The External Influences on Korea's Monetary Policy

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The External Influences on Korea’s Monetary Policy

By

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Claremont Graduate University
2023
Approval of the Dissertation Committee

This dissertation has been dully read, reviewed, and critiqued by the Committee listed below, which hereby approves the manuscript of Seh-Beom Koo as fulfilling the scope and quality requirements for meriting the degree of Doctor of Philosophy in Economics.

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The main purpose of this study was to investigate the external influences on Korea’s monetary policy over the period from 1990 to 2020. The focus was on the effects of US interest rates, payments imbalances and exchange rate changes on Korean monetary policy.

Two types of measures of Korean monetary policy were considered. These are the effects on Korean interest rates and the effects on the domestic money supply and monetary base.

The purpose in estimating the basic Taylor rules was to go beyond unconditional estimates of pass through from US to Korean interest rates and to attempt to control for domestic influences on Korean interest rates. This gave us better estimates of the actual influences of the US interest rate and exchange rate changes by controlling for Korean interest rate changes that would have occurred even without the foreign developments. Correspondingly, the estimation of sterilization and offset coefficients by a set of simultaneous equations attempted to control for domestic as well as external influences on its money supply. Estimating both the Taylor rule and sterilization/offset coefficients together could give a better idea of the patterns of Korean responses. The Global Financial Crisis (GFC), during 2007-2008, was chosen as a structural break point.

The empirical tests of the Taylor rule implied that the impact of the US interest rate on Korean policy rate has been steady but weak throughout most circumstances. On the other
hand, the impact of the exchange rate on Korean policy rate had varied before and after the GFC.

The analysis of the Bank of Korea (BOK) monetary policy reports explained the different impacts that the exchange rate has had on Korean policy rate before and after the GFC. The reports indicated that the overall balance of payments, in the aftermath of the Asian Financial Crisis, has been a main concern of Korean monetary authority while the status of domestic economy has been a main factor contributing to the impact that the exchange has had on Korean policy rate during the postcrisis period.

The test results from the Sterilization and Offset study showed almost perfect sterilization of reserve changes resulting from intervention in the exchange market. Since the offset coefficients, close to 1, were overstated, the results from the interest rate passthrough model were used as a measure of capital mobility. It was found to be imperfect.

Overall, Korea has had a fairly open capital account, managed floating exchange rate regime and independent central bank. Korean monetary policy has been influenced by monetary developments in the US, but it still has had a good deal of independence.
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Chapter 1: Introduction

The main purpose of this study is to investigate the external influences on Korea’s monetary policy over the period from 1990 to 2020 or 2021. ¹ Specifically, the focus will be on the effects of US interest rates and exchange rate changes. Regarding foreign influences on Korean monetary policy, I will be looking at two types of measures of monetary policy. These are the effects on Korean interest rates and the effects on the domestic money supply and monetary base, the two standard ways in which monetary policy is measured.²

The purpose in estimating the basic Taylor rules is to go beyond unconditional estimates of pass through from US to Korean interest rates and to attempt to control for domestic influences on Korean interest rates. This gives us better estimates of the actual influences of the US interest rate and exchange rate changes by controlling for Korean interest rate changes that would have occurred even without the foreign developments.³ Correspondingly, the estimation of sterilization and offset coefficients by a set of simultaneous equations attempts to control for domestic as well as external influences on its money supply.

Estimating both the Taylor rule and sterilization/offset coefficients together can give a better idea of the patterns of Korean responses. Specifically, estimating both equations will help us see if they give clues about whether Korea is able to use sterilization to limit the effects of US policies on its exchange rate and interest rate. Also, a careful analysis of the extent to which the equations yield the same or different results will be implemented. Our study is unique because it considers both the Taylor rule and sterilization policy when the spillover effects from the US to emerging economies are examined. Previous studies have looked at only one or the other regarding the spillover effects.

The dissertation is organized as follows. Chapter 2 contains the analysis of the Taylor rule with the addition of external variables. Chapter 3 estimates the sterilization and offset coefficients. Both

¹ The time period is chosen because of data availability.
² For the balance of payments, I refer to the overall or official settlements balance which corresponds to changes in international reserves. That's the influence that I am testing with the sterilization coefficients in terms of effects on the money supply.
³ I compare these results with those of simple pass-through estimates to see how much difference there is.
Chapter 2 and chapter 3 contain methodologies, data and empirical results for each. Chapter 4 analyzes the Bank of Korea (BOK) monetary policy. Chapter 5 concludes.

**Chapter 2: The Taylor rule**

**2.1. Literature review**

An inflation targeting framework has been adopted by many central banks around the world since the 1990s. The policy is thought to be beneficial in leading to more independent central banks and in making more credible monetary policy by reducing inflation. On the other hand, a lower inflation rate has a risk of being achieved with lower output and higher unemployment (Bernanke and Mishkin, 1997).

A prototypical Taylor rule (Taylor 1993, 1999) stated that a policy interest rate is determined as a linear function of the deviation of inflation from its target and the deviations of output from its potential level (the output gap). Since then, the Taylor rule has been modified continuously. Perhaps, the most salient change of the Taylor rule was the transformation of the linear rule to a nonlinear rule. A nonlinear Taylor rule reflects that central banks may react to economic circumstances in a complex nonlinear way. The addition of other variables, such as an exchange rate variable, can be perceived as another noticeable modification.

The general form of the Taylor rule is based on the equation for determining monetary policy. The Taylor rule was proposed using the equation for monetary policy as a general guideline. The equation for monetary policy assumed that the central bank sets a target for the nominal interest rate $i_t$ based on inflation and output as in the following (Mankiw, 2009):

$$i_t = \pi_t + \rho + \theta_\pi (\pi_t - \pi_t^*) + \theta_\psi (\psi_t - \psi_t^*)$$  \hspace{1cm} (1)

---

4 Ch. 4 discusses how the estimated results compare with the BOK’s discussions of what they think is going on and why they are adopting particular policies.

5 Note that this pertains to only a short run event, not to a long run tradeoff based on Phillips curve analysis.

6 The nonlinearity of the Taylor rule will be discussed on Section 2.1.2.
where $\pi_t^*$ is the central bank’s target for the inflation rate, $Y_t^*$ is the natural level of output and $\rho$ is the natural rate of interest. $\theta_\pi$ and $\theta_\nu$ are two policy parameters. The larger the value of $\theta_\pi$, the more the central bank responds to the deviation of inflation from its target. The larger the value of $\theta_\nu$, the central bank responds more to the deviation of income from its natural level.

Since $\theta_\pi$ is assumed to be greater than zero, whenever inflation increases, the central bank raises the nominal interest rate by a larger amount. Economic intuition is that when a positive demand shock increases output and inflation, they lower real interest rate, given that central banks does not increase nominal interest rate. The lower real rate causes higher output and, consequently, upward pressure on inflation, which will lower the real rate again. This explanation leads to this conclusion: For inflation to be stable, the central bank must respond to inflation with an even greater increase in the nominal interest rate when the inflation rate is above the target.\footnote{This conclusion is very important because (1) it has a direct policy implication and (2) it implies nonlinearity of the Taylor rule.} This conclusion is called the Taylor principle.\footnote{Note that it goes the other way when inflation falls below target.}

There are two different uses of the Taylor rule approach. One is positive analysis of how central banks actually set a policy (such as the central bank’s target for the inflation rate, $\pi_t^*$) and the other is a normative approach that gives advice on how they should set policy.

### 2.1.1. The linear Taylor rule

The Taylor principle is embedded in the Taylor (1993) rule. The earlier form of the Taylor rule went beyond the general rule and assumed the federal funds rate responds to changes in inflation and output in the following form:

$$r_t = p_t + 0.5y_t + 0.5(\pi_t - 2) + 2$$

where $r_t$ is the Federal funds rate, $p_t$ is the inflation rate over the previous four quarters and $y_t$ is the percentage deviation of real GDP from target. The constant of 2 percent subtracted from inflation is the Fed’s inflation target $\pi_t^*$ and the second constant of 2 percent is an estimate of the natural rate of interest $\rho$.\footnote{This conclusion is very important because (1) it has a direct policy implication and (2) it implies nonlinearity of the Taylor rule.}
Since the birth of the rule in 1993, the Taylor rule has been modified steadily. Taylor (1998) added two more variables to the earlier model, the central bank’s target inflation rate ($\pi^*$) and the estimate of the equilibrium real rate of interest ($r_f^*$) shown below:

$$r_t = \pi_t + gy_t + h(\pi_t - \pi^*) + r_f^* \tag{3}$$

where $\pi_t$ is the inflation rate.

Taylor (1999) and Ghosh et al. (2016) added the effects of the exchange rate on monetary policy shown as:

$$i_t = f\pi_t + gy_t + h_0e_t + h_1e_{t-1} \tag{4}$$

where $i_t$ is the short-term nominal interest rate and $e_t$ is the real exchange rate.

Recent studies follow the linear Taylor rule using GMM (generalized method of moments) derived in Clarida et al. (1998) which assumed that policymakers respond to forecasts of inflation and output gap. Clarida et al. (1998) modified the model by including many considerations such as central bank’s tendency to smooth interest rate disturbances. They found that since 1979 the G3 (Germany, Japan, and the US) central banks had pursued inflation targeting and it worked quite well for them. However, the E3 (UK, France, and Italy) central banks mostly followed German monetary policy. Caporale et al. (2018) is a nice study to use as a reference regarding Taylor rule (Eq.5).

2.1.2. The nonlinear Taylor rule

It has been argued that the linear Taylor rule may not be enough to grasp the complexities stemming from the monetary policy. Furthermore, it is suggested that a Taylor rule may be described best in a complex nonlinear form. Nonlinearities in the Taylor rule can be the result of either the macroeconomic structure of the economy (the output-inflation trade-off) or of asymmetry in the central banks’ preferences (Taylor and Davradakis, 2006). For instance, policy responses can differ
depending on the state of business cycle. Output stabilization will be given priority during recessions and inflation will be a main concern during expansions.\(^9\)

Asymmetry in the central banks’ preferences concerning the weight assigned to deviations of inflation from target and the output gap may cause a nonlinear rule. Dolado et al. (2000) found that the US Fed and the central banks of Spain, France and Germany are less responsive to inflation when it is below target as opposed to above target.

A vital aspect of the nonlinear Taylor rule is derived from the assumption that the utility functions underlying policy decisions are nonlinear. Specifically, it is possible that policy makers have increasing disutility as target variables (inflation or unemployment) deviate more from the optimal levels (inflation target). The linear Taylor rule has made an implicit assumption that the utility function underlying policy decisions are linear. While many studies demonstrate the usefulness of the nonlinearity of the Taylor rule, I could not find any Taylor rule literature that has derived the nonlinearity formulation from the utility function.

Some studies found the nonlinearities in the conduct of monetary policies of the UK. Taylor and Davradakis (2006) examined the possible nonlinearities in the monetary policy of the Bank of England by dividing high and low inflation regimes using the optimal threshold value of inflation to analyze the different response of the monetary policies in the two inflation regimes. Their finding suggests that the Bank of England sets interest rates following a nonlinear Taylor rule. Martin and Milas (2013) also found that the interest-setting behavior of the UK policymakers is best described by a nonlinear model during the Global Financial Crisis.

More recently, Caporale et al. (2018) compared the results of the linear Taylor rule model with the nonlinear model in emerging economies. The linear model employs the model very similar to the one from Clarida et al. (1998) and the nonlinear model uses the specification used in Taylor and Davradakis (2006).

\(^9\) This is assuming, to some extent, that both inflation and unemployment are included in the equation.
The application of the nonlinearity of the Taylor rule takes various forms. Miles and Schreyer (2012) used quantile regression to address nonlinearity. Quantile regression, employed in this study, divides the range of dependent variables to five quantiles and, then, analyzes the monetary responses in each quantile. Martin and Milas (2013) applied a 'switching monetary policy rule’ where policymakers follow a traditional Taylor rule before the crisis and then switch to an alternative linear policy rule, including financial stress and excluding inflation, in the crisis regime.

Another major modification of the baseline Taylor rule was the inclusion of international factors such as an exchange rate variable. Policy makers in open economies experiencing external shocks may react to exchange rates fluctuations (Ghosh et al, 2016). Many studies concluded that it is not required to include the exchange rate for the developed economies, while it may be important for the emerging economies. The papers that analyzed the developed countries, Clarida et al. (1998), Taylor and Davradakis (2006), and Martin and Milas (2013), did not include the exchange rate as an explanatory variable in the Taylor rule.

On the other hand, the studies regarding emerging economies included an exchange rate as a salient factor affecting the monetary policy. Caporale et al. (2018) and Martin and Schreyer (2013) stressed the importance of the international impact on the monetary policy. Additionally, it has been found that central banks in emerging markets frequently intervene in the foreign exchange market and have an implicit comfort zone for smoothing exchange rate fluctuations which functions as an exchange rate target (Ghosh et al, 2016; Caporale et al 2018).

2.2. Methodology and data

2.2.1. The linear Taylor rule

Note that smaller and more open economies should react more to exchange rate changes (Willett, 2009).

Note that sterilized intervention is one form of exchange market intervention.
I first estimate the following linear Taylor rule as in Clarida et al. (1998) and Caporale et al. (2018),

\[ r_t = \alpha_0 + \alpha_1 r_{t-1} + \alpha_2 \sum(E_{t+k-1} \pi_{t+k} - \pi^*) + \alpha_3 \sum(E_{t+k} y_{t+k}) + \alpha_4 \sum(E_{t+k} rer_{t+k}) + \epsilon_t \]  

(5)

where \( r_t \) is the short-term interest rate, \( \pi_{t+k} \) is the CPI inflation, \( \pi^* \) is the inflation target and \( y_{t+k} \) is the output gap calculated as the difference between the log of output from its potential, and \( rer_{t+k} \) is real effective exchange rate. A 3-month lead average is used for these variables because it is assumed that policy makers respond to forecasts of inflation, the output gap and the exchange rate over the coming quarter.

In addition to forward-looking specification of the inflation (as specified by a 3-month leading average of the inflation), I can consider backward-looking specification of the Taylor rule by using the change in prices over the previous year (the lagged inflation). The purpose in considering the backward-looking model of the Taylor rule is to investigate if the policy rate reacts to the past growth and inflation (as opposed to the reaction to the anticipated growth and inflation in the forward-looking model).

Following the methods by Klein and Shambaugh (2015) and Cheng and Rajan (2019), the monetary independency is examined by the following equation:

\[ \Delta R_t = \alpha + \beta \Delta R_{b_t} + \gamma (\Delta Y_{t-1}) + \sigma (\Delta \pi_{t-1}) + \Delta e_{t-1} + \mu_t \]  

(6)

where \( \Delta R_t \) is the (monthly annual) change in the policy interest rate of Korea at time \( t \), \( \Delta R_{b_t} \) is the (monthly annual) change in 1-month Treasury bill interest rate of the US (base-country) at time \( t \), \( \Delta Y_{t-1} \) is the (monthly annual) change in the industrial production index (IPI), \( \Delta \pi_{t-1} \) is the (monthly annual) change in inflation rate and \( \Delta e_{t-1} \) is the (monthly annual) change in real effective exchange rate (REER) relative to the US dollar. The equation is in the form of the first difference estimation because the estimation of level regressions can lead to spurious results due to existence of a unit root and strong persistence of nominal interest rate.

2.2.2. The nonlinear Taylor rule
Although I am not testing for the nonlinear Taylor rule, this section explains the nonlinear models which serves as a suggestion for future research.

The nonlinear Taylor rule, which seems more plausible as supported by evidence (Martin and Milas, 2013; Miles and Schreyer, 2012), was estimated in the following model (Taylor and Davradakis, 2006; Caporale et al., 2018):

\[
\begin{align*}
    r_t &= I [\pi_{t,1} \geq \pi^*] \left[ \beta_0^H + \beta_1^HR_{t-1} + \beta_2^H\sum(E_{t-1},\pi_{t,k} - \pi') + \beta_3^H\sum(E_{t-1},y_{t,k}) + \beta_4^H\sum(E_{t-1},rer_{t,k}) \right] \\
    &+ I [\pi_{t,1} < \pi^*] \left[ \beta_0^L + \beta_1^Lr_{t-1} + \beta_2^L\sum(E_{t-1},\pi_{t,k} - \pi') + \beta_3^L\sum(E_{t-1},y_{t,k}) + \beta_4^L\sum(E_{t-1},rer_{t,k}) \right] + \varepsilon_t
\end{align*}
\]  

The threshold variable from this equation is the inflation rate to test whether central banks respond more aggressively when inflation overshoots than when it undershoots their target.\(^{12}\) The first lag of inflation, \(\pi_{t,1}\), is used. \(\pi'\) is the target inflation rate announced by the BOK. \(\pi^*\) is the optimal threshold value of inflation which defines the high or low inflation regime of the model and is estimated endogenously.\(^{13}\) \(I [\cdot]\) is the dummy indicator function that is 1 when \(\pi_{t,1} \geq \pi^*\) and is 0 otherwise.

Taylor and Davradakis (2006) estimated the optimal threshold value of inflation\(^{14}\) in the following way. The optimal threshold value of inflation, \(\pi^*\), can be estimated by minimizing an appropriate criterion function using a one-dimensional grid search, including the possible breakpoints of inflation, over the interval \(\Pi^* = [\min (\pi_t), \max (\pi_t)]\). Hanson (1996) has shown that a grid search that minimizes the total sum squared residuals will provide consistent estimates of the thresholds.

