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# Estimates of New Keynesian Phillips Curve: Observations Based on the Case of Korea

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송 현 지

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# Abstract

## Estimates of New Keynesian Phillips Curve: Observations Based on the Case of Korea

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Recently, an apparent flattening of New Keyneisan Phillips Curve (NKPC) has been indicated not only in the United States but also in many other small open economy countries including Canada, New zealand, U.K, and Korea. The implications of such phenomenon concedes the costs of trade-offs between the inflation and output gap variability, in which inflation has become less responsive to the variability of domestic macroeconomic activities. This paper's main objective is to discover some of evidences and conceivable explanations behind this structural flattening of New Keynesian Phillips Curve in Korea. We estimate a dynamic stochastic general equilibrium (DSGE) model of a small open economy to investigate such changes by employing Bayesian estimation methodology. Using data for Korea, we find that the flattening of New Keynesian Phillips Curve has become evident, however; the slope of New Keynesian Phillips Curve does not seem monotonically decreasing when it comes to the rolling window estimation analysis. We consider various reasons for this structural flattening including problems with data and estimation methodology and finally implement few robustness checks.

**Keyword :** Small open economy model, New Keynesian Phillips Curve, Structural Estimation, Bayesian analysis, MCMC
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# Contents

# 1 Introduction

In recent years, inflation has become less responsive to the fluctuations of domestic macroeconomic variables, in other words, the baseline New Keynesian Phillips Curve (NKPC) has been flattened over time. As the New Keynesian Phillips Curve measures the structural changes of inflation dynamics, flattening of its slope concedes a relatively lower costs of trade-offs between inflation and the output gap variability, which in fact, would lead to consequences over monetary policy regimes in terms of optimality price stability. Schmitt-Grohe and Uribe (2008) also states the significance of a policy tradeoff between inflation and output stabilization where the flattening of NKPC helps anchor inflation expectations.

In addition to its policy implications, there has been a growing literature on the estimation of the New Keynesian Phillips Curve followed by Gali and Gerter (1999). As discussed in Robert (2006), a conspicuous flattening of NKPC has been appeared not only in the United States but in many other small open economy countries including U.K, Canada, and Austrailia[1]. Indeed, the inflation in those countries has remained at a low and steady level. Kim and Ahn (2008) also report the similar phenomena in their paper called "An assesment of New Keynesian Phillips Curve in the Korean Economy". Conjointly, Moon,Yun, and Lee (2004) and Park and Joo (2011) suggest that the forward-looking behavior of inflation takes a critical role on explanations of an observed inflation dynamics in Korea. In contempt of the growing interests on this topic in Korea, most literatures are limited to the area of a single equation model estimation (i.e. a classical GMM) where lack of identification alters the sampling distribution of estimators and test statistics.

The objective of this paper is, therefore, to analyze some of possible explanations of the flattening NKPC in Korea by assessing a small open economy dynamic stochastic general equilibrium (DSGE) model estimation along with the New Keynesian framework estabilished by Gali and Monacelli (2005) and Lubik and Schorfheide (2007). Using Korean data compounded with the full information Bayesian analysis, we find an apparent flattening of a baseline structural NKPC between pre and post-inflation

[1] see Bean (2006), Iakova (2007), and Kuttner & Robinson (2010)

targeting period, namely 1980:Q1 to 1997:Q4 and 1998:Q1 to 2013:Q4, however; when it comes to the 10 year rolling window estimation, the slope of NKPC does not seem monotonically decreasing. This might be due to the problems associated with data for the financial crisis period and estimation methodology, thus we consider variety of reasoning behind this context. We also implement few robustness checks in order to further examine the structural flattening of New Keynesian Phillips Curve.

The remaining part of this paper proceeds as follows. Section 2 presents a structural small open economy model which we proceed to estimate. In Section 3, we discuss the econometric strategy and theoretical backgrounds behind the Bayesian analysis. In addition to the methodology, we also demonstrate the choice of priors. Section 4 reports the estimation results and Section 5 contatins few robustness checks. The conclusions are in Section 6.

# 2 Description of the model

## 2.1 A structural small open economy model

The model used in this paper is along with the lines of New Keynesian framework initially established by Gali and Monacelli (2005) and simplified by Lubik and Schorfheide (2007) for a small open economy. As stated in Lubik and Schorfheide (2007), the model contains the baseline forward looking IS-equation and a Phillips Curve. The monetary policy rule is considered as an interest rate rule (adjusted by central bank) with inclusion of the nominal exchange rate depreciation and changes in terms of trade. In addition, the nominal exchange rate depreciation is described as a means of the consumer price index (CPI) with assumption of the purchasing power parity (PPP). The simplified version of small open economy model equations could be determined as following.

The New Keynesian Phillips Curve (NKPC) implied by optimal price setting of domestic firms could be defined as follows:

$$\pi_t = \beta E_t \pi_{t+1} + \alpha\beta\Delta q_{t+1} - \alpha\Delta q_t + \frac{\kappa}{\tau + \alpha(2-\alpha)(1-\tau)}(y_t - \bar{y}_t) \tag{1}$$

where $\bar{y}_t = \frac{-\alpha(2-\alpha)(1-\tau)}{\tau y_t^*}$ is potential output in the absence of nominal rigidities and when $\alpha = 0$, it represents the case of closed economy variant. The slope coefficient $\kappa > 0$ conquers the size of price stickiness.[2] In addition, $\kappa$, the slope coefficient of NKPC, is composed of a function with underlying structural parameters including demand elasticities.

As we are interested in the slope of NKPC and its curvature, we decided to focus on the slope of NKPC itself by simplifying the equation (1). Thus, the above equation could be rewritten as:

$$\pi_t = \beta E_t \pi_{t+1} + \alpha\beta \triangle q_{t+1} - \alpha \triangle q_t + \tilde{\kappa}(y_t - \bar{y}_t)$$

where $\tilde{\kappa} \equiv \frac{\kappa}{\tau+\alpha(2-\alpha)(1-\tau)}$ is the slope of New Keynesian Phillips Curve.

A forward-looking (open economy) IS equation imposed by the consumption Euler equation could be defined as following:

$$\begin{aligned} y_t = {} & E_t y_{t+1} - [\tau + \alpha(2-\alpha)(1-\tau)](R_t - E_t \pi_{t+1} - \rho_z z_t) \\ & + \alpha[\tau + \alpha(2-\alpha)(1-\tau)] E_t \Delta q_{t+1} - \alpha(2-\alpha)\frac{1-\tau}{\tau} E_t \Delta y^*_{t+1} \end{aligned} \tag{2}$$

where $0 < \alpha < 1$ is the openness measure (an import share), and $\tau$ is the intertemporal substitution elasticity. Again, when $\alpha = 0$, the IS-curve abridges to the case of closed economy. An aggregate output $y_t$ and the CPI inflation rate $\pi_t$ are endogenous variables. Terms of trade, $q_t$, is defined as a relative price of exports in terms of imports. ${y_t}^*$ is exogenous world output and $z_t$ is the growth rate of an underlying non stationary world technology process $A_t$.

Nominal exchange rate depreciation, noted as $e_t$, is introduced via definition of the consumer price index (CPI) under the assumption of the relative purchasing power parity (PPP):

$$\pi_t = \Delta e_t + (1-\alpha)\Delta q_t + \pi_t^* \tag{3}$$

Monetary policy rule is depicted as an interest rate rule. Central bank conducts contingent monetary policy regimes by adjusting its instrument in response to movements in CPI inflation and output growth.

[2] i.e. as the value of $\kappa$ increases, the nominal rigidities disintegrate

In addition, the nominal exchange rate depreciation $\Delta e_t$ is included in the policy rule as follows:

$$R_t = \rho_R R_{t-1} + (1-\rho_R)[\psi_1 \pi_t + \psi_2 y_t + \psi_3 \Delta e_t] + \varepsilon_t^R \tag{4}$$

We assume that the policy coefficients $\psi_1, \psi_2, \psi_3 \geq 0$. The interest rate smoothing factor $0 < \rho_R < 1$ is also included in order to match the persistence in nominal interest rates.

As suggested in Lubik and Schorfheide, we choose to introduce the law of motion for the terms of trade growth rate as a substitute of solving model endogenously:

$$\Delta q_t = \rho_q \Delta q_{t-1} + \varepsilon_{q,t} \tag{5}$$

The relationship between terms of trade and prices of internationally traded products are as following:

$$[\tau + \alpha(2-\alpha)(1-\tau)]\Delta q_t = \Delta y_t^* - \Delta y_t \tag{6}$$

A linear rational expectations model comprises the equations (1) - (6). We assume that the rest of world output and inflation, also noted as $y_t^*$ and $\pi_t^*$, follow univariate AR(1) process with autoregressive coefficients $\rho_{y^*}$ and $\rho_{\pi^*}$, respectively.

# 3 Estimation strategy

In this section, the Bayesian inference methods[3] are discussed as an econometric methodology of the model (as described in Section 2) evaluation. We then outline the description of the data set and the choice of priors which is designed to construct the posterior distribution of parameters.

## 3.1 Econometric methodology

According to An and Schorfheide (2007), dynamic stochastic general equilibrium (DSGE) models have been prominent as micro-founded optimization based models in

[3] For more details, please refer to An and Schorfheide (2007)

macroeconomic areas. Along with many applicable traditional econometric techniques, DSGE bayesian inference has been endorsed in order to back up some of potential pitfalls from the conventional econometric methodology where model misspecification and identification alter sampling distributions. Hence, in this paper, we try to contemplate the estimation of the slope of New Keynesian Phillips Curve in Korea by applying the Bayesian estimation methodology.

In a Bayesian inference framework, the likelihood function is combined with the dynamic stochastic general equilibrium model in the line of rational expectations cross coefficient restrictions. We then collect the policy rule parameters into the 4 x 1 vector $\psi = [\psi_1, \psi_2, \psi_3, \rho_R]'$ and other DSGE model parameters (including non-policy parameters and standard deviations of exogenous shocks) into the 13 x 1 vector $\theta$[4]. Note that all structural shocks are assumed to be normally distributed and have no correlation with any of them at all leads and lags. In this way, we can acquire the joint probability distributions of all endogenous variables of the model described as in section 2.

In our empirical analysis on the baseline of Bayesian estimation technique, we collect the model observables into vector $Y_t$ where annualized interest rates, annualized inflation rates, output growth, depreciation rates, and changes in terms of trade are included. In fact, the vector $Y_t$ could be indicated as following

$$Y_t = [4R_t, 4\pi_t, \Delta y_t + z_t, \Delta e_t, \Delta q_t]'$$

Note that all the endogenous model observable variables are demeaned and $\Delta y_t$ is complied with the productivity growth $z_t$ as $y_t$ itself is the ratio of output and world productivity $A_t$.

Bayesian estimation starts from a prior distribution with density $p(\psi, \theta) = p(\psi)p(\theta)$ of the model's structural parameters. This prior distribution depicts available information prior to the estimation based on data observations. As well, observations of the data set are adopted through the likelihood function $\mathscr{L}_D(\psi, \theta|Y^T)$, where $Y^T = \{Y_1, \ldots, Y_T\}$. Via Bayes theorem, the likelihood function which is hinged on data observations is taken into account to update the prior and to the posterior distribution of model's structural parameters. Followed by Adolfson (2007), this posterior distribution could be described in terms of measures of location (i.e. mode and mean) and spread (standard deviation

[4]where $\theta = [\alpha, r, \kappa, \tau, \rho_z, \rho_q, \rho_{\pi^*}, \rho_{y^*}, \sigma_R, \sigma_z, \sigma_q, \sigma_{\pi^*}, \sigma_{y^*}]'$

and probability intervals). In turn, the posterior distribution could be expressed as

$$p_D(\psi, \theta|Y^T) = \frac{\mathscr{L}_D(\psi, \theta|Y^T)p(\psi)p(\theta)}{\int \mathscr{L}_D(\psi, \theta|Y^T)p(\psi)p(\theta)d(\psi, \theta)} \tag{7}$$

We then advocate the Bayes simulation theorem by generating draws from posterior distributions and observe the convergence diagnostics for MCMC methods. According to An and Schorfheide (2007), this procedure along with the impulse response functions and variance decomposition enable us to access the dynamics of dispersions and relative precedence of structural shocks for all model parameters.

There is a growing empirical literature on the New Keynesian DSGE model in conjunction with Bayesian inference techniques. Preceding literatures highlight on the matter of contention related to the parameter identification where, in some cases, structural parameters are dispersed from the reduced form as an implication of the rational expectations theorem. However, Bayesian estimation of DSGE models often compromise some of possible pitfalls of a classical GMM (with a single equation approach) or VAR where sampling distribution of test statistics are altered by virtue of weak identifications. As a result, those conventional econometric techniques end up with poor approximation of the sampling distribution. Hence, we are trying to focus on potential problems aroused in earlier literatures and thus conduct more percise approach of priors and posterior distributions to retrieve more information extorted from the sampling distributions in this paper.

## 3.2 Description of Data

In order to obtain an empirical analysis, we use following data observations, namely, real output growth, inflation, nominal interest rates, exchange rate changes, and changes in term of trade. All of data sets are at quarterly frequencies for the period of 1980:Q1 to 2013:Q4 and most of series could be accessed through the Bank of Korea (BOK, Economic Statistics System) and Statistics Korea[5]. Data sets are seasonally adjusted and demeaned. In our empirical analysis, we divide the whole period into two sub-periods - pre-inflation targeting period (1980:Q1 to 1997:Q4) and post-inflation targeting period

[5]For the reference, please visit http://ecos.bok.or.kr and www.kostat.go.kr

(1998:Q1 to 2013:Q4)[6].

Detailed data set procedures are as follows. Output growth rate are computed as log differences of real GDP per capita and scaled by 100 to convert into quarter-to-quarter percentages. Population are splined from annual population projection data (retrieved from Statistics Korea) into quarterly frequencies by using Eviews. Inflation rates are obtained through Bank of Canada and defined as log differences of the consumer price indicies (CPI) and multiplied by 400 in order to obtain annualized percentage rates. The overnight Money Market Rate (percent per annum) are used as a mean of the nominal interest rates and obtained from IMF, International Financial Statistics (IFS) for the entire period. (Narrow) Nominal effecive exchange rate indices for Korea are obtained through Bank for International Settlements (BIS) and take log differences scaled by 100 in order to convert the indices into depreciation rates. Lastly, the changes of terms of trade are converted in log differences scaled by 100 to obtain percentage changes. Data for the period of 1988:1 to 2013:4 are obtained through Bank of Korea. For the period of 1980:1 to 1987:4 are retrived from World Bank as the whole set of the sample period data are not available at the Bank of Korea. The net barter terms of trade indices (2000=100) from World bank are converted into the base year of 2010 as 100[7] and splined into quarterly frequencies by quadratic match average frequency conversion. All the data series are demeaned prior to the empirical analysis.

## 3.3 Choice of Prior

In Bayesian inference framework, we start by assigning a prior distribution of the model's structural parameters. Prior distribution allows us to reach some of available information prior to the estimation. Note that all prior distributions are assumed to have no correlation with each other and factors such as the size restriction and non-negativity of parameters are considered by truncating the estimating parameter distributions. In addition, the joint prior distribution is truncated at the boundary

[6] Although the Bank of Korea changed its policy regimes to inflation targeting in May 1998 (1998:Q2), we divided the sampling data observations from 1998:Q1 to 2013:Q4 for convenience.

[7] As the BOK terms of trade data base year is 2010, we try to fix the sampling period data along with lines.

of determinacy region regarding the solution of the linear rational expectations' non existence.

As noted in Table 1, information about the prior distributions of model structural parameters for Korea are described. For model parameters bounded between 0 and 1 ( ie. [0,1) ) including $\rho_R, \alpha, \rho_q, \rho_z, \rho_{y^*}, \rho_{\pi^*}$, beta distributions are assigned. In addition, the inverse gamma distribution is used for the parameters assumed to be non-negative. (ie. shock standard deviations $\sigma_R, \sigma_q, \sigma_z, \sigma_{y^*}, \sigma_{\pi^*}$).

Table 1. Prior Distribution

| Name | Domain | Density | P(1) | P(2) |
|---|---|---|---|---|
| $\psi_1$ | R+ | Gamma | 1.50 | 0.50 |
| $\psi_2$ | R+ | Gamma | 0.25 | 0.13 |
| $\psi_3$ | R+ | Gamma | 0.25 | 0.13 |
| $\rho_R$ | [0,1) | Beta | 0.50 | 0.20 |
| $\alpha$ | [0,1) | Beta | 0.20 | 0.05 |
| $r$ | R+ | Gamma | 2.50 | 1.00 |
| $\tilde{\kappa}$ | R+ | Gamma | 0.10 | 0.05 |
| $\tau$ | [0,1) | Gamma | 0.50 | 0.20 |
| $\rho_q$ | [0,1) | Beta | 0.40 | 0.20 |
| $\rho_z$ | [0,1) | Beta | 0.80 | 0.10 |
| $\rho_{y^*}$ | [0,1) | Beta | 0.85 | 0.07 |
| $\rho_{\pi^*}$ | [0,1) | Beta | 0.90 | 0.06 |
| $\sigma_R$ | R+ | InvGamma | 0.40 | 4.00 |
| $\sigma_q$ | R+ | InvGamma | 1.00 | 4.00 |
| $\sigma_z$ | R+ | InvGamma | 1.00 | 4.00 |
| $\sigma_{y^*}$ | R+ | InvGamma | 1.00 | 4.00 |
| $\sigma_{\pi^*}$ | R+ | InvGamma | 0.50 | 4.00 |

(NOTE) P(1) and P(2) indicate the benchmark values of parameter means and standard deviations. The prior distribution is truncated at the boundary of the determinacy region in order to obtain proper estimation results.

