Reference Rates and Monetary Policy Effectiveness in Korea

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The views expressed in this paper are those of the authors and do not necessarily reflect the views and policies of the Bank of Korea. When reporting or citing this paper, the authors’ names should always be explicitly stated.

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The authors would like to thank Woon Gyu Choi, Ho Soon Shin, Sung Hwang, Jong Ku Kang, Han Geun Moon, Inseon Hwang, Inkoo Kim, and the seminar participants at the Bank of Korea for their helpful comments and suggestions.
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Reference Rates and Monetary Policy Effectiveness in Korea

This paper empirically examines the role of the reference rates for effective monetary policy in Korea. Desirable reference rates should have strong interconnectedness with macroeconomic variables, and be robust so that their actual paths do not deviate largely from expectations. We first compare some widely used reference rates in Korea using an impulse response analysis based upon Factor Augmented Vector Autoregression.

We find that the KORIBOR delivers the largest responses to macroeconomic variables, while the differences in responses among the reference rates are moderate. To compare the robustness of the reference rates, we compute their impulse responses at multiple conditional quantile levels and examine the probability of the actual responses differing greatly from market expectations. We also find that the probability increases after an expansionary monetary policy shock, and that the KORIBOR shows relatively small increase. This implies the advantage of the KORIBOR in terms of the robustness. The bank debenture rate is shown to be most vulnerable to such a shock. Negative output and inflation shocks also give rise to increased instability due to economic downturns, and the relative performances of the reference rates are analogous to those during a case of monetary policy shock.

**Keywords:** Factor augmented vector autoregression, Impulse response function, Monetary policy effectiveness, Quantile impulse response, Reference rates

**JEL classification:** C32, E44, E52, E58
1. Introduction

Reference rates are money market interest rates used for pricing financial instruments so as to reduce their trading costs and improve liquidity. They also play important roles in effective monetary policy, as media linking the policy rate to the financial markets and real economy. The existing literature has studied this medium role in terms of the relationships between the reference rates and the policy rate (Kobayashi, 2009; Carpenter and Demiralp, 2011; Ivrendi and Pearce, 2014), and between the reference rates and macroeconomic stability (Sudo, 2012; Muto, 2013; Kawasaki et al., 2012).

The loan and interest rate swap markets are where the reference rates are primarily used, and inter-bank offered rates (IBOR), as exemplified by LIBOR, have been monopolistically used in both markets for a long time. The effectiveness of LIBOR is however now being reexamined, in the wake of the LIBOR scandal in 2012, and attempts to develop alternative reference rates and replace the current ones are in progress (IOSCO, 2012; HM Treasury, 2012; EBA & ESMA, 2013, 2014; FSB, 2013; BIS, 2013).

In Korea, the certificate of deposit (CD) rate has been used as a representative reference rate in both the loan and the derivatives markets. However, the CD markets have shrunken substantially since introduction of the loan-to-deposit ratio regulation following the global financial crisis. There has consequently been much discussion of enhancing the representativeness of reference rates by replacing the CD rate, through for example the introduction of various reference rates in the loan market and promoting the KORIBOR (Korea Inter-Bank Offered Rate) in the derivatives market.

Since they play important roles in facilitating effective monetary policy, it is crucial to evaluate the various reference rates in terms of their monetary policy transmission roles, and derive recommendations for the discussion of reference rate reform. However, there is little research in Korea concerning proper operation of the reference rates, or the impacts on monetary policy effectiveness caused by changes in these rates.
With this in mind, this paper examines the role of the reference rates used in Korea with an emphasis on the effectiveness of monetary policy and on financial market and real economic stability. According to the BIS (2013), the reference rates desirable for facilitating effective monetary policy should have strong interconnectedness with broad sets of macroeconomic variables including the policy rate, lending rates, and real output. They are required to have robustness as well, which means that their actual responses to monetary or macroeconomic shocks should not depart greatly from those expected.

