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ESTIMATED NEW KEYNESIAN PHILLIPS CURVES (NKPC) MODEL IN DYNAMIC INFLATION BASED ON PANEL DATA PERSPECTIVE IN ASEAN

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ABSTRACT

The development of the theory of dynamic inflation begins by linking wage inflation and unemployment. In further developments, factor of expectation is classified into inflation model. In measuring the factor of expectation emerges a debate about the use of variable *lag* inflation or expectation inflation. Lag variable represents the backward-looking behavior while expectation inflation represents the behavior of forward looking.

The study used inflation data is important for ASEAN, because ASEAN is one of the strengths of the international economy. This study analyzes the dynamics of inflation in the ASEAN using framework the New-Keynesian Phillips Curve (NKPC) model. The data used is the quarterly panel data from 10 ASEAN members in the period 2005.I - 2013.IV.The study of this dynamic inflation applies quarter to quarter inflation data, meaning that the inflation rate is the percentage change in the general price of the current quarter compared to last quarter general price divided by the last quarter. The empirical results are estimated by using the Generalized Method of Moment (GMM), both of the system and first different indicates that the pattern formation of inflation expectations are backward-looking and forward-looking. In addition, the estimated NKPC models show the backward-looking behavior is more dominant than the forward looking. Changes in inflation are not entirely influenced by expectations of inflation in each country. Changes in inflation are also influenced by the output gap, changes in money supply, and exchange rate.

Based on the findings of this study, it can be concluded that the NKPC models can explain the dynamics of inflation in each country in the ASEAN region. Significance of parameter estimates backward-looking, forward-looking, and the output gap indicate that the hypothesis of this model is proved to be true. However, the hypothesis that the forward looking behavior is more dominant than backward looking is not found.

Keywords: Dynamic Inflation, ASEAN, Forward Looking, Backward-Looking, NKPC

INTRODUCTION

The dynamic economy of ASEAN member countries with high growth of outputs requires inflation control which is based on a good understanding of inflation. Various studies on inflation using national data aggregation have been conducted, but only a few studies have concern about inflation and built a model of inflation based on data from a community of country. Ideally, the research that examines dynamic inflation using panel data of a community of country is also conducted to better understand inflation. The research is

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important because ASEAN is a a community of big countries with regional growth differences that cause variations in inflation. These variations certainly cannot be seen using aggregate data but can be seen using data of each country. In addition, the calculation of consumer price index compiled by regions of the countries shows that inflation is a phenomenon of the rise in general price level.

Moreover, quoting Mehrotra et al. (2007), research using provincial data is important for big countries because the provinces throughtout the country have different institution, economic performance, and level of market development. Economic obstacles between regions, for example trade obstacles can also be a source of differences in inflation formation process. Furthermore, inflation differences between regions reduce the ability of a region to adjust the economic shocks. In addition, the role of inflation and inflation expectations in various areas that have various inflation dynamics also influences the effectiveness of monetary policy.

Research on inter-provincial inflation has been carried out by Mehrotra et al. (2007) using data of China. In their research, they found the variation of inflation in each province and forward looking inflation component in 22 of the 29 provinces studied. Likewise, Chaban and Voss (2012) who examined inflation in Canada found a variation of inflations in 10 provinces. The contribution of this research compared to previous inflation studies is the use of panel data of 10 ASEAN countries, in contrast to Mehrotra et al. (2007) and Chaban and Voss (2012), who used provincial panel. Furthermore, this research analyzes the dynamic inflation in ASEAN to use the framework of the New Keynesian Phillips Curve (NKPC) model. In addition, this research will also see the effect of the output gap in each country and the monetary level in each country. Estimation of dynamic inflation used quarter-to-quarter (qtq) inflation data and the method used was GMM system for panel data.