However, there can be an endogeneity issue because expected future inflation values and actual output values can be correlated with the regression error term (due to overlapping forecast errors entering the

\(^{12}\) Although this is possible, this should be tested to see whether it actually occurs. The results from Akdoğan (2015) support this view.

\(^{13}\) \(\pi^*\) is estimated using a one-dimensional grid search over a certain range and involves the GMM (generalized method of moments) estimator. The detailed derivation of the value is explained in the Literature review.

\(^{14}\) Note the literature has called this as optimal threshold value of inflation, but it is actually a proxy for the central bank’s target rate. However, it is not clear how well this value captures the actual target rate of central banks. In my work, I will refer to it as target rates rather than optimal rates.
error term). For this reason, a generalized method of moments (GMM) was used to minimize the criterion function in this way:

$$ J = \hat{\varepsilon} Z W^{-1} Z \hat{\varepsilon} $$

where $\hat{\varepsilon}$ is the estimated residual vector and $Z$ is a vector of $l$ instruments that are included in the information set and are exogenous. The GMM estimator works by minimizing a weighted average of the squared values of the $l$ sample moments $Z' \hat{\varepsilon}$. An efficient GMM estimator can be constructed in the linear model using a two-step procedure to construct the weight matrix $W$ based on centered estimates of the moment conditions (see Hansen, 2003). With the weight matrix chosen, a grid-search procedure will be used to satisfy,

$$ (\pi_2, \pi_1) = \arg \min_{\pi_1, \pi_2 \in \Pi^*} J, \quad \pi_1 > \pi_2 $$

The estimation of the threshold and other parameters involves the GMM estimator and a one-dimensional grid search over the range $\Pi^*$, including the possible breakpoint of $\pi_t$ [0.10, 0.90]:

$$ \hat{\pi}^* = \arg \min_{\pi \in \Pi^*} J $$

where $J$ is the function minimized by GMM as demonstrated in Eq. (8).

While Taylor and Davradakis (2006) derived the threshold inflation rate in the same way as above, the study set a zone bounded by the threshold inflation rate where the inflation is treated as being on target, instead of using a dummy variable.

Quartile regression can be useful in estimating Taylor rule equation. Miles and Schreyer (2012) employed four different quantiles and found non-linearity of monetary policy in the sample countries across the quantiles as the interest rates respond to the other variables in a nonlinear way. The study used the least absolute deviations (LAD) before applying quantile regression.

The target rate and the optimal rate of inflation are two distinct rates. The target rate may or may not be optimal. The method used to estimate the optimal value of inflation may not fulfill the ultimate
The goal of capturing the central bank’s actual inflation target because actual central bank objectives may differ from the estimation of optimal values. In this regard, the optimal values of inflation can be investigated for how well they estimate the actual targets for the corresponding periods.

While there are several methods to estimate the optimal value of inflation, there is considerable disagreement among economists about the estimation. So, no particular estimates should be given more weight. For example, the Fed’s target rate is currently 2.5%, while some leading economists have argued that the rate should be raised to 3% or 4%.

There are two different uses of the Taylor rule approach: One is positive analysis of how central banks actually set policy and the other one is a normative approach which advises on how they should set policies. The target inflation rate may correspond to positive approach of the Taylor rule, while the optimal inflation rate can be an example of normative approach.

### 2.2.3. Forming expectations

Different methods have been used to estimate the forecasts of inflation, output and exchange rate.

One important criterion to pay attention is the time period of the forecast variables. Friedman’s ‘long and variable lags’ of monetary policy (Friedman, 1961) favors a longer time period of inflation and output forecasts because inflation and output often responds to change in interest rates and money supply with lags. The problem with the longer time horizon is that forecasts may be inaccurate. I decided to use shorter time frame, quarterly and monthly, mainly because of the availability of the forecast reports and forecast accuracy.

These are the studies that assumed that policy makers respond to forecasts of inflation and the output gap, for example, on Clarida et al. (1998), the baseline equation stated that the central bank has a target nominal short term interest rate ($r_t^*$), which depends on both expected inflation and output:

$$r_t^* = r + \beta (E[\pi_{t+n} | \Omega_t] - \pi^*) + \gamma (E[y_{t+1} | \Omega_t] - y_t^*)$$

(11)
where \( r \) is the long-run equilibrium nominal rate, \( \pi_{t+n} \) is the rate of inflation between period \( t \) and \( t + n \), \( y_t \) is real output, and \( \pi^* \) and \( y^* \) are respective bliss points for inflation and output. It is assumed that \( y_t^* \) is given by potential output. \( E \) is the expectation operator and \( \Omega_t \) is the information available to the central bank at the time it sets interest rates.

Having the central bank responding to forecasts of inflation and output will let central banks use all pertinent information to form beliefs about future inflation and output.

The study chose a horizon of the inflation forecast of one year because the authors believe that policy makers are relatively less concerned about the month-to-month variation in inflation and more concerned about medium and long-term trends.

Sevensson (1997) studied the two-year inflation forecast as an explicit intermediate target. Specifically, the forecast of the forward inflation rate is from year \( t+1 \) to year \( t+2 \), conditional upon information available in year \( t \), and it is set to equal the inflation target.

From the model,

\[
\pi_{t+1} = \pi_t + \alpha_1 y_t + \alpha_2 x_t + \varepsilon_{t+1},
\]

(12)

\[
y_{t+1} = \beta_1 y_t + \beta_2 (i_t - \pi_t) + \beta_3 x_t + \eta_{t+1},
\]

(13)

\[
x_{t+1} = \gamma x_t + \theta_{t+1}
\]

(14)

where \( \pi_t = p_t + p_{t-1} \) is the inflation rate in year \( t \), \( y_t \) is an endogenous output variable, \( x_t \) is an exogenous variable, \( i_t \) is the monetary policy instrument (repo rate) and \( \varepsilon_t, \eta_t \) and \( \theta_t \) are shocks in year \( t \). The change in inflation is increasing in lagged output and the lagged exogenous variable. Output is serially correlated, decreasing in the lagged real repo rate, \( i_t - \pi_t \), and increasing in the lagged exogenous variable. The repo rate is believed to affect output with a one-year lag, and inflation with a two-year lag (These relationships are controversial and may vary across countries) and over time.

Since the repo rate affects inflation with a two-year lag, \( \pi_{t+2} \) is expressed in terms of year \( t \) variable and \( t+1 \) and \( t+2 \) disturbances:

\[
\pi_{t+2} = (\pi_t + \alpha_1 y_t + \alpha_2 x_t + \varepsilon_{t+1})
\]
\[ + \alpha_1 [ \beta_1 y_{t-1} + \beta_3 \bar{x}_t + \beta_5 x_t + \eta_{i+1} ] + \alpha_2 ( \gamma x_t + \theta_{i+1} ) + \varepsilon_{i+2} = \alpha_1 \pi_t + \alpha_2 y_t + \alpha_3 x_t + \alpha_4 i_t + ( \varepsilon_{i+1} + \alpha_1 \eta_{i+1} + \alpha_2 \theta_{i+1} + \varepsilon_{i+2} ), \]

where

\[ a_1 = 1 + \alpha_1 \beta_2, \quad a_2 = \alpha_1 (1 + \beta_1), \quad a_3 = \alpha_1 \beta_3 + \alpha_2 (1 + \gamma) \]

and \( a_4 = \alpha_1 \beta_2 \)

From my search, this is the only study that derives the inflation forecast in a detailed formula.

Martin & Milas (2013) and Caporale et al. (2018) assumed that policymakers respond to forecasts of inflation and the output gap over the coming quarter:

\[ r_t = \alpha_0 + \alpha_1 \sum_{k=1}^{3} ( E_t \pi_{t+k} - \pi' ) + \alpha_2 \sum_{k=1}^{3} ( E_t y_{t+k} ) + \varepsilon_t \]

where \( r_t \) is the short-term interest rate, \( \pi_{t+k} \) is the CPI inflation, \( \pi' \) is the inflation target and \( y_{t+k} \) is the output gap calculated as the difference between the log of output from its potential. The assumption of a 3-month horizon makes the specification similar to models estimated on quarterly data where policymakers react to expected inflation and output in the next period. Caporale et al. (2018), in particular, used the 3-month leading average of the inflation rate (calculated as the percentage from CPI). A 3-month lead average is used for all variables because it is assumed that policy makers respond to forecasts of inflation, the output gap and the exchange rate over the coming quarter. I contrast the result, a 3-month lead average, with the one with static expectations, which assumes that the next period will be the same as the previous one.

Three different ways to form expectations regarding the exchange rate have been used in the literature.\(^\text{15}\) The first perspective assumes that economic agents are rational and would form an unbiased estimator of future exchange rate. The agents will have perfect foresight and the actual

---
\(^\text{15}\) See Ouyang et al. (2010)
nominal exchange rate at the next period will be the proxy. In the second case, agents are assumed to have static expectations having the exchange rate of the current period as the proxy. The last view takes adaptive expectations forming forward-looking expectations. The 3-month non-deliverable CNY (Chinese Yuan Renminbi) forward rate is used.\textsuperscript{16}

For my study, I use the 3-month leading average of all variables (the inflation gap, the output gap and the exchange rate) which is similar to the method used by Caporale et al (2018). The rationale behind the 3-month lead average usage for all variables is that it is assumed that policy makers respond to forecasts of inflation, the output gap and the exchange rate over the coming quarter. However, I only come up with the perfect foresight approach and the static expectations approach for the monthly data models because I could not get the monthly projected data regarding the forward expectations approach model.

\textbf{2.2.4. Data for both studies (The Taylor rule and the Sterilization/Offset study)}

The data are quarterly and monthly ranging from 1990M1(Q1) to 2020M12(Q4).

The data are obtained from IMF IFS (Exchange rate, NFA, GDP) and the BOK ECOS (Monetary base, international reserves, M2). Fiscal balance is obtained from KOSIS (Korean Statistical Information Service) and RGDP (Real GDP) is obtained from FRED (Federal Reserve Economic Data).

For the visual inspection of the variables, the charts of the variables are contained on Fig. 1 and 2 (Appendix A).

- Interest rate

\textsuperscript{16} Note that some other studies also use the forward exchange rate.
For the Taylor rule, the benchmark interest rate of the Bank of Korea will be used.

- Inflation rate

For inflation rate, the Consumer Price Index (CPI) is most frequently used in studies. All the studies I have referred to have used CPI for the inflation rate. CPI is used to calculate the inflation rate and its t3-month leading average.

Inflation target is obtained from the Bank of Korea website for the years it has been published.

In principle, inflation rate, $\pi_{t-1}$, is measured as:

\[
\text{Inflation rate} = \left\{ \frac{\text{current CPI} - \text{CPI of the last quarter}}{\text{CPI of the last quarter}} \right\} \times 100
\]

For Sterilization/Offset studies, inflation rate (CPI annual percentage change) is calculated as:

\[
\Delta \pi_t = \log(cpi_t) - \log(cpi_{t-1}) \text{ for quarterly data}
\]
\[
\Delta \pi_t = \log(cpi_t) - \log(cpi_{t-12}) \text{ for monthly data}
\]

where $\Delta \pi_t$ is the inflation rate.

For the Taylor rule study, inflation rate is measured as:

\[
\sum_{k=1}^{3} \left( E_{t-1} \pi_{t+k} - \pi_t^r \right)
\]

For quarterly data:

\[
\pi_{t+k} = \frac{\pi_t + \pi_{t+1}}{2} \quad \text{for perfect foresight}
\]
\[
\pi_{t+k} = \pi_t \quad \text{for static expectation}
\]
\[
\pi_{t+k} = \frac{\pi_t + E_{t+1} \pi_{t+1}}{2} \quad \text{for forward expectation}
\]

For monthly data,
\[ \pi_{t+k} = (\pi_t + \pi_{t+1} + \pi_{t+2})/3 \quad \text{for perfect foresight} \]
\[ \pi_{t+k} = \pi_t \quad \text{for static expectation} \]
\[ \pi_{t+k} = (\pi_t + E_{t+1} \pi_{t+1} + E_{t+2} \pi_{t+2})/3 \quad \text{for forward expectation} \]

(17)

where \( \pi_{t+k} \) is the 3-month leading average of the inflation rate and \( \pi' \) is the inflation rate target. The inflation rate target is obtained from the website of the BOK. The difference between the two (\( \pi_{t+k} \) and \( \pi' \)) are the inflation gap.

- Exchange rate and a measure of intervention

Nominal exchange rates are measured as domestic currency per US dollar, period average.

For the Taylor rule study, the 3-month leading average of the log of the real effective exchange is obtained from the following equation:

\[ \sum_{k=1}^{3} (E_{t+k} \text{reer}_{t+k}) \]

For quarterly data:

\[ \text{reer}_{t+k} = (\log \text{reer}_t + \log \text{reer}_{t+1})/2 \quad \text{for perfect foresight} \]
\[ \text{reer}_{t+k} = \log \text{reer}_{t+1} \quad \text{for static expectation} \]
\[ \text{reer}_{t+k} = (\log \text{reer}_t + \log E_{t+1} \text{reer}_{t+1})/2 \quad \text{for forward expectation} \]

For monthly data:

\[ \text{reer}_{t+k} = (\log \text{reer}_t + \log \text{reer}_{t+1} + \log \text{reer}_{t+2})/2 \quad \text{for perfect foresight} \]
\[ \text{reer}_{t+k} = \log \text{reer}_{t+1} \quad \text{for static expectation} \]
\[ \text{reer}_{t+k} = (\log \text{reer}_t + \log E_{t+1} \text{reer}_{t+1} + \log E_{t+2} \text{reer}_{t+2})/2 \quad \text{for forward expectation} \]

(18)

where \( \text{reer}_{t+k} \) is the 3-month leading average of the log of the real effective exchange rate.

The Sterilization/Offset study uses the exchange rate in the following way:
\( \Delta \text{REER}_t \) is the change in the real effective exchange rate (REER) and is measured as:

\[
\Delta \text{REER}_t = \log(\text{REER}_t) - \log(\text{REER}_{t-1}) \text{ for quarterly data}
\]

\[
\Delta \text{REER}_t = \log(\text{REER}_t) - \log(\text{REER}_{t-12}) \text{ for monthly data}
\]

Specifically, the forward-looking real effective exchange rate will be the 3-month leading average of the natural log of the real effective exchange rate.

Regarding the exchange market intervention policy, the relative changes of both variables (reserves and the exchange rate) have to be analyzed to derive the extent of the intervention. For this, I followed the method on Willett and Kim (2006) and Willett (2009) to derive Combined Propensities to Intervene (CPI) as will be shown on Chapter 2.3.2.3.

- Output

For monthly data, industrial production is used. RGDP is used for quarterly data.

For the Taylor rule study, the output gap, \( y_{t+k} \), is calculated in the following way:

\[
\sum_{k=1}^{3} (E_{t+k} y_{t+k})
\]

For quarterly data:

\[
y_{t+k} = (3\text{-month leading average of log RGDP – HP filter trend} / \text{HP filter trend}
\]

where 3-month leading average of log RGDP

\[
= (\log \text{RGDP}_t + \log \text{RGDP}_{t-1}) / 2 \quad \text{for perfect foresight}
\]

\[
= \log \text{RGDP}_t \quad \text{for static expectation}
\]

\[
= (\log \text{RGDP}_t + \log E_t \text{RGDP}_{t+1}) / 2 \quad \text{for forward expectation}
\]

For monthly data:

\[
y_{t+k} = (3\text{-month leading average of log IPI – HP filter trend} / \text{HP filter trend}
\]
where 3-month leading average of log IPI
\[
= \frac{(\log \text{IPI}_t + \log \text{IPI}_{t+1} + \log \text{IPI}_{t+2})}{3}
\]
for perfect foresight
\[
= \log \text{IPI}_t
\]
for static expectation
\[
= \frac{(\log \text{IPI}_t + \log E_{t+1}\text{IPI}_{t+1} + \log E_{t+2}\text{IPI}_{t+2})}{3}
\]
for forward expectation

(19)

where \( y_{t+k} \), the output gap, is the proportional deviation of the 3-month leading average of the log IPI (or RGDP) from its Hodrick-Prescott (HP, 1997) trend.

However, due to the problems with the HP filter, I also use other estimates of trends including linear trends. Baxter-King (BK), Christiano-Fitzgerald (CF) and Butterworth (BW) filters are used.

The sterilization/Offset study measures \( Y_{c,t} \), cyclical income, which is the real output deviated from its trend scaled by the trend. The cyclical adjustment of the income is measured by HP filter trend. The variable is measured as:

\[
Y_{c,t} = \frac{[\log(\text{Real GDP}) - \text{HP filter trend}]}{\text{HP filter trend}}
\]

- Foreign interest rate

Since the Fed policy rate is zero for much of the period, I use short-term and medium-term rates of the US Treasury securities.