To this end we conduct an impulse response analysis to compare (i) the influences of reference rates on the real economy and financial markets through the monetary policy transmission mechanism, and (ii) the responses of the reference rates and their robustness to monetary policy and macroeconomic shocks. Since our analysis focuses on monetary policy effectiveness, it is essential to avoid the price puzzle problem well known to be present in the conventional VAR (Sims, 1992; Christiano, Eichenbaum and Evans, 1996). We in addition examine the relationships between the reference rates and a wide range of macroeconomic factors. Considering all of this, we use Bernanke, Boivin and Eliasz (2005)’s Factor Augmented VAR(FAVAR), in which common factors from a broad set of macroeconomic variables are included in setting up the model.1)

To assess robustness, we apply the conditional quantile analysis method to the FAVAR impulse response function, and analyze how the tails of the reference rates’ probability density functions change in response to macroeconomic shocks. Conditional quantile analysis, first suggested by Koenker and Basset (1978), is being increasingly used for time series analysis (Koenker and Xiao, 2006; Galvao, 2009; Xiao, 2009; Galvao et al., 2008, 2009; White et al., 2012), and in monetary economics (Greenwood-Nimmo et al., 2012; Kim, Lee and Mizen, 2015). Kim, Lee and Mizen (2015) define and draw quantile impulse response functions in a structural VAR model. Our paper uses a simpler method, applying quantile regression equations to those for factors rather than the impulse response function of Kim, Lee and Mizen (2015) to draw its quantile impulse response function.

1) Park (2009) and Sung and Kang (2009) apply FAVAR to measure the monetary policy effects in Korea.
The remainder of this paper is organized as follows. Section 2 reviews the discussions regarding reference rate reforms at the global and domestic levels, as well as the current state of reference rates in Korea. Section 3 shows the results of empirical analysis regarding the influence of reference rates on the financial markets and real economy. It also analyzes the dynamic responses of reference rates to monetary policy and macroeconomic shocks. Finally, Section 4 concludes.

2. Discussions of Global and Domestic Reference Rate Reform

2.1. Global reference rate reform

Inter-Bank Offered Rates (IBOR), which had been used as reference rates in a number of countries, have in the course of the global financial crisis and the 2012 LIBOR scandal come to face problems related to their representativeness and reliability. Since the financial crisis the volume of unsecured inter-bank borrowings has declined due to the increased awareness of credit risk, leading in consequence to a deterioration in IBOR representativeness. Enlarged differences among banks’ credit risks, as well as deepened volatility, have also worked as factors weakening IBOR representativeness assuming common bank credit risk premiums.
Following growing allegations in 2008 that some major global banks had engaged in LIBOR manipulation, US and UK regulators launched investigations and LIBOR manipulation was made public when Barclays settled with the authorities concerned to pay a 0.45 billion dollar fine. It was henceforth well known that IBOR, which is calculated by the offering method, is vulnerable to manipulation. Its reliability has in consequence been threatened.

In order to solve these problems with IBOR representativeness and reliability, major economies including the UK and the EU have proposed plans for IBOR reform, focused on the recovery of its reliability and the restructuring of its governance. This is also in line with the efforts for reference rate reform pursued by international organizations such as the BIS, IOSCO and the FSB.

(1) UK

Shortly after the LIBOR manipulation scandal in June 2012, the British government asked Martin Wheatley, head of the Financial Services Authority (FSA) at that time, to conduct a review of the calculation and use of LIBOR. In compliance with this, a discussion paper was released in August 2012 and, after consultation with stakeholders, the final report on LIBOR reform, the Wheatley Review of LIBOR, was released to the public in September 2012.

The Wheatley Review reached three key, fundamental conclusions, drawing upon which it suggested a ten-point plan for LIBOR reform. The three key conclusions are as follows: that ① it is desirable to reform rather than replace LIBOR, ② transaction data should be prioritized in the process of LIBOR submission, and ③ market participants should keep playing a significant role in LIBOR production and oversight. The ten-point plan based upon these three fundamental conclusions relates mainly to the strengthening of regulation with respect to the administration and submission of LIBOR, to transferring the responsibility for LIBOR to a new administrator, to complying with the submission guidelines and adopting a code of conduct for submitters, to ending the compilation of LIBOR for currencies and tenors with insufficient trade data, to encouraging banks to participate in the LIBOR compilation process,
and to working closely in the international community to establish effective
global benchmarks.