In terms of the value of prior mean and standard deviations, we refer to other precending literatures on Bayesian estimation. As suggested in Lubik and Schorfheide (2007), we adopt loose priors for the policy rule parameters namely $\psi_1$, $\psi_2$, and $\psi_3$ [8].

[8] Recall an interest rate rule:

$$R_t = \rho_R R_{t-1} + (1-\rho_R)[\psi_1 \pi_t + \psi_2 y_t + \psi_3 \Delta e_t] + \varepsilon_t^R$$

The policy rule priors are centered at the values implied by the Taylor rule (ie. 1.50 and 0.50 for $\psi_1$ and 0.25 and 0.13 for $\psi_2$). The exchange rate depreciation prior mean is centered at the value of 0.25 with its standard deviation value of 0.13. Likewise, the interest rate smoothing factor, $\rho_R$, is assumed to be centered at a prior mean of 0.50 with a standard deviation of 0.20.

Note that an openness measure parameter $\alpha$ follows the beta distribution with a mean of 0.20 and a standard deviation of 0.05. Since the discount factor $\beta$ is defined as $\beta = exp[-r/400]$, we use the annualized steady state real interest rate $r$ with a mean of 2.50 and a relatively large standard deviation of 1.00. The slope coefficient (of NKPC) parameter, $\tilde{\kappa}$[9] is assumed to be centered at 0.10 with a standard deviation value of 0.05. The intertemporal substitution elasticity parameter $\tau$ is assumed to follow gamma distribution with a mean of 0.50 and a standard deviation of 0.20 as the model holds singularity at $\tau = 1$.

For the prior distributions of exogenous shock parameters ($\rho_y^*$ and $\rho_{\pi^*}$), we implement a pre-sample analysis for the period of 1965:Q1 to 1979:Q4. We use the United States GDP (relative ratio to the domestic GDP) and CPI inflation rates in order to fit an AR(1) process of each coefficients by Eviews. As a result, we obtain $\rho_\pi^*$ centered at 0.90 with standard deviation of 0.06 and $\rho_y^*$ centered at 0.85 with standard deviation of 0.07.

# 4 Estimation results

In this section, the resulting parameter estimates and implied model dynamics are discussed. By fitting the estimation of a linearized small open economy DSGE model to the data of Korea, we tacitly compute posterior distributions of the structural

$\psi_1$ is coefficient for the inflation rate, $\psi_2$ is related to the output growth, and $\psi_3$ is coefficient for the exchange rate depreciation.

[9] As many literatures on the slope of NKPC for Korea point out, the slope coefficient of New Keynesian Phillips Curve in Korea tend to be estimated as a relatively smaller value, for instance 0.01 or even smaller. To see some differences, we choose the value of 0.10 which is smaller than other small open economy average (0.50) but slightly larger than precending Korean literatures.

parameters. The data are divided into two subperiods for the empirical analysis in order to demonstrate few distinctions between pre-inflation and post-inflation targeting periods. We then report notable estimation results and some other findings from several robustness exercises.

## 4.1 Has the New Keynesian Phillips Curve become flatter in Korea?

The Bayesian estimates of the structural parameters in overall periods (ie. 1980:Q1 to 2013:Q4) and two subperiods (Period 1: 1980:Q1 to 1997:Q4, Period 2: 1998:Q1 to 2013:Q4) for Korea can be found in Table 2 and 3, repectively. In addition to 90 percent posterior probability intervals, posterior means are reported as point estimates.

Table 2. Estimation results for overall period

| | **Prior** | **Posterior** | | |
|---|---|---|---|---|
| | Mean | Mean | 90% interval | |
| $\psi_1$ | 1.50 | 1.1532 | 0.9240 | 1.3723 |
| $\psi_2$ | 0.25 | 0.4284 | 0.1432 | 0.6724 |
| $\psi_3$ | 0.25 | 0.0537 | 0.0100 | 0.0962 |
| $\rho_R$ | 0.50 | 0.8385 | 0.7993 | 0.8809 |
| $\alpha$ | 0.20 | 0.0414 | 0.0235 | 0.0565 |
| $r$ | 2.50 | 2.4621 | 0.8961 | 3.9100 |
| $\tilde{\kappa}$ | 0.10 | 0.0712 | 0.0119 | 0.1357 |
| $\tau$ | 0.50 | 0.1088 | 0.0702 | 0.1474 |
| $\rho_q$ | 0.40 | 0.2426 | 0.1150 | 0.3769 |
| $\rho_z$ | 0.80 | 0.5749 | 0.4178 | 0.7490 |
| $\rho_{y^*}$ | 0.85 | 0.9832 | 0.9731 | 0.9936 |
| $\rho_{\pi^*}$ | 0.90 | 0.5472 | 0.4320 | 0.6666 |
| $\sigma_R$ | 0.40 | 0.4237 | 0.3720 | 0.4708 |
| $\sigma_q$ | 1.00 | 1.2462 | 1.1239 | 1.3713 |
| $\sigma_z$ | 1.00 | 0.2721 | 0.4898 | 0.6499 |
| $\sigma_{y^*}$ | 1.00 | 0.8370 | 0.4754 | 1.1760 |
| $\sigma_{\pi^*}$ | 0.50 | 2.7395 | 2.4718 | 3.0321 |

In general, New Keynesian Phillips Curve (when it is correctly defined by the model) is not influenced by any changes caused in the economy including a structural policy rule. As NKPC pins down a proportionate relationship between marginal costs and output, it is not affected by any real activity involved with responsiveness of stimulating marginal costs. Hence, determining changes of NKPC remains a critical matter in order to reconcile its instability.

As a result of NKPC with empirical analysis along with lines of Bayesian inference framework, we find that all structural parameter estimate values belongs to conceivable ranges. In addition, the estimate result of New Keynesian Phillips curve parameter, $\tilde{\kappa}$, is projected as 0.0712 for the full sample period. Likewise, Table 3 represents two sets of estimation results of all the structural parameters for Korea. As mentioned in earlier section, we find that the slope coefficient of NKPC for Korea falls into relatively smaller value compared to other estimates as in US or Canada. In Table 3, the first and left set represent the estimation results for period 1 (pre-inflation targeting period, 1980:Q1 - 1997:Q4) and the second set depicts results of the period 2 (post-inflation targeting period, 1998:Q1 - 2013:Q4). Notice that the slope of overall NKPC declines from the value of 0.2647 with its 90% interval of [0.1396,0.3859] to 0.1233 with the range of [0.0743,0.1738].

Table 3. Estimation results for period 1 and 2

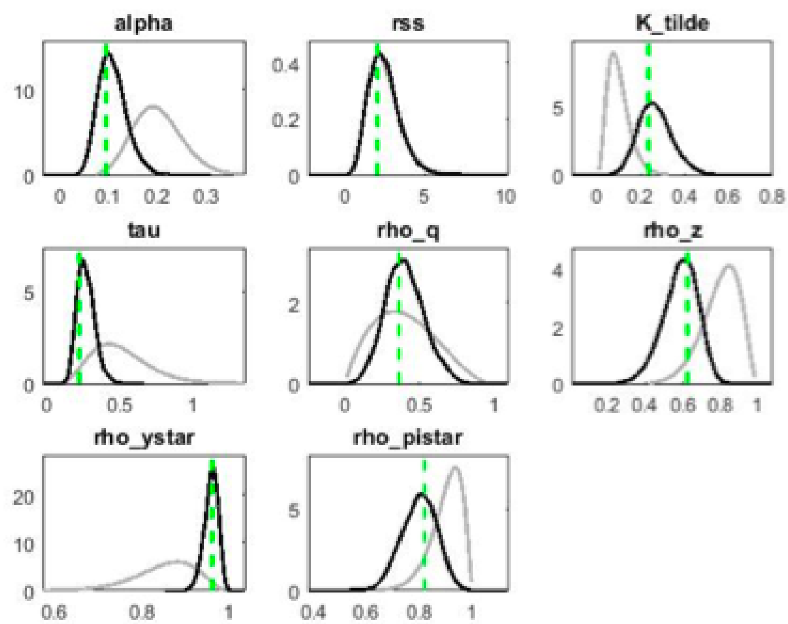
| | Prior | Posterior | | | | Prior | Posterior | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Mean | 90% interval | | | Mean | Mean | 90% interval | |
| $\psi_1$ | 1.50 | 1.3606 | 0.9827 | 1.6812 | $\psi_1$ | 1.50 | 1.5857 | 1.2352 | 1.9168 |
| $\psi_2$ | 0.25 | 0.4227 | 0.1734 | 0.6700 | $\psi_2$ | 0.25 | 0.3573 | 0.1425 | 0.5586 |
| $\psi_3$ | 0.25 | 0.0901 | 0.0294 | 0.1498 | $\psi_3$ | 0.25 | 0.0764 | 0.0351 | 0.1209 |
| $\rho_R$ | 0.50 | 0.7134 | 0.6350 | 0.7871 | $\rho_R$ | 0.50 | 0.7545 | 0.7018 | 0.8034 |
| $\alpha$ | 0.20 | 0.1072 | 0.0608 | 0.1517 | $\alpha$ | 0.20 | 0.0708 | 0.0448 | 0.0957 |
| $r$ | 2.50 | 2.4493 | 0.9086 | 3.8703 | $r$ | 2.50 | 2.5017 | 0.9473 | 3.9582 |
| $\tilde{\kappa}$ | 0.10 | 0.2647 | 0.1396 | 0.3859 | $\tilde{\kappa}$ | 0.10 | 0.1233 | 0.0743 | 0.1738 |
| $\tau$ | 0.50 | 0.2612 | 0.1639 | 0.3531 | $\tau$ | 0.50 | 0.2153 | 0.1197 | 0.3085 |
| $\rho_q$ | 0.40 | 0.3994 | 0.1782 | 0.6069 | $\rho_q$ | 0.40 | 0.1871 | 0.0359 | 0.3254 |
| $\rho_z$ | 0.80 | 0.5846 | 0.4355 | 0.7322 | $\rho_z$ | 0.80 | 0.9575 | 0.9330 | 0.9834 |
| $\rho_{y^*}$ | 0.85 | 0.9570 | 0.9313 | 0.9827 | $\rho_{y^*}$ | 0.85 | 0.8700 | 0.8028 | 0.9399 |
| $\rho_{\pi^*}$ | 0.90 | 0.7980 | 0.6871 | 0.9016 | $\rho_{\pi^*}$ | 0.90 | 0.8651 | 0.7599 | 0.9707 |
| $\sigma_R$ | 0.40 | 0.4073 | 0.3402 | 0.4703 | $\sigma_R$ | 0.40 | 0.2026 | 0.1695 | 0.2336 |
| $\sigma_q$ | 1.00 | 0.8961 | 0.7806 | 1.0181 | $\sigma_q$ | 1.00 | 1.5052 | 1.2838 | 1.7163 |
| $\sigma_z$ | 1.00 | 0.5408 | 0.4308 | 0.6418 | $\sigma_z$ | 1.00 | 0.4561 | 0.3637 | 0.5426 |
| $\sigma_{y^*}$ | 1.00 | 1.0329 | 0.5419 | 1.4841 | $\sigma_{y^*}$ | 1.00 | 1.4235 | 0.6881 | 2.1771 |
| $\sigma_{\pi^*}$ | 0.50 | 2.0757 | 1.7669 | 2.3357 | $\sigma_{\pi^*}$ | 0.50 | 3.8138 | 3.2315 | 4.3876 |

The preference parameter $\alpha$ is estimated to be lower (with value of 0.0414 for the overall sample period) than the recognized import proportion of Korea. The bank of Korea accompanies a moderate anti-inflationary policy as the estimates indicate (ie.

$\psi_1 = 1.15$). Notice that the value of inflation parameter estimates increases from 1.3606 in period 1 to 1.5857 in period 2. We also find that the bank of Korea concerns for the output ($\psi_2 = 0.43$) and the exchange rate ($\psi_3 = 0.0537$) during the full sample period.

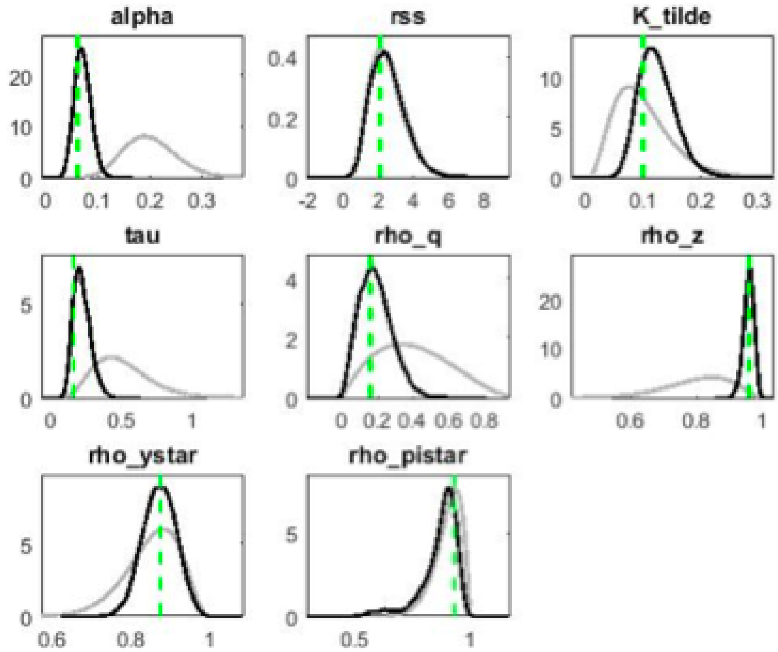
The interest rate smoothing term parameter also indicates a reasonably high magnitude with $\rho_R = 0.84$. Moreover, the stochastic process demonstrates some persistence as in data. Most of parameter estimates reflect a high degree of autocorrelation with foreign output shock (ie. $\rho_y^* = 0.98$). Despite the fact that the posterior distribution spread and its location do not differ conspicuously from its prior information via Bayes theorem, an informative data update appears to be more centered for the policy rule parameters. For the more detailed distribution spread for prior and posteriors, please see figure 1 and 2.

Figure 1. Prior and Posterior Distribution(Period 1)




(NOTE) The Figure depicts the prior and posterior distributions for the period of 1980:Q1 to 1997:Q4 with posterior mean (dashed lines).

Figure 2. Prior and Posterior Distribution(Period 2)




(NOTE) The Figure depicts the prior and posterior distributions for the period of 1998:Q1 to 2013:Q4 with posterior mean (dashed lines).

## 4.2 Iterative and Rolling Estimation Results

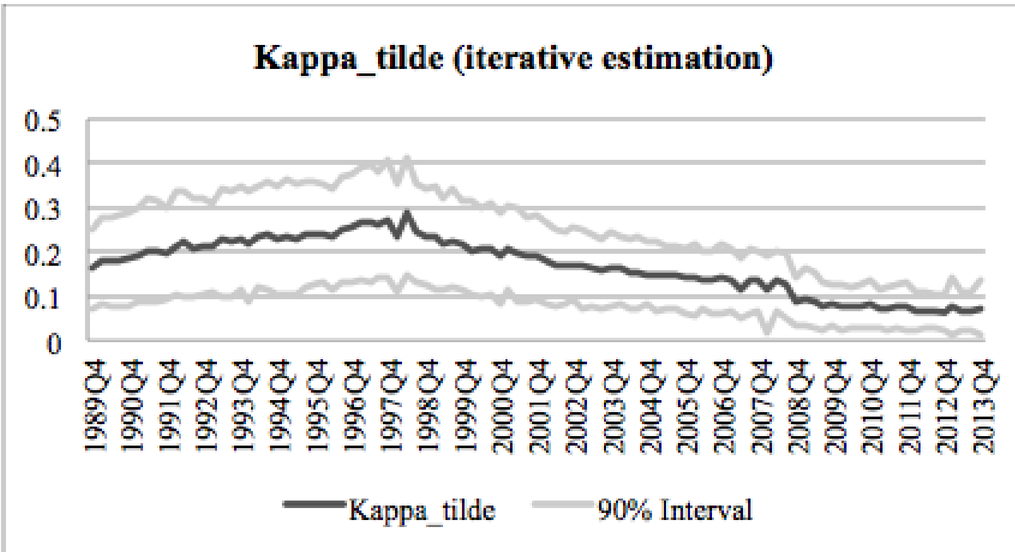
In order to gauge a clear-cut of estimation results during the full sample period, we try to evaluate the results in the way of iteration and rolling-window estimation techniques. In this way, more percise conceptual changes between sample periods could be attained.

### 4.2.1 Iterative methods for the parameter estimation

In this section, we proceed an iterative estimation methods in order to capture distinctive changes between various subdivision of a time period. We first estimate the structural parameters for the initial period (1980:Q1 - 1989:Q4) then add an additional sample data[10] to the estimation at each time of iterative period 'til 2013:Q4.

[10]Here, the sample data set are all quarterly. Hence, we re-estimate the sampling distribution by adding one more quarterly data into the estimation model at each time. This allows us to estimate total number of 97 times of estimations.