2.2.4.1. Data/variables that are only used for the Sterilization/Offset study

The following are the definitions and specifications of the data.
• Monetary variables

NFA$_t$ is foreign reserves denominated in domestic currency minus official foreign liabilities and is measured as:

\[ NFA^*_t = \text{Reserve} \times e_t - \text{Foreign Liabilities} \]

where $e_t$ is nominal exchange rate (KRW per US$)

$\Delta NFA^*_t$ is the change in $\Delta NFA_t$ without revaluation effect scaled by the GDP and is measured as:

\[ \Delta NFA^*_t = \frac{[NFA_t - NFA_{t-1}(e_t/e_{t-1})]}{\text{GDP}_t} \]

$\Delta NDA^*_t$ is the change in the (net domestic assets + net other assets – capital item) + revaluation effect scaled by the GDP and is measured as:

\[ \Delta NDA^*_t = \frac{[\Delta NDA_t + \Delta NOA_t - \Delta K_t + NFA_{t-1}((e_t/e_{t-1}) - 1)]}{\text{GDP}_t} \]

$mm_t$ is money multiplier for M2 and is measured as:

\[ mm_t = \frac{\text{M2}}{\text{Monetary base}} \]

$\Delta mm_t$ is the change in money multiplier for M2 and is measured as:

\[ \Delta mm_t = \log(mm_t) - \log(mm_{t-1}) \]

• Fiscal variable

$\Delta G_t$ is the fiscal deficit deviated from its trend scaled by the GDP. The trend is measured as HP filter.
\[ G_t = \frac{[G_t - HP \text{ filter trend}]}{\text{GDP}}. \]

- Exchange rate and foreign interest rate

Exchange rate and foreign interest rate are discussed above as two independent variables. However, the Sterilization/Offset study employs a variable named ‘exchange rate adjusted foreign interest rate’ that incorporates the two variables.

\[ \Delta(r_t + E_{t+1}) \] is the change in exchange rate adjusted foreign interest rate. The foreign interest rate is the interest rate of US 3-month treasury bill. \( F_{3\text{-month}} \) is the 3-month non-deliverable KRW forward rate. I use the following formulations representing three kinds of the expected change in the exchange rate:

\[
\begin{align*}
\Delta(r_t + E_{t+1}) & = \Delta(r_t + \ln e_{t+1}) \quad \text{if perfect foresight} \\
& = \Delta(r_t + \ln F_{3\text{-month}}) \quad \text{if forward-looking} \\
& = \Delta(r_t + \ln e_t) \quad \text{if static expectations}
\end{align*}
\]

2.2.5. Time periods & subsamples or structural breaks

Caporale et al. (2018) had a sample between 1998:01 and 2015:03 for Korea, so the significant portion of the Asian Financial Crisis in 1997 is omitted. At first, the study suggests the possible structural break by visual inspection. It is suggested that the Global Financial Crisis appeared to have a significant impact on the policy rates and the real effective exchange rates. Then, two unit root tests (allowing for up to \( m \) unknown breaks) were performed: They are the Lumsdaine and Papell (1997) test and Lee and Strazicich (2003) test. According to the test results, the break dates correspond to the 2001 dot-com bubble crash in the US and the 2007-08 Global Financial Crisis. All variables during the break dates are treated as I(0), which means the dummy indicator function equals 0 in equation (7).
Martin and Milas (2013) had a sample range between 1992 and 2010. The Quandt-Andrews breakpoint test was performed and detected a structural break at 2007 when the GFC erupted. Then, the model used in the study separated the data into a no-crisis period during 1992-2007 and a crisis period covering 2007-2010.

Originally, the time periods from my study range from 1990 to 2020 and I should consider both the Asian Financial Crisis (AFC) and the Global Financial Crisis (GFC) as breaks. However, since the BOK policy rate is only available after the adoption of inflation targeting during 1998 (after the AFC), the actual time period tested will be between 1999M5(1999q3) and 2020M12(2020Q4). Besides the whole period, there is only one break for the estimation. I add both dummy variables and drop the crises periods out of the estimates. For the first period, inflation targeting is estimated. For the second period, announced inflation targets is used.

The Independence of the BOK was strengthened by the revision of the Bank of Korea Act in December 1997 which entered into force in April 1998. Thus, the time period tested is a period when the BOK has become and remained independent. For the term period to analyze, I start with around 1990 and do one estimation for the whole period with dummy for the Global Financial Crisis and another where they do separate estimations for before and after the Crisis.

2.2.6. Stationarity

To check stationarity, stand unit root test, such as ADF (Augmented Dicky Fuller) test, is performed.

Regarding the global financial crisis, I look at the residuals from the basic estimating equations to see if the central bank behaves differently during this period.

2.3. Results: The Taylor rule studies

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17 After the 1997-98 financial crisis, Korea adopted inflation targeting using interest rate as an operational target. On September 30, 1998, the BOK began to use the interest rate as an explicit operational target.
2.3.1. The extended linear Taylor rule model and simple interest rate passthrough model

Before explaining the results, the following two models are explained: Simple interest rate passthrough model and the extended linear Taylor rule model. Also, the forward expectations framework is explained.

- Simple equation of interest rate passthrough

To examine the influence of the US monetary policy to the Korean policy, the following equation is estimated:

\[ r_t = \alpha_0 + \alpha_1 r_{us} + \epsilon_t \]  \hspace{1cm} (20)

where \( r_{us} \) is the interest rate for US treasury rate bill.

- Forward expectations framework

The forward expectations framework is only applied to the Taylor rule model using quarterly data. Since I couldn’t get the forward exchange rate, only inflation and output variables used projected values.

Inflation gap using forward expectations is calculated as:

\[ \text{Inflation gap} = ((\text{inflation rate} + \text{projected inflation})/2) - \text{inflation target} \]

Since I assume that policy makes respond to forecasts of inflation, the output gap and the exchange rate over the coming quarter, a 3-month lead average is used for these variables in the estimation (Svensson 1997, Martin and Milas 2013, Caporale et al 201).\(^{18}\) The inflation target is the announced inflation target rate and is obtained from the website of the BOK.

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\(^{18}\) This is explained on section 2.2.3. Forming expectations.
Output gap using forward expectations is calculated as:

$$\text{Output gap} = (\ln(\text{RGDP}) + \ln(\text{projected RGDP}))/2$$

The projected inflation rate and projected RGDP (which are quarterly) are extrapolated from the annual forecast of inflation rate and RGDP from the BOK.

- The extended linear Taylor rule

To examine the influence of the US monetary policy to the Korean policy, the interest rate of the US is added to the linear Taylor rule equation (5):

$$r_t = a_0 + a_1 r_{t-1} + a_2 \sum (E_{t-1} \pi_{t+k} - \pi_t') + a_3 \sum (E_{t-1} \beta_{t+k}) + a_4 \sum (E_{t-1} \beta_{t+k}) + a_5 r_{us} + \varepsilon_t \quad (21)$$

where $r_{us}$ is the interest rate for US treasury rate bill.

2.3.2. The extended linear Taylor rule results

The results from the simple interest rate passthrough models suggest that the Korean monetary authority has reacted to the US monetary policy on most occasions, but not strongly. Simple interest rate passthrough results on Table 1-1 and 1-2 illustrate the result of the simple equation (Eq.1) between US interest rate (explanatory variable) and the BOK policy rate (response variable). The coefficients on US interest rate are statistically significant across all periods for the whole period model. The coefficients are around 0.06 for both quarterly and are 0.025 for the monthly data. The results indicate that 1% increase in US monthly T-bill rate will raise the Korean policy rate by 0.025% on average for the monthly data. This is very small effect implying that the US interest rate does not have a major impact on Korean monetary autonomy.

However, the coefficients behave differently for the subperiod models. Before the GFC, US interest rate coefficients are significant (at 0.124 for the quarterly data and at 0.029 for the monthly data). These estimates are larger, but they are not high enough to be considered as having crucial impact on
Korean policy. The coefficients are not statistically significant during post-crisis period for both quarterly and monthly data.

### 2.3.2.1. Baseline results

The backward-looking Taylor model is shown on Table 2.

However, the limitation of the backward-looking Taylor rule model is explained well on Klein and Shambaugh (2015):

> A more complete picture would take into account the fact that policy if forward looking and based on high frequency data, that the changes in GDP and inflation respond contemporaneously to changes in the policy rate. Thus, we are not suggesting that estimates of the output gap and the inflation gap, used in this backward model, are the actual coefficients used in a policy reaction function.

I use the results from the backward-looking Taylor rule model as a reference to get a general idea, but not as a main baseline model, because the model is not quite reliable due to its limitations. For example, the adjusted R squared values (which are 0.489 before the crisis and 0.654 after the crisis) are quite low compared to the ones from the forward-looking Taylor rule models. The only part of the results that agree with the forward-looking model is the result of the inflation rate coefficient (which is statistically and economically significant during the postcrisis period) and the US interest rate coefficient which is statistically significant throughout.

Examining the results of Table 3 and Table 4, the Taylor rule model for the monthly data (Table 4) seems to have more explanatory power as there are more variables with statistical significance and the adjusted R square values are higher. The adjusted R square values of the quarterly data (Table 3) fluctuate around 0.76 – 0.92, while the values of the monthly data (Table 4) stay within the range of 0.97–0.99.
This makes sense because the BOK implements monetary policy according to its monthly monetary reports. However, the monthly data model does not have the results for the forward expectations perspective due to data availability. Although there are difficulties in forecasting accurately, perfect foresight models should bring the result closer to the forward exchange model because people seldom expect the economic indicators to remain as they are (static expectations view). So, I use the extended Taylor rule model of the perfect foresight for the monthly data with subperiods for the analysis because it is the most intelligible model among all relatively.

I focus on this model for the following analysis on Table 5 and 6. On both tables, I progressively include variables in succeeding columns. The US interest variable is estimated on the first specification, (1). Exchange rate variable is added on the second specification, (2), because there is a meaningful correlation between US interest rate variables and Exchange rate variable. The third specification, (3), adds the inflation gap and the output gap variables. Since both the inflation gap and the output gap variables are weakly correlated to US interest rate variable, they are added on the last column together.

Table 5 reports the results of the model during the pre-crisis period. The first specification (1) estimates the coefficient on the US interest rate with no control variables. This part is identical to the simple interest rate passthrough model in Table 2. The coefficient is positive and statistically significant equaling 0.029 (meaning that 1% increase in US interest rate increases Korean policy rate by 0.029%) which is a very small amount. On the second specification (2), the coefficient on US interest rate remains significant with a slightly smaller magnitude (at 0.022) while the coefficient on the exchange rate is positive but not significant (at 0.128). Although not statistically significant, the magnitude of the exchange rate coefficient is much larger (about six times) than the magnitude of the US interest rate coefficient. The results indicate that increases in the Korean policy rate are likely to occur with increases of the US interest rate after discounting the effect of exchange rates between the US and Korea. On the other hand, a slightly smaller magnitude of the US interest coefficient when including the Exchange rate variable suggests that the effect of the US interest rate is partly explained by the Exchange rate. Furthermore, the positive correlation between US interest rate and Exchange
rate (which is 0.4110) along with the positive correlation between US interest rate and Korean policy rate implies, and confirms, that the effect of US interest rate on Korean policy rate is overestimated in the first specification.

There are two major routes that the US interest rate affects the Korean policy rate. The US interest rate can directly affect Korean policy rate or the US interest rate can affect Korean policy rate via the exchange rate. The larger US interest coefficient on the first specification (0.029), than the US interest coefficient on the second specification (0.022), implies that the second route (vis the exchange rate) also has a positive impact from the US interest rate to Korean policy rate. This finding is reasonable because the correlation between the US interest rate and the exchange rate is positive and the exchange rate coefficient is positive (although not statically significant).

The third specification (3) shows that the coefficient on US interest rate still remain statistically significant and positive (at 0.020). The magnitude of the US interest rate coefficient, while very small, does not decrease much: Thus, it seems US interest rate still has an independent and statistically significant association with Korean monetary policy even though the magnitude tells that its impact on Korean monetary policy is not economically significant. Meanwhile, the coefficient on the inflation gap is not significant and negative (at -0.130) and the coefficient on the output gap is statistically significant and negative (at -4.65e-06), which indicate that one percent increase of IPI in the output gap (the deviation of the foreseeable output from the output trend) hardly impacts Korean monetary policy given the miniscule magnitude of the coefficient.

However, the inflation gap and the output gap do little to explain the effect of US interest on Korean monetary policy because the domestic economic variables (inflation gap and output gap) are very weakly correlated with US interest rate in this model for the precrisis period. The correlation between the US interest rate and the inflation gap is -0.0300 and the correlation between the US interest rate and the output gap is -0.0550 in the regression for the precrisis period. The failure to find a significant effect of the exchange rate in Table 6 does not necessarily mean that the currency value is not an important concern to the BOK. Much of the research suggests that the exchange rate does matter for the monetary policy in Korea and other emerging Asian economies (Thailand for example). For
instance, McCauley (2006) similarly found no significance of the exchange rate coefficient when the Taylor rule for Thailand was estimated. McCauley believed that the exchange rate does matter for the Thailand monetary policy and that the failure to find a significant effect may mean that another instrument is employed to limit the exchange rate fluctuations. Miles and Schreyer (2012) suggest that there is a strong possibility that the instrument would be exchange market intervention. This is the motivation to test the Combined Propensities to Intervene (CPI) on Table 8-3.

Table 6 illustrates the results of the Taylor rule model during the post-crisis period. The coefficient on US interest rate on the first specification is statistically insignificant and positive (at 0.009). On the second specification, the US interest rate coefficient becomes statistically significant and positive (at 0.027), which is very small, and the coefficient on exchange rate is significant and negative (at -0.224) meaning that one unit increase of the expected REER (one Won depreciation per US$ in real terms) is associated with 0.224% decrease in Korean policy rate. While the coefficient on the US interest rate is still very small, the magnitude of the coefficient on the exchange rate is relatively larger (which is almost eight times larger, in absolute values, than the US interest rate coefficient). This indicates that the exchange rate is more economically important than the US interest rate is directly regarding their impact on Korean monetary policy.

The results show that the inclusion of the exchange rate variable reveals the true effect of US interest on Korean monetary policy as the variable (US interest rate) no longer captures the partial effect of the exchange rate variable (meaning the presence of the exchange rate is discounted). Specifically, the negative correlation between the exchange rate and Korean policy rate and positive correlation between US interest rate and the exchange rate variable (which is quite significant at 0.5704) reveal that the effect of US interest rate on Korean monetary policy is underestimated on the first specification. It is evident that the exchange rate variable (which is significant and negative) had a partial effect on US interest variable weakening its original effect (which is significant and positive) on the first specification. Also, it is notable that the exchange rate is found to be an important omitted variable when the effect of US interest rate on Korean monetary policy is analyzed.
The negative coefficient on the exchange rate can be explained in the following ways. The BOK monetary policy reports (section 2.3.2.2.) show that the sustained domestic economy downturn tends to lead won depreciation (against US dollar, the exchange rate increases) and eventually the BOK implements expansionary monetary policy to address the sluggish economy. Thus, it is domestic economy slowdown that triggers the monetary authority to engage in an expansionary policy. On the other hand, a low economy tends to lead to won depreciation and eventually the policy rate decreases. So, the J-curve effects do not seem to be prevalent.

So, there seems to be multiple routes that the US interest rate affects Korean policy rate during the postcrisis period. The first route is a direct route of the US interest rate that influences Korean policy rate. Its magnitude is 0.027 shown on the second specification. The second route can work this way: The US interest rate hike can induce won to depreciate against US dollar (the exchange rate increase) and Korean policy rate can be raised to attract capital inflows. The monetary policy reports from section 2.3.2.2. reveal that the US interest rate changes affect the exchange rate via international capital flow movements, but the US monetary policy and its effect on capital flows do not directly, but rarely, affect Korean monetary policy changes. So the impact from this route can be minimal.

The third route is also the paths from the US interest rate to Korean policy rate through the exchange rate, albeit with a different impact. The net effect of the combined two route, which is 0.009 (although not statistically significant), implies that the third route brings on negative impact of the US interest rate on Korean policy rate. This seems reasonable because the negative coefficient of the exchange variable is more economically significant than the positive impact the US interest rate has on the exchange rate.

It seems the path from the US interest rate to the exchange rate and the one from the exchange rate to Korean policy rate are working individually. As explained on section 2.3.2.2., the status of domestic economy is a deciding factor that affects the exchange rate and Korean monetary policy eventually.
The monetary policy reports from section 2.3.2.2. reveal that the US interest rate changes affect the exchange rate via international capital flow movements, but the US monetary policy and its effect on capital flows do not directly affect Korean monetary policy changes.

So, we can infer that the net negative impact, that the US interest rate have on Koren policy rate through the exchange rate, can be understood as the positive impact that the US interest rate has on the exchange rate is deflected, and overwhelmed, by the stronger negative impact that the exchange rate has on Korean policy rate.

The third specification demonstrates that the coefficient on US interest rate stays significant and positive with a similar magnitude (at 0.025) and the coefficient on the exchange rate remains significant and negative with a slightly smaller magnitude in absolute value (-0.173). Still, the coefficient on US interest rate is very small and the coefficient on the exchange rate is much larger (in absolute values). It is hard to attribute the slightly larger exchange rate coefficient to the inclusion of the inflation gap and the output gap variables because the correlation among them (the inflation gap/output gap and the exchange rate) are very weak. The coefficient on the inflation gap, which is significant and positive with sizeable magnitude (at 10.067), is totally implausible because its interpretation doesn’t make sense: The coefficient means that one point increase in the inflation gap (the deviation of the foreseeable inflation rate from the inflation target) is associated with 10.067% increase of Korean policy rate. Additionally, the standard error for the coefficient is too high equaling 4.270. The wildly absurd coefficient on the inflation gap can be attributed to the application of perfect foresight perspective to the model. As can be seen from Table 3, only the forward expectation approach for the quarterly data contains the reasonable coefficient gap on the inflation gap, which is significant and positive (at 0.437) and has a standard error equaling 0.145. This makes sense because perfect foresight approach merely uses the future values of the next period in place of the expected values, but the future values are not the expected values. Since we do not have a result of the forward expectation approach for the monthly data (due to data availability), we can only conclude that I cannot have any confidence in the coefficient on the inflation gap on Table 6. The coefficient on the
output gap, which is not significant and negative (at -3.47e-08), reveals that the output gap has almost zero impact on Korean monetary policy.

