	21.73333	131777000	4.77977	102.159	
2017q1	5731333.33	21.85667	132396333	4.57941	102.842	
2017q2	5473000	21.97333	132951667	4.38439	103.025	
2017q3	5599666.67	22.12667	133191667	4.30185	103.514	
2017q4	5264333.33	22.23333	133249667	4.15767	104.32	
2018q1	5144333.33	22.41667	133943000	4.04213	105.131	
2018q2	5175000	22.61	134864333	3.94887	105.789	
2018q3	5291000	22.78667	135051000	3.77217	106.218	

QDATE	WJBDNL	NW	FLF	OUR	CPI	
2018q4	5383000	23	135679000	3.82086	106.633	
2019q1	5218666.67	23.19667	136180333	3.83779	106.822	
2019q2	5112666.67	23.40667	135954000	3.65799	107.745	
2019q3	5005333.33	23.62333	136836000	3.60135	108.09	
2019q4	4834333.33	23.80667	137415333	3.58259	108.794	

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