Figure 3. Iterative estimation result



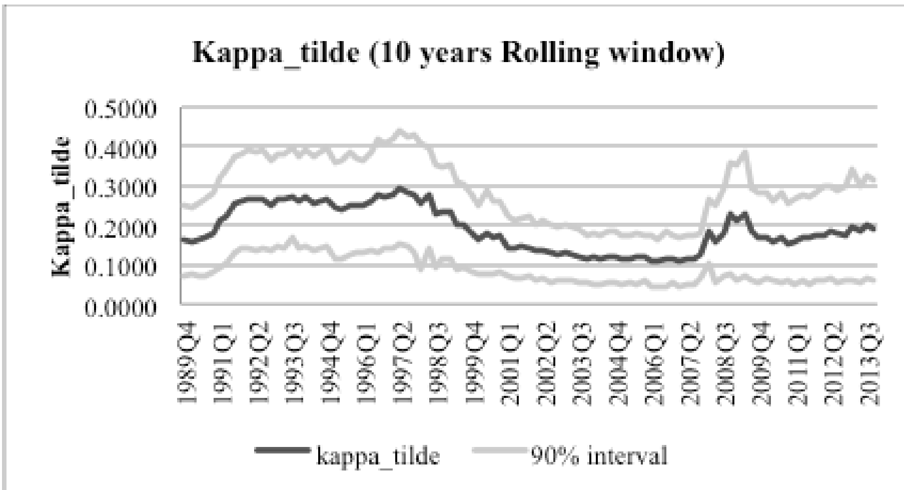

(NOTE) Figure 3 represents the iterative estimation results of slope coefficients of New Keynesian Phillips Curve ($\tilde{\kappa}$ for the period of 1980:Q1 to 2013:4. The solid lines are estimates of $\tilde{\kappa}$ and above and below lines are 90 % interval.

As figure 3 represents, the estimates of slope of New Keynesian Phillips Curve starts from 0.1635 and increases up to 0.2865 for the sampling period of 1980:Q1 - 1998:Q2. As the post-inflation targeting period data are included in the estimation model, the estimate value of $\tilde{\kappa}$ (slope of NKPC) decreases as low as 0.0712 for the entire sample period. We find that the flattening of NKPC for Korea has been appeared when we used an iterative estimation methodology.

### 4.2.2 Rolling estimation analysis

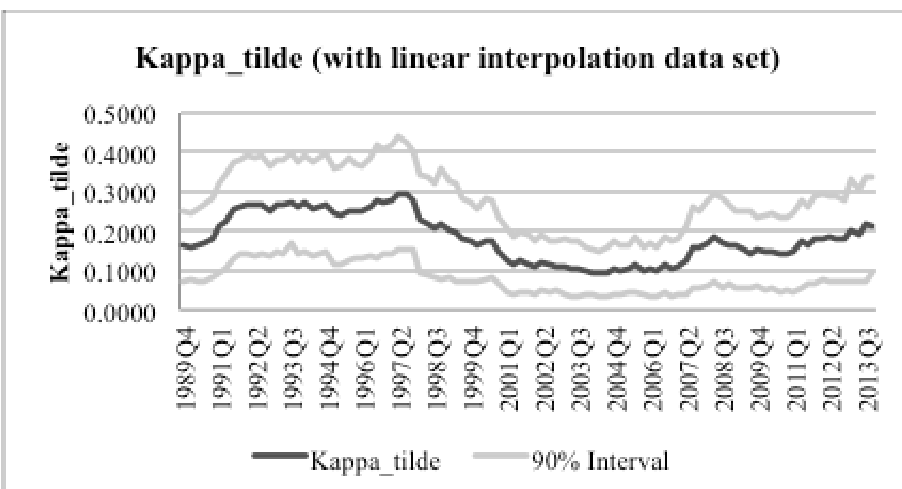
Similar to the iterative estimation methods, we now apply 10-year rolling window estimations for the entire sample period. In this way, we use 40 data observations at each time of Bayesian estimation and onwards. Figure 4 suggests that the flattening of NKPC does not seem evident as the estimation value of $\tilde{\kappa}$ starts from 0.1579 and there appears a jump in the period of 1998:Q2 to 2008:Q1. This might be due to the data involved in the process of estimation as it includes implied volatility during Asian financial crisis (1998:Q1 - 1998:Q4) and Global financial crisis (2007:Q1 - 2008:Q4) in terms of output, inflation, changes in exchange rate and terms of trade (Figure 6). Thus, we decided to use linear interpolation data set (by using Eviews) in order to obtain the estimation results without any huge jump in the data set, however; as figure 5 indicates the flattening does not seem monotonically decrasing as a result.

Figure 4. Slope of NKPC (10 years Rolling window)



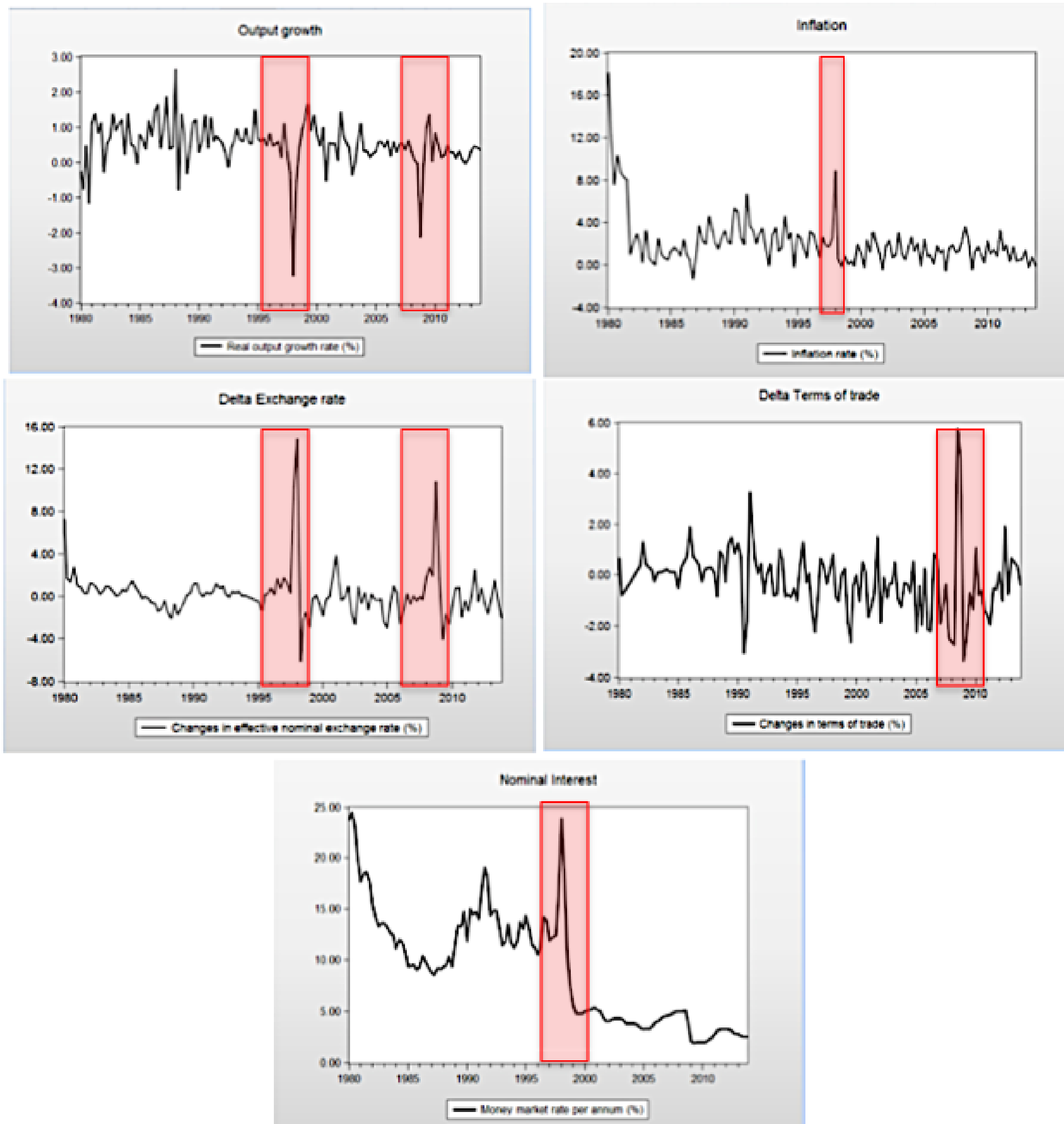

(NOTE) The Figure depicts the 10-year rolling estimation results of slope of NKPC ($\tilde{\kappa}$ for the period of 1980:Q1 to 2013:4. The solid lines are estimates of $\tilde{\kappa}$ and above and below lines are 90 % interval.

Figure 5. Slope of NKPC (10 years Rolling window, linear interpolation data)




(NOTE) The Figure depicts the 10-year rolling estimation results (with linear interpolation dataset) of slope of NKPC ($\tilde{\kappa}$ for the period of 1980:Q1 to 2013:4. The solid lines are estimates of $\tilde{\kappa}$ and above and below lines are 90 % interval.

Figure 6. Data plotting (1980:Q1 - 2013:Q4)




(NOTE) The shaded area indicates the changes of data set (output growth, inflation, exchange rate depreciation, changes in terms of trade, and nominal interest rate) during the crisis periods namely, Asian financial crisis (1998:Q1 - 1998:Q4) and Global financial crisis (2007:Q1 - 2008:Q4).

## 4.3 Variance Decomposition

In this section, we discuss and report variance decompositions in order to measure the relevance of individual shocks to the observed estimate values. As computed in Table 4, dynamics of output growth rate for Korea are mostly explained (as of 92%) by world demand shock in pre-inflation targeting period (period 1, 1980:Q1 - 1997:Q2). In period 2 (post-inflation targeting, 1998:Q1 - 2013:Q4), the proportion of world output shock declines as technology shock takes more portion in terms of output variance decomposition.

Table 4. Variance Decomposition for two subperiods

Period 1

| | Output | Inflation | Interest rate | Exchange rate |
|---|---|---|---|---|
| Policy | 0.0463 | 0.0221 | 0.1013 | 0.0027 |
| Terms of trade | 0.0017 | 0.0016 | 0.0017 | 0.0586 |
| Technology | 0.0207 | 0.0064 | 0.0107 | 0.0008 |
| World output | 0.9208 | 0.9468 | 0.8844 | 0.1152 |
| World inflation | 0.0105 | 0.0231 | 0.0020 | 0.8228 |

Period 2

| | Output | Inflation | Interest rate | Exchange rate |
|---|---|---|---|---|
| Policy | 0.0134 | 0.0009 | 0.0077 | 0.0000 |
| Terms of trade | 0.0017 | 0.0022 | 0.0008 | 0.0210 |
| Technology | 0.4700 | 0.8484 | 0.9737 | 0.0223 |
| World output | 0.4099 | 0.0219 | 0.0002 | 0.0006 |
| World inflation | 0.1050 | 0.1265 | 0.0176 | 0.9561 |

Inflation is demonstrated predominantly as of 95% by world demand shock in pre-inflation targeting period whereas technology shock is able to explain roughly 84% of inflation movements in period 2. Likewise, interest rate movements are largely determined by world output shock and technology shock in period 1 and 2, respectively. Lastly, exchange rate movements on the other hand are mostly explained by world inflation shock in both pre and post inflation targeting periods.

## 4.4 Impulse Response Function

In this section, we investigate model dynamics by implementing the impulse reponse functions. As addressed in figure 7 and 8, expansionary monetary policy depreciates the domestic currency and increases the value of CPI inflation and overall output level. When the level of terms of trade raises, the domestic demand enhances and the inflation level decreases via effects of nominal appreciation. The weakened nominal exchange rate incites the central banks to be responsive for their policy regimes which leads to further pressures on productions. Futhermore, an advanced technoloy level allows economy to have a lower level of inflation and interest rate and by that increase the value of currency. As the technology progress is assumed to be a discrepancy stationary productivity, it would have permanent forces on output level. With existence of world demand shocks, the domestic output decreases whereas inflation and the exchange rate boost. Rest of world's inflation shock appreciate the value of domestic currency but deepens the level of domestic price inflation as central bank responds to exchange rate movements in order to loose corresponding policy regimes.

Figure 7. Impulse response for period 1

[Period 1]

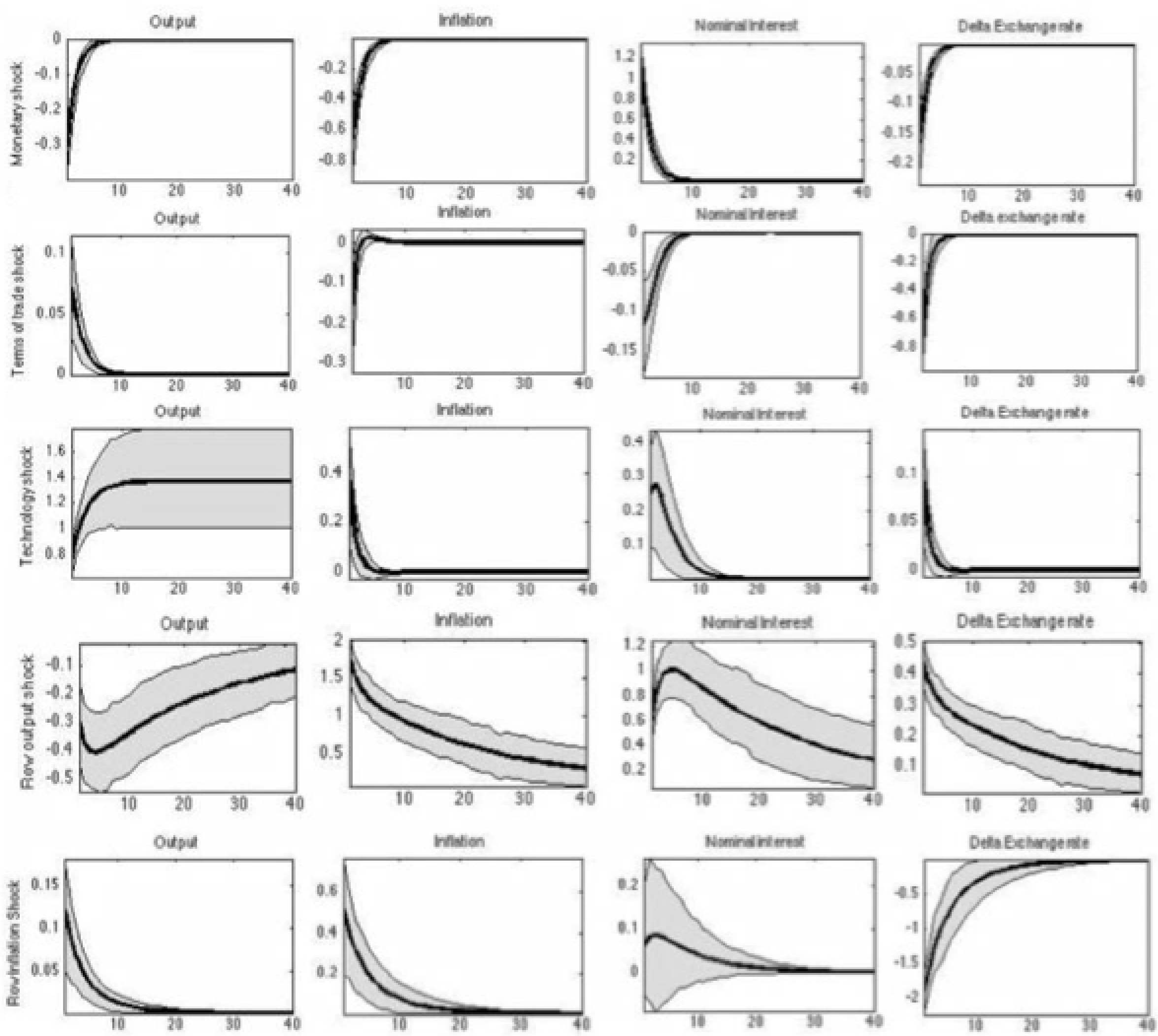
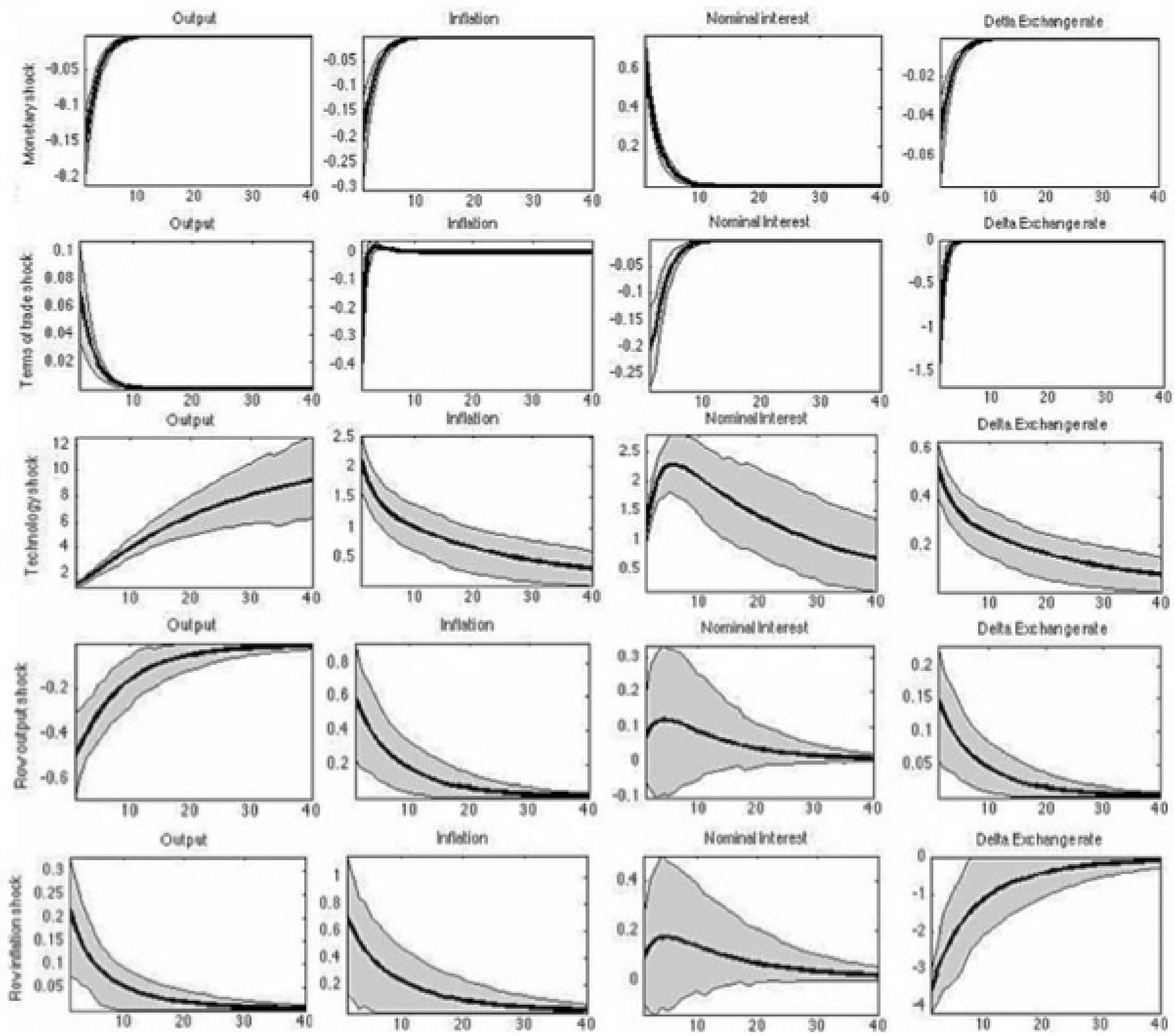