LITERATURE REVIEW

The development model of dynamic inflation was pioneered by Calvo (1983) who made up the NKPC model. NKPC Model assumes that in an imperfect competition in the market, companies can set prices based markup above marginal cost. Furthermore, in every random period, there is a possibility $(1-\theta)$ for companies to rearrange the prices and a possibility θ for the companies not to change the prices. This condition can be written as:

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$$p_t = \theta p_{t-1} + (1-\theta) p_t^*, \tag{1.1}$$

where the aggregate price level, p_t consisting of rearranged prices, p_t^*, and the old prices that did not change. The company's choice to rearrange the prices can be expressed in the following equation:

$$p_t^* = \mu + (1-\theta\beta)\sum_{k=o}^{\infty} (\theta\beta)^k \theta p_{t-1} E_t mc_{t+k}^n \tag{1.2}$$

where μ is the value of optimal markup, β is discount factor, and mc_{t+k}^n is nominal marginal cost. Sigma sign in equation (1.2) shows the new prices which are arranged based on the whole expectations mc_{t+k}^n. In addition, companies can also choose not to change the prices based on the weighted value of the expectation of future nominal marginal costs. Based on the conditions, equation (1.1) and (1.2) can be arranged in a new equation that generates a new-Keynesian Phillips curve (NKPC) model as follows:

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\theta)(1-\theta\beta)}{\theta}(mc_t + \mu), \tag{1.3}$$

where inflation, π_t relates to expectations of future inflation and the difference in real marginal cost $(mc_t = mc_t^n - p_t)$ of its optimum level. In general condition, aggregate real marginal cost is proportional to the difference between actual output and potential output, y_t^* By this assumption, NKPC becomes

$$\pi_t = \beta E_t \pi_{t+1} + \lambda y_t \tag{1.4}$$

where y_t is the output gap, i.e. actual output minus potential output, ($y_t^a - y_t^*$), and $\lambda = \frac{(1-\theta)(1-\theta\beta)}{\theta}$.

For policy implications, Rudd and Whelan (2005a) state that NKPC inflation is influenced completely by forward-looking behavior. There is no inertia in inflation, which means that there is no structural impact of the past inflation on inflation. Then, solving the equation (1.4) in a rational assumption obtains the equation:

$$\pi_t = \lambda \sum_{k=0}^{\infty} \beta^k E_t y_{t+k} \tag{1.5}$$

There are at least three policy implications of NKPC model presented by Rudd and Whelan (2005a). The first is the absence of inertia in the inflation model. Inflation is

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influenced entirely by forward-looking behavior. Second, the involvement of variable of *lag* inflation as a proxy for the future value from the output gap affecting inflation is not applicable. According to the supporters of NKPC, if the central bank is able to maintain the inflation target with credible policies, the role of lag inflation in the expectation becomes small. In this situation, inflation can be controlled at a low cost. However, if the policy is not credible, inflation expectations are compiled by the public based on the last occured inflation (lag) and not the central bank's announcement. The latter policy implication is the occurrence of meisleading nature of NAIRU-based analysis, so NAIRU cannot be used as a macro-economic policy guideline. Estimation of time-varying NAIRU showing low inflation can be explained by a decrease in NAIRU. Implicitly, this means that the central bank can increase the economic activities without having to increase inflation. In fact, models (1.4) and (1.5) show that there is a positive effect between output gap and inflation.

METHODOLOGY

This research used panel data of 10 countries that exist in ASEAN ranging from year 2005 quarter 1 through year 2013 quarter 4. Most of the data were taken from the Central Bank of each country in ASEAN, ASEAN secretariate, IMF, and the World Bank.

Table 1. Variable Definitions

Variable	Symbol	Unit	Note
Inflation	$\pi_{i,t}$	Percent	Quarter-to-quarter provincial inflation
Actual Output	y_{it}^{a}	IDR billion	Real GDP
Potential Output	y_{it}^{*}	IDR billion	Obtained using H-P Filter method
Output gap	y_{it}	Percent	$y_{it} = \frac{\left(y_{it}^{a} - y_{it}^{*}\right)}{y_{it}^{*}} \times 100\%$
Changes in the amount of real money supply	ΔM_{it}	IDR billion	ΔM_{it} is a real change in currency (ΔK_{it}) plus the change in real demand deposits (ΔG_{it}). ΔK_{it} is the current currency flow in the central bank and ΔG_{it} is the changes in deposits in each country.
ΔM_{it} compared to y_{it}^{a}	m_{it}	Percent	$m_{it} = \frac{\Delta M_{it}}{y_{it}^{a}} \times 100\%$

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The following are the dynamic inflation models used in this research referring to research conducted by Gali and Gertler (1999).

$$\pi_{i,t} = \gamma_b \pi_{i,t-1} + \gamma_f \pi_{i,t+1} + \lambda y_{it} \quad (1.6)$$

$$\pi_{i,t} = \gamma_b \pi_{i,t-1} + \gamma_f \pi_{i,t+1} + \lambda y_{it} + \delta_m m_{it} \quad (1.7)$$

where π_{it} is inflation, y_{it} is output gap, and m_{it} is monetary aggregate. Furthermore, γ_b dan γ_f and are defined as backward looking and forward looking parameters.