(2) EU

The European financial supervisory authorities, the ESMA and the EBA, prepared plans for reference rate reform so as to resolve the problems in the reference rate calculation process disclosed in the LIBOR scandal. Their final report, ‘Principles for Benchmarks-Setting Processes in the EU’ insisted that the reference rate calculation process be properly controlled, that the administrators of reference rates guarantee their robustness as well as setting clear principles and procedure regarding their governance, and that submitters of reference rates should not only prepare but also execute internal control procedures.

In the report issued in February 2014, ‘Review of the Implementation of EBA-ESMA Recommendations to EURIBOR-EBF’, it was assessed that there had been significant progress made in the composition and governance of the EURIBOR-EBF steering committee, the reduction of tenors, and the reinforcement of internal procedures undertaken in the process of calculation. It was in addition suggested that the ESMA and the EBA continue to monitor the implementation of their recommendations.

(3) IOSCO

In September 2012, IOSCO created a board-level task force on financial market benchmarks, co-chaired by Martin Wheatley (chief executive officer of the FCA, UK) and Gary Gensler (commissioner of the CFTC, USA), and assigned it the task of developing an overarching framework of principles for benchmarks used in financial markets. IOSCO subsequently suggested principles for benchmarks addressing important issues such as governance, the quality of benchmark design, methodology and accountability, in its final report on

2) EBA stands for European Banking Authority, and ESMA for European Securities and Markets Authorities.
Table 1: IOSCO’s ‘Principles for Financial Benchmarks’

<table>
<thead>
<tr>
<th>Contents</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Governance</strong></td>
<td></td>
</tr>
<tr>
<td>o Ensuring integrity of benchmark determination process, and building appropriate governance so that trade-off problems do not occur</td>
<td></td>
</tr>
<tr>
<td>o Need for organization responsible for benchmark integrity</td>
<td></td>
</tr>
<tr>
<td><strong>Quality of Benchmark</strong></td>
<td></td>
</tr>
<tr>
<td>o In process of benchmark design, including elements able to reliably indicate economic realities</td>
<td></td>
</tr>
<tr>
<td>o Benchmark calculation based on observable transactions However, restrictive permission of non-transactional data, such as bid and extrapolation, depending upon market situation and benchmark characteristics</td>
<td></td>
</tr>
<tr>
<td>o Need for clear guidelines about hierarchy in importance of data</td>
<td></td>
</tr>
<tr>
<td><strong>Quality of Methodology</strong></td>
<td></td>
</tr>
<tr>
<td>o Providing sufficient information able to assess representativeness of benchmark to stakeholders, through publishing of methodology used in calculation</td>
<td></td>
</tr>
<tr>
<td>o Providing code of conduct guidelines for data submitters</td>
<td></td>
</tr>
<tr>
<td><strong>Accountability</strong></td>
<td></td>
</tr>
<tr>
<td>o Publishing to provide a process can express frustration of stakeholders in relation to the determination of the benchmark</td>
<td></td>
</tr>
<tr>
<td>o Regularly checking whether benchmark administrator in compliance with certain criteria and requirements; appointing independent internal or external auditors</td>
<td></td>
</tr>
</tbody>
</table>

‘Principles for Financial Benchmarks’ published in July 2013. Specifically, the principles consist of establishing governance to ensure the integrity of the benchmark determination process, improving the benchmark quality using data anchored by observable transactions, promoting the quality and integrity of the methodology for benchmark calculation by setting a code of conduct related to submission, and strengthening benchmark accountability through auditing by independent institutions.

(4) FSB

With the debate over how to reform reference rates growing in 2013, the G20 asked the FSB (Financial Stability Board) to undertake a fundamental review of major interest rate benchmarks and reform plans.3) In the first instance, the FSB endorsed the IOSCO Principles for Financial Benchmarks published in July 2013, and made additional suggestions for reform including moving to transactions-

3) G20 Leaders’ Declaration, St. Petersburg Summit, September 2013.
based calculation and minimizing transition risks and costs, and promoting international coordination. Based upon these principles its final report, ‘Reforming Major Interest Rate Benchmarks’, was published in July 2014. This report suggested a multiple-rates approach, strengthening of the existing IBOR with transaction data((IBOR+) and developing alternative risk-free reference rates\(^4\) to be used in derivatives transactions. It additionally suggested that reference rate reform requires a sufficient transition period in order to minimize litigation risk, and should be implemented in consideration of its impacts on other countries.

