A hybrid model of new Keynesian Phillips Curve: An application in Indonesia

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A R T I C L E   I N F O

A B S T R A C T

This study attempts to prove whether inflation dynamics in Indonesia can be explained by the hybrid model of New Keynesian Phillips Curve (NKPC). Output gap variable and dummy variable are also incorporated in this study as the external shock of the increase in fuel oil prices in 2004. By using a steady state model, it can be concluded that inflation dynamics in Indonesia could be explained by the hybrid model of NKPC. The variable of forward looking has significant effect on inflation dynamics, but the variable of inflationary pressure (output gap) has no significant effect on inflation dynamics. In addition, the increase in fuel oil prices in 2004 also gives pressure on the inflation rate, but when interacting with the variable of inflation (backward and forward), it even reduces its pressure on the inflation rate.

A B S T R A K

Penelitian ini mencoba untuk membuktikan apakah dinamika inflasi di Indonesia dapat dijelaskan dengan model hibrida dari New Keynesian Phillips Curve (NKPC). Variabel output gap dan variabel dummy juga dimasukkan dalam penelitian ini sebagai external shock adalah kenaikan harga bahan bakar minyak pada 2004. Dengan menggunakan model steady state, dapat disimpulkan bahwa dinamika inflasi di Indonesia dapat dijelaskan dengan model hibrida NKPC. Variabel forward looking berpengaruh secara signifikan terhadap dinamika inflasi, tetapi variabel tekanan inflasi (output gap) tidak berpengaruh signifikan terhadap dinamika inflasi. Selain itu, kenaikan harga BBM pada 2004 juga memberikan tekanan pada inflasi, tetapi ketika berinteraksi dengan variabel inflasi (backward dan forward), pengaruhnya bahkan mengurangi tekanan pada laju inflasi.

1. INTRODUCTION

Inflation is widely known as a monetary phenomenon as it is, sometimes, also part of a fiscal phenomenon (Hervino 2011). An empirical study related to the inflation rate (nominal wage inflation and unemployment) was firstly conducted by Phillips (1958), and later on adopted by Samuelson and Sollow (1960) in the United States with relevant results (traditional Phillips curve). The relationship between these two variables was also able to explain the link between price inflation and cyclical indicator of output. Then, it was more profoundly examined by Phelps (1967), Friedman (1968) and Lucas (1972b) related to the trade-off relationship between the two variables. In their analysis, Friedman-Phelps explained that the trade-off occurrence was actually not permanent, this was due to the

slow pace of the expectations of economic agents to see the reality, and the policy makers were likely to keep the unemployment rate below the natural rate so that it increased the inflation rate. This approach is known as acceleration hypothesis.

In subsequent development, the analysis of Phillips Curve, in the short term, began to shift and brought triangle model. This model explained that this inflation dynamics was derived from three sources, namely real activity (unemployment), supply shocks, and inertia (previous inflation rate). This model became very important for macroeconomic policy and then gave birth to the concept of Non-Accelerating Inflation Rate of Unemployment, or commonly known as NAIRU.

Next, Sargent (1971) and Lucas (1972b) introduced rational expectation which was incorporated

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into the economic modeling, and this became an alternative modeling in the framework of Phillips Curve, known as *islands model*. This model explained that, in the short term, trade-off inflation and output were the results of the presence of asymmetric information (imperfect information) because of the presence of price-setters. This model turned out to be in line with the views of the New Keynesian where it became part of the New Keynesian Macroeconomics. From this came the new Phillips curve model, known as the New Keynesian Phillips Curve (NKPC).

There are several factors that distinguish views between the traditional Phillips Curve and the new one. (1) Within the framework of new Phillips Curve, pricing behavior is the result of optimization process of a company in monopolistic market when it faces obstacles in adjusting the price rate ; (2) In traditional approach, it is assumed that the economic agents are adaptive expectations (backward-looking), while in new approach (NKPC) they are rational expectations (forward-looking phenomenon). And (3) as a result of the pricing optimization process by the company, the indicator of economic activity which is relevant to the NKPC approach is proxied with real marginal costs.

Since then, there have been a lot of empirical studies related to the inflation dynamics referring to the NKPC. This NKPC is the development of the theory of traditional Phillips Curve in which there is a trade-off between inflation rate and unemployment in the short term and will be perfectly inelastic (vertical) in the long term (Mankiw 2007). This NKPC is derived from the framework of optimization which is associated with rational expectations and nominal rigidities (Rudd and Whelan 2005), so that the NKPC explains that inflation has forward-looking dynamics (Jondeau and Bihan 2004).