To sum up, the results so far indicate that the US interest rate do have an independent and statistically significant association with Korean monetary policy before and after the GFC. However, it is hard to label US interest rate as having a major impact on Korean monetary policy because the magnitude of the coefficient on US interest rate is very small indicating not a meaningful economic significance.

On the other hand, the magnitude of the coefficient on the exchange rate (in absolute values) is much larger than the coefficient on the US interest rate (the absolute values are about seven to eight times larger). Evidently, the exchange rate variable is more significant economically than the US interest rate regarding their effects on Korean monetary policy. So, the results up to this point firmly weaken the argument of Rey (2015) that exchange rate has become a less important mediator to achieve an independent monetary policy.

Furthermore, the results bolster the idea that the exchange rate plays an important role in monetary policy of Korea as suggested by much of the cited research. Dooley et al (2002) believe that the BOK pursued exchange rate stability as a monetary goal. Parsley and Popper (2009) also explained that the BOK pursues exchange rate stability as a monetary policy goal. However, this study finds that the central bank actively targets inflation, but the exchange rate has been only indirectly important in Korea. Specifically, the exchange rate is found to influence monetary policy only indirectly through its effect on output and inflation in Korea.

This finding is somewhat in line with the results of the precrisis period model in Table 5. Since the above-stated studies deal with the data before the GFC, their analysis can be compared to the results from Table 5. Although the coefficients on the exchange rate from Table 5 are not statistically significant, the overall results of Table 5 indicate that the exchange rate still partially explains the effects of the US interest rate on Korean monetary policy. So, the indirect importance of the exchange rate in Korea (on Parsley and Popper, 2009) may be reflected on the relatively weak coefficient on the
exchange rate (both statistically and economically) before the crisis. However, my study does not find the indirect route of the exchange rate influencing monetary policy through the effect on output and inflation. The inclusion of the inflation gap and the output gap on the third specification of Table 5 do not seem to alter the coefficient on the exchange rate much before the crisis and the low correlation between the exchange rate variable and the inflation gap (or the output gap) confirm the finding.

The results of the post-crisis period reflect more influence of the exchange rate variable on Korean monetary policy as indicated by the significant (both statistically and economically) coefficient on the exchange rate after the crisis. The magnitude of the coefficient on the exchange rate is much larger than the one of the US interest rate coefficient (it is about seven to eight times larger). So, it seems the exchange rate has a stronger impact on Korean monetary policy than the impact of the US interest rate.

The negative impact that the exchange rate has on Korean monetary policy implies that the status of Korean economy plays an important role regarding the influence of the exchange rate on Korean monetary policy after the GFC.

While the result shows that the US interest rate has an independent link with Korean monetary policy, the result also implies that the US interest rate and Korean policy rate can be linked via the exchange rate. The partial effect of the exchange rate on Korean monetary policy is initiated by US interest rate, making the exchange rate as a mediating variable. Thus, a part of US interest rate has an independent link with Korean policy rate and a part of US interest rate impact Korean rate through the exchange rate.

For instance, an increase in US interest rate can be directly associated with an increase in Korean policy rate, by a magnitude of 0.027: An increase in US interest rate can raise the exchange rate (Won depreciates against US dollar) causing higher policy rate to attract more capital inflows. However, an
increase in US interest rate can raise the exchange rate (Won depreciates against US dollar) which occurs with a decrease in Korean policy rate.

On the other hand, an economic downturn can induce won to depreciate (increasing the exchange rate) causing the monetary authority to implement expansionary monetary policy. For instance, a decrease in US interest rate can be directly associated with a decrease in Korean policy rate, by a magnitude of 0.027. However, a decrease in US interest rate can lower the exchange rate (Won appreciates against US dollar) which results in the buildup of reserves (intervention policy) causing an improvement of the balance of payment and an expansionary monetary policy to repel further capital inflows.

That is how the contrasting effect of the two routes have caused the ambiguous (not significant and smaller) US interest coefficient, which is 0.009, on the first specification for the postcrisis period (Table 6).

Apart from the US interest rate, there can be other variables that influence the exchange rate. The variables pertaining to money supply, such as M2, reserves and net domestic assets (NDA), can influence the exchange rate. Other factors can be the developments in other economies, and developments in Korea such as shifts in export demands and capital flows. Inflation differentials will be one but not the only factor.

2.3.2.2. The Bank of Korea monetary policy report analysis: the exchange rate

(1) The analysis of the exchange rate during the pre-crisis period (1990:m1 – 2007:m11)

According to the charts on Table 12, the BOK policy rate and the exchange rate during the pre-GFC period show similar trends of movements. Both of them hit the low point during 2005m10 and reach peak right before the GFC during 2008m8. So, the simple visible inspection of the two variables tells me that the exchange rate and the BOK policy rate are likely to have a positive correlation.
The BOK policy rate during the precrisis period experiences one subperiod experiencing the rate decreases and two subperiods experiencing the rate increases: The rate increases from 1999m10 to 2001m1 (from 4.75% to 5.25%) and from 2005m10 to 2008m9 (from 3.25% to 5.25%). The rate decreases from 2001m2 to 2005m9 (from 5.25% to 4.00%).

Examining the monthly monetary policy reports, the sustained economy growth gives rise to won appreciation against US dollar (the exchange rate decrease) leading to an expansionary monetary policy (the policy rate decreases). Once the policy rate increases to cool down the economy, the economy slows down. This will cause won to depreciate amidst the period of the policy rate hikes. For instance, after the local minimum point at 2005m10, where the policy rate and the exchange rate hit the lowest points during the precrisis period, won begins to depreciate and the policy rate increases steadily.

The sequences of the positive correlations of won depreciation (appreciation) and the policy rate increases (rate decreases) could have been formed because there had been concerns regarding the balance of payment during the period between AFC and GFC. It is well known that the most alarming economic indicator that had raised concern regarding the AFC was the current account deficit. When the crisis hit, the policy rate was initially raised to a stratospheric level to ward off a collapse in the external balance of payments (Kim and Lee, 2011). The monetary policy reports show that the trend continued up until the GFC hit. Even during early to mid-2000s, Koren monetary authorities have paid avid attention to the current account balance. As can be explained on Section 2.3.2.3., international reserves, which was not as high as compared to the post-GFC period, had been accumulating as a safety measure.

Another reason that can explain the positive correlations of won depreciation (appreciation) and the policy rate increases (rate decreases) can be found from the responsiveness of the BOK to the US monetary policy. The BOK may not have closely monitored and responded to the US monetary policy during the precrisis period. According to the monetary reports, the BOK seems to scrutinize and follow the stance of the US monetary policy only after the GFC. Accordingly, the change of the expectations regarding the US monetary policy stance have affected the exchange rate (won against
(2) The analysis of the exchange rate during the post-crisis period (2009:m7 – 2020:m12)

Observing the charts on Table 12 (of the BOK policy rate, the US interest rate and the exchange rate, REER) after the postcrisis period, the BOK policy rate seems to go through overall declining trend and the exchange rate goes through increasing trend generally.

Specifically, the BOK policy rate during the postcrisis period experiences three subperiods of rate decreasing periods and two subperiods of rate increasing periods: The rate increases from 2010m7 to 2012m6 (from 2.00% to 3.25%) and from 2017m11 to 2019m6 (from 1.25% to 1.75%). The rate decreases from 2012m7 to 2017m10 (from 3.25% to 1.25%) and from 2019m7 to 202012 (from 1.75% to 0.50%). Overall, the net change of the policy rate is -1.50% and the total subperiods experiencing the rate decreases (six years and eight months) greatly exceeds the total subperiods experiencing the rate increases (two years and six months). So, the visible inspection that the BOK policy rate declines overall is found to be right.

The trend of the exchange rate changes during the period is more obvious: The REER mostly increases from the initial value of 89.74 to the final value of 141.12. Thus, analyzing the trends of the exchange rate (decreasing) and the BOK policy rate (increasing), I can say that the two variables may have a negative correlation.

For more in-depth analysis, the monthly monetary policy reports will be referred to. According to the reports, the Korean won tends to appreciate against US dollar (the exchange rate declines) in the following cases:

- When the domestic economy sustains steady and strong growth:
- When there are foreign investment inflows: The inflows are mostly caused by the easing monetary policy of the advanced economies (mostly by the US rate decreases) or its
expectations. For instance, quantitative easing of the advanced economies during 2012m10 and 2013m1 have caused foreign investment inflows and consequently won appreciation.

- When there is a current account surplus
- When global risk factors subside. US-China trade dispute negotiations eased the tension in the global market and domestic economy. This may have contributed to the appreciation of won.
- US government exchange rate policy can affect the exchange rate: Newly elected Trump administration has implemented an exchange rate policy to weaken the US dollar during 2017m2 (most likely for mercantilist purpose). Consequently, won against US dollar appreciated.

And the won tends to depreciate against US dollar (the exchange rate increases) in the following cases:

- When the domestic economy slows down.
- When there are foreign investment outflows: The outflows are mostly caused by the tight monetary policy of the advanced economies (mostly by the US rate increases). For example, tapering off of the quantitative easing of the US during 2013m6 have led foreign investment outflows and won depreciation.
- Sometimes, the improvement of the US economy precedes won depreciation.
- When there is global and domestic economy downturn due to global risk factors or volatile financial market. For instance, global risk factors, such as US-China trade disputes, or disasters, such as the outbreak of COVID-19, can cause won depreciation.

From the findings from the monetary policy reports, it is notable that a sustained domestic economy downturn tends to lead won depreciation (against US dollar, the exchange rate increases) and eventually the BOK implements expansionary monetary policy to address the sluggish economy.

However, won depreciation led by foreign capital outflows (mainly due to US interest rate increases) does not seem to trigger the BOK to implement monetary policy to ease the situation. During the
extended period of won depreciation, due to strong US dollar and US interest rate hike, from 2014m8 to 2015m12, the Korean policy rate has actually decreased four times from 2.50% to 1.50%. So, the BOK did not attempt to counter the capital outflows using monetary policy at all during this period of time. Indeed, the continuous rate decreases are preceded by the slow economy.

The impact of the US interest rate on Korean policy rate via the exchange rate does not seem to be significant. Won depreciation and capital outflows caused by US interest rate hike rarely affect Korean monetary policy. In theory, a US interest hike can cause won depreciation (and capital outflows) and, consequently, the BOK can lower the policy rate to fend off further outflows and currency depreciation. However, the reports show that the importance of the domestic economy heavily outweighs the concern regarding the balance of payment and the exchange rate.

Thus, it is domestic economy slowdown that triggers the monetary authority to engage in expansionary policy. Slow economy tends to lead won depreciation and eventually the policy rate decreases. The direct link between the exchange rate and the policy rate does not seem to be substantial so far.

**2.3.2.3. Combined Propensities to Intervene (CPI)**

In addition to the analysis of the interest rate passthrough from US to Korea, I find it important to examine Korea’s exchange rate policy because (1) the US interest rate affect the exchange rate and the exchange rate policy of Korea and (2) the US interest rate influence Korean monetary policy via the exchange rate (shown on Table 6). Regarding the exchange rate policy, intervention through the management of reserves has been used extensively in Korea. Aizenman et al (2011) explain the role that foreign reserves play in Asian emerging economies seeking to limit exchange rate movements.

To observe how reserves are used as a way to intervene and manage the exchange rate, the relative changes of both variables have to be analyzed to derive the extent of the intervention. For this, I followed the method on Willett and Kim (2006) and Willett (2009) to derive Combined Propensities to Intervene (CPI) where it is calculated in the following way:
CPI = \( \frac{\sum \Delta R}{\sum \Delta R + \sum \Delta E} \)

where \( \sum \Delta R \) = Sum of monthly changes in reserves (as a percentage of one-month lag of M2) for the subperiods and \( \sum \Delta E \) = Sum of monthly log changes in exchange rates for the subperiods.

In this study, I divide the time periods into two subperiods: the first period contains the pre-crisis (GFC) period and the second period includes the post-crisis period. I did not divide the periods into more subperiods according to the exchange rate changes because the aim of the analysis is to observe the general tendency of the monetary intervention policy before and after the crisis.

Table 8-1 and 8-2 show the size of exchange rate movement changes over time and the changes in international reserves, used to slow down the movements of the exchange rates, over time. To get a better idea of the varying degrees of official management of the exchange rate, Table 8-3 presents the estimation of the authorities’ combined propensities to intervene (CPI) over the time periods around the GFC. The rapid accumulation of the reserve during the period implies that an intervention of a given size would yield a much lower percentage in reserves toward the end of the period than at the beginning. To correct for this, I calculate reserve changes as a percentage of the previous month’s M2.

During the pre-crisis period (1990m1-2007m11), there was a huge increase in reserves (148.06%) compared to the relative change in the exchange rate (34.18%), implying that building up adequate levels of reserves had been a major objective then (even though the CPI is high at 0.812). The finding that reserves had been accumulated regardless of the exchange rate movements indicates that the lack of cohesion between reserves and the exchange rate (and the US interest rate) can be attributed to the lack of intervention.

In the period after the crisis (2009m7-2020m12), the reserves increase (16.26%) and won appreciates against US dollar (the exchange rate decreases by 13.36%) produce the CPI value of 0.549. This implies that heavy intervention, which is consistent with a mercantilist interpretation, took place to limit the loss of export competitiveness owing to the substantial appreciation of the won.

The charts on Table 12 indicates that, while the exchange rate have fluctuated, reserves steadily increased from the aftermath of the Asian Financial Crisis most times. From the analysis of the CPI, it...
seems that the motivation to accumulate reserves has changed from the pre-crisis period to the post-crisis period.

To sum up, the reserve accumulation before the GFC was intended to amass enough level of reserves as a precautionary measure to safeguard against possible economic downturn (Bird and Rajan, 2003). Like other Asian countries hit hard by the AFC, Korea have amassed reserves and have done it beyond plausible precautionary levels. However, the reserve buildup after the GFC seems to be mainly due to intervention policy of the BOK to counter the domestic currency appreciation. The active intervention can be explained by a mercantilist view because the policy has taken place to avoid the rapid appreciation of the won that can make exports less competitive. The result from Table 8-3 is comparable to the result from the Taylor rule models (Table 5-6). The heavy intervention during the post-crisis period (on Table 8-3), indicate that the changes of the exchange rate and reserves are highly correlated (the correlation between the exchange rate and reserves increase from -0.32, during the pre-crisis period, to 0.84, during the post-crisis period) then. And the heavy intervention in the post-crisis period implies that the monetary policy (between the US and Korea) and the exchange rate policy of Korea (to intervene the exchange rate movements) are interlinked.

Again, the results contradict Rey’s (2015) assertion that independent monetary policy is possible if and only if capital account is managed. The active exchange rate policy does influence Korean monetary policy. Furthermore, the persistent intervention policy may have bolstered the link between the US interest rate and Korean policy rate by limiting the decrease of the exchange rate and its impact on Korean monetary policy.

This conclusion makes sense if the BOK is able to effectively sterilize most of its interventions in the exchange market. In this regard, it will be worthwhile to test if Korea has sterilized its interventions in the next chapter (Sterilization and Offset study).
Chapter 3: The Sterilization and offset coefficients

The sterilized intervention has been operated widely in unpegged exchange rate regimes and also in pegged regimes. It allows exchange rate regimes to be separated from the domestic monetary policy in the short run (Willett et al., 2009). Thus, under a fixed exchange rate regime and imperfect capital mobility, sterilization is one of the monetary policies that can be performed.

However, the caveat lies in the degree of factors in the model. Suppose capital is highly mobile but not perfectly so. And many economies claim to have floating exchange rate de jure, which is actually managed float regime de facto because they intervene in the foreign exchange market.

3.1. Literature review: Brief background of the past empirical methodologies of estimating the extent of sterilization

To estimate the scope of sterilization, I cannot just examine the correlations between the reserve changes and the base (or money supply) because I would not know what variables are exogenous and endogenous. Thus, it may be helpful to examine the types of equations used to derive sterilization and offset coefficients in other papers.

Ouyang et al. (2010) classified the following three groups of current studies that estimate the extent of sterilization from the earlier simple model to more advanced simultaneous equations.

The first group of the studies estimated sterilization coefficients on the monetary policy reaction function of central banks such as the following:

$$\Delta NDA_t = c_0 + c_1 \Delta NFA_t + X' \beta + u_t$$

(22)

where $\Delta NDA_t$ and $\Delta NFA_t$ represent the change in net domestic assets and net foreign assets, respectively. $X$ represents other explanatory variables that might influence a monetary authority’s reaction. This group of studies assume that capital flows are exogenously determined. Hassan et al. (2013) used the equation to measure sterilization coefficients.
The second group used a VAR model to estimate the lagged effects of NDAs and NFRs in the following forms:

\[
\Delta NDA_t = a_{10} + \sum_{i=1}^{k} a_{1i} \Delta NDA_{t-i} + \sum_{i=1}^{k} \beta_{1i} \Delta NFA_{t-i} + \epsilon_{1t}
\]

(23)

\[
\Delta NFA_t = a_{20} + \sum_{i=1}^{k} a_{2i} \Delta NFA_{t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta NDA_{t-i} + \epsilon_{2t}
\]

(24)

The important limitation of this approach is that all variables are treated as endogenous and that it cannot estimate the contemporaneous effects among the variables.