The selection of estimation method is based on NKPC model. The following is the equation (1.8) that can be rewritten as follows

$$\pi_t = \lambda y_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} + u_t \quad (1.8)$$

Where y_t is the output gap $\left(y_{it}^a - y_{it}^*\right)$. In practice, $E_t\{\pi_{t+1}\}$ is usually converted into $\pi_{t+1} - \eta_{t+1}$, where η_t symbolizes a step forward of forcast error of inflation (Vinod, 2010). The changes lead to the equation change into

$$\pi_t = \gamma_0 + \lambda y_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} + \varepsilon_t \quad (1.9)$$

thus, endogenity problem arises because the error correlation, ε_t with the regressor resulting in inconsistent estimates $\hat{\gamma}_0$, $\hat{\lambda}$, $\hat{\gamma}_f$, and $\hat{\gamma}_b$. If there is problem of endogenity, then OLS is inconsistent and the estimation method that should be used is GMM.

Mileva (2007) describes how the data panel and with a model similar to equation (1.8) can face problems. First, endogenity problem can appear where regressor is correlated with the error term. Second, time-invariant characteristics of the province (fixed effect), such as geography and demography, may be correlated with the explanatory variables. The effect of fixed effect in the error term consists of the observed and unobserved effects. Third, the emergence of lag variable increases outocorrelation. Fourth, panel data have short time dimension and relatively large space dimension. To solve the problem that arises, Mileva (2007) suggests the use of Arellano-Bond GMM estimator or GMM system.

RESULTS AND ANALYSIS

The testing of data integration order is made toward inflation-quarter data, π_{it}, the output gap, and monetary variable, m_{it}. Order integration testing of panel data used IPS test of Im, Peseran and Shin (2003), LLC test of Levin, Lin, and Chu (2002), as well as ADF Fisher test and PP Fisher test of Maddala and Wu (1999).

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Table 2. Panel Data Unit Root Test at Level Order

Variable		LLC H_0 = unit root	IPS H_0 = unit root	ADF Fisher H_0 = unit root	PP Fisher H_0 = unit root
π_{it}	Statistik	-24,7837	-22,2389	562,340	527,364
	(prob)	(0,0000)*	(0,0000)*	(0,0000)*	(0,0000)*
y_{it}	Statistik	-19,4621	-27,8572	512,534	498,827
	(prob)	(0,0000)*	(0,0000)*	(0,0000)*	(0,0000)*
m_{it}	Statistik	-17,5328	-23,7583	482,837	852,723
	(prob)	(0,0000)*	(0,0000)*	(0,0000)*	(0,0000)*

Notes: * significance at level α 5%

The overall unit root tests, either LLC, IPS, ADF Fisher, and PP Fisher indicate that the null hypothesis, which contains a unit root, was rejected, so it is concluded all data are integrated at the order level. The test results in Table 4.1 show that P-value is entirely under 5%, so it is concluded that there was no root units in all variables of level order. Because the data are integrated at the level order, level data in the estimated GMM model are used.

Gali and Gertler (1999) compare the results of estimated NKPC models to show that the use of output gap in dynamic inflation model is not appropriate. In the explanation, they use a pair of independent variables of future inflation, π_{t+1} and y_{it} in NKPC model. The estimation results of NKPC using independent variable π_{t+1} and the variable of part of labor income share (s_t) show estimation of positive parameter for π_{t+1} and (s_t). The econometric success provides the basis for Gali and Gertler (1999) and Gali et al. (2005) not to use the output gap, but part of the labor income in the model. Part of labor income is labor income percentage compared to the total output of economy.