Since the validity of NKPC is still in debate, many empirical studies in some countries have been trying to assess it. Finally, there comes new model of Phillips curve, known as a hybrid model of NKPC. Besides incorporating forward-looking (typical NKPC), this model also incorporates lags of inflation which are certainly not contained in the core inflation model. This model tries to combine the variable of forward-looking with some lags of inflation variable (backward-looking) and inflationary pressure variable (output gap). Finally, this model could be accepted in general and increasingly applied in the analysis of monetary policy.

The empirical studies using this hybrid model are divided into two sides. First, the studies con-

ducted by Fuhrer (1997), Robert (2001), Estrella and Fuhrer (2002), and Soderlind et al. (2002) explained that the variable of forward-looking in inflation is not important. In general, their studies produced that the variable of backward-looking has more influence than the variable of forward-looking. Second, the researches done by Gali and Gertler (1999) in the United States, Gali et al. (2001) in Europe, Sbordone (2002), and Amato and Gerlach (2000) explained that the variable forward-looking has a dominant influence and is able to explain the inflation dynamics in Europe and USA. This result is also in line with the research done by Insukindro and Sahadewo (2010) in Indonesia.

Based on the explanations above, the researcher would like to empirically reprove the NKPC hybrid approach developed by Galf and Gertler (1999). The aim of this study is to analyze whether the inflation dynamics in Indonesia, in the short and long term, is more dominated by the traditional approach of Phillips curve (backward-looking domination) or vice versa (forward-looking), or even both of them. The researcher certainly also includes some of the events that give a shock to the inflation rate developments in Indonesia, such as the increase in world fuel oil prices in 2004.

This study is divided into several parts. First, background of the study; second, empirical study; third, method of research; fourth, results and discussion; and the last; conclusion and suggestion.

2. THEORETICAL FRAMEWORK AND HYPOTHESES
Empirical Study
The research related to the inflation dynamics (inflationary finance and inflation dynamics) in Indonesia was first conducted by Aghevli and Khan (1977). The purpose of this research was to build a dynamics model of financing the budget deficit and the mechanism of inflationary in a continuous time framework. This research used annual data from the period of 1951-1972 and applied methods developed by Sargan (1974) and Wymer (1972), i.e. using simultaneous model in which each equation is estimated by stochastic differential equations. The results of this study showed that the model used was able explain the phenomenon of inflation in Indonesia in which when the budget deficit occurred, there was an increase in the money supply and affected inflationary pressures. Additionally, when the government ran an expansive monetary policy, the government revenues would increase by adding the circulation of money. Thus, it would increase inflation, reduce the real value

of the tax, and decline the welfare (inflation tax).

Fuhrer (1997) examined the extent to which inflation as a forward-looking phenomenon. By incorporating future price and excess demand into the model, the results indicated that future price expectation was not able to describe the price level and the behavior of inflation itself. The dynamic model by incorporating backward-looking element has the result that is much different from the dynamic model that incorporates forward-looking elements. This means that when the model was used for forecasting purposes, the dynamic model of forward-looking was better, but when it was used as a policy simulation, the mix elements of backward and forward-looking became very important in explaining the behavior of inflation in terms of the dynamic model.

Gali and Gertler (1999) tried to build and estimate the structural model of the Phillips Curve called The New Phillips Curve. They included the variable of real marginal cost to measure the impact of productivity gains of the inflation proxied by output gap and labor income share. In addition, they also included elements of backward and forward-looking. The result obtained from this study showed that the New Phillips Curve model containing element of forward-looking was able to explain the inflation dynamics (dominant), because when this model was tested by incorporating elements of backward-looking, it was significant but quantitatively it was not important because its element of forward-looking was still more dominant. When comparing the significance of each proxy of the real marginal cost, the result showed that the labor income share had more dominant influence on inflation dynamics than the output gap did.

The study on inflation dynamics modeling was carried out by Rudd and Wheelan (2005) related to the discovery of Gali, and Gertler (2001) that proxied real marginal cost with labor income share. According to Ruud and Whelan (2005), NKPC failed as an empirical model because the model had not been able to explain the effect of variable of inflation of the previous period on the rate of inflation. NKPC failure is due to the weakness of the rational expectations in explaining the existing phenomenon of reality, such as the assumptions used, (1) the price are sticky and (2) the behavior of economic agents who optimized the conditions where the rate of price was fixed. On this basis then developed the variant of NKPC called hybrid model of NKPC where such model combines forward-looking element, inflation of the previous period

(backward-looking) and the inflationary pressures proxied by the output gap. By using the Generalized Method of Moments (GMM), the hybrid model of NKPC turned out to be stable and useful model to predict future inflation.