2.2. Reform and current state of reference rates in Korea

(1) Reference rate reform in Korea

In Korea the CD rate has been used as a reference rate in loan and interest rate swap contracts. Since the global financial crisis, however, the volume of issuance and transactions in CDs has shrunken significantly in line with implementation of the loan-to-deposit ratio regulation\(^5\) announced in December 2012. As a result the CD rate has faced a problem of lack of representativeness, since it does not adequately reflect money market conditions.

<table>
<thead>
<tr>
<th>Table 2: Marketable CD Outstanding Balance, and Issuance Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outstanding balance (end of period)</td>
</tr>
<tr>
<td>08</td>
</tr>
<tr>
<td>20.0</td>
</tr>
<tr>
<td>Issued amount (monthly average)</td>
</tr>
<tr>
<td>08</td>
</tr>
<tr>
<td>5.9</td>
</tr>
</tbody>
</table>

Source: The Bank of Korea

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\(^4\) The OIS (Overnight Index Swap) rate is being suggested as an alternative for IBOR in some advanced countries, while short-term government bond rates are more possible alternatives in the US and Japan.

\(^5\) The loan-to-deposit ratio regulation (loans / deposits ≤ 100) was adopted to prevent domestic banks from providing loans in excess of their long-term stable deposits. In calculation of the ratio funding through CD issuance is not regarded as deposits, which has weakened banks’ incentives to issue CDs.
Meanwhile, following the 2012 LIBOR scandal, the CD rate, which had been displaying rigid movements, has also faced allegations of manipulation, calling its reliability into doubt. In response to this dispute the Korean government, the Bank of Korea, the Financial Supervisory Service, and private experts have established a task force to discuss plans for reform of the short-term reference rates.

The task force has agreed on three major guidelines with respect to reference rate reform: ① creating reference rates to replace the CD rate in the loan market, ② promoting the CD rate’s marketability, and ③ seeking alternative reference rates for the derivatives market. Based upon these guidelines, in December 2012 the short-term COFIX was introduced as an alternative reference rate for short-term loans such as those to corporations for operating funds. In addition, to try to improve the CD rate’s effectiveness, eight banks with substantial amounts of adjustable rate loans based on the CD rate are now required to issue marketable CDs sufficient to maintain a monthly average balance totaling 2 trillion won. There have also been improvements made in the process of CD rate calculation, through the establishment of basic principles to be followed in the rate submission process.

In line with those measures, the FSC made an announcement in November 2013 encouraging use of the KORIBOR as an alternative reference rate in the interest rate swap and other derivatives markets. A plan for improvement of the KORIBOR, prepared by the Korea Federation of Banks, then came into force in April 2014. It is assessed that since implementation of this plan there have been positive changes in the KORIBOR, which had previously shown rigid movements like the CD rate; the KORIBOR has now come to better reflect market conditions. However, despite the announcement encouraging KORIBOR use, the CD rate is still predominantly used in interest rate swap transactions.

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7) More than 90% of interest rate swaps in Korea, which amount to 4,000 trillion won in notional value, use CD rates as references for the variable rates.
Figure 3: Money Market Rates

![Chart showing money market rates](chart)

Table 3: KORIBOR Reform (Enforced from April 2014)