NKPC model, developed by Gali and Gertler (1999), explains that inflation expectations $\pi_{i,t+1}$, and lag inflation $\pi_{i,t-1}$, simultaneously affect the prevailing inflation. This model assumes that the company determines the price level based on information on the past inflation (backward-looking-rule-of-tumb), while the rest behaves forward looking.

Table 3 shows the estimated NKPC in model A using GMM with variable instrument π_{t-4}. Estimating equation of NKPC indicates *backward looking, forward looking* parameter estimation and the significant output gap at α = 5%, which is indicated by P-value of all parameters less than 5%. P-value for the J-statistic is also greater than 5%. The null

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hypothesis which states that there is no over-identification is accepted. Model A also shows the direction of the coefficient *backward looking*, *forward looking*, and the output gap according to the theory (positive).

Table 3. Dynamic Inflation Model Based on NKPC

$$\pi_{i,t} = \gamma_b \pi_{i,t-1} + \gamma_f \pi_{i,t+1} + \lambda y_{it} \quad \text{(A)}$$

$$\pi_{i,t} = \gamma_b \pi_{i,t-1} + \gamma_f \pi_{i,t+1} + \lambda y_{it} + \delta_m m_{it} \quad \text{(B)}$$

		(A) π_{it}		(B) π_{it}	
γ_b	Parameter Values	0,086555		0,092685	
	t-statistic	5,51876		4,041432	
	Prob.	(0,0000)*		(0,0001)*	
γ_f	Parameter Values	0,041260		0,044727	
	t-statistic	3,885509		3,487576	
	Prob.	(0,0001)*		(0,0005)*	
λ	Parameter Values	0,04338		0,036467	
	t-statistic	3,698731		2,775005	
	Prob.	(0,0002)*		(0,0056)*	
δ_m	Parameter Values			0,015129	
	t-statistic			8,293415	
	Prob.			(0,0000)*	
N		360		360	
Instrument rank		30		30	
Hansen test:					
	J-stat.	29,78955		29,68664	
	Prob.	0,3236		0.2807	
Average *lag*		0,095		0,102	
Wald- test:					
		$\gamma_b - \gamma_f = 0$	$\gamma_b + \gamma_f = 1$	$\gamma_b - \gamma_f = 0$	$\gamma_b + \gamma_f = 1$
Chi-square		9,3145	1529,900	5,986	746,564
Prob.		(0,0000)	(0,0000)	(0,0144)	(0,0000)

Notes: * significance at level α 5%

Results of estimated NKPC model indicate the pattern of formation of inflation expectations is *backward looking and forward looking*. This means that inflation expectations are influenced by the experience of the past inflation and estimation of inflation expectations in the future. Notwithstanding the foregoing, it can be seen that backward looking parameter is greater than *forward looking*. Hypothesis $\gamma_b - \gamma_f = 0$ or $\gamma_b = \gamma_f$ is also rejected Wald test. Chi-square value (9.31) and P-value (0.0000) indicate that the value γ_b is not equal to γ_b. Based on the value of parameter and Wald test, it is found that the behavior of *backward*

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looking is more dominant in the formation of inflation expectations than that of *forward looking* behavior.

Testing the number of parameters of *backward looking* and *forward looking* the same as one $\gamma_b + \gamma_f = 1$ is also performed using Wald test. This test is made to determine whether the establishment of expectations is perfect or full. The results of Wald test with chi-suare (1529.9) value and P-value (0.000) conclude that the hypothesis stating $\gamma_b + \gamma_f = 1$ is rejected. This means that the formation of inflation expectations is not full and in the long-term Phillips curve is not vertical. The test results indicate that inflation is also influenced by the output gap. Conclusion of the Wald test results is in line with the significant value of the output gap parameter, λ, and this means that output gap affects inflation.

NKPC estimation results also show the persistence of inflation in ASEAN. The average time of inflation adjustment of 0.095, which is calculated based on the method presented by Koyck (1954) in Gujarati (2003) shows that the average length of time of inflation adjustment is 0.095 quarter or approximately 1,1 week. This value indicates the low level of inflation persistence.

Model B shows the estimated results of NKPC with additional monetary variables. Estimation of model B shows the estimation of *backward looking, forward looking* parameters, the output gap, and monetary variables is significant at α=5%, which is indicated by P-value of all parameters less than 5%. P-value for J-statistic is also greater than 5%. The null hypothesis which states that there is no over-identification is accepted. Table 3 also shows the direction of the coefficient of *backward looking, forward looking,* and the output gap of model B is in accordance with the theory (positive).