In Mexico, the study of inflation dynamics using the Phillips Curve approach was also performed by Ramos and Torres (2008). Their research intended to explain the short-term dynamic inflation on the economy of Mexico using NKPC and NKPC hybrid model approaches. By using GMM estimation method, the NKPC framework was able to explain characteristics of inflation in Mexico well. Similarly, the hybrid model explained that the inflation dynamics in Mexico was able to be explained by the phenomenon of backward and forward-looking. In simple terms, it can be explained that although inflation expectations (forward-looking) is very important in influencing the inflation rate, the inflation persistence (lagged inflation) also has an important role.

3. RESEARCH METHOD

To achieve the purpose of this study, the researcher uses a dynamic model (ECM-EG) in estimating the hybrid model of NKPC. This is done because many of the previous studies used GMM method in estimating the hybrid model of the NKPC, because it makes the model more stable, as expressed by Rudd and Whelan (2005). In analyzing the inflation dynamics in Indonesia, the researcher uses time series of monthly data by taking samples from the period of 2001 - 2014. The variables used in this research are the implicit growth rate (deflator) of gross domestic product (GDP) as a proxy of the inflation rate and the output gap which is the percentage of the deviation between the actual output and its potential level. The national output is using the data in real Gross Domestic Product. To calculate potential output, the researcher uses a Hodrick-Prescott filter (HP filter). All data are the real data with a uniform base year i.e. 2000. For GDP data, the researcher conducts interpolation from low frequency to high frequency by using cubic splained method. All data are derived from the Economic and Financial Statistics (SEKI) of Bank Indonesia.

Since the characteristics of time series data are stochastic (in which mean, variance, and covariance are not the same), the stationary test of all variables should be conducted before estimating the models. The stationary test of this unit-root is conducted using Structural Unit-Root Test or Phillips-Peron (PP) Test because allegedly there are changes in the

Table 1
Stationary Test of the Data (Limit Level)

	PP	ADF
Inflation	-10.58033 (0.0000)*	-10.62595 (0.0000)*
Output Gap	-6.972127 (0.0000)*	-6.643119 (0.0000)*

Note. (.) = probability value. * = Significance at the level of 1 percent .

Table 2
Research Results Estimation

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
C	0.382741	0.377491	0.354332	0.262647	0.257860	0.161622
	(0.0001)	(0.0001)	(0.0002)	(0.0149)	(0.0172)	(0.1734)
Inflation (-1)	0.191033	0.193202	0.181168	0.351675	0.168949	0.343428
	(0.0134**)	(0.0116)**	(0.0187)**	(0.0042)*	(0.0275)**	(0.0048)*
Inflation (1)	0.195342	0.199263	0.188240	0.176287	0.368004	0.359969
	(0.0118)**	(0.0093)*	(0.0146)**	(0.0216)**	(0.0031)*	(0.0036)*
Inflation (-1)*Dummy	-	-	-	-0.280573	-	-0.287580
				(0.0732)***		(0.0642)***
Inflation(1)*Dummy	-	-	-	-	-0.290991	-0.297817
					(0.0642)***	(0.0565)***
Output Gap	0.008878	-	-	-	-	-
	(0.7362)					
Dummy	-	-	0.182643	0.376041	0.379393	0.582236
			(0.2411)	(0.0469)**	(0.0439)**	(0.0075)*
R2	0.072148	0.073350	0.081250	0.099558	0.100768	0.119991
F Test	4.147126	6.411684	4.746046	4.422607	4.482411	4.335976
	(0.007320)*	(0.002090)*	(0.003366)*	(0.002037)*	(0.001849)*	(0.001001)*
AIC	2.413792	2.329660	2.400159	2.392153	2.390807	2.381320
SC	2.489399	2.453071	2.475455	2.486272	2.484927	2.494264
Log Likelihood	-193.9310	-194.7195	-194.0131	-192.3526	-192.2416	-190.4589
DW-Stat	2.340558	2.352459	2.325816	2.300006	2.305620	2.270342
White Hetero	2.704911	1.165136	10.45441	11.69984	11.62765	11.78370
	(0.9749)	(0.9482)	(0.2346)	(0.3056)	(0.3107)	(0.3801)
Ramsey Reset Test	2.682825	2.725837	2.691199	2.271753	3.604359	0.821933
	(0.0235)	(0.0216)	(0.0231)	(0.0501)	(0.0594)	(0.3660)

Note. (.)= probability; *. **, *** = level of significance 1, 5, and 10 percent .

structure of the variables of inflation and the output gap in Indonesia during the study period. The PP test results are confirmed using stationary test of Augmented Dickey Fuller (ADF).