Figure 8. Impulse response for period 2

[Period 2]




(NOTE) Figure 7 & 8 demonstrate posterior means and 90 % probabilty intervals for impulse response functions for structural shocks (monetary, terms of trade, technology, rest of world demand and inflation shock).

# 5 Robustness

In this section, we now examine the regression specification by implementing few robustness checks. We first address an alternative prior value (as in Lubik and Schorfheide, 2005) and then use a different data set without financial crisis.

## 5.1 Alternative Prior

We now address the question whether the flattening of New Keynesian Phillips Curve has been evident by assessing structural estimation with alternative prior distributions. In particular, we impose different prior distributions based on the Lubik and Schorfheide, 2005 (Table 5). The prior for the slope coefficient $\tilde{\kappa}$ in the New Keynesian Phillips curve has become relatively larger (as the value of 0.5) compared to the previous case (0.1). In addition to this change, prior for the domestic output growth, $\rho_z$, is centered at 0.2. Priors for the rest of world inflation $\rho_{\pi^*}$ are centered at 0.8 with $\sigma_{\pi^*}$ at 0.5. Priors for the rest of world output shock $\rho_{y^*}$ are centered at 0.9 with standard deviation at 1.00.

Table 5. Alternative prior distributions

| Name | Domain | Density | P(1) | P(2) |
|---|---|---|---|---|
| $\psi_1$ | R+ | Gamma | 1.50 | 0.50 |
| $\psi_2$ | R+ | Gamma | 0.25 | 0.13 |
| $\psi_3$ | R+ | Gamma | 0.25 | 0.13 |
| $\rho_R$ | [0,1) | Beta | 0.50 | 0.20 |
| $\alpha$ | [0,1) | Beta | 0.20 | 0.05 |
| $r$ | R+ | Gamma | 2.50 | 1.00 |
| $\tilde{\kappa}$ | R+ | Gamma | 0.50 | 0.25 |
| $\tau$ | [0,1) | Gamma | 0.50 | 0.20 |
| $\rho_q$ | [0,1) | Beta | 0.40 | 0.20 |
| $\rho_z$ | [0,1) | Beta | 0.20 | 0.05 |
| $\rho_{y^*}$ | [0,1) | Beta | 0.90 | 0.05 |
| $\rho_{\pi^*}$ | [0,1) | Beta | 0.80 | 0.10 |
| $\sigma_R$ | R+ | InvGamma | 0.40 | 4.00 |
| $\sigma_q$ | R+ | InvGamma | 1.00 | 4.00 |
| $\sigma_z$ | R+ | InvGamma | 1.00 | 4.00 |
| $\sigma_{y^*}$ | R+ | InvGamma | 1.00 | 4.00 |
| $\sigma_{\pi^*}$ | R+ | InvGamma | 0.50 | 4.00 |

Table 6 and 7 indicate the overall period and two subperiods estimation results. As shown in the table 6, the estimates of $\tilde{\kappa}$ over the full sample (1980:Q1 - 2013:Q4) is 0.1076 with [0.0242, 0.2124] of 90% interval. Similar to the initial estimation results, the estimation results of two sub samples suggests the flattening of New Keynesian Phillips Curve in Korea. ($\tilde{\kappa}$ changes from 0.8718 to 0.2242 in period 1 and 2, respectively.)

Table 6. Estimation results (overall period)

| | Prior | Posterior | | |
|---|---|---|---|---|
| | Mean | Mean | 90% interval | |
| $\psi_1$ | 1.50 | 1.0976 | 0.9244 | 1.2751 |
| $\psi_2$ | 0.25 | 0.3877 | 0.1597 | 0.6336 |
| $\psi_3$ | 0.25 | 0.0526 | 0.0095 | 0.0948 |
| $\rho_R$ | 0.50 | 0.8279 | 0.7819 | 0.8757 |
| $\alpha$ | 0.20 | 0.0360 | 0.0203 | 0.0500 |
| $r$ | 2.50 | 2.5365 | 0.9175 | 4.1107 |
| $\tilde{\kappa}$ | 0.50 | 0.1076 | 0.0242 | 0.2124 |
| $\tau$ | 0.50 | 0.1115 | 0.0724 | 0.1498 |
| $\rho_q$ | 0.40 | 0.2325 | 0.1000 | 0.3552 |
| $\rho_z$ | 0.20 | 0.2160 | 0.1364 | 0.2909 |
| $\rho_{y^*}$ | 0.90 | 0.9829 | 0.9731 | 0.9941 |
| $\rho_{\pi^*}$ | 0.80 | 0.4313 | 0.3050 | 0.5646 |
| $\sigma_R$ | 0.40 | 0.4253 | 0.3713 | 0.4753 |
| $\sigma_q$ | 1.00 | 1.2519 | 1.1222 | 1.3664 |
| $\sigma_z$ | 1.00 | 0.6579 | 0.5873 | 0.7227 |
| $\sigma_{y^*}$ | 1.00 | 0.7629 | 0.4878 | 1.0278 |
| $\sigma_{\pi^*}$ | 0.50 | 2.6883 | 2.4066 | 2.9448 |

Table 7. Estimation results for two subperiods

| | Prior | Posterior | | | | Prior | Posterior | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Mean | 90% interval | | | Mean | Mean | 90% interval | |
| $\psi_1$ | 1.50 | 1.2352 | 0.9674 | 1.5016 | $\psi_1$ | 1.50 | 1.0282 | 0.9403 | 1.1197 |
| $\psi_2$ | 0.25 | 0.3734 | 0.1345 | 0.6081 | $\psi_2$ | 0.25 | 0.4529 | 0.1842 | 0.7057 |
| $\psi_3$ | 0.25 | 0.0920 | 0.0355 | 0.1481 | $\psi_3$ | 0.25 | 0.0367 | 0.0096 | 0.0643 |
| $\rho_R$ | 0.50 | 0.5315 | 0.3999 | 0.6509 | $\rho_R$ | 0.50 | 0.7448 | 0.6892 | 0.8004 |
| $\alpha$ | 0.20 | 0.1400 | 0.0755 | 0.2039 | $\alpha$ | 0.20 | 0.0926 | 0.0542 | 0.1280 |
| $r$ | 2.50 | 2.5329 | 0.9907 | 4.1573 | $r$ | 2.50 | 2.5993 | 1.0586 | 4.2115 |
| $\tilde{\kappa}$ | 0.50 | 0.8718 | 0.5319 | 1.2068 | $\tilde{\kappa}$ | 0.50 | 0.2242 | 0.0765 | 0.3682 |
| $\tau$ | 0.50 | 0.4166 | 0.2703 | 0.5678 | $\tau$ | 0.50 | 0.4535 | 0.2911 | 0.6117 |
| $\rho_q$ | 0.40 | 0.4434 | 0.2720 | 0.6104 | $\rho_q$ | 0.40 | 0.1902 | 0.0371 | 0.3266 |
| $\rho_z$ | 0.20 | 0.1943 | 0.1203 | 0.2707 | $\rho_z$ | 0.20 | 0.2038 | 0.1239 | 0.2842 |
| $\rho_{y^*}$ | 0.90 | 0.9658 | 0.9423 | 0.9894 | $\rho_{y^*}$ | 0.90 | 0.9846 | 0.9751 | 0.9957 |
| $\rho_{\pi^*}$ | 0.80 | 0.6929 | 0.5761 | 0.8143 | $\rho_{\pi^*}$ | 0.80 | 0.4739 | 0.2937 | 0.6616 |
| $\sigma_R$ | 0.40 | 0.4941 | 0.3901 | 0.5919 | $\sigma_R$ | 0.40 | 0.2484 | 0.1990 | 0.2953 |
| $\sigma_q$ | 1.00 | 0.9037 | 0.7786 | 1.0269 | $\sigma_q$ | 1.00 | 1.5098 | 1.2942 | 1.7145 |
| $\sigma_z$ | 1.00 | 0.6655 | 0.5691 | 0.7643 | $\sigma_z$ | 1.00 | 0.5892 | 0.4952 | 0.6816 |
| $\sigma_{y^*}$ | 1.00 | 0.8783 | 0.5212 | 1.2482 | $\sigma_{y^*}$ | 1.00 | 0.8273 | 0.5077 | 1.1405 |
| $\sigma_{\pi^*}$ | 0.50 | 2.0396 | 1.7669 | 2.3033 | $\sigma_{\pi^*}$ | 0.50 | 3.2787 | 2.7436 | 3.7480 |

## 5.2 Data exclusion

A second robustness check concerns the specification of the sample data periods. As discussed in Section 4.2.2, the data for the overall estimation periods contains major volatilities during the Asian Financial crisis (1997:Q1 - 1998:Q4). The data are informative as the posterior estimates are clearly pulled away from the prior, therefore, we decided to exclude the sampling data period from 1997:Q1 to 1998:Q4 in order to gauge an explicit estimation results.

As a result, the estimates of first subsample period (1980:Q1 - 1996:Q4) is 0.1963 with [0.1024, 0.2936] 90 % interval. In the second period without financial crisis data (1999:Q1 - 2013:Q4), the value decreases to 0.0751 with [0.0205, 0.1299] of 90% interval. The log marginal data density has been improved from -636.39 (initial estimation, period 1) to -591.48 (data exclusion, period 1). Likewise, the log data density changes from -616.36 to -511.31 for period 2. From this, we could note that the estimation results seem more reliable when excluding the data period with outliers.

Table 7. Estimation results

| | Prior | Posterior | | | | Prior | Posterior | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Mean | 90% interval | | | Mean | Mean | 90% interval | |
| $\psi_1$ | 1.50 | 1.3845 | 0.9651 | 1.7612 | $\psi_1$ | 1.50 | 1.2628 | 0.9026 | 1.6162 |
| $\psi_2$ | 0.25 | 0.4196 | 0.1642 | 0.6593 | $\psi_2$ | 0.25 | 0.6122 | 0.3236 | 0.9236 |
| $\psi_3$ | 0.25 | 0.1143 | 0.0373 | 0.1889 | $\psi_3$ | 0.25 | 0.0676 | 0.0134 | 0.1196 |
| $\rho_R$ | 0.50 | 0.7243 | 0.6456 | 0.8101 | $\rho_R$ | 0.50 | 0.8545 | 0.8026 | 0.9087 |
| $\alpha$ | 0.20 | 0.1142 | 0.0629 | 0.1618 | $\alpha$ | 0.20 | 0.0837 | 0.0543 | 0.1119 |
| $r$ | 2.50 | 2.4422 | 0.8306 | 3.8575 | $r$ | 2.50 | 2.5025 | 0.9877 | 3.9909 |
| $\tilde{\kappa}$ | 0.10 | 0.2658 | 0.1388 | 0.3889 | $\tilde{\kappa}$ | 0.10 | 0.1763 | 0.0684 | 0.2790 |
| $\tau$ | 0.50 | 0.2582 | 0.1623 | 0.3465 | $\tau$ | 0.50 | 0.3596 | 0.2184 | 0.4990 |
| $\rho_q$ | 0.40 | 0.4318 | 0.2100 | 0.6660 | $\rho_q$ | 0.40 | 0.2449 | 0.0424 | 0.4295 |
| $\rho_z$ | 0.80 | 0.5981 | 0.4485 | 0.7513 | $\rho_z$ | 0.80 | 0.5790 | 0.4133 | 0.7339 |
| $\rho_{y^*}$ | 0.85 | 0.9615 | 0.9399 | 0.9870 | $\rho_{y^*}$ | 0.85 | 0.9433 | 0.9094 | 0.9768 |
| $\rho_{\pi^*}$ | 0.90 | 0.7731 | 0.6703 | 0.8877 | $\rho_{\pi^*}$ | 0.90 | 0.5779 | 0.4411 | 0.7182 |
| $\sigma_R$ | 0.40 | 0.3881 | 0.3229 | 0.4533 | $\sigma_R$ | 0.40 | 0.1466 | 0.1218 | 0.1692 |
| $\sigma_q$ | 1.00 | 0.9227 | 0.7883 | 1.0433 | $\sigma_q$ | 1.00 | 1.5558 | 1.3319 | 1.8099 |
| $\sigma_z$ | 1.00 | 0.5468 | 0.4384 | 0.6506 | $\sigma_z$ | 1.00 | 0.4357 | 0.3564 | 0.5140 |
| $\sigma_{y^*}$ | 1.00 | 0.9578 | 0.5608 | 1.3546 | $\sigma_{y^*}$ | 1.00 | 1.2662 | 0.5449 | 2.1302 |
| $\sigma_{\pi^*}$ | 0.50 | 1.8980 | 1.6358 | 2.1651 | $\sigma_{\pi^*}$ | 0.50 | 2.3646 | 1.9934 | 2.7083 |

# 6 Concluding Remarks

Policy makers have recently noted an apparent flattening of the New Keynesian Phillips Curve and this phenomenon has been captured not only in the United States but many other countries including Canada, UK, Australia, Newzealand and Korea. The implications of such change include the cost of trade-offs between output gap and inflation, and the significance of implementing an optimal monetary policy has been highlighted by policy makers. In this paper, we specify a simple, structural general equilibrium model of a small open economy by applying Bayesian estimation analysis in order to review possible explanations of flattening NKPC.

Using Korean data, we find that the flattening is evident in the baseline structural New-Keynesian Phillips Curve. In addition, the evidence presented in Sections 4 and 5 indicates that something has changed in the way inflation responds to the real marginal costs. However, when it comes to the rolling window estimation methodology, the slope of Phillips Curve does not seem monotonically decreasing. We consider a variety of reasons for this structural flattening including econometric strategies and data problems along with volatilities. Finally, the results seem consistent when we use alternative prior distribution and data set to check robustness.

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# 국문초록

최근 캐나다, 뉴질랜드, 한국 등을 포함한 소규모 개방경제 체제하의 나라들에서 새 케인지안 곡선의 평탄화 문제가 대두되고 있다. 본 연구에서는 이러한 현상이 경제 정책 입안자들에게 어떠한 영향을 미치고 있는지를 베이즈 추론기법에 근거하여 추정하고자 한다. 필립스 곡선이 평탄화 되었다는 것은 중앙은행이 1998년 5월부터 채택한 물가안정 목표제도와 밀접한 관련이 있으며, 기대 인플레이션 및 통화정책의 유효성에 관해 논의할 여지가 있음을 시사한다. 한국의 경우 전통적인 계량경제학 기법인 GMM 혹은 MLE 방식에 기반하여 선행된 연구가 있으나, 동태적 일반균형 모형(DSGE)을 기반으로 한 베이즈 추론이 응용된 사례는 없었다는 점을 고려하여 한국의 필립스 곡선의 추세에 대해 추정하고자 하였다. 물가안정 목표제를 도입한 시점을 기준으로 두 기간간의 매개변수를 추정하고하 하였고, 추정결과 한국의 경우 필립스 곡선의 기울기가 감소한 것으로 나타났다.