<table>
<thead>
<tr>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principles of interest rate submission</strong></td>
</tr>
<tr>
<td>- Interest rate-submitting bank presents bid interest rates based on following:</td>
</tr>
<tr>
<td>- Transactions which interest rate-submitting bank has performed in market with other financial institutions</td>
</tr>
<tr>
<td>- In same markets, transactions of other banks which interest rate-submitting bank is aware of</td>
</tr>
<tr>
<td>- Bids that other banks have presented to interest rate-submitting bank in same markets</td>
</tr>
<tr>
<td>- Professional judgment as to when related transaction data does not exist</td>
</tr>
<tr>
<td><strong>Enforcement of internal control procedures</strong></td>
</tr>
<tr>
<td>- Interest rate-submitting bank enforces preparation of internal control procedures that include the following:</td>
</tr>
<tr>
<td>- Confirmation of compliance with interest rate-submitting principles of persons in charge</td>
</tr>
<tr>
<td>- Detailed methods of calculation, and of storage of submitted interest rate records</td>
</tr>
</tbody>
</table>

(2) Current state of reference rates in Korea

There are a number of reference rates currently being used for loan contracts, including the CD rate, the KORIBOR, the COFIX, the bank debenture rate, and the fund transfer rate. This is attributed to the on-going efforts to diversify

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8) This means the opportunity cost (market opportunity rate) of funds that can be raised in the market, as well as the internal transfer price between a head office and the branches, adjusted in accordance with bank policy.
reference rates, through replacing the CD rate with its lack of representativeness problem by alternative rates. There have in consequence been substantial changes in the reference rates for household and corporate loans – from the CD rate to the COFIX, and from the CD Rate to the bank debenture rate and the KORIBOR, respectively.

According to international entities such as IOSCO, the BIS and the FSB, desirable reference rates should meet a variety of requirements.\(^9\) They should appropriately reflect overall market conditions (representativeness); be free from involving conflicts of interest between lenders and borrowers (fairness); properly reflect credit risk and funding costs, which are considered as intrinsic characteristics of reference rates in the loan markets (credit risk reflection); be readily available without constraints (ready availability); and be available even in cases of market turbulence (robustness). In addition, in terms of their intrinsic roles in monetary policy transmission it is required that reference rates have close interconnectedness with the policy rate, long-term interest rates, deposit and loan rates, and other real and financial variables (interconnectedness with macroeconomic variables).

Among the reference rates currently used in the Korean lending markets, none satisfy all of these requirements. The KORIBOR is however assessed as most desirable in terms of its representativeness, fairness, reflection of credit risk and readily availability. In other words, the KORIBOR reflects various funding channels including through CDs and bank debentures, guaranteeing its greater representativeness compared to the other reference rates. In addition, it is considered that the KORIBOR’s fairness has increased since implementation of the guidelines concerning submission and internal control processes. In contrast, the CD and bank debenture rates are vulnerable in the aspects of representativeness and fairness, since both the CD and the bank debenture markets are comparatively small and there are incentives for keep the rates high owing to the relatively large volumes of loans based on them.

As for the COFIX, which is based on deposit rates, its representativeness and ready availability are relatively weak. The fund transfer rate is also problematic in terms of representativeness, fairness and ready availability; it is easily affected by internal bank policies related to fund transfers or administrative procedures, and the rate level is not open to the public.

In the next section we analyze the robustness and interconnectedness with real and financial market variables of the Korean reference rates, through empirical analysis.
Table 4: Trading and Issuance Volumes of Main Short-Term Benchmarks

(As of 2014, trillion won)

<table>
<thead>
<tr>
<th></th>
<th>Marketable CDs</th>
<th>1-year or less maturity1) bonds (MSBs)</th>
<th>(Bank debentures)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trading volume</td>
<td>0.1</td>
<td>4.9</td>
<td>2.3</td>
</tr>
<tr>
<td>(daily average)</td>
<td></td>
<td></td>
<td>0.9</td>
</tr>
<tr>
<td>Issuance volume</td>
<td>0.1</td>
<td>0.9</td>
<td>0.5</td>
</tr>
<tr>
<td>(daily average)</td>
<td></td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Outstanding balance</td>
<td>3.5</td>
<td>430.4</td>
<td>121.7</td>
</tr>
<tr>
<td>(end of October 2014)</td>
<td></td>
<td></td>
<td>66.0</td>
</tr>
</tbody>
</table>

Notes: 1) Trading volume and outstanding balance based on remaining maturities, issuance amount based on issuance maturities

Table 5: Interest Rates Used