The unit-root test is done to detect whether all of the variables are stationary at their limit level. If all variables are stationary at their limit degree, the model to be built is steady state model (long-term). But if they are not stationary at their limit deree, the stationary test is done on the level one or two. This is done to avoid spurious regression. If all variables have the same level of integration (stationary on the level one or two) and co integrated, then the model to be built is EMC Engle Granger (ECM-EG).

However, the researcher believes that the majority of macroeconomic data in Indonesia must not be stationary at the level because there are structural changes such as during the 1997's economic crisis, the increase in world oil prices and others, so that the stationary level of the data will be at the different level. For this reason, the model that will

be developed by the researcher is ECM-EG model. After that, stability test is done by using CUSUM and CUSUMQ. Then classical assumption test and validity test of Ramsey RESET model are conducted on the models.

The general model of a Hybrid of New Keynesian Phillips Curve is

$$\pi_t = \gamma f E_t \pi_{t+1} + \gamma b \pi_{t-1} + k x_t \tag{1}$$

This model tries to combine forward-looking variable with some lags of inflation variable (backward-looking), and also with the inflationary pressures variable (output gap).

4. DATA ANALYSIS AND DISCUSSION
All variables (inflation and output gap), except dummy variable, are stationary at the limit level. These results are confirmed by the PP and ADF test (see Table 1).

Since all variables are stationary at the limit level, the model that is built in answering the pur-

pose of this study is steady state (long-term) model. In this regard, the researcher presents 6 estimation results in Table 2.

The best inflation model in this study is model 6. It is based on several indicators, such as (1) having the smallest value of Akaike Info Criterion (AIC) and Schwarsz Criterion (SC); (2) having the most substantial and absolute value of log likelihood; (3) passing the heteroscedasticity and autocorrelation tests; and (4) passing the validity test of Ramsey reset model. Based on the estimation results of this long-term model, the researcher can explain that the inflation dynamics in Indonesia is backward looking (traditional) and forward looking (NKPC). This implies that the inflation dynamics in Indonesia can be explained by the hybrid model of NKPC. This can be confirmed by the significance of the two variables in influencing (positive) the inflation dynamics in Indonesia. A greater effect can be seen from the parameters of forward looking variable.

The results of this study strengthen the results of researches done by Gali and Gertler (1999) in the United States, Gali et al. (2001) in Europe, Sbordone (2002), Amato and Gerlach (2000), and Insukindro and Sahadewo (2010) in Indonesia, which explained that the forward-looking variable has a dominant influence. However, what makes it different from the previous studies is on the use of steady state model in answering the purpose of this study.

In this study, the researcher does not find any significant role of the output gap variable in influencing inflation dynamics in Indonesia (see model 1). The opposite is even explained by the significance (positive) of the increase in fuel oil prices (dummy variable) that affects the inflation dynamics in Indonesia. But when the dummy variable interacts with the inflation variable of the backward and forward, the effect of the interaction on the inflation dynamics in Indonesia is even negative, although it is significant.

5. CONCLUSION, IMPLICATION, SUGGESTION, AND LIMITATIONS

There are some conclusions asserted by the researcher in relation to whether the inflation dynamics in Indonesia can be explained by the hybrid model of NKPC. By incorporating output gap variable and dummy variable (increase in fuel oil prices in 2004), it can also be concluded that the inflation dynamics in Indonesia can be explained by the hybrid model of NKPC. This means that the factors of backward and forward looking affect the inflation

dynamics in Indonesia, although the forward looking is more dominant. For the output gap variable, the researcher finds no effect in this study. Especially, for the increase in fuel oil prices, partially it can give a pressure on inflation rate, whereas when interacting with backward and forward looking variables, it reduces the pressure on the inflation rate in Indonesia.

The variable of inflation is derived from the growth of the implicit deflator of GDP. Yet, by seeing the inflation phenomenon from the items commonly purchased by the public (the growth of the Consumer Price Index), it is possible to obtain better results.

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