**주요어:** 소규모 개방경제, 새 케인지안 필립스 곡선, 베이즈 추론, MCMC

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경제학석사학위논문

# Estimates of New Keynesian Phillips Curve: Observations Based on the Case of Korea

뉴 케인지안 필립스 곡선의 추정: 한국의 동향 분석

2016 년 2 월

서울대학교 대학원

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송 현 지

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이 논문을 경제학석사학위논문으로 제출함

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# Abstract

## Estimates of New Keynesian Phillips Curve: Observations Based on the Case of Korea

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Recently, an apparent flattening of New Keyneisan Phillips Curve (NKPC) has been indicated not only in the United States but also in many other small open economy countries including Canada, New zealand, U.K, and Korea. The implications of such phenomenon concedes the costs of trade-offs between the inflation and output gap variability, in which inflation has become less responsive to the variability of domestic macroeconomic activities. This paper's main objective is to discover some of evidences and conceivable explanations behind this structural flattening of New Keynesian Phillips Curve in Korea. We estimate a dynamic stochastic general equilibrium (DSGE) model of a small open economy to investigate such changes by employing Bayesian estimation methodology. Using data for Korea, we find that the flattening of New Keynesian Phillips Curve has become evident, however; the slope of New Keynesian Phillips Curve does not seem monotonically decreasing when it comes to the rolling window estimation analysis. We consider various reasons for this structural flattening including problems with data and estimation methodology and finally implement few robustness checks.

**Keyword :** Small open economy model, New Keynesian Phillips Curve, Structural Estimation, Bayesian analysis, MCMC

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# Contents

# 1 Introduction

In recent years, inflation has become less responsive to the fluctuations of domestic macroeconomic variables, in other words, the baseline New Keynesian Phillips Curve (NKPC) has been flattened over time. As the New Keynesian Phillips Curve measures the structural changes of inflation dynamics, flattening of its slope concedes a relatively lower costs of trade-offs between inflation and the output gap variability, which in fact, would lead to consequences over monetary policy regimes in terms of optimality price stability. Schmitt-Grohe and Uribe (2008) also states the significance of a policy tradeoff between inflation and output stabilization where the flattening of NKPC helps anchor inflation expectations.

In addition to its policy implications, there has been a growing literature on the estimation of the New Keynesian Phillips Curve followed by Gali and Gerter (1999). As discussed in Robert (2006), a conspicuous flattening of NKPC has been appeared not only in the United States but in many other small open economy countries including U.K, Canada, and Austrailia[1]. Indeed, the inflation in those countries has remained at a low and steady level. Kim and Ahn (2008) also report the similar phenomena in their paper called "An assesment of New Keynesian Phillips Curve in the Korean Economy". Conjointly, Moon,Yun, and Lee (2004) and Park and Joo (2011) suggest that the forward-looking behavior of inflation takes a critical role on explanations of an observed inflation dynamics in Korea. In contempt of the growing interests on this topic in Korea, most literatures are limited to the area of a single equation model estimation (i.e. a classical GMM) where lack of identification alters the sampling distribution of estimators and test statistics.

The objective of this paper is, therefore, to analyze some of possible explanations of the flattening NKPC in Korea by assessing a small open economy dynamic stochastic general equilibrium (DSGE) model estimation along with the New Keynesian framework estabilished by Gali and Monacelli (2005) and Lubik and Schorfheide (2007). Using Korean data compounded with the full information Bayesian analysis, we find an apparent flattening of a baseline structural NKPC between pre and post-inflation

[1] see Bean (2006), Iakova (2007), and Kuttner & Robinson (2010)

targeting period, namely 1980:Q1 to 1997:Q4 and 1998:Q1 to 2013:Q4, however; when it comes to the 10 year rolling window estimation, the slope of NKPC does not seem monotonically decreasing. This might be due to the problems associated with data for the financial crisis period and estimation methodology, thus we consider variety of reasoning behind this context. We also implement few robustness checks in order to further examine the structural flattening of New Keynesian Phillips Curve.

The remaining part of this paper proceeds as follows. Section 2 presents a structural small open economy model which we proceed to estimate. In Section 3, we discuss the econometric strategy and theoretical backgrounds behind the Bayesian analysis. In addition to the methodology, we also demonstrate the choice of priors. Section 4 reports the estimation results and Section 5 contatins few robustness checks. The conclusions are in Section 6.

# 2 Description of the model

## 2.1 A structural small open economy model

The model used in this paper is along with the lines of New Keynesian framework initially established by Gali and Monacelli (2005) and simplified by Lubik and Schorfheide (2007) for a small open economy. As stated in Lubik and Schorfheide (2007), the model contains the baseline forward looking IS-equation and a Phillips Curve. The monetary policy rule is considered as an interest rate rule (adjusted by central bank) with inclusion of the nominal exchange rate depreciation and changes in terms of trade. In addition, the nominal exchange rate depreciation is described as a means of the consumer price index (CPI) with assumption of the purchasing power parity (PPP). The simplified version of small open economy model equations could be determined as following.

The New Keynesian Phillips Curve (NKPC) implied by optimal price setting of domestic firms could be defined as follows:

$$\pi_t = \beta E_t \pi_{t+1} + \alpha\beta \Delta q_{t+1} - \alpha \Delta q_t + \frac{\kappa}{\tau + \alpha(2-\alpha)(1-\tau)}(y_t - \bar{y}_t) \tag{1}$$

where $\bar{y}_t = \frac{-\alpha(2-\alpha)(1-\tau)}{\tau y_t^*}$ is potential output in the absence of nominal rigidities and when $\alpha = 0$, it represents the case of closed economy variant. The slope coefficient $\kappa > 0$ conquers the size of price stickiness.[2] In addition, $\kappa$, the slope coefficient of NKPC, is composed of a function with underlying structural parameters including demand elasticities.

As we are interested in the slope of NKPC and its curvature, we decided to focus on the slope of NKPC itself by simplifying the equation (1). Thus, the above equation could be rewritten as:

$$\pi_t = \beta E_t \pi_{t+1} + \alpha\beta \triangle q_{t+1} - \alpha \triangle q_t + \tilde{\kappa}(y_t - \bar{y}_t)$$

where $\tilde{\kappa} \equiv \frac{\kappa}{\tau+\alpha(2-\alpha)(1-\tau)}$ is the slope of New Keynesian Phillips Curve.

A forward-looking (open economy) IS equation imposed by the consumption Euler equation could be defined as following:

$$\begin{aligned} y_t = E_t y_{t+1} - [\tau + \alpha(2-\alpha)(1-\tau)](R_t - E_t \pi_{t+1} - \rho_z z_t) \\ + \alpha[\tau + \alpha(2-\alpha)(1-\tau)] E_t \Delta q_{t+1} - \alpha(2-\alpha)\frac{1-\tau}{\tau} E_t \Delta y^*_{t+1} \end{aligned} \tag{2}$$

where $0 < \alpha < 1$ is the openness measure (an import share), and $\tau$ is the intertemporal substitution elasticity. Again, when $\alpha = 0$, the IS-curve abridges to the case of closed economy. An aggregate output $y_t$ and the CPI inflation rate $\pi_t$ are endogenous variables. Terms of trade, $q_t$, is defined as a relative price of exports in terms of imports. ${y_t}^*$ is exogenous world output and $z_t$ is the growth rate of an underlying non stationary world technology process $A_t$.

Nominal exchange rate depreciation, noted as $e_t$, is introduced via definition of the consumer price index (CPI) under the assumption of the relative purchasing power parity (PPP):

$$\pi_t = \Delta e_t + (1-\alpha)\Delta q_t + \pi_t^* \tag{3}$$

Monetary policy rule is depicted as an interest rate rule. Central bank conducts contingent monetary policy regimes by adjusting its instrument in response to movements in CPI inflation and output growth.

[2] i.e. as the value of $\kappa$ increases, the nominal rigidities disintegrate

In addition, the nominal exchange rate depreciation $\Delta e_t$ is included in the policy rule as follows:

$$R_t = \rho_R R_{t-1} + (1 - \rho_R)[\psi_1 \pi_t + \psi_2 y_t + \psi_3 \Delta e_t] + \varepsilon_t^R \tag{4}$$

We assume that the policy coefficients $\psi_1, \psi_2, \psi_3 \geq 0$. The interest rate smoothing factor $0 < \rho_R < 1$ is also included in order to match the persistence in nominal interest rates.

As suggested in Lubik and Schorfheide, we choose to introduce the law of motion for the terms of trade growth rate as a substitute of solving model endogenously:

$$\Delta q_t = \rho_q \Delta q_{t-1} + \varepsilon_{q,t} \tag{5}$$

The relationship between terms of trade and prices of internationally traded products are as following:

$$[\tau + \alpha(2 - \alpha)(1 - \tau)]\Delta q_t = \Delta y_t^* - \Delta y_t \tag{6}$$

A linear rational expectations model comprises the equations (1) - (6). We assume that the rest of world output and inflation, also noted as $y_t^*$ and $\pi_t^*$, follow univariate AR(1) process with autoregressive coefficients $\rho_{y^*}$ and $\rho_{\pi^*}$, respectively.

# 3 Estimation strategy

In this section, the Bayesian inference methods[3] are discussed as an econometric methodology of the model (as described in Section 2) evaluation. We then outline the description of the data set and the choice of priors which is designed to construct the posterior distribution of parameters.

## 3.1 Econometric methodology

According to An and Schorfheide (2007), dynamic stochastic general equilibrium (DSGE) models have been prominent as micro-founded optimization based models in

[3]For more details, please refer to An and Schorfheide (2007)

macroeconomic areas. Along with many applicable traditional econometric techniques, DSGE bayesian inference has been endorsed in order to back up some of potential pitfalls from the conventional econometric methodology where model misspecification and identification alter sampling distributions. Hence, in this paper, we try to contemplate the estimation of the slope of New Keynesian Phillips Curve in Korea by applying the Bayesian estimation methodology.

In a Bayesian inference framework, the likelihood function is combined with the dynamic stochastic general equilibrium model in the line of rational expectations cross coefficient restrictions. We then collect the policy rule parameters into the 4 x 1 vector $\psi = [\psi_1, \psi_2, \psi_3, \rho_R]'$ and other DSGE model parameters (including non-policy parameters and standard deviations of exogenous shocks) into the 13 x 1 vector $\theta$[4]. Note that all structural shocks are assumed to be normally distributed and have no correlation with any of them at all leads and lags. In this way, we can acquire the joint probability distributions of all endogenous variables of the model described as in section 2.

In our empirical analysis on the baseline of Bayesian estimation technique, we collect the model observables into vector $Y_t$ where annualized interest rates, annualized inflation rates, output growth, depreciation rates, and changes in terms of trade are included. In fact, the vector $Y_t$ could be indicated as following

$$Y_t = [4R_t, 4\pi_t, \Delta y_t + z_t, \Delta e_t, \Delta q_t]'$$

Note that all the endogenous model observable variables are demeaned and $\Delta y_t$ is complied with the productivity growth $z_t$ as $y_t$ itself is the ratio of output and world productivity $A_t$.

Bayesian estimation starts from a prior distribution with density $p(\psi, \theta) = p(\psi)p(\theta)$ of the model's structural parameters. This prior distribution depicts available information prior to the estimation based on data observations. As well, observations of the data set are adopted through the likelihood function $\mathscr{L}_D(\psi, \theta | Y^T)$, where $Y^T = \{Y_1, \ldots, Y_T\}$. Via Bayes theorem, the likelihood function which is hinged on data observations is taken into account to update the prior and to the posterior distribution of model's structural parameters. Followed by Adolfson (2007), this posterior distribution could be described in terms of measures of location (i.e. mode and mean) and spread (standard deviation

[4]where $\theta = [\alpha, r, \kappa, \tau, \rho_z, \rho_q, \rho_{\pi^*}, \rho_{y^*}, \sigma_R, \sigma_z, \sigma_q, \sigma_{\pi^*}, \sigma_{y^*}]'$

and probability intervals). In turn, the posterior distribution could be expressed as

$$p_D(\psi,\theta|Y^T) = \frac{\mathscr{L}_D(\psi,\theta|Y^T)p(\psi)p(\theta)}{\int \mathscr{L}_D(\psi,\theta|Y^T)p(\psi)p(\theta)d(\psi,\theta)} \tag{7}$$

We then advocate the Bayes simulation theorem by generating draws from posterior distributions and observe the convergence diagnostics for MCMC methods. According to An and Schorfheide (2007), this procedure along with the impulse response functions and variance decomposition enable us to access the dynamics of dispersions and relative precedence of structural shocks for all model parameters.

There is a growing empirical literature on the New Keynesian DSGE model in conjunction with Bayesian inference techniques. Preceding literatures highlight on the matter of contention related to the parameter identification where, in some cases, structural parameters are dispersed from the reduced form as an implication of the rational expectations theorem. However, Bayesian estimation of DSGE models often compromise some of possible pitfalls of a classical GMM (with a single equation approach) or VAR where sampling distribution of test statistics are altered by virtue of weak identifications. As a result, those conventional econometric techniques end up with poor approximation of the sampling distribution. Hence, we are trying to focus on potential problems aroused in earlier literatures and thus conduct more percise approach of priors and posterior distributions to retrieve more information extorted from the sampling distributions in this paper.

## 3.2 Description of Data

In order to obtain an empirical analysis, we use following data observations, namely, real output growth, inflation, nominal interest rates, exchange rate changes, and changes in term of trade. All of data sets are at quarterly frequencies for the period of 1980:Q1 to 2013:Q4 and most of series could be accessed through the Bank of Korea (BOK, Economic Statistics System) and Statistics Korea[5]. Data sets are seasonally adjusted and demeaned. In our empirical analysis, we divide the whole period into two sub-periods - pre-inflation targeting period (1980:Q1 to 1997:Q4) and post-inflation targeting period

[5]For the reference, please visit http://ecos.bok.or.kr and www.kostat.go.kr

(1998:Q1 to 2013:Q4)[6].

Detailed data set procedures are as follows. Output growth rate are computed as log differences of real GDP per capita and scaled by 100 to convert into quarter-to-quarter percentages. Population are splined from annual population projection data (retrieved from Statistics Korea) into quarterly frequencies by using Eviews. Inflation rates are obtained through Bank of Canada and defined as log differences of the consumer price indicies (CPI) and multiplied by 400 in order to obtain annualized percentage rates. The overnight Money Market Rate (percent per annum) are used as a mean of the nominal interest rates and obtained from IMF, International Financial Statistics (IFS) for the entire period. (Narrow) Nominal effecive exchange rate indices for Korea are obtained through Bank for International Settlements (BIS) and take log differences scaled by 100 in order to convert the indices into depreciation rates. Lastly, the changes of terms of trade are converted in log differences scaled by 100 to obtain percentage changes. Data for the period of 1988:1 to 2013:4 are obtained through Bank of Korea. For the period of 1980:1 to 1987:4 are retrived from World Bank as the whole set of the sample period data are not available at the Bank of Korea. The net barter terms of trade indices (2000=100) from World bank are converted into the base year of 2010 as 100[7] and splined into quarterly frequencies by quadratic match average frequency conversion. All the data series are demeaned prior to the empirical analysis.

## 3.3 Choice of Prior

In Bayesian inference framework, we start by assigning a prior distribution of the model's structural parameters. Prior distribution allows us to reach some of available information prior to the estimation. Note that all prior distributions are assumed to have no correlation with each other and factors such as the size restriction and non-negativity of parameters are considered by truncating the estimating parameter distributions. In addition, the joint prior distribution is truncated at the boundary

[6] Although the Bank of Korea changed its policy regimes to inflation targeting in May 1998 (1998:Q2), we divided the sampling data observations from 1998:Q1 to 2013:Q4 for convenience.

[7] As the BOK terms of trade data base year is 2010, we try to fix the sampling period data along with lines.

of determinacy region regarding the solution of the linear rational expectations' non existence.

As noted in Table 1, information about the prior distributions of model structural parameters for Korea are described. For model parameters bounded between 0 and 1 ( ie. [0,1) ) including $\rho_R, \alpha, \rho_q, \rho_z, \rho_{y^*}, \rho_{\pi^*}$, beta distributions are assigned. In addition, the inverse gamma distribution is used for the parameters assumed to be non-negative. (ie. shock standard deviations $\sigma_R, \sigma_q, \sigma_z, \sigma_{y^*}, \sigma_{\pi^*}$).

Table 1. Prior Distribution

| Name | Domain | Density | P(1) | P(2) |
|---|---|---|---|---|
| $\psi_1$ | R+ | Gamma | 1.50 | 0.50 |
| $\psi_2$ | R+ | Gamma | 0.25 | 0.13 |
| $\psi_3$ | R+ | Gamma | 0.25 | 0.13 |
| $\rho_R$ | [0,1) | Beta | 0.50 | 0.20 |
| $\alpha$ | [0,1) | Beta | 0.20 | 0.05 |
| $r$ | R+ | Gamma | 2.50 | 1.00 |
| $\tilde{\kappa}$ | R+ | Gamma | 0.10 | 0.05 |
| $\tau$ | [0,1) | Gamma | 0.50 | 0.20 |
| $\rho_q$ | [0,1) | Beta | 0.40 | 0.20 |
| $\rho_z$ | [0,1) | Beta | 0.80 | 0.10 |
| $\rho_{y^*}$ | [0,1) | Beta | 0.85 | 0.07 |
| $\rho_{\pi^*}$ | [0,1) | Beta | 0.90 | 0.06 |
| $\sigma_R$ | R+ | InvGamma | 0.40 | 4.00 |
| $\sigma_q$ | R+ | InvGamma | 1.00 | 4.00 |
| $\sigma_z$ | R+ | InvGamma | 1.00 | 4.00 |
| $\sigma_{y^*}$ | R+ | InvGamma | 1.00 | 4.00 |
| $\sigma_{\pi^*}$ | R+ | InvGamma | 0.50 | 4.00 |

(NOTE) P(1) and P(2) indicate the benchmark values of parameter means and standard deviations. The prior distribution is truncated at the boundary of the determinacy region in order to obtain proper estimation results.