The third group estimated the contemporaneous relationship between NDAs and NFRs using a set of simultaneous equations. It is noted that domestic monetary conditions are altered by changes in international capital flows and foreign reserves. And, at the same time, international capital flows respond to a change in domestic monetary conditions. The simultaneous equations are specified as:

\[
\Delta NFA_t = a_{10} + a_{11} \Delta NDA_t + X_1 \beta_1 + \epsilon_{1t}
\]

(25)

\[
\Delta NDA_t = a_{20} + a_{21} \Delta NFA_t + X_2 \beta_2 + \epsilon_{2t}
\]

(26)

where \(X_1\) and \(X_2\) are the vectors of controls in the respective functions. Eqs. (25) and (26) are the balance of payments and the monetary reaction functions, respectively. The coefficient \(a_{11}\) represents the offset coefficient which is bounded by 0 during no capital mobility stage and -1 when capital mobility is perfect. The coefficient \(a_{21}\) represents the sterilization coefficient with -1 representing perfect sterilization of reserve buildup and 0 meaning no sterilization of the central bank. Brissimis et al. (2002), Ouyang et al. (2008), Ouyang et al. (2010) used the third group of the estimation to derive the two coefficients. I will use this method.

There is one study that I think is noteworthy to mention. Herring and Marston (1977) derived the two coefficients separately. The offset coefficient is calculated from a structural model of asset demands and supplies, a portfolio model:

\[
\alpha_1 = \frac{\{H_{b}^{dl} - F_{b}^{pd}\}}{\{qDD_b - (H_{b}^{dl} - F_{b}^{pd})\}}
\]

(27)
where $\alpha_1$ is the offset coefficient, $DD_b$ is the demand for bank deposits, $H_{hf}^{fd}$ is home bonds held by foreign investors, and $F_{hf}^{pd}$ is foreign bonds held by home investors.

The sterilization is derived separately from the loss function of monetary authorities. The loss function includes inflation and output as control variables and has foreign exchange reserves as the independent variable. Interestingly, the equation to derive sterilization coefficient resembles the monetary reaction function used for the Taylor rule:

$$\Delta MP = a_1 q_1 \Delta Z + a_2 \Delta RFX$$  \hspace{1cm} (28)

where $a_2$ is the sterilization coefficient, $\Delta MP$ is the change in monetary policy, $\Delta Z$ is current and lagged changes in domestic variables (including inflation and output changes), and $\Delta RFX$ is the changes in foreign exchange reserves.

I find this study significant because of its pioneering work during early days. Although the study had not reached the stage to develop simultaneous equations for sterilization and coefficient variables, it has probably triggered the advent of the improvement of the subsequent models. For instance, the study recognized the importance of examining offset coefficient and sterilization coefficient together to have a complete picture of the analysis. And, to my knowledge, this may be the first paper to include monetary loss function when sterilization coefficient is derived. The only notable limitation of the study may be not incorporating the analysis of the two coefficients and having complete separate section on each variable.

3.2. Methodology and data

Although Ouyang et al. (2010) is the only study that contains Korea as a sample country, most of the papers that I have referred to apply the identical method to derive sterilization and offset coefficients. Ouyang et al. (2008), and Ouyang and Rajan (2011) followed the same method while Wang et al. (2019) applied a slight modification. They followed a modified BGT model (Brissmis et al., 2002) in which the study has used the similar framework of the method, where the simultaneous equations are derived from the minimization of a loss function of the monetary authority. Thereby, the variables used on the baseline equations for these studies are almost identical.
The only study that shows vast difference in variables is Hassan et al. (2013). As the study used the simple reaction function of central banks, only NFA and DC (Domestic Credit) and inflation rate are used as main variables. For the BGT model, the data expanded to include more variables. In addition to NFA, NDA (which is analogous to DC) and inflation rate, there are money multiplier, exchange rate, income, foreign interest rate and government spending variables. The BGT model indicates that each variable is connected organically with each other. All variables are endogenous while being interlinked with each other forming the constraints in the loss function. The only variable that is exogenous in the BGT model is the current account (the current account is endogenized in the modified BGT model). However, previous literatures, such as Hassan et al. (2013), had each equation estimated individually and the endogenous variables are chosen in an *ad hoc* manner.

### 3.2.1. Methodology


Wang et al. (2019) followed the similar framework of the previous papers to derive the sterilization and offset coefficient with a noticeable difference of including reserve requirement ratio into the equations. However, I decided to abstain from using the model from Wang et al. (2019) for the following reasons: (1) The study shows that the results including the reserve requirement ratio did not produce significantly different result from the results from the model sans the reserve requirement ratio. (2) For Wang et al. (2019), which focus solely on China, it is said that the reserve requirement ratio remains a major policy tool in China. My study considers only Korea where a variety of monetary target policy has been set (Willett, 2009). However, I checked if there have been any changes in reserve requirements in Korea.

Using the framework of simultaneous equations from Ouyang et al (2010), I estimate offset and sterilization coefficients for Korea in the following form:
\[ \Delta NFA_t = a_0 + \sum a_{1i} \Delta NDA_{t,i} + \sum a_{2i} \Delta mm_{t,i} + \sum a_{3i} \Delta p_{t,i} + \sum a_{4i} \Delta Yc_{t,i} + \sum a_{5i} \Delta REER_{t,i} + \sum a_{6i} \Delta (r_{t,i}^* + E_t e_{t+1,i}) + \epsilon_t \]  
(29)

\[ \Delta NDA_t = \beta_0 - \sum \beta_{1i} \Delta NFA_{t,i} + \sum \beta_{2i} \Delta mm_{t,i} + \sum \beta_{3i} \Delta p_{t,i} + \sum \beta_{4i} \Delta Yc_{t,i} + \sum \beta_{5i} \Delta G_{t,i} + \sum \beta_{6i} \Delta (r_{t,i}^* + E_t e_{t+1,i}) + \nu_t \]  
(30)

where \( \Delta NFA_t \) is the annualized monthly/quarterly change in the adjusted net foreign assets scaled by the GDP; \( \Delta NDA_{t,i} \) is the annualized monthly/quarterly change in the adjusted net domestic asset scaled by the GDP; \( \Delta mm_{t,i} \) is the annualized monthly/quarterly change in money multiplier for M2; \( \Delta p_{t,i} \) is the annualized monthly/quarterly change in consumer price index; \( Yc_{t,i} \) is cyclical income; \( \Delta G_{t,i} \) is cyclical fiscal balance scaled by GDP; \( \Delta REER_{t,i} \) is the annualized monthly/quarterly change in the real effective exchange rate; \( \Delta (r_{t,i}^* + E_t e_{t+1,i}) \) is the annualized monthly/quarterly change in foreign interest rate plus the expected nominal exchange rate (KRW/US$; \( e_t \) = Nominal exchange rate (KRW per US$). While the interest rate is used as the indicator of monetary policy in the Taylor rule, the money supply is USED as the indicator in the sterilization studies.

Figure 3 and 4 (on Appendix A) contain charts of the variables.

### 3.2.2. Data/variables

Variables in the equations are explained in chapter 2.2.4 and 2.2.4.1. The balance of payment function is represented by equation (29) and the monetary policy function is illustrated by equation (30). The coefficient \( \sum \alpha_i \) is the offset coefficient and coefficient \( \sum \beta_i \) is the sterilization coefficient respectively.

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19 On data section (2.2.4.), the cyclical adjustment of income is estimated and the differences or similarities of the income estimation from the Taylor rule is explained.
3.3. Time period & Subsamples from structural breaks, other issues and directions for future research

Ouyang et al. (2008) has the sample period from 1990 to 2005. A Chow breakpoint test result confirms that there was a structural break post-crisis (AFC). The study divides the sample period into two subsamples: The pre-crisis period is between 1990:q1 and 1997:q1 and the post-crisis period is between 1998:q3 and 2005:q3. It is notable that the crises period (1997:q2 – 1998:q2) is excluded from the subsamples. Brissmis et al. (2002) has the sample from 1980 to 1992. To capture the effect of German monetary unification on the domestic money supply, the baseline equation includes a dummy (which takes the value of 1 in the third quarter of 1990 and a value of zero otherwise).

For my dissertation, the estimations are based on the sample period from 1990M1(Q1) to 2021M12(Q4). A version that takes the whole period that does not take out major financial crises (the Global Financial Crisis) will be tested. Besides the whole period, I also use breaks for the estimation. All the breaks and subsamples used for the Taylor rule are applied in the same manner for sterilization studies. Equivalent to the Taylor rule, the global financial crisis during 2008 is used as breaks.

To account for the crises and other structural breaks in the sample, I add dummy variables or drop the crises periods out of the estimates.

3.3.1. Other issues

Stationarity is checked for the variables. There should generally be deviations from targets or change.

3.3.2. Directions for future research

It will be important to take the interest earnings of international reserves into account because the interest earnings would, ceteris paribus, lead to an upward trend in reserves even with no intervention. Creating the variable using the US 3-month Treasury bill rate will help.
In addition to the OLS method, 2SLS (two-stage least squares) and 3SLS (three-stage least squares) estimation methods can be used to check the results. Alternative types of variables can be tested. Instead of having only US dollar as foreign exchange reserves, various currency compositions of reserves can be tested. Quarterly dummies can be included to account for possible seasonality. The lagged cyclical income and lagged change in REER can be replaced with the trade balance.

The rolling (forward) recursive estimation, which can demonstrate the dynamic changes of the offset and sterilization coefficients, can be applied. The contrasting results between the recursive estimation and the baseline regression on Ouyang et al (2010) illustrate the importance of the recursive estimation.

3.4. Results: The Sterilization/Offset studies

Table 9-10 illustrate the results of the simultaneous equations (eq. 29, 30) which estimate sterilization and offset coefficients. The results of quarterly data in subperiods are illustrated in Table 9 and the results of monthly data in subperiods are illustrated in Table 10. I focus on the monthly data (on Table 10) because the monthly data seems to grasp more consistent and credible results that go along with the BOK’s monthly monetary policy reports.

The sterilization coefficients have stayed around -1.0, before and after the crisis, showing that the BOK has sterilized its reserve accumulations heavily throughout the crisis. Almost full sterilization means that the BOK was able to sterilize most of its interventions in the exchange market. Accordingly, the conclusion from the chapter regarding the Combined Propensities to Intervene (2.3.2.3.) makes sense. Specifically, it seems reasonable that the persistent intervention policy may have bolstered the link between the US interest rate and Korean monetary policy by limiting the decrease of the exchange rate and its impact on Korean monetary policy.

The offset coefficients have also stayed close to -1.00, before and after the crisis. In principle, the offset coefficient should reflect the degree of capita flow mobility. So, the offset coefficients close to -1 should imply very high freedom in capital flow mobility. However, the offset coefficients of almost
-1.0, as a measure of capital mobility, during both periods are misleading and overstated because perfect sterilization occurs only when capital mobility is imperfect. Instead of the offset coefficient, US interest rate coefficient from simple interest rate passthrough model (without the interest rate smoothing coefficient) will be considered as a measure for capital mobility. On Table 11, US interest rate coefficients are statistically significant and are about 0.5 for both quarterly and monthly data. For the model with subperiods, US interest rate coefficients are significant and are about 0.3 during pre-crisis period, while the coefficients are significant and are about -0.4 during post-crisis period. Regardless of being positive or negative, the absolute magnitude of the coefficients between 0.3 and 0.5 indicate that capital mobility in Korea has been far from perfect, but has been fairly open to foreign influences.

As a main variable of interest, the coefficients on exchange rate expectations adjusted foreign interest rate, the coefficients are statistically significant and negative with a very small magnitude, which is -0.001, in both functions (the balance of payment function and the monetary policy function) and for both subperiods (the precrisis and postcrisis periods): The coefficient, -0.001, means that one percent increase of the annual US T-bill rate (adjusted for the annual change in the monthly expected exchange rate) decrease the annual change in NFA by -0.001 billion won (the balance of payment function) and decrease the annual change in NDA by -0.001 won (the monetary policy function). The very small magnitudes of the coefficient indicate that there is no substantial effect of the US interest rate on the balance of payment and on the monetary policy of Korea.

The result confirms the there is consistent, yet weak, ties between US interest rate and Korean monetary policy which is parallel with the results from the Taylor rule equations (Table 5-6). This is expected because higher exchange adjusted US interest rate can lead to capital outflows and consequent reduction of reserve build-up (the balance of payment function) and the worsened balance of payment can lead the monetary authority to implement a contractionary monetary policy to attract capital inflows (the monetary policy function).
The coefficients on the exchange rate variable (real effective exchange rate) are statistically significant and positive with a small magnitude, equaling 0.008, before the crisis meaning that one unit increase of the annual change in REER (devaluation of won against US dollar) is associated with an increase of the annual change in NFA by 0.008 billion won (the balance of payment function) and is associated with an increase of the annual change in NDA by 0.008 billion won (the monetary policy function). However, the exchange rate coefficients are statistically significant and negative with a small economic significance, equaling -0.007, after the crisis meaning that one unit increase of the annual change in REER (devaluation of won against US dollar) is associated with a decrease of the annual change in NFA by 0.007 billion won (the balance of payment function) and is associated with an decrease of the annual change in NDA by 0.007 billion won (the monetary policy function). The very small magnitude of the coefficient indicates that it is not economically significant. However, the magnitude of the exchange rate variable is seven (or eight) times larger than the magnitude of the (exchange adjusted) foreign interest rate. This is very similar to the result from the Taylor rule study.

For the postcrisis model on Table 6, the magnitude of the exchange rate variable is also seven (or eight) times larger than the magnitude of the US interest rate. The precrisis model in Table 5 does not have a significant exchange rate variable, but its coefficient has a magnitude which is five (or six) time larger than the magnitude of the US interest rate. So, the exchange rate variable definitely has much higher economic significance than the US interest rate variable on Korean monetary policy (for the Taylor rule and the monetary policy function) and on the balance of payment (the balance of payment function).

The positive coefficient of the exchange variable before the crisis can be explained by the volume effect of the elasticity approach to the balance of payments. The rise of the REER (devaluation of won) will lead to the improvement of the current account (due to the volume effect), consequent accumulation of reserves (for the balance of payment function) and the improved balance of payment will cause the monetary authority to implement expansionary monetary policy to resist further capital inflows (for the monetary policy function). For won devaluation (the exchange rate increase) to bring on Korean policy rate increase, the Marshall-Lerner condition has to be satisfied for the volume effect
has to dominate the price effect.\footnote{According to the Marshall-Lerner condition, a devaluation will improve the current account only if the sum of the foreign elasticity of demand for exports and the home country elastic of demand for imports is greater than unity.} Korea has had very high elasticity of demand of exports as an export-driven economy and many study show that the Marshall-Lerner condition was fulfilled for Korea.\footnote{Gylfason (1987), with a sample period of 1969-1981, Giorgianni and Milesti-Ferretti (1997), with a sample period of 1971-1989, Kee et al (2008), with a sample period of 1988-2001, and Bahmani-oskoee and Baek (2015), with a sample period of 1991-2012.}

The positive coefficient of the exchange rate for the precrisis period contrasts with the result from the Taylor rule study. On the Taylor rule study for the precrisis period (Table 5), won depreciation causes the Korean policy rate to increase. The distinction between the two results is found from the difference in the independent variables. While the change in NFA (the balance of payment) and the change in NDA (the monetary policy regarding the money supply) are responsive to the variation of money supply, Korean policy rate decisions are based on the monthly monetary policy reports and the meeting of the BOK. So, the decision of the policy rate is not dependent solely on a single indicator.

The policy rate increase in response to won depreciation for the Taylor rule study may have nothing to do with the improved balance of payments. The decision seems to be mainly affected by the concerns regarding the low level of reserves amidst the aftermath of the AFC (Kim and Lee, 2011). As can be observed from the reserve levels on Table 12, they are relatively low up to the point of GFC. And there could have been concerns regarding the balance of payment collapse because of the J-curve effect: Won depreciation will initially bring on the balance of payment to worsen. So, the newly deteriorated balance of payment along with low reserve levels could have sent warning signs to Korean monetary authority.

On the contrary, the negative coefficient of the exchange variable after the crisis can be explained by the active exchange rate policy: An appreciation of won (a fall in the REER) will likely lead the BOK to engage in intervention policy accumulating reserves to limit the appreciation (the balance of payment function) and the improved balance of payment will lead to an expansionary monetary policy.
to restrain further capital inflows (the monetary policy function). The results from section 2.3.2.3. (Table 8-3) explains that there have been heavy interventions countering the exchange rate movements after the GFC. Also, it is notable that the heavy (almost perfect) sterilization made it possible for the BOK to engage in aggressive intervention policy.

Again, the negative coefficient of the exchange rate variable during the postcrisis period tells a different story from the result of the Taylor rule study. Won appreciation brings on the policy rate increase for the Taylor rule study of the postcrisis period (Table 6). The deciding factor for the result is the status of the domestic economy. Sustained economy growth will bring about won appreciation and, consequently, the policy rate increase of the BOK. It goes the other way too. An economic slowdown will cause won to depreciate and the policy rate to decrease. A high level of reserves during the postcrisis period enabled the BOK to engage in the expansionary monetary policy in response to won depreciation. More focus on the domestic economy after the crisis explains the relevance of the inflation gap on the model (Table 6).

Since the foreign interest rate is adjusted for exchange rate expectations, it can be analyzed separately (independently) from the exchange rate variable. Thus, I do not test for the omitted variable bias as I have done for the Taylor rule models (Table 5-6).