Of the estimated model B, it is found that monetary variable turns out to affect inflation. This means that if relative money supply compared to GRDP increases, the inflation will rise, while if it is decreased, it will lead to inflation decrease. In the estimation of model B, it can be seen that the significance level of backward looking parameter is always significant at α = 5%. This level of significance is the same as in model A. This means that, the additional explanatory variable causes the reduced strength of the *looking forward* parameter in influencing inflation.

Even if the level of significance of *forward looking* parameter declines, the estimated results of NKPC model with fixed monetary variable shows *backward looking* and *forward looking* determines the pattern formation of inflation expectations. Inflation is influenced by

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the experience of inflation in the past time and also the estimated inflation expectations in the future by *backward looking* parameter value greater than that of *forward looking*.

Wald test results with P-value (0.000) for model B concludes that the hypothesis which states that $\gamma_b + \gamma_f = 1$ is rejected. This means that the formation of inflation expectations is not full in NKPC model with additional monetary variables. Besides, the meaning of rejection of the hypothesis in the long term of NKPC model is not vertical. The test results indicate that inflation is also affected by other significant variables in the model. In addition, the average time of inflation adjustment for model 4 is 0.102. Similar with in NKPC model (model A), the average time needed to adjust the inflation is about 1 week. This value indicates the low level of inflation persistence.

DISCUSSION

Consistency of positive direction parameter estimation of the Phillips curve and NKPC shows that the opinions of Gali and Gertler (1999) and Gali et al, (2005) which state that the output gap cannot be a proxy for economic activities can not be accepted. Based on these results, the use of the output gap in the estimated dynamic inflation model in this research may be confirmed. Moreover, in all estimated models, significant values of output gap are obtained.

The conclusion that the output gap in ASEAN countries can be accepted as factors affecting inflation is the same as the conclusion of research conducted by Mehrotra (2007). Variable significance of national output gap on inflation indicates that demand and supply of outputs in ASEAN are important variables that explain the dynamic inflation. The high national economy in ASEAN which causes actual output to be above its potential has an implication on inflation in each country, and vice versa.

Based on the estimated NKPC model, either in reduced form (model A) or after the addition of monetary shock variable (model B), it is found that estimation parameters of *forward looking* γ_f, or backward looking γ_b, are entirely significant and marked positive. These results prove that the formation pattern of inflation expectations is *backward looking* and *forward looking*. This means that the inflation expectations are influenced by the experience of the past inflation and inflation expectations in the future.

Even if inflation is influenced by the behaviors of *backward looking* and *forward looking*, NKPC estimation model results show that the behavior of backward looking is more

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dominant than that of forward looking. However, in all estimated models, the dominant value of component of *backward looking* decrease when the explanatory variables in hybrid model of NKPC is coupled with monetary variables. The findings of the dominance of *backward looking* behavior is different from the predictions of NKPC model and previous studies conducted by Gali and Gertler (1999), Gali et al. (2005), Abbas and SGRO (2011), and Mehrotra et al. (2007).

CONCLUSION AND RECOMMENDATION

The result of estimated NKPC model also found that the dynamics of inflation in ASEAN is not only influenced by expectations that underlie the behaviors of *backward looking* and *forward looking*. Other explanatory variables such as the output gap and monetary variables also influence inflation. Conclusion stating that the amount of money supply in each country influences the inflation is the same as the conclusion of previous research that examines the influence of money on inflation. These results suggest that the regulation of money supply in each country can be used to control inflation like monetary policy prescriptions at national level.

The final conclusion that can be drawn from the results of estimation is that the level of inflation persistence is, in fact, low. The average value of the inflation adjustment time is about one week. This means that if there is a shock which causes inflation to be different from the point of equilibrium, the economic actors quickly adjust the existing inflation back to the equilibrium value.

Thus, the policy that can be taken in supporting the economy in ASEAN is the policy of inflation control that can be made by optimizing the control policy of monetary aggregates (money supply) in each country. The central bank can set the target of money supply to control inflation. Both fiscal and monetary policies must be credible and trusted by economic agents because they determine the price fluctuations.

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