In terms of the value of prior mean and standard deviations, we refer to other precending literatures on Bayesian estimation. As suggested in Lubik and Schorfheide (2007), we adopt loose priors for the policy rule parameters namely $\psi_1$, $\psi_2$, and $\psi_3$ [8].

[8] Recall an interest rate rule:

$$R_t = \rho_R R_{t-1} + (1 - \rho_R)[\psi_1 \pi_t + \psi_2 y_t + \psi_3 \Delta e_t] + \varepsilon_t^R$$

The policy rule priors are centered at the values implied by the Taylor rule (ie. 1.50 and 0.50 for $\psi_1$ and 0.25 and 0.13 for $\psi_2$). The exchange rate depreciation prior mean is centered at the value of 0.25 with its standard deviation value of 0.13. Likewise, the interest rate smoothing factor, $\rho_R$, is assumed to be centered at a prior mean of 0.50 with a standard deviation of 0.20.

Note that an openness measure parameter $\alpha$ follows the beta distribution with a mean of 0.20 and a standard deviation of 0.05. Since the discount factor $\beta$ is defined as $\beta = exp[-r/400]$, we use the annualized steady state real interest rate $r$ with a mean of 2.50 and a relatively large standard deviation of 1.00. The slope coefficient (of NKPC) parameter, $\tilde{\kappa}$[9] is assumed to be centered at 0.10 with a standard deviation value of 0.05. The intertemporal substitution elasticity parameter $\tau$ is assumed to follow gamma distribution with a mean of 0.50 and a standard deviation of 0.20 as the model holds singularity at $\tau = 1$.

For the prior distributions of exogenous shock parameters ($\rho_y^*$ and $\rho_{\pi^*}$), we implement a pre-sample analysis for the period of 1965:Q1 to 1979:Q4. We use the United States GDP (relative ratio to the domestic GDP) and CPI inflation rates in order to fit an AR(1) process of each coefficients by Eviews. As a result, we obtain $\rho_\pi^*$ centered at 0.90 with standard deviation of 0.06 and $\rho_y^*$ centered at 0.85 with standard deviation of 0.07.

# 4 Estimation results

In this section, the resulting parameter estimates and implied model dynamics are discussed. By fitting the estimation of a linearized small open economy DSGE model to the data of Korea, we tacitly compute posterior distributions of the structural

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$\psi_1$ is coefficient for the inflation rate, $\psi_2$ is related to the output growth, and $\psi_3$ is coefficient for the exchange rate depreciation.

[9] As many literatures on the slope of NKPC for Korea point out, the slope coefficient of New Keynesian Phillips Curve in Korea tend to be estimated as a relatively smaller value, for instance 0.01 or even smaller. To see some differences, we choose the value of 0.10 which is smaller than other small open economy average (0.50) but slightly larger than precending Korean literatures.

parameters. The data are divided into two subperiods for the empirical analysis in order to demonstrate few distinctions between pre-inflation and post-inflation targeting periods. We then report notable estimation results and some other findings from several robustness exercises.

## 4.1 Has the New Keynesian Phillips Curve become flatter in Korea?

The Bayesian estimates of the structural parameters in overall periods (ie. 1980:Q1 to 2013:Q4) and two subperiods (Period 1: 1980:Q1 to 1997:Q4, Period 2: 1998:Q1 to 2013:Q4) for Korea can be found in Table 2 and 3, repectively. In addition to 90 percent posterior probability intervals, posterior means are reported as point estimates.

Table 2. Estimation results for overall period

| | Prior | Posterior | | |
|---|---|---|---|---|
| | Mean | Mean | 90% interval | |
| $\psi_1$ | 1.50 | 1.1532 | 0.9240 | 1.3723 |
| $\psi_2$ | 0.25 | 0.4284 | 0.1432 | 0.6724 |
| $\psi_3$ | 0.25 | 0.0537 | 0.0100 | 0.0962 |
| $\rho_R$ | 0.50 | 0.8385 | 0.7993 | 0.8809 |
| $\alpha$ | 0.20 | 0.0414 | 0.0235 | 0.0565 |
| $r$ | 2.50 | 2.4621 | 0.8961 | 3.9100 |
| $\tilde{\kappa}$ | 0.10 | 0.0712 | 0.0119 | 0.1357 |
| $\tau$ | 0.50 | 0.1088 | 0.0702 | 0.1474 |
| $\rho_q$ | 0.40 | 0.2426 | 0.1150 | 0.3769 |
| $\rho_z$ | 0.80 | 0.5749 | 0.4178 | 0.7490 |
| $\rho_{y^*}$ | 0.85 | 0.9832 | 0.9731 | 0.9936 |
| $\rho_{\pi^*}$ | 0.90 | 0.5472 | 0.4320 | 0.6666 |
| $\sigma_R$ | 0.40 | 0.4237 | 0.3720 | 0.4708 |
| $\sigma_q$ | 1.00 | 1.2462 | 1.1239 | 1.3713 |
| $\sigma_z$ | 1.00 | 0.2721 | 0.4898 | 0.6499 |
| $\sigma_{y^*}$ | 1.00 | 0.8370 | 0.4754 | 1.1760 |
| $\sigma_{\pi^*}$ | 0.50 | 2.7395 | 2.4718 | 3.0321 |

In general, New Keynesian Phillips Curve (when it is correctly defined by the model) is not influenced by any changes caused in the economy including a structural policy rule. As NKPC pins down a proportionate relationship between marginal costs and output, it is not affected by any real activity involved with responsiveness of stimulating marginal costs. Hence, determining changes of NKPC remains a critical matter in order to reconcile its instability.

As a result of NKPC with empirical analysis along with lines of Bayesian inference framework, we find that all structural parameter estimate values belongs to conceivable ranges. In addition, the estimate result of New Keynesian Phillips curve parameter, $\tilde{\kappa}$, is projected as 0.0712 for the full sample period. Likewise, Table 3 represents two sets of estimation results of all the structural parameters for Korea. As mentioned in earlier section, we find that the slope coefficient of NKPC for Korea falls into relatively smaller value compared to other estimates as in US or Canada. In Table 3, the first and left set represent the estimation results for period 1 (pre-inflation targeting period, 1980:Q1 - 1997:Q4) and the second set depicts results of the period 2 (post-inflation targeting period, 1998:Q1 - 2013:Q4). Notice that the slope of overall NKPC declines from the value of 0.2647 with its 90% interval of [0.1396,0.3859] to 0.1233 with the range of [0.0743,0.1738].

Table 3. Estimation results for period 1 and 2

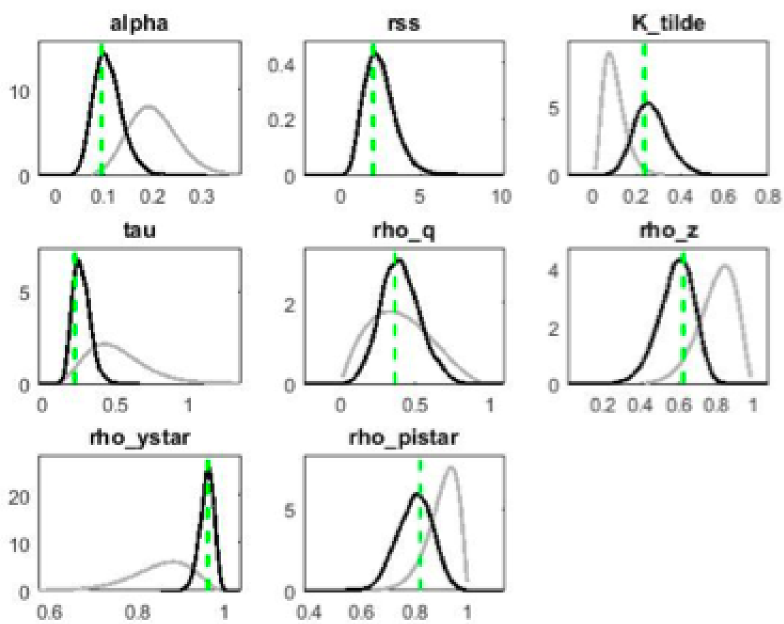
| | **Prior** | **Posterior** | | | | **Prior** | **Posterior** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Mean | 90% interval | | | Mean | Mean | 90% interval | |
| $\psi_1$ | 1.50 | 1.3606 | 0.9827 | 1.6812 | $\psi_1$ | 1.50 | 1.5857 | 1.2352 | 1.9168 |
| $\psi_2$ | 0.25 | 0.4227 | 0.1734 | 0.6700 | $\psi_2$ | 0.25 | 0.3573 | 0.1425 | 0.5586 |
| $\psi_3$ | 0.25 | 0.0901 | 0.0294 | 0.1498 | $\psi_3$ | 0.25 | 0.0764 | 0.0351 | 0.1209 |
| $\rho_R$ | 0.50 | 0.7134 | 0.6350 | 0.7871 | $\rho_R$ | 0.50 | 0.7545 | 0.7018 | 0.8034 |
| $\alpha$ | 0.20 | 0.1072 | 0.0608 | 0.1517 | $\alpha$ | 0.20 | 0.0708 | 0.0448 | 0.0957 |
| $r$ | 2.50 | 2.4493 | 0.9086 | 3.8703 | $r$ | 2.50 | 2.5017 | 0.9473 | 3.9582 |
| $\tilde{\kappa}$ | 0.10 | 0.2647 | 0.1396 | 0.3859 | $\tilde{\kappa}$ | 0.10 | 0.1233 | 0.0743 | 0.1738 |
| $\tau$ | 0.50 | 0.2612 | 0.1639 | 0.3531 | $\tau$ | 0.50 | 0.2153 | 0.1197 | 0.3085 |
| $\rho_q$ | 0.40 | 0.3994 | 0.1782 | 0.6069 | $\rho_q$ | 0.40 | 0.1871 | 0.0359 | 0.3254 |
| $\rho_z$ | 0.80 | 0.5846 | 0.4355 | 0.7322 | $\rho_z$ | 0.80 | 0.9575 | 0.9330 | 0.9834 |
| $\rho_{y^*}$ | 0.85 | 0.9570 | 0.9313 | 0.9827 | $\rho_{y^*}$ | 0.85 | 0.8700 | 0.8028 | 0.9399 |
| $\rho_{\pi^*}$ | 0.90 | 0.7980 | 0.6871 | 0.9016 | $\rho_{\pi^*}$ | 0.90 | 0.8651 | 0.7599 | 0.9707 |
| $\sigma_R$ | 0.40 | 0.4073 | 0.3402 | 0.4703 | $\sigma_R$ | 0.40 | 0.2026 | 0.1695 | 0.2336 |
| $\sigma_q$ | 1.00 | 0.8961 | 0.7806 | 1.0181 | $\sigma_q$ | 1.00 | 1.5052 | 1.2838 | 1.7163 |
| $\sigma_z$ | 1.00 | 0.5408 | 0.4308 | 0.6418 | $\sigma_z$ | 1.00 | 0.4561 | 0.3637 | 0.5426 |
| $\sigma_{y^*}$ | 1.00 | 1.0329 | 0.5419 | 1.4841 | $\sigma_{y^*}$ | 1.00 | 1.4235 | 0.6881 | 2.1771 |
| $\sigma_{\pi^*}$ | 0.50 | 2.0757 | 1.7669 | 2.3357 | $\sigma_{\pi^*}$ | 0.50 | 3.8138 | 3.2315 | 4.3876 |

The preference parameter $\alpha$ is estimated to be lower (with value of 0.0414 for the overall sample period) than the recognized import proportion of Korea. The bank of Korea accompanies a moderate anti-inflationary policy as the estimates indicate (ie.

$\psi_1 = 1.15$). Notice that the value of inflation parameter estimates increases from 1.3606 in period 1 to 1.5857 in period 2. We also find that the bank of Korea concerns for the output ($\psi_2 = 0.43$) and the exchange rate ($\psi_3 = 0.0537$) during the full sample period.

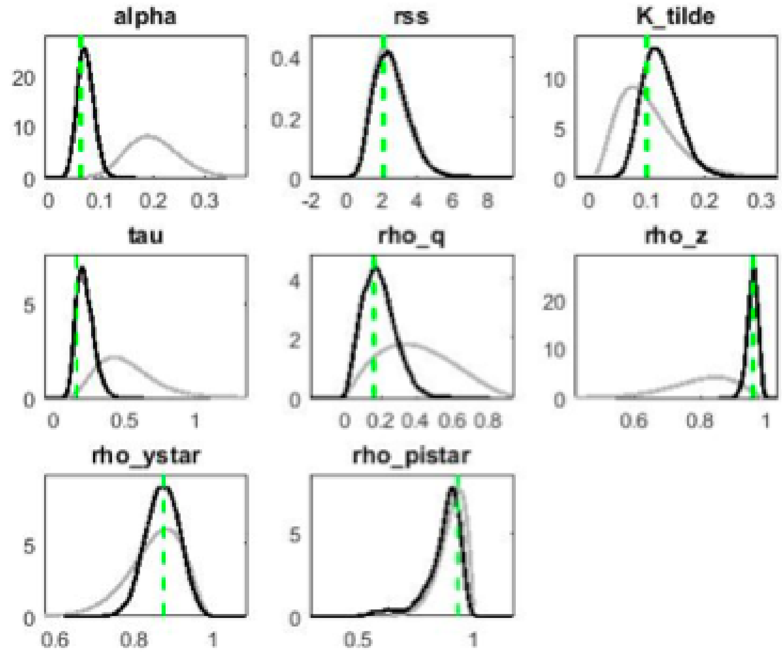
The interest rate smoothing term parameter also indicates a reasonably high magnitude with $\rho_R = 0.84$. Moreover, the stochastic process demonstrates some persistence as in data. Most of parameter estimates reflect a high degree of autocorrelation with foreign output shock (ie. $\rho_y^* = 0.98$). Despite the fact that the posterior distribution spread and its location do not differ conspicuously from its prior information via Bayes theorem, an informative data update appears to be more centered for the policy rule parameters. For the more detailed distribution spread for prior and posteriors, please see figure 1 and 2.

Figure 1. Prior and Posterior Distribution(Period 1)




(NOTE) The Figure depicts the prior and posterior distributions for the period of 1980:Q1 to 1997:Q4 with posterior mean (dashed lines).

Figure 2. Prior and Posterior Distribution(Period 2)




(NOTE) The Figure depicts the prior and posterior distributions for the period of 1998:Q1 to 2013:Q4 with posterior mean (dashed lines).

## 4.2 Iterative and Rolling Estimation Results

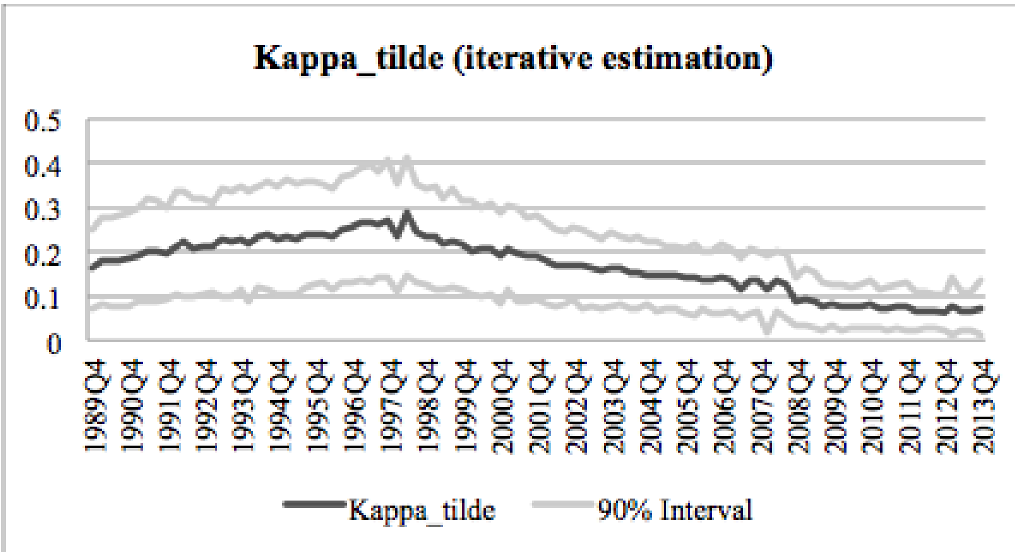
In order to gauge a clear-cut of estimation results during the full sample period, we try to evaluate the results in the way of iteration and rolling-window estimation techniques. In this way, more percise conceptual changes between sample periods could be attained.

### 4.2.1 Iterative methods for the parameter estimation

In this section, we proceed an iterative estimation methods in order to capture distinctive changes between various subdivision of a time period. We first estimate the structural parameters for the initial period (1980:Q1 - 1989:Q4) then add an additional sample data[10] to the estimation at each time of iterative period 'til 2013:Q4.

[10] Here, the sample data set are all quarterly. Hence, we re-estimate the sampling distribution by adding one more quarterly data into the estimation model at each time. This allows us to estimate total number of 97 times of estimations.