Thus, the findings regarding the exchange rate from the Sterilization model also contradicts the theory by Rey (2015) that exchange rate does not play a role in pursuing an independent monetary policy. The exchange rate coefficients are statistically significant across all periods and functions, while the economic significance is not substantial. So, there is a steady, yet weak, link between the exchange rate and monetary policy regarding the money supply. In addition, the different effects the exchange rate has on the balance of payments and the monetary policy (mostly open market operations) before and after the GFC reveals the different focus of the monetary policy around the crisis. Active intervention policy to manage exchange rates after the crisis has affected the balance of payments and the direction of monetary policy.
The coefficients on the fiscal policy variable are statistically significant and positive with a small magnitude, equaling 0.035, after the crisis, meaning that one billion won increase of the annual change of fiscal balance is associated with an increase of the annual change in NFA by 0.035 billion won (the balance of payment function) and is associated with an increase of the annual change in NDA by 0.035 billion won (the monetary policy function). The magnitude of the coefficient is small meaning that it is not economically meaningful. The result is interesting because (1) I expected negative coefficients and (2) the fiscal policy variable is highly correlated with the exchange adjusted foreign interest rate (correlation is 56%). However, there is no obvious explanation for the correlation between the fiscal policy and the US interest rate.

Other domestic policy variables (money multiplier, inflation rate and income) will be analyzed independently from the foreign interest variable because their correlations with the exchange adjusted foreign interest variable are fairly weak. The coefficients on the money multiplier are statistically significant, with a small magnitude, and negative across all criteria, equaling -0.03 ~ -0.04, meaning that one unit increase of the annual change in money multiplier is associated with a decrease of the annual change in NFA by 0.03 billion won for the balance of payment function (and a decrease of the annual change in NDA by 0.03 billion won for the monetary policy function). This is expected because the rise in the money multiplier increases the domestic money supply and pushes interest rates down, reducing the capital inflows and reserve build-up, which would lead to a contractionary monetary policy. Although, the magnitudes of the coefficient are quite small (-0.03 ~ -0.04), they are much larger than the ones of the foreign interest rate coefficient (-0.001) and the exchange rate coefficient (0.008 and -0.007).

The coefficients on inflation are statistically significant and negative with decent magnitudes, during the postcrisis period, at -0.15 meaning that one percent increase of the annual change in the inflation rate is associated with a decrease of the annual change in NFA by 0.15 billion won for the balance of payment function (and a decrease of the annual change in NDA by 0.15 billion won for the monetary
policy function). The negative coefficients are anticipated because higher inflation can generate concerns regarding exchange rate depreciation, interest rate hikes and capital losses, causing a reduction of reserve accumulation and a contractionary monetary policy. However, the effects of inflation are pronounced after the crisis as the coefficients are statistically significant (at 1%) and have larger magnitude (in absolute terms) during the postcrisis period. These results are consistent with the result of the Taylor rule model (Table 6) that shows the coefficient of the inflation gap to be significant and larger during the postcrisis period. Also, much larger magnitude of the inflation coefficient (0.15) and money multiplied coefficient (-0.03) compared to the magnitude of the foreign interest rate (-0.001) and the exchange rate (0.008) can indicate that the impact of the inflation targeting and money supply is much more pronounced than the impact of the US interest rate or the exchange rate policy on Korean monetary policy or on its balance of payment during the postcrisis period.

Finally, the results from the output coefficients from this monthly data are inconclusive. The coefficients on the output before the crisis are statistically significant, and positive with a miniscule magnitude, with a miniscule value, 1.0e-07, while the coefficients, after crisis, are not significant and negative. On the other hand, the results from the quarterly data are not much different: The coefficients on the output, after crisis, are significant, with a miniscule magnitude, and negative at about -7.3e-08 meaning that one unit increase of the output gap (the difference between IPI from its trend scaled by the trend) is associated with a miniscule value of the change in NFA and of the change in NDA: The decrease of the annual change in NFA by -7.3e-08 billion won for the balance of payment function (and a decrease of the annual change in NDA by -7.3e-08 billion won for the monetary policy function). Basically, the output gap brings no substantial change in Korean monetary policy or on its balance of payment.

The results from the domestic policy variables are consistent with the ones from the Taylor rule models: Inflation rate becomes statistically significant and its effect become pronounced (economically) after the GFC and the output variable brings meaningful results on the quarterly data. The similar results confirm that that the BOK has been fairly prompt in responding to the inflation.
rate changes on a monthly basis while the policy changes to the output changes have been made only after sustained period of time. Additionally, the results confirm that the BOK has started to keep track of inflation gap, output gap and global economy closely after the crisis. Finally, Korean market seems to respond to the BOK monthly policy reports on monthly basis. Along with the extended Taylor rule results, the comparison between the test results and the BOK monetary reports will bring productive intuitions.

Also, the results from the domestic policy variables are consistent with the findings from the Taylor rule model. After the GFC, the Taylor rule model finds that domestic economy plays a vital role in influencing the exchange rate and the policy rate (Table 6). The inflation gap becomes statistically and economically significant in the model. Similarly, the results from the simultaneous equations show that the inflation rate becomes an important measuring stick to gauge if the economy is heating up or cooling down during the postcrisis period. Unfortunately, the output variables did not explain much about the status of the economy.

To sum up, the highly statistically significant sterilization coefficients at around -1 suggest that the BOK has heavily (almost perfectly sterilized its reserve accumulation (along with the interventions in the exchange market) throughout from 1990s. The estimated offset coefficients close to -1.0, which is statistically significant, are vastly overstated and ambiguous. The degree of capital mobility is represented better by the US interest rate coefficient from the simple interest rate passthrough model. The coefficient between 0.3 and 0.5 show a moderate degree of capital mobility and a degree of Korea’s capital control.

The exchange rate adjusted foreign interest rate is statistically significant across all the estimations with the correct sign (at -0.001), albeit with not being economically meaningful. This demonstrates that there is a consistent, but not substantial, link between the US interest rate and Korean monetary policy.
The exchange rate coefficient indicates a different effect around the crisis. The coefficients, before the crisis, are statistically significant and positive with very small magnitude (at 0.008), while the coefficients, after the crisis, are negative and statistically significant with still very small magnitude (at -0.007). The coefficients show steady, but weak, links between the exchange rate and the balance of payments/monetary policy (open market operations). The different directions of the coefficients before and after the crisis indicate that the monetary authority has actively managed the exchange rate through intervention after the crisis. Comparing with how the exchange rate affects the monetary policy with the Taylor rule models, it is found that the different direction of the policy is due to the kind of monetary policy tools that is used. Since the policy rate changes focus on different criteria from open market operations, the monetary policy directions caused by exchange rate changes can differ between the Taylor rule models and the Sterilization/Offset studies. Above all, the results strongly refute Rey’s (2015) theory of ‘Dilemma not Trilemma’ by emphasizing the importance of role of exchange rate on its impact on the monetary policy.

The coefficients on the money multiplier are statistically significant, with a small magnitude, and negative across all criteria, equaling -0.03 ~ -0.04. The inflation rate coefficients are statistically significant and negative with a fair magnitude during the postcrisis period, at -0.15. As can be seen from the larger magnitudes of the coefficients, the variables regarding domestic economy (inflation rate, money multiplier) have more substantial impact on the monetary policy (open market operations) than the variables concerning the international economy (US interest rate, exchange rate). Also, the stronger impact of the inflation rate variable during the postcrisis period is in agreement with the results from the Taylor rule model. However, the results from the output coefficients, which have very miniscule value of coefficients, show that the output has almost no impact on the balance of payments and the monetary policy. Finally, the coefficients on government spending are statistically significant and positive with a small magnitude, equaling 0.035, after the crisis.
Chapter 4: The Bank of Korea monetary policy reports analysis and discussions

The Bank of Korea had started to publish the monthly monetary policy reports from Oct, 1999. My analysis ranges between Oct, 1999 and Dec, 2020. There are 243 reports total. During this period, there have been 44 changes of the policy rates. So, there have been a policy rate change in about every six months on average (255 months/44 rate changes = 5.8 month per one rate change).

My analysis centers on the policy rate changes. Section 2 contains eight subperiods divided according to the movement of the policy rate changes. Section 3 compares the analysis of the BOK policy reports with the result of my empirical results of the Taylor rule study and the Sterilization/Offset study.

< Charts of the BOK policy rate, inflation rate, inflation gap and output gap changes>

- The BOK policy rates over time
- Inflation rate over time

- Inflation gaps over time
Output gaps over time

4.1. The trend of the BOK policy rate changes over time

4.1.1. Initial increase: from 1999:M10 to 2001:M1

The monetary reports start with two policy rate increases. The first policy rate increase is from 4.75% to 5.00% during 2000M2. The second increase is from 5.00% to 5.25% during 2000M10.

During this period, domestic economy keeps growing and inflation is steadily increasing, while financial market is unstable overall. For the second increase of the rate, there was an inflation hike right before (a month prior) the rate increase. Domestic financial market had been unstable before the policy rate increases.
4.1.2. Steady decrease: from 2001:M2 to 2005M9; with one increase in between (2002M5)

During this subsequent period, the policy rate mostly declines (except one increase during 2002M5) eight times from 5.25% to 4.00%:

It declines from 5.25% to 5.00% (during 2001M2), from 5.00% to 4.75% (during 2001M7), from 4.75% to 4.50% (during 2001M8), from 4.50% to 4.00% (during 2001M9).

Then, there is an increase from 4.00% to 4.25% during 2002M5.

It declines again from 4.25% to 4.00% (during 2003M5), from 4.00% to 3.75% (during 2003M7), from 3.75% to 3.50% (during 2004M8), from 3.50% to 3.25% (during 2004M11).

During the first four policy rate decreases, from 5.25% (2001M2) to 4.00%(2001M9), domestic economy is declining steadily and inflation rate is increasing at high rate continuously. Korean Won is appreciating against US dollar (W/$ exchange rate is decreasing), while ongoing credit risk issue is easing as fund-raising for corporations is improving.

The first rate cut (2001M2) is followed by three consecutive periods of economy downturn, while inflation rate is unstable and domestic financial market is volatile due to credit risk issue. The second and the third rate cut (2001M7, 2001M8) are followed by continuous economy slowdown and rapid inflation rate increase. The increasing inflation rate can be misleading because it is due to high international oil price and not due to demand-side inflationary pressure. Worse, it can lead to high inflation expectation. However, domestic financial market begins to stabilize as the improvement of corporate fund-raising from financial institutions resolve credit risk issue.

The large 50 basis point (bps) drop (4.50% to 4.00%) on 2001M9 is apparently due to Sep 11th terrorist attack, which causes concerns regarding economy slowdown and volatile oil price. Following the Sep 11th attack, the economy picks up from Nov, 2001. From then, the economy improves, inflation rate increases and domestic financial market becomes stable. As inflation expectation builds up due to increasing demand pressure, the policy rate is increased from 4.00 to 4.25% on 2002M5.
After the policy rate increase, economy growth slows and inflation rate rises sharply as food and oil price becomes volatile. Financial market becomes volatile as geopolitical risk (possible war between US and Iraq) are looming. Then, there are four consecutive policy rate declines from 4.25% to 3.25%.

The rate declines during 2003M5 and 2003M7 are followed by economy slowdown and decreasing inflation rate. The main rationale behind these two rate cuts is to avoid the contraction of the economy and to calm down volatile housing price.

The rate declines during 2004M8 and during 2004M11 can be attributed to ongoing economy slowdown due to high international oil price and IT sector cooling down worldwide. During this time, CPI increases rapidly due to high oil price, but not by demand-driven inflationary pressure. Core inflation remains stable then.

4.1.3. Steady increase: from 2005M10 to 2008M9

Up to the run-up to the GFC, the policy rate increases eight times from 3.25% to 5.25%:

From 3.25% to 3.50% (during 2005M10), from 3.50% to 3.75% (during 2005M12), from 3.75% to 4.00% (during 2006M2), from 4.00% to 4.25% (during 2006M6), from 4.25% to 4.50% (during 2006M8), from 4.50% to 4.75% (during 2007M7), from 4.75% to 5.00% (during 2007M8), from 5.00% to 5.25% (during 2008M8).

During this three-year period of steady policy rate increases, the economy is generally going through steady improvement and CPI (and core inflation rate) is mostly stable (but increasing).

The economy seems to be stabilized from the geopolitical risks and the financial market is stable until 2007M9 (which signals the onset of the GFC). From then, the financial market price variables become volatile.

All eight rate increases (2005M10, 2005M12, 2006M2, 2006M6, 2006M8, 2007M7, 2007M8, 2008M8) are implemented to cool down the increasing demand-side inflationary pressure due to strong economy recovery and high oil price. The economy starts to cool down from the mid-2008, so the
only rate increase that is followed by weak growth is the last one (2008M8). Financial market remains stable mostly.

4.1.4. Sharp decrease: from 2008M10 to 2010M6

During the GFC, the policy rate decreases sharply six times from 5.25% to 2.00%:

From 5.25% to 5.00% (during 2008M10), from 5.00% to 4.25% (during 2008M10: on Oct 27th), from 4.25% to 4.00% (during 2008M11), from 4.00% to 3.00% (during 2008M12), from 3.00% to 2.50% (during 2009M1), from 2.50% to 2.00% (during 2009M2). Six consecutive rate cuts include one 100 bps decrease, one 75 bps decrease and two 50 bps decrease of the policy rates.

They are obviously caused by the breakout of the GFC associated with the collapse of Lehman Brothers on September 2008. Domestically, severe economy slowdown and decelerating inflation rate (mostly due to weak demand-side inflationary pressure) incurs around the rate decreases. Financial market is volatile suffering from huge outflow of foreign investment funds.

The economy slowly recovers from 2009M6. As economy and domestic demand (especially consumption) recovers, CPI becomes stable from 2009M8. Volatile financial market begins to cool off from 2009M3. From then, financial market price variables become more stable and credit risk (lending from financial institutions to households and corporations) issue subsides. It seems the monetary policy decision affects financial market first, then the domestic economy and lastly inflation rate.

4.1.5. Steady increase: from 2010M7 to 2012M6

After the GFC, the policy rate increases five times from 2.00% to 3.25%:

From 2.00% to 2.25% (during 2010M7), from 2.25% to 2.50% (during 2010M11), from 2.50% to 2.75% (during 2011M1), from 2.75% to 3.00% (during 2011M3), from 3.00% to 3.25% (during 2011M6).
All five rate increases are followed by ongoing economy recovery and highly increasing inflation rate which is primarily due to increasing demand-side inflationary pressure from steady economy recovery and a consequent high inflation expectation. Notably, the increase during 2010M7 comes after two consecutive periods of accelerating inflation rate.

The domestic economy starts to show slow growth from 2012M1. CPI and core inflation slows down from 2012M1. Financial market begin to demonstrate volatility from 2011M6. Domestic stock prices decrease and won (against US$) depreciates from then. The market unrest is mainly due to the increase of external risk such as European economy slowdown and Middle East geopolitical risk.\(^{23}\) Won appreciates against US$ mostly due to foreign portfolio investment inflows and the economy upturn. However, it starts to depreciate and become volatile from 2011M6.\(^{24}\)

### 4.1.6. Continuous decrease from 2012M7 to 2017M10

The policy rate decreases eight times from 3.25% to 1.25%:

- From 3.25% to 3.00% (during 2012M7), from 3.00% to 2.75% (during 2012M10), from 2.75% to 2.50% (during 2013M5), from 2.50% to 2.25% (during 2014M8), from 2.25% to 2.00% (during 2014M10), from 2.00% to 1.75% (during 2015M3), from 1.75% to 1.50% (during 2015M6), from 1.50% to 1.25% (during 2016M6).

The economy starts from sluggish growth and goes through small ups and downs. However, it is not until 2017M3, that it experiences expanded growth. CPI remains low mostly and begins to turn upside from 2015M5 and fluctuates. Then, from 2016M9 on, it keeps on moving upside.

The first three policy rate decreases (2012M7, 2012M10 and 2013M5) are followed by sluggish economy and CPI at low level. Specifically, domestic economy is expected to sustain negative output.

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\(^{23}\) From this period (2010M4), the monetary reports start to observe global economy trends.

\(^{24}\) From 2010M3, right before this period (at the end of GFC), the report keeps track of exchange rate (Won against US$) on monthly basis.
gap and negative inflation gap is expected to hold.\textsuperscript{25} The slow economy can be attributed to global risk factors such as economic downturn in Major Economies and international financial market unrest. Won appreciates against US$, then depreciates and fluctuates from 2013M2 due to investment fund outflows and heightened Korean geopolitical risk.

In between the series of the policy rate decreases, the economy regains strength. From 2013M8 to 2014M5, the economy recovers and inflation rate fluctuates between increases and decreases. During this period, US economy is improving, but the risk from tapering off of US quantitative easing remains.\textsuperscript{26} Won appreciates against US$ during this period due to funds inflows and favorable US economy.

During the last five policy rate decreases (2014M8, 2014M10, 2015M3, 2015M6 and 2016M6), the economy fluctuates between slowdown and recovery periods, then starts to expand growth from 2017M4. Inflation rate (both CPI and core rate), similarly, fluctuates between increases (which are not due to demand inflationary pressure) and decreases till it begins to increase steadily from 2016M10. It is hard to find a pattern regarding exchange rate movements (Won against US$) in this period.