Figure 3. Iterative estimation result



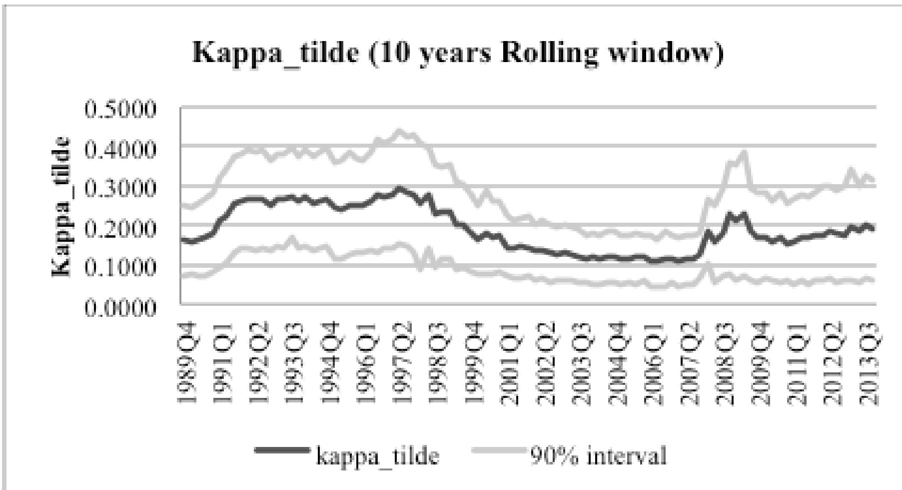

(NOTE) Figure 3 represents the iterative estimation results of slope coefficients of New Keynesian Phillips Curve ($\tilde{\kappa}$ for the period of 1980:Q1 to 2013:4. The solid lines are estimates of $\tilde{\kappa}$ and above and below lines are 90 % interval.

As figure 3 represents, the estimates of slope of New Keynesian Phillips Curve starts from 0.1635 and increases up to 0.2865 for the sampling period of 1980:Q1 - 1998:Q2. As the post-inflation targeting period data are included in the estimation model, the estimate value of $\tilde{\kappa}$ (slope of NKPC) decreases as low as 0.0712 for the entire sample period. We find that the flattening of NKPC for Korea has been appeared when we used an iterative estimation methodology.

### 4.2.2 Rolling estimation analysis

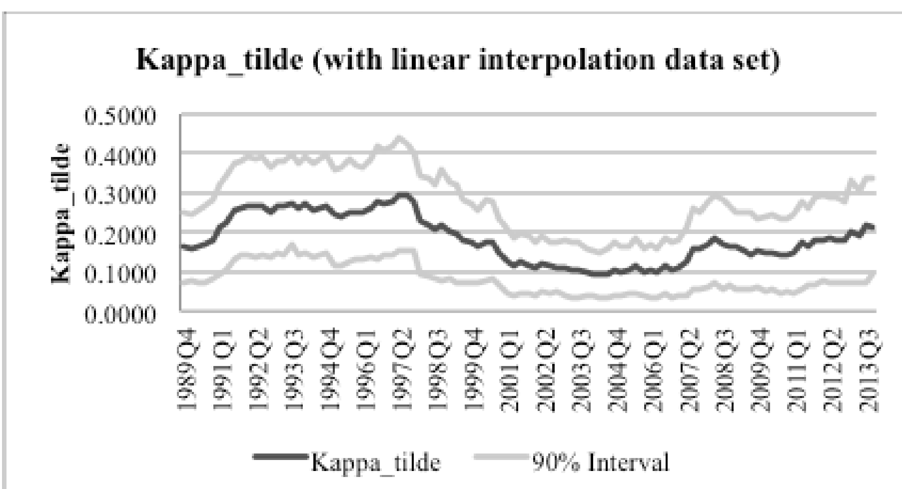
Similar to the iterative estimation methods, we now apply 10-year rolling window estimations for the entire sample period. In this way, we use 40 data observations at each time of Bayesian estimation and onwards. Figure 4 suggests that the flattening of NKPC does not seem evident as the estimation value of $\tilde{\kappa}$ starts from 0.1579 and there appears a jump in the period of 1998:Q2 to 2008:Q1. This might be due to the data involved in the process of estimation as it includes implied volatility during Asian financial crisis (1998:Q1 - 1998:Q4) and Global financial crisis (2007:Q1 - 2008:Q4) in terms of output, inflation, changes in exchange rate and terms of trade (Figure 6). Thus, we decided to use linear interpolation data set (by using Eviews) in order to obtain the estimation results without any huge jump in the data set, however; as figure 5 indicates the flattening does not seem monotonically decrasing as a result.

Figure 4. Slope of NKPC (10 years Rolling window)



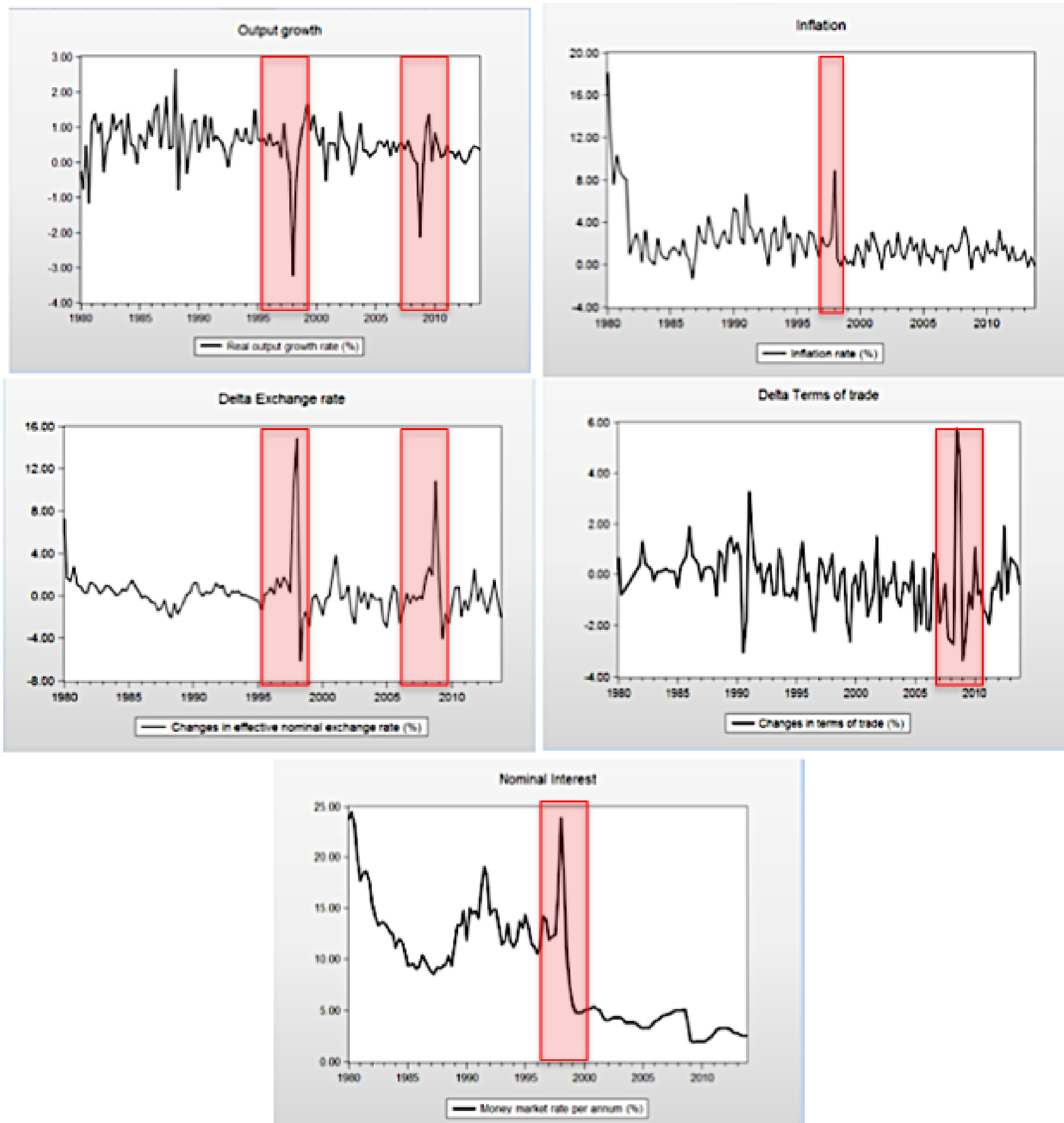

(NOTE) The Figure depicts the 10-year rolling estimation results of slope of NKPC ($\tilde{\kappa}$ for the period of 1980:Q1 to 2013:4. The solid lines are estimates of $\tilde{\kappa}$ and above and below lines are 90 % interval.

Figure 5. Slope of NKPC (10 years Rolling window, linear interpolation data)




(NOTE) The Figure depicts the 10-year rolling estimation results (with linear interpolation dataset) of slope of NKPC ($\tilde{\kappa}$ for the period of 1980:Q1 to 2013:4. The solid lines are estimates of $\tilde{\kappa}$ and above and below lines are 90 % interval.

Figure 6. Data plotting (1980:Q1 - 2013:Q4)




(NOTE) The shaded area indicates the changes of data set (output growth, inflation, exchange rate depreciation, changes in terms of trade, and nominal interest rate) during the crisis periods namely, Asian financial crisis (1998:Q1 - 1998:Q4) and Global financial crisis (2007:Q1 - 2008:Q4).

## 4.3 Variance Decomposition

In this section, we discuss and report variance decompositions in order to measure the relevance of individual shocks to the observed estimate values. As computed in Table 4, dynamics of output growth rate for Korea are mostly explained (as of 92%) by world demand shock in pre-inflation targeting period (period 1, 1980:Q1 - 1997:Q2). In period 2 (post-inflation targeting, 1998:Q1 - 2013:Q4), the proportion of world output shock declines as technology shock takes more portion in terms of output variance decomposition.

Table 4. Variance Decomposition for two subperiods

Period 1

| | Output | Inflation | Interest rate | Exchange rate |
|---|---|---|---|---|
| Policy | 0.0463 | 0.0221 | 0.1013 | 0.0027 |
| Terms of trade | 0.0017 | 0.0016 | 0.0017 | 0.0586 |
| Technology | 0.0207 | 0.0064 | 0.0107 | 0.0008 |
| World output | 0.9208 | 0.9468 | 0.8844 | 0.1152 |
| World inflation | 0.0105 | 0.0231 | 0.0020 | 0.8228 |

Period 2

| | Output | Inflation | Interest rate | Exchange rate |
|---|---|---|---|---|
| Policy | 0.0134 | 0.0009 | 0.0077 | 0.0000 |
| Terms of trade | 0.0017 | 0.0022 | 0.0008 | 0.0210 |
| Technology | 0.4700 | 0.8484 | 0.9737 | 0.0223 |
| World output | 0.4099 | 0.0219 | 0.0002 | 0.0006 |
| World inflation | 0.1050 | 0.1265 | 0.0176 | 0.9561 |

Inflation is demonstrated predominantly as of 95% by world demand shock in pre-inflation targeting period whereas technology shock is able to explain roughly 84% of inflation movements in period 2. Likewise, interest rate movements are largely determined by world output shock and technology shock in period 1 and 2, respectively. Lastly, exchange rate movements on the other hand are mostly explained by world inflation shock in both pre and post inflation targeting periods.

## 4.4 Impulse Response Function

In this section, we investigate model dynamics by implementing the impulse reponse functions. As addressed in figure 7 and 8, expansionary monetary policy depreciates the domestic currency and increases the value of CPI inflation and overall output level. When the level of terms of trade raises, the domestic demand enhances and the inflation level decreases via effects of nominal appreciation. The weakened nominal exchange rate incites the central banks to be responsive for their policy regimes which leads to further pressures on productions. Futhermore, an advanced technoloy level allows economy to have a lower level of inflation and interest rate and by that increase the value of currency. As the technology progress is assumed to be a discrepancy stationary productivity, it would have permanent forces on output level. With existence of world demand shocks, the domestic output decreases whereas inflation and the exchange rate boost. Rest of world's inflation shock appreciate the value of domestic currency but deepens the level of domestic price inflation as central bank responds to exchange rate movements in order to loose corresponding policy regimes.

Figure 7. Impulse response for period 1

[Period 1]

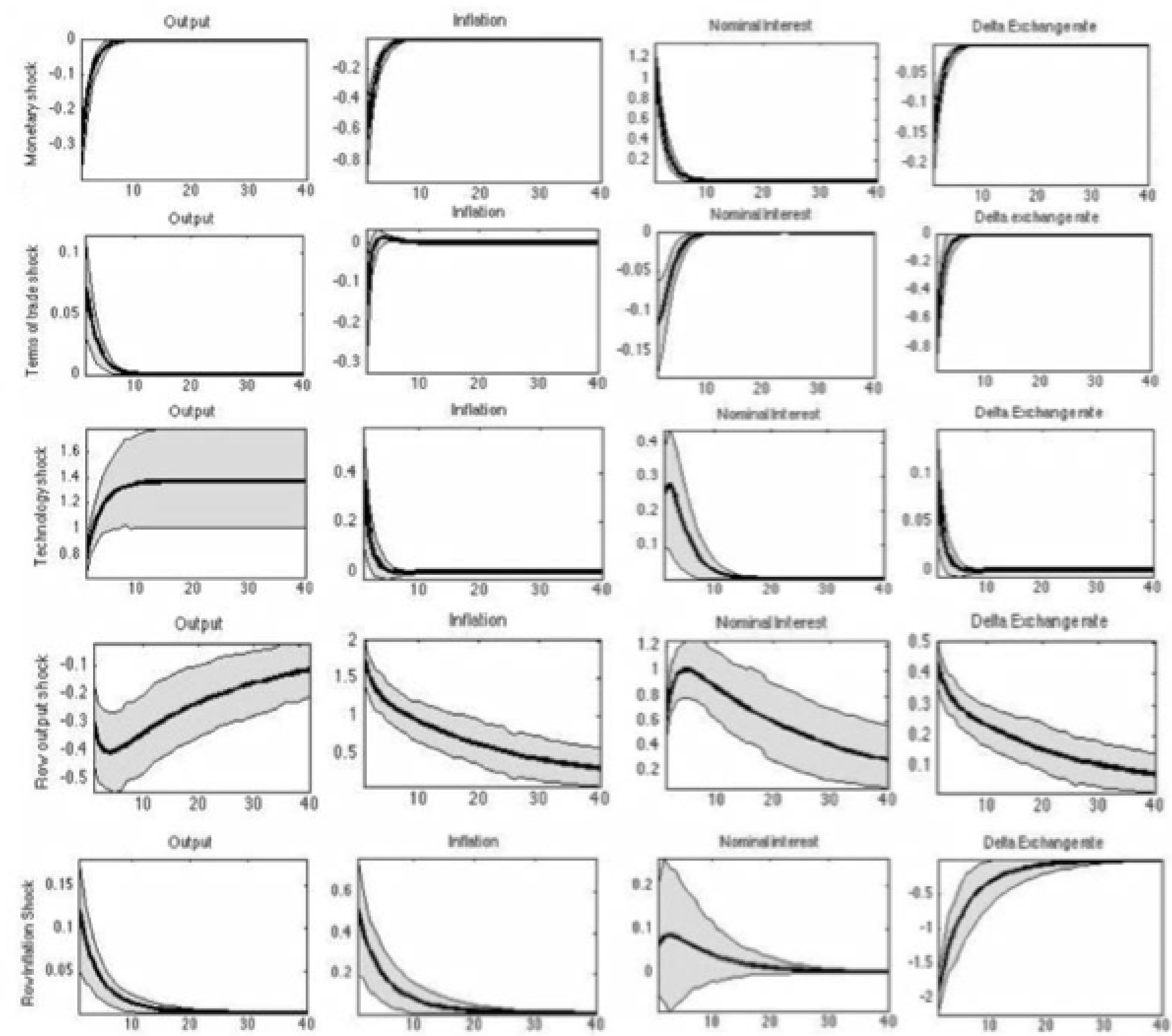
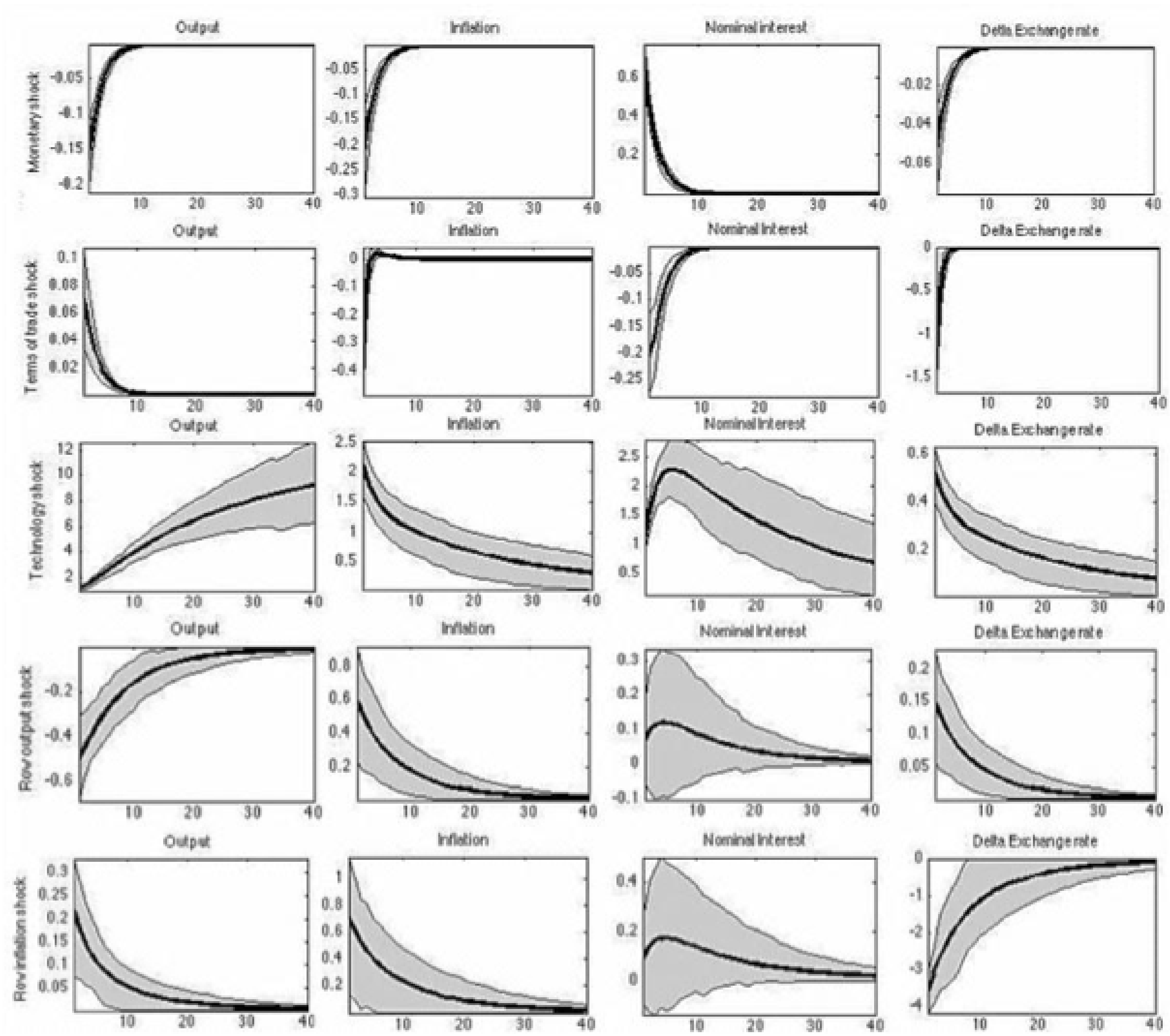


Figure 8. Impulse response for period 2

[Period 2]




(NOTE) Figure 7 & 8 demonstrate posterior means and 90 % probabilty intervals for impulse response functions for structural shocks (monetary, terms of trade, technology, rest of world demand and inflation shock).

# 5 Robustness

In this section, we now examine the regression specification by implementing few robustness checks. We first address an alternative prior value (as in Lubik and Schorfheide, 2005) and then use a different data set without financial crisis.

## 5.1 Alternative Prior

We now address the question whether the flattening of New Keynesian Phillips Curve has been evident by assessing structural estimation with alternative prior distributions. In particular, we impose different prior distributions based on the Lubik and Schorfheide, 2005 (Table 5). The prior for the slope coefficient $\tilde{\kappa}$ in the New Keynesian Phillips curve has become relatively larger (as the value of 0.5) compared to the previous case (0.1). In addition to this change, prior for the domestic output growth, $\rho_z$, is centered at 0.2. Priors for the rest of world inflation $\rho_{\pi^*}$ are centered at 0.8 with $\sigma_{\pi^*}$ at 0.5. Priors for the rest of world output shock $\rho_{y^*}$ are centered at 0.9 with standard deviation at 1.00.

Table 5. Alternative prior distributions

| Name | Domain | Density | P(1) | P(2) |
|---|---|---|---|---|
| $\psi_1$ | R+ | Gamma | 1.50 | 0.50 |
| $\psi_2$ | R+ | Gamma | 0.25 | 0.13 |
| $\psi_3$ | R+ | Gamma | 0.25 | 0.13 |
| $\rho_R$ | [0,1) | Beta | 0.50 | 0.20 |
| $\alpha$ | [0,1) | Beta | 0.20 | 0.05 |
| $r$ | R+ | Gamma | 2.50 | 1.00 |
| $\tilde{\kappa}$ | R+ | Gamma | 0.50 | 0.25 |
| $\tau$ | [0,1) | Gamma | 0.50 | 0.20 |
| $\rho_q$ | [0,1) | Beta | 0.40 | 0.20 |
| $\rho_z$ | [0,1) | Beta | 0.20 | 0.05 |
| $\rho_{y^*}$ | [0,1) | Beta | 0.90 | 0.05 |
| $\rho_{\pi^*}$ | [0,1) | Beta | 0.80 | 0.10 |
| $\sigma_R$ | R+ | InvGamma | 0.40 | 4.00 |
| $\sigma_q$ | R+ | InvGamma | 1.00 | 4.00 |
| $\sigma_z$ | R+ | InvGamma | 1.00 | 4.00 |
| $\sigma_{y^*}$ | R+ | InvGamma | 1.00 | 4.00 |
| $\sigma_{\pi^*}$ | R+ | InvGamma | 0.50 | 4.00 |

Table 6 and 7 indicate the overall period and two subperiods estimation results. As shown in the table 6, the estimates of $\tilde{\kappa}$ over the full sample (1980:Q1 - 2013:Q4) is 0.1076 with [0.0242, 0.2124] of 90% interval. Similar to the initial estimation results, the estimation results of two sub samples suggests the flattening of New Keynesian Phillips Curve in Korea. ($\tilde{\kappa}$ changes from 0.8718 to 0.2242 in period 1 and 2, respectively.)

Table 6. Estimation results (overall period)

| | Prior | Posterior | | |
|---|---|---|---|---|
| | Mean | Mean | 90% interval | |
| $\psi_1$ | 1.50 | 1.0976 | 0.9244 | 1.2751 |
| $\psi_2$ | 0.25 | 0.3877 | 0.1597 | 0.6336 |
| $\psi_3$ | 0.25 | 0.0526 | 0.0095 | 0.0948 |
| $\rho_R$ | 0.50 | 0.8279 | 0.7819 | 0.8757 |
| $\alpha$ | 0.20 | 0.0360 | 0.0203 | 0.0500 |
| $r$ | 2.50 | 2.5365 | 0.9175 | 4.1107 |
| $\tilde{\kappa}$ | 0.50 | 0.1076 | 0.0242 | 0.2124 |
| $\tau$ | 0.50 | 0.1115 | 0.0724 | 0.1498 |
| $\rho_q$ | 0.40 | 0.2325 | 0.1000 | 0.3552 |
| $\rho_z$ | 0.20 | 0.2160 | 0.1364 | 0.2909 |
| $\rho_{y^*}$ | 0.90 | 0.9829 | 0.9731 | 0.9941 |
| $\rho_{\pi^*}$ | 0.80 | 0.4313 | 0.3050 | 0.5646 |
| $\sigma_R$ | 0.40 | 0.4253 | 0.3713 | 0.4753 |
| $\sigma_q$ | 1.00 | 1.2519 | 1.1222 | 1.3664 |
| $\sigma_z$ | 1.00 | 0.6579 | 0.5873 | 0.7227 |
| $\sigma_{y^*}$ | 1.00 | 0.7629 | 0.4878 | 1.0278 |
| $\sigma_{\pi^*}$ | 0.50 | 2.6883 | 2.4066 | 2.9448 |

Table 7. Estimation results for two subperiods

| | Prior | Posterior | | | | Prior | Posterior | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Mean | 90% interval | | | Mean | Mean | 90% interval | |
| $\psi_1$ | 1.50 | 1.2352 | 0.9674 | 1.5016 | $\psi_1$ | 1.50 | 1.0282 | 0.9403 | 1.1197 |
| $\psi_2$ | 0.25 | 0.3734 | 0.1345 | 0.6081 | $\psi_2$ | 0.25 | 0.4529 | 0.1842 | 0.7057 |
| $\psi_3$ | 0.25 | 0.0920 | 0.0355 | 0.1481 | $\psi_3$ | 0.25 | 0.0367 | 0.0096 | 0.0643 |
| $\rho_R$ | 0.50 | 0.5315 | 0.3999 | 0.6509 | $\rho_R$ | 0.50 | 0.7448 | 0.6892 | 0.8004 |
| $\alpha$ | 0.20 | 0.1400 | 0.0755 | 0.2039 | $\alpha$ | 0.20 | 0.0926 | 0.0542 | 0.1280 |
| $r$ | 2.50 | 2.5329 | 0.9907 | 4.1573 | $r$ | 2.50 | 2.5993 | 1.0586 | 4.2115 |
| $\tilde{\kappa}$ | 0.50 | 0.8718 | 0.5319 | 1.2068 | $\tilde{\kappa}$ | 0.50 | 0.2242 | 0.0765 | 0.3682 |
| $\tau$ | 0.50 | 0.4166 | 0.2703 | 0.5678 | $\tau$ | 0.50 | 0.4535 | 0.2911 | 0.6117 |
| $\rho_q$ | 0.40 | 0.4434 | 0.2720 | 0.6104 | $\rho_q$ | 0.40 | 0.1902 | 0.0371 | 0.3266 |
| $\rho_z$ | 0.20 | 0.1943 | 0.1203 | 0.2707 | $\rho_z$ | 0.20 | 0.2038 | 0.1239 | 0.2842 |
| $\rho_{y^*}$ | 0.90 | 0.9658 | 0.9423 | 0.9894 | $\rho_{y^*}$ | 0.90 | 0.9846 | 0.9751 | 0.9957 |
| $\rho_{\pi^*}$ | 0.80 | 0.6929 | 0.5761 | 0.8143 | $\rho_{\pi^*}$ | 0.80 | 0.4739 | 0.2937 | 0.6616 |
| $\sigma_R$ | 0.40 | 0.4941 | 0.3901 | 0.5919 | $\sigma_R$ | 0.40 | 0.2484 | 0.1990 | 0.2953 |
| $\sigma_q$ | 1.00 | 0.9037 | 0.7786 | 1.0269 | $\sigma_q$ | 1.00 | 1.5098 | 1.2942 | 1.7145 |
| $\sigma_z$ | 1.00 | 0.6655 | 0.5691 | 0.7643 | $\sigma_z$ | 1.00 | 0.5892 | 0.4952 | 0.6816 |
| $\sigma_{y^*}$ | 1.00 | 0.8783 | 0.5212 | 1.2482 | $\sigma_{y^*}$ | 1.00 | 0.8273 | 0.5077 | 1.1405 |
| $\sigma_{\pi^*}$ | 0.50 | 2.0396 | 1.7669 | 2.3033 | $\sigma_{\pi^*}$ | 0.50 | 3.2787 | 2.7436 | 3.7480 |

## 5.2 Data exclusion

A second robustness check concerns the specification of the sample data periods. As discussed in Section 4.2.2, the data for the overall estimation periods contains major volatilities during the Asian Financial crisis (1997:Q1 - 1998:Q4). The data are informative as the posterior estimates are clearly pulled away from the prior, therefore, we decided to exclude the sampling data period from 1997:Q1 to 1998:Q4 in order to gauge an explicit estimation results.

As a result, the estimates of first subsample period (1980:Q1 - 1996:Q4) is 0.1963 with [0.1024, 0.2936] 90 % interval. In the second period without financial crisis data (1999:Q1 - 2013:Q4), the value decreases to 0.0751 with [0.0205, 0.1299] of 90% interval. The log marginal data density has been improved from -636.39 (initial estimation, period 1) to -591.48 (data exclusion, period 1). Likewise, the log data density changes from -616.36 to -511.31 for period 2. From this, we could note that the estimation results seem more reliable when excluding the data period with outliers.

Table 7. Estimation results

| | Prior | Posterior | | | | Prior | Posterior | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Mean | 90% interval | | | Mean | Mean | 90% interval | |
| $\psi_1$ | 1.50 | 1.3845 | 0.9651 | 1.7612 | $\psi_1$ | 1.50 | 1.2628 | 0.9026 | 1.6162 |
| $\psi_2$ | 0.25 | 0.4196 | 0.1642 | 0.6593 | $\psi_2$ | 0.25 | 0.6122 | 0.3236 | 0.9236 |
| $\psi_3$ | 0.25 | 0.1143 | 0.0373 | 0.1889 | $\psi_3$ | 0.25 | 0.0676 | 0.0134 | 0.1196 |
| $\rho_R$ | 0.50 | 0.7243 | 0.6456 | 0.8101 | $\rho_R$ | 0.50 | 0.8545 | 0.8026 | 0.9087 |
| $\alpha$ | 0.20 | 0.1142 | 0.0629 | 0.1618 | $\alpha$ | 0.20 | 0.0837 | 0.0543 | 0.1119 |
| $r$ | 2.50 | 2.4422 | 0.8306 | 3.8575 | $r$ | 2.50 | 2.5025 | 0.9877 | 3.9909 |
| $\tilde{\kappa}$ | 0.10 | 0.2658 | 0.1388 | 0.3889 | $\tilde{\kappa}$ | 0.10 | 0.1763 | 0.0684 | 0.2790 |
| $\tau$ | 0.50 | 0.2582 | 0.1623 | 0.3465 | $\tau$ | 0.50 | 0.3596 | 0.2184 | 0.4990 |
| $\rho_q$ | 0.40 | 0.4318 | 0.2100 | 0.6660 | $\rho_q$ | 0.40 | 0.2449 | 0.0424 | 0.4295 |
| $\rho_z$ | 0.80 | 0.5981 | 0.4485 | 0.7513 | $\rho_z$ | 0.80 | 0.5790 | 0.4133 | 0.7339 |
| $\rho_{y^*}$ | 0.85 | 0.9615 | 0.9399 | 0.9870 | $\rho_{y^*}$ | 0.85 | 0.9433 | 0.9094 | 0.9768 |
| $\rho_{\pi^*}$ | 0.90 | 0.7731 | 0.6703 | 0.8877 | $\rho_{\pi^*}$ | 0.90 | 0.5779 | 0.4411 | 0.7182 |
| $\sigma_R$ | 0.40 | 0.3881 | 0.3229 | 0.4533 | $\sigma_R$ | 0.40 | 0.1466 | 0.1218 | 0.1692 |
| $\sigma_q$ | 1.00 | 0.9227 | 0.7883 | 1.0433 | $\sigma_q$ | 1.00 | 1.5558 | 1.3319 | 1.8099 |
| $\sigma_z$ | 1.00 | 0.5468 | 0.4384 | 0.6506 | $\sigma_z$ | 1.00 | 0.4357 | 0.3564 | 0.5140 |
| $\sigma_{y^*}$ | 1.00 | 0.9578 | 0.5608 | 1.3546 | $\sigma_{y^*}$ | 1.00 | 1.2662 | 0.5449 | 2.1302 |
| $\sigma_{\pi^*}$ | 0.50 | 1.8980 | 1.6358 | 2.1651 | $\sigma_{\pi^*}$ | 0.50 | 2.3646 | 1.9934 | 2.7083 |

# 6 Concluding Remarks

Policy makers have recently noted an apparent flattening of the New Keynesian Phillips Curve and this phenomenon has been captured not only in the United States but many other countries including Canada, UK, Australia, Newzealand and Korea. The implications of such change include the cost of trade-offs between output gap and inflation, and the significance of implementing an optimal monetary policy has been highlighted by policy makers. In this paper, we specify a simple, structural general equilibrium model of a small open economy by applying Bayesian estimation analysis in order to review possible explanations of flattening NKPC.

Using Korean data, we find that the flattening is evident in the baseline structural New-Keynesian Phillips Curve. In addition, the evidence presented in Sections 4 and 5 indicates that something has changed in the way inflation responds to the real marginal costs. However, when it comes to the rolling window estimation methodology, the slope of Phillips Curve does not seem monotonically decreasing. We consider a variety of reasons for this structural flattening including econometric strategies and data problems along with volatilities. Finally, the results seem consistent when we use alternative prior distribution and data set to check robustness.

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# 국문초록

최근 캐나다, 뉴질랜드, 한국 등을 포함한 소규모 개방경제 체제하의 나라들에서 새 케인지안 곡선의 평탄화 문제가 대두되고 있다. 본 연구에서는 이러한 현상이 경제 정책 입안자들에게 어떠한 영향을 미치고 있는지를 베이즈 추론기법에 근거하여 추정하고자 한다. 필립스 곡선이 평탄화 되었다는 것은 중앙은행이 1998년 5월부터 채택한 물가안정 목표제도와 밀접한 관련이 있으며, 기대 인플레이션 및 통화정책의 유효성에 관해 논의할 여지가 있음을 시사한다. 한국의 경우 전통적인 계량경제학 기법인 GMM 혹은 MLE 방식에 기반하여 선행된 연구가 있으나, 동태적 일반균형 모형(DSGE)을 기반으로 한 베이즈 추론이 응용된 사례는 없었다는 점을 고려하여 한국의 필립스 곡선의 추세에 대해 추정하고자 하였다. 물가안정 목표제를 도입한 시점을 기준으로 두 기간간의 매개변수를 추정하고하 하였고, 추정결과 한국의 경우 필립스 곡선의 기울기가 감소한 것으로 나타났다.

**주요어:** 소규모 개방경제, 새 케인지안 필립스 곡선, 베이즈 추론, MCMC

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