The rate decreases on 2014M8, 2014M10 and 2015M3 can be attributed to ongoing slow economy and the growth of global economy risk factor (European economy slowdown) and they coincide with the negative forecasts of domestic economy and inflation from the reports. However, the rate decrease on 2015M6 mainly derives from export contraction due to the outbreak of MERS (Middle East Respiratory Syndrome) shock. Finally, the rate decrease on 2016M6 is a quintessential example of how BOK responds to noticeable inflation rate changes that diverge significantly from its target level. The report of 2016M6 reads, “inflation is expected to fall significantly due to low international oil prices”.

4.1.7. Increase from 2017M11 to 2019M6

The policy rate increases twice from 1.25% to 1.75%:

\textsuperscript{25} In other words, the economy and inflation do not meet the potential (target) level. In addition, it is noticeable that the notes keep track of inflation gap and output gap from this period (2012M7).

\textsuperscript{26} It is noticeable that the reports start to keep track of US economy and monetary policy stance after the GFC.
From 1.25% to 1.50% (during 2017M11), from 1.50% to 1.75% (during 2018M11).

The domestic economy sustains strong and steady growth till 2019M4. Inflation rate remains low mostly, but high inflation rates precede the policy rate increases. Financial market is volatile prior to the rate increases.

The rate increase during 2017M11 occurs amid a period of economy expansion and an increase of core inflation rate. Domestic economy growth exceeds the GDP growth forecast from the previous period for about four consecutive periods. However, core inflation increase occurs once a month before the rate increase. This is an example that the BOK responds to price changes more promptly than to output changes.

Preceding the rate increase of 2018M11, domestic economy is still growing steadily and CPI increases for two consecutive periods after being low for a while.

4.1.8. Decrease from 2019M7 to 2020M12

The policy rate decreases four times from 1.75% to 0.50%:

From 1.75% to 1.50%(during2019M7), from 1.50% to 1.25%(during2019M10), from 1.25% to 0.75%(during2020M3), from 0.75% to 0.50%(during2020M5).

The economy is slowing down for the most part and inflation rate fluctuates.

The rate decrease during 2019M7 is succeeded by sluggish economy and lower inflation than the expectation. Domestic economy falls below GDP projection (from previous period) for about four consecutive periods prior to the rate decrease. Meanwhile, CPI falls below its projection only twice during the prior six months. Financial market is volatile and global risk factors, such as US-China trade dispute and global economy slowdown, are threatening domestic economy.

The rate decrease of 2019M10 shows similar pattern with more deterioration. Domestic economy keeps falling below GDP projection from previous period and CPI is expected to be at lower 0% for some time (actual CPI falls to negative rate).
After partial economy recovery due to the rate cut of 2019M10, global and domestic economy is hit hard by COVID-19 outbreak. The pandemic causes the 50 bp (basis point) rate cut during 2020M3 and a rate decrease during 2020M5. The economy slowed significantly and inflation rate dropped considerably. However, the economy slowly rebounds from 2010M10 and inflation rate picks up from 2020M8. Financial market is volatile, but it regains stability from 2020M5.

4.2. Comparison between the BOK reports and the result from my study

4.2.1. The Taylor rule analysis

Table 4 will be comparable to the BOK reports analysis as it deals with monthly data and divides the sample into two subperiods (pre- and post-GFC crisis). Also, it will be most fruitful to use Table 4. However, Table 3 (quarterly data, with subperiods) will also be considered.

Analyzing the BOK reports, it becomes evident that the GFC has become a turning point for the monetary policy. After the GFC, the BOK reports contain expectations and results concerning inflation gap, output gap and global economy. Also, the reports keep track of exchange rate movements (Won against US$) after the GFC (from 2010M3). Concerning global economy, attention has been given to the US monetary policy stance in particular.

The finding that US interest coefficients are only significant and positive for monthly data (Table 4) reflects that the BOK do respond to US monetary policy on a monthly basis. This is an important finding because (1) the US interest coefficients are mostly not significant and inconsistent for the quarterly data (Table 9) and (2) the coefficients retain the steady explanatory power amongst other independent variables (inflation gap, output gap and exchange rate). These reasons explain that the BOK responds exclusively to US monetary policy on a monthly basis.

The following are three examples that shows that the BOK are more responsive to inflation rate compared to output changes:
• The rate decrease on 2016M6 is a quintessential example of how BOK responds to noticeable inflation rate change that diverge significantly from its target level. The report of 2016M6 reads, “inflation is expected to fall significantly due to low international oil prices”.

• The rate increase during 2017M11 occurs amid a period of economy expansion and an increase of core inflation rate. Domestic economy growth exceeds the GDP growth forecast from the previous period for about four consecutive periods. However, core inflation increase occurs once which is a month before the rate increase.

• The rate decrease during 2019M7 is succeeded by sluggish economy and lower inflation than the expectation. Domestic economy falls below GDP projection (from previous period) for about four consecutive periods prior to the rate decrease. Meanwhile, CPI falls below its projection only twice for the prior six months.

Because of the preceding observations from the monetary reports, inflation gap should be statistically significant and positive and exchange rate be statistically significant during post-crisis period. Another main reason, from the reports, that explains the discrepancy of inflation gap coefficients pre-crisis and post-crisis is that international oil price had been so volatile during pre-crisis that high oil price had raised CPI level then.

While the exchange rate becomes statistically significant as expected, the results indicate that the coefficients of the inflation gap are implausible to interpret (Table 5 and 6). So, I abstain from further analysis regarding the inflation gap coefficients.

4.2.2. The Sterilization/offset study analysis

Table 10 will be comparable to the BOK reports analysis as it deals with monthly data and divides the sample into two subperiods (pre- and post-GFC crisis). However, Table 9 (quarterly data, with subperiods) will also be considered.

From the result of Table 10, I have reasoned that the BOK have aimed at inflation during post-crisis:

In response to high inflation, the BOK implements contractionary monetary policy after crisis.
The BOK policy notes confirm the results. There is definitely different focus on monetary policy before and after the GFC. Before the GFC, the reports pay particular attention to current account balance and its degree (of being narrow and wide). In fact, the reports keep track of the current account from the beginning (1999M10) till 2007M6 (right before the GFC), but the monthly notes on the current account stop after 2007M6.

However, the focus shifts to inflation after the GFC. During post-crisis period, the BOK responded promptly to the inflation rate changes. From 2012M7, the reports keep track of inflation gap and inflation expectations. Additionally, the BOK did not respond to the pre-crisis inflations because many of them are due to high international oil prices (and not demand-side inflationary pressure). The results from Table 10 indicate that the coefficients on the inflation rate become statistically significant and economically important, with the expected signs, during the postcrisis period. The magnitude of the coefficients increases by five to six times after the crisis.

It is hard to draw convincing argument from the results of output coefficients in Table 9 because the coefficients show inconclusive result.

Chapter 5: Conclusion

Analyzing the two main monetary policy tools interest rates and the money supply, controlling for various variables, in the form of the Taylor rule and the sterilization/offset study, I examined the effect of the US influences on Korean monetary policy in a refined way. Two types of external influences on Korean monetary policy have been analyzed: The US interest rate and the fluctuations in the exchange rate (won against the US dollar). Regarding Korean monetary policy, I have examined the following two types of monetary policy tools: Korean policy rate and the monetary policy concerning the money supply in Korea. The Taylor rule study examined external influences on the Korean policy rate, while the Sterilization/Offset study analyzed the effects of balance of payments imbalances on the money supply.
The empirical tests of the extended Taylor rule (with US interest rates) were performed in various ways (quarterly and monthly, as a whole period and with subperiods). For the subperiods, the Global Financial Crisis during 2007-2008 was chosen as a structural break point. The results varied according to the different criteria of the models, but the Taylor rule model of the monthly data with the subperiods (Table 4) produced the most intelligible result. So, I focused on that model for the analysis.

The results revealed that the impact of the US interest rate on Korean policy rate has been statistically significant, but small in terms of economic impact. Meanwhile, the impact of the exchange rate on Korean policy rate varied before and after the GFC period. Before the crisis, the role of the exchange rate on Korean monetary policy had been less pronounced and indirect. However, statistically not significant and economically less significant exchange rate variable before the crisis does not mean that the currency value had not been an important issue to Korean monetary authority. Progressive inclusion of the variables (on Table 5) showed that the exchange rate variable explained a part of the impact that the US interest rate has on Korean policy rate. A slightly smaller size of the US interest rate coefficient when the exchange variable is included suggested that the impact of the US interest rate on Korean policy rate is partially explained by the exchange rate. The US interest coefficient decreased from 0.029 to 0.022 when the exchange rate is added (Table 5).

After the crisis, the impact of the exchange rate on Korean policy rate had been more pronounced (economically and statistically) with a different direction. The status of the domestic economy had played a major role in the impact that the exchange rate had on the Korean policy rate. The negative coefficient on the exchange rate reflected that the sustained domestic economy downturn can lead to won depreciation (the exchange rate increase) and, consequently, the expansionary monetary policy to deal with the slow economy. On the other hand, the overheated economy tends to cause won appreciation and contractionary monetary policy.

The economic significance of the exchange rate variable was much higher (about eight times higher) than that of the US interest rate variable regarding their impacts on Korean policy rate.
In addition, the results implied that the US interest rate can impact Korean policy rate directly or it can impact Korean policy rate through the exchange rate. An increase in the US interest rate could directly affect an increase in Korean policy rate (0.027 on the second column of Table 6). The indirect route contained two distinct effects: A positive impact that an increase in the US interest rate that raises the exchange rate (won depreciation) and a negative impact that an increase in the exchange rate (won depreciation), due to a slow economy, can bring an expansionary monetary policy. The overall effect was the combination of the two contrasting effects of the two routes culminating to an ambiguous US interest coefficient (0.009 on the first column of Table 6).

The analysis of the BOK monetary reports confirmed the results of the Taylor rule study before and after the GFC and the mechanism of the impact that the exchange rate has on Korean policy rate from the Taylor rule tests. Specifically, the reports showed that the current account balance (or the overall balance of payment in a broad sense) had been the main concern regarding the influence the exchange rate has had on Korean policy rate during the precrisis period, while the status of domestic economy had been the major factor concerning the impact the exchange rate has had on Korean policy rate during the postcrisis period.

During the precrisis period, won depreciation brought concerns regarding a collapse in the external balance of payments in the aftermath of the AFC. The concern regarding the balance of payments led to a high level of the policy rate to avert the balance of payment deterioration. This trend continued up until the GFC period. During the postcrisis period, however, sustained domestic economy slowdowns led to won depreciation and eventually expansionary monetary policy (the policy rate decrease) to address the sluggish economy.

Since the results from the inflation gap and the output gap were implausible, I abstain from further analysis regarding them. The only conclusion I can make from these two variables is that they did not explain much concerning the impacts that the US interest and the exchange rate have on Korean monetary policy because the correlation between them (the inflation gap and the output gap) and the exchange rate or the US interest rate were very weak.
These results contribute to the debate on the “dilemma” versus the “trilemma” argument by Rey (2015). The results from the Taylor rule study firmly denied the argument of Rey (2015) that exchange rate is not an important factor to achieve an independent monetary policy. Moreover, the results advocated the importance of the exchange rate regarding its impact on Korean monetary policy. The studies by Dooley et al (2002) and Parsley and Popper (2009), which explain that the BOK pursued exchange rate stability as a monetary policy goal, are in line with the results of my study.

Meanwhile, less significance (statistically) of the exchange rate variable in its impact on Korean monetary policy before the crisis led me to question the involvement of another variable that was in effect. McCauley (2006) similarly found no significance (statistical) of the exchange rate coefficient when estimating a Taylor rule for Thailand. McCauley believed that the exchange rate does matter for Thai monetary policy and that the failure to find a significant effect may mean that another instrument was used to limit exchange rate fluctuations. Miles and Schreyer (2012) suggested foreign currency interventions to be the missing instrument variable.

However, exchange market intervention, that results in changes in foreign reserves, could be more relevant variable that is employed to limit the exchange rate fluctuations (Miles and Schreyer, 2012; Aizenman et al, 2011). To examine the degree of Korean exchange rate policy around the GFC period, I have measured the Combined Propensities to Intervene (CPI). The CPI during two subperiods indicated that the main purpose of the reserve buildup before the GFC was to have precautionary measure to protect against potential economic downturn. On the other hand, the reserves had been accumulated after the GFC because the BOK had actively engaged in intervention policy to prevent Korean currency from appreciating.

Considering the active exchange rate policy after the GFC and its effect on the macroeconomic trilemma (with free capital mobility, independent monetary policies are feasible if and only if exchange rates are floating), it seems plausible that examining modus tollens claim of the trilemma could strengthen the argument for the trilemma and weaken the argument for the dilemma (Rey, 2015). The Modus tollens claim of the trilemma is: if exchange rates are controlled, domestic
monetary policy becomes more dependent on foreign influences, such as the US interest rate.27

Putting it more specifically, the persistent intervention policy, after the GFC, could have bolstered the impact that the US interest rate has on Korean policy rate by limiting the fluctuation of the exchange rate and its impact on Korean monetary policy. For this conclusion to be correct, the BOK has to be able to sterilize most of the interventions in the exchange market which has been tested on the sterilization/offset study.

The empirical test results for the Sterilization/Offset study showed almost perfect sterilization coefficients throughout the whole period (which are about -1.0) which suggested that the BOK has completely sterilized its reserve accumulation and the intervention in the exchange market from 1990s.28 However, the offset coefficients, of almost -1.0, during both periods were misleading and overstated because perfect sterilization occurs only when capital mobility is imperfect. Instead of the offset coefficient, US interest rate coefficient from simple interest rate passthrough model (Table 15) was considered as a measure for capital mobility. The US interest rate coefficients between 0.3 and 0.5 showed a moderate degree of capital mobility.

The variables regarding domestic economies, the inflation rate, money multiplier and government spending, were economically more significant than the variables concerning the international impacts, such as the US interest rate and the exchange rate. This was expected because domestic factors should affect Korean economy more directly. Only the output variable shows a minimal impact on the monetary policy.

27 This conclusion (if exchange rates are controlled, domestic monetary policy becomes more dependent on foreign influences, such as the US interest rate) can be seen as an argument that commits a logical fallacy, “denying the antecedent”, of the “trilemma”. However, since the premise of the “trilemma” contains an “if and only if” claim (with free capital mobility, independent monetary policies are feasible if and only if exchange rates are floating), the conclusion becomes the modus tollens claim which is valid.

28 Regarding the influence that I have tested with the sterilization coefficients in terms of the effects on the money supply, the balance of payments employed are the overall or official settlements balance which corresponds to changes in international reserves.
The stronger impact (both statistically and economically) of the inflation rate on domestic monetary policy during the postcrisis period confirmed the finding from the BOK monetary reports that the BOK had used inflation targeting as the chief strategy after the crisis. The BOK monetary policy reports confirmed the results as the reports have started to the monitor inflation gap and output gap closely after the crisis. 29

Examining the results of this study and the BOK analysis, Korea has a fairly open capital account, managed floating exchange rate regime (which is closer to free-floating than to fixed regimes)30 and independent central bank31. And Korean monetary policy is influenced by monetary developments in the US, but it still has a good deal of independence.

The high level of sterilization raises questions about arguments that Korea's managed float exchange rate has been an important source of discipline over domestic inflation (McKinnon and Schnabl, 2003a,b, 2004).

---

29 Prior to the GFC, the BOK reports had kept track of current account balance and its degree (i.e. narrowness) on monthly basis. However, the notes on current account have become very sporadic after the crisis. Meanwhile, the reports began to focus heavily on inflation and output after the crisis. Inflation gap and output gap, that compares the value with the target level, have become available only after the GFC.

30 Korea has intervened a good deal regarding the exchange rate policy. See Willett (2009). The authorities still say it is a free float, but this is not accurate.

31 The Independence of the BOK was strengthened by the revision of the Bank of Korea Act in December 1997 which entered into force in April 1998. Thus, the time period tested in this study is the period when the BOK has become and remained independent.
Appendix A.

Fig. 1. Charts of the variables for the Taylor rule: quarterly data

- Policy rates over time

- Inflation gaps over time
• Output gaps over time

• REER over time
Fig. 2. Charts of the variables for the Taylor rule: monthly data

- Policy rates over time

- Inflation gaps over time
- Output gaps over time

- REER over time
Fig. 3. Charts of the variables for the Sterilization/Offset study: quarterly data

- ΔNFA over time

- ΔNDA over time
• Δmm (money multiplier) over time

• Inflation rate over time
• \( y \) (output gap) over time

![Graph of \( y \) over time](image)

• \( \Delta G \) (fiscal balance) over time

![Graph of \( \Delta G \) over time](image)
• ΔREER over time

• Δ(r + Ee): the change in exchange rate adjusted foreign interest rate over time
Fig. 4. Charts of the variables for the Sterilization/Offset study: monthly data

- ΔNFA over time

- ΔNDA over time
- $\Delta mm$ (money multiplier) over time

- Inflation rate over time
- $Y$ (output gap) over time

- $\Delta G$ (fiscal balance) over time
- $\Delta$REER over time

- $\Delta(r + Ee)$: the change in exchange rate adjusted foreign interest rate over time
Appendix B.

- Simple interest rate passthrough results (with the interest rate smoothing coefficient):
  
  Table 1-1 & 1-2

Table 1-1.

Interest rate passthrough for the whole period, quarterly; 1990:q1 – 2020:q4, monthly; 1990:m1 – 2020:m12

<table>
<thead>
<tr>
<th></th>
<th>quarterly</th>
<th>monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>US interest rate</td>
<td>0.060*</td>
<td>0.025***</td>
</tr>
<tr>
<td></td>
<td>(0.042)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>Adj. R-square</td>
<td>0.928</td>
<td>0.9895</td>
</tr>
</tbody>
</table>

Dependent variable: The BOK policy rate

Note: Standard errors are in parenthesis. The asterisks denote statistical significance at the 1(***), 5(**), and 10(*) per cent levels.

Table 1-2.


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>US interest rate</td>
<td>0.124***</td>
<td>-0.039</td>
<td>0.029***</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td>(0.044)</td>
<td>(0.052)</td>
<td>(0.008)</td>
<td>(0.012)</td>
</tr>
<tr>
<td>Adj. R-square</td>
<td>0.789</td>
<td>0.897</td>
<td>0.9667</td>
<td>0.982</td>
</tr>
</tbody>
</table>

Dependent variable: The BOK policy rate

Note: Standard errors are in parenthesis. The asterisks denote statistical significance at the 1(***), 5(**), and 10(*) per cent levels.
### Table 2.

The extended linear Taylor rule backward-looking, monthly; 1990:m1-2007:m11 and 2009:m7-2020:m12

<table>
<thead>
<tr>
<th></th>
<th>1990:m1-2007:m11</th>
<th>2009:m7-2020:m12</th>
</tr>
</thead>
<tbody>
<tr>
<td>US interest rate</td>
<td>0.230*** (0.045)</td>
<td>0.199*** (0.067)</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>-2.880*** (0.848)</td>
<td>0.602 (0.519)</td>
</tr>
<tr>
<td>Inflation rate</td>
<td>-9.871 (6.580)</td>
<td>22.795*** (3.358)</td>
</tr>
<tr>
<td>Output</td>
<td>2.994*** (0.932)</td>
<td>7.133*** (0.766)</td>
</tr>
<tr>
<td>Adj. R-square</td>
<td>0.489</td>
<td>0.654</td>
</tr>
</tbody>
</table>

Note: Standard errors are in parenthesis. The asterisks denote statistical significance at the 1(***)**, 5(**), and 10(*) per cent levels.
Table 3.

The extended linear Taylor rule forward-looking, quarterly; 1990:q1-2007:q4 and 2009:q3-2020:q4

<table>
<thead>
<tr>
<th></th>
<th>Perfect foresight</th>
<th>Static expectation</th>
<th>Forward expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>US interest rate</td>
<td>0.087(0.051)</td>
<td>-0.010(0.052)</td>
<td>0.088*(0.048)</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>0.430(0.460)</td>
<td>-0.272(0.346)</td>
<td>0.400(0.431)</td>
</tr>
<tr>
<td>Inflation gap</td>
<td>-6.210(17.005)</td>
<td>31.412*** (11.399)</td>
<td>-10.315(9.818)</td>
</tr>
<tr>
<td>Output gap</td>
<td>0.000015 (9.66e-06)</td>
<td>0.000021** (9.34e-06)</td>
<td>0.000016* (9.36e-06)</td>
</tr>
<tr>
<td>Adj. R-square</td>
<td>0.795</td>
<td>0.921</td>
<td>0.804</td>
</tr>
</tbody>
</table>

Note: Standard errors are in parenthesis. The asterisks denote statistical significance at the 1(***), 5(**), and 10(*) per cent levels. Forward expectation model uses Perfect foresight value for REER
### Table 4.

The extended linear Taylor rule forward-looking, monthly; 1990:m1-2007:m11 and 2009:m7-2020:m12

<table>
<thead>
<tr>
<th></th>
<th>Perfect foresight</th>
<th>Static expectation</th>
<th>Forward expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>US interest rate</td>
<td>0.020**(0.009)</td>
<td>0.025*(0.013)</td>
<td>0.020**(0.009)</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>0.098 (0.103)</td>
<td>-0.173** (0.078)</td>
<td>0.103 (0.099)</td>
</tr>
<tr>
<td>Inflation gap</td>
<td>-0.130 (4.193)</td>
<td>10.067** (4.270)</td>
<td>0.701 (2.386)</td>
</tr>
<tr>
<td>Output gap</td>
<td>-4.65e-06*** (1.14e-06)</td>
<td>-3.47e-08 (1.57e-06)</td>
<td>-4.58e-06*** (1.12e-06)</td>
</tr>
<tr>
<td>Adj. R-square</td>
<td>0.971</td>
<td>0.984</td>
<td>0.971</td>
</tr>
</tbody>
</table>

Note: Standard errors are in parenthesis. The asterisks denote statistical significance at the 1(***), 5(**), and 10(*) per cent levels.
### Table 5. The extended linear Taylor rule forward-looking, with Perfect foresight perspective, monthly; 1990:m1-2007:m11 (before the GFC)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US interest rate</td>
<td>0.029***</td>
<td>0.022**</td>
<td>0.020**</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.010)</td>
<td>(0.009)</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>0.128</td>
<td>0.098</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.110)</td>
<td>(0.103)</td>
<td></td>
</tr>
<tr>
<td>Inflation gap</td>
<td></td>
<td></td>
<td>-0.130</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(4.193)</td>
</tr>
<tr>
<td>Output gap</td>
<td></td>
<td>-4.65e-06***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.14e-06)</td>
<td></td>
</tr>
<tr>
<td>Adj. R-square</td>
<td>0.967</td>
<td>0.967</td>
<td>0.971</td>
</tr>
</tbody>
</table>

Dependent variable: The BOK policy rate

Note: Standard errors are in parenthesis. The asterisks denote statistical significance at the 1(***), 5(**), and 10(*) per cent levels

### Table 6. The extended linear Taylor rule forward-looking, with Perfect foresight perspective, monthly; 2009:m7-2020:m12 (after the GFC)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US interest rate</td>
<td>0.009</td>
<td>0.027**</td>
<td>0.025*</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.013)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>-0.224***</td>
<td>-0.173**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.076)</td>
<td>(0.078)</td>
<td></td>
</tr>
<tr>
<td>Inflation gap</td>
<td></td>
<td></td>
<td>10.067**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(4.270)</td>
</tr>
<tr>
<td>Output gap</td>
<td></td>
<td>-3.47e-08</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.57e-06)</td>
<td></td>
</tr>
<tr>
<td>Adj. R-square</td>
<td>0.982</td>
<td>0.983</td>
<td>0.984</td>
</tr>
</tbody>
</table>

Dependent variable: The BOK policy rate

Note: Standard errors are in parenthesis. The asterisks denote statistical significance at the 1(***), 5(**), and 10(*) per cent levels
Table 7. Correlations among the variables

```
. pwcorr r_bok lr_bok inf_gap REER_la y_gap r_us if inrange(t,1,215)
   r_bok  lr_bok  inf_gap  REER_la  y_gap  r_us
    r_bok  1.0000
   lr_bok  0.9813  1.0000
   inf_gap  0.0841  0.1028  1.0000
  REER_la -0.2277 -0.2832 -0.0876  1.0000
   y_gap  0.0247  0.1004 -0.1834 -0.1248  1.0000
    r_us  0.6572  0.6146 -0.0300  0.4110 -0.0550  1.0000

. pwcorr r_bok lr_bok inf_gap REER_la y_gap r_us if inrange(t,235,372)
   r_bok  lr_bok  inf_gap  REER_la  y_gap  r_us
    r_bok  1.0000
   lr_bok  0.9911  1.0000
   inf_gap -0.0132 -0.0469  1.0000
  REER_la -0.6854 -0.6728 -0.1726  1.0000
   y_gap  0.1248  0.1292 -0.0764 -0.0395  1.0000
    r_us -0.3695 -0.3808 -0.0449  0.5704 -0.0234  1.0000

. pwcorr r_bok lr_bok inf_gap REER_la y_gap r_us
   r_bok  lr_bok  inf_gap  REER_la  y_gap  r_us
    r_bok  1.0000
   lr_bok  0.9945  1.0000
   inf_gap  0.1815  0.1876  1.0000
  REER_la -0.5055 -0.5221 -0.1610  1.0000
   y_gap  0.0980  0.1129 -0.1199 -0.0899  1.0000
    r_us  0.6691  0.6510  0.0926  0.2576  0.0068  1.0000
```
Table 8-1. Changes in nominal exchange rates during two subperiods in Korea, 1990:m1-2020:m12

<table>
<thead>
<tr>
<th>Sub-periods</th>
<th>Exchange rates</th>
<th>Changes in exchange rates (whole period)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beginning</td>
<td>Ending</td>
</tr>
<tr>
<td>Pre-crisis period:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990m1-2007m11</td>
<td>683.4</td>
<td>917.0</td>
</tr>
<tr>
<td>Post-crisis period:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009m7-2020m12</td>
<td>1264.0</td>
<td>1095.1</td>
</tr>
</tbody>
</table>

Sources: Bank of Korea data; author’s calculations.

Note: Exchange rates and changes in exchange rates are in Korean Won per US dollar, so a negative change implies appreciation of the Won.

Table 8-2. Changes in foreign currency reserves during two subperiods in Korea, 1990:m1-2020:m12

<table>
<thead>
<tr>
<th>Sub-periods</th>
<th>Reserves</th>
<th>Changes in reserves (whole period)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beginning</td>
<td>Ending</td>
</tr>
<tr>
<td>Pre-crisis period:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990m1-2007m11</td>
<td>13.65</td>
<td>261.47</td>
</tr>
<tr>
<td>Post-crisis period:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009m7-2020m12</td>
<td>236.51</td>
<td>430.12</td>
</tr>
</tbody>
</table>

Sources: Bank of Korea data; author’s calculations.

Note: Foreign currency reserves and changes in foreign currency reserves are in billions of US dollars.

Table 8-3. Combined Propensities to Intervene (CPI) and Components of CPI during two subperiods in Korea, 1990:m1-2020:m12

<table>
<thead>
<tr>
<th>Time period</th>
<th>CPI for the subperiods</th>
<th>Sum of monthly changes in reserves, as a percentage of one-month lag of M2, for the subperiods</th>
<th>Sum of monthly log changes in exchange rates ($\Delta e$) for the subperiods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-crisis period:</td>
<td>0.812</td>
<td>148.06% ($=247.82/167.38$)</td>
<td>34.18% ($=233.6/683.4$)</td>
</tr>
<tr>
<td>1990m1-2007m11</td>
<td>(=148.06/(148.06+34.18))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-crisis period:</td>
<td>0.549</td>
<td>16.26% ($=193.61/1190.71$)</td>
<td>-13.36% ($=-168.9/1264.0$)</td>
</tr>
<tr>
<td>2009m7-2020m12</td>
<td>(=16.26/(16.26+13.36))</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources: Bank of Korea data; author’s calculations.

Note: Components of CPI = Changes in reserves as percentage of one-month lag of M2 (in billions of US dollars) and changes in exchange rates, respectively.
Table 9.


<table>
<thead>
<tr>
<th>Random effects model</th>
<th>ΔNDA_t (offset)</th>
<th>ΔNDA_t (sterilization)</th>
<th>Δmm_t</th>
<th>Δp_t</th>
<th>Y_{c,t-1}</th>
<th>ΔREER_{e,t-1}</th>
<th>ΔG_{t-1}</th>
<th>Δ(r_{t-1} + E_{e,t-1})</th>
<th>Adj. R-square</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1990:q1-2007:q4</td>
<td>2009:q3-2020:q4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perfect foresight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.998</td>
</tr>
<tr>
<td>ΔNDA_t</td>
<td>-0.984***</td>
<td>-1.016***</td>
<td>-0.984***</td>
<td>-1.016***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.323)</td>
<td>(0.013)</td>
<td>(0.010)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔNFA_t</td>
<td>-0.041***</td>
<td>-0.042***</td>
<td>-0.065***</td>
<td>-0.066***</td>
<td>-0.041***</td>
<td>-0.042***</td>
<td>-0.065***</td>
<td>-0.066***</td>
<td></td>
</tr>
<tr>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.007)</td>
<td>(0.011)</td>
<td>(0.012)</td>
<td>(0.003)</td>
<td>(0.011)</td>
<td>(0.012)</td>
<td>(0.007)</td>
<td></td>
</tr>
<tr>
<td>Δmm_t</td>
<td>-0.007(0.014)</td>
<td>-0.014(0.012)</td>
<td>-0.014(0.012)</td>
<td>-0.014(0.014)</td>
<td>-0.007(0.014)</td>
<td>-0.014(0.012)</td>
<td>-0.008(0.012)</td>
<td>-0.014(0.012)</td>
<td></td>
</tr>
<tr>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td></td>
</tr>
<tr>
<td>Δp_t</td>
<td>0.022</td>
<td>0.022</td>
<td>-0.085</td>
<td>-0.082</td>
<td>0.022</td>
<td>-0.085</td>
<td>-0.082</td>
<td>-0.082</td>
<td></td>
</tr>
<tr>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
<td></td>
</tr>
<tr>
<td>Y_{c,t-1}</td>
<td>3.51e-08(2.43e-08)</td>
<td>3.54e-08*3.7(2.47e-08)</td>
<td>-7.45e-08*3.7(6e-08)</td>
<td>-7.18e-08*3.7(0e-08)</td>
<td>3.52e-08(2.43e-08)</td>
<td>3.56e-08(2.47e-08)</td>
<td>-7.46e-08*3.7(6e-08)</td>
<td>-7.19e-08*3.6(9e-08)</td>
<td></td>
</tr>
<tr>
<td>ΔREER_{e,t-1}</td>
<td>-0.0004(0.003)</td>
<td>-0.006(0.004)</td>
<td>-0.007*</td>
<td>-0.007*</td>
<td>-0.0005</td>
<td>-0.0006</td>
<td>-0.006*</td>
<td>-0.007*</td>
<td></td>
</tr>
<tr>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td></td>
</tr>
<tr>
<td>Adj. R-square</td>
<td>0.998</td>
<td>0.998</td>
<td>0.995</td>
<td>0.996</td>
<td>0.998</td>
<td>0.998</td>
<td>0.995</td>
<td>0.989</td>
<td></td>
</tr>
</tbody>
</table>

Note: Standard errors are in parenthesis. The asterisks denote statistical significance at the 1(***), 5(**), and 10(*) per cent levels.
Table 10.

<table>
<thead>
<tr>
<th></th>
<th>Perfect foresight</th>
<th>Static expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1989:m1-2007:m11</td>
<td>2009:m7-2020:m12</td>
</tr>
<tr>
<td>Random effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔNDAₜ</td>
<td>-0.940</td>
<td>-0.981</td>
</tr>
<tr>
<td>(offset)</td>
<td>(0.007)</td>
<td>(0.005)</td>
</tr>
<tr>
<td>ΔNFAₜ</td>
<td>-1.061</td>
<td>-1.016</td>
</tr>
<tr>
<td>(sterilization)</td>
<td>(0.008)</td>
<td>(0.005)</td>
</tr>
<tr>
<td>Δmmₜ</td>
<td>-0.032</td>
<td>-0.034</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.005)</td>
</tr>
<tr>
<td>Δpₑ₋₁</td>
<td>-0.024</td>
<td>-0.028*</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>Yₑ₋₁</td>
<td>1.02e-07*(5.49e-08)</td>
<td>1.13e-07*(5.80e-08)</td>
</tr>
<tr>
<td></td>
<td>(5.49e-08)</td>
<td>(5.80e-08)</td>
</tr>
<tr>
<td>ΔREERₑ₋₁</td>
<td>0.008</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
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<tr>
<td>ΔGₑ₋₁</td>
<td>-0.002</td>
<td>0.0001</td>
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<td>(0.008)</td>
<td>(0.008)</td>
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<tr>
<td>Δ(rₑ₋₁ + Eₑ₋₁)</td>
<td>-0.001</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(0.0001)</td>
<td>(0.0001)</td>
</tr>
<tr>
<td>Adj. R-square</td>
<td>0.999</td>
<td>0.999</td>
</tr>
</tbody>
</table>

Note: Standard errors are in parenthesis. The asterisks denote statistical significance at the 1(***) , 5(**), and 10(*) per cent levels.
Table 11. Simple interest rate passthrough results (without the interest rate smoothing coefficient)

Interest rate passthrough for the whole period, quarterly; 1990:q1 – 2020:q4, monthly; 1990:m1 – 2020:m12

<table>
<thead>
<tr>
<th>US interest rate</th>
<th>quarterly</th>
<th>monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.532***(0.055)</td>
<td>0.498***(0.034)</td>
<td></td>
</tr>
</tbody>
</table>

Dependent variable: The BOK policy rate

Note: Standard errors are in parenthesis. The asterisks denote statistical significance at the 1(***), 5(**), and 10(*) per cent levels.


<table>
<thead>
<tr>
<th></th>
<th>quarterly</th>
<th>monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990:q1 – 2007:q4</td>
<td>0.292***(0.039)</td>
<td>-0.382***</td>
</tr>
<tr>
<td>2009:q3 – 2020:q4</td>
<td>-0.382***</td>
<td>0.225***(0.026)</td>
</tr>
<tr>
<td>1990:m1 – 2007:m11</td>
<td>0.225***(0.026)</td>
<td>-0.366***</td>
</tr>
<tr>
<td>2009:m7 – 2020:m12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dependent variable: The BOK policy rate

Note: Standard errors are in parenthesis. The asterisks denote statistical significance at the 1(***), 5(**), and 10(*) per cent levels.
Table 12.

- International reserves chart

![International reserves chart](image)

- US interest rate over time

![US interest rate over time](image)
References


Hansen, B., 1996. Inference when a Nuisance Parameter is Not Identified Under the Null Hypothesis. Econometrica. 64, pp. 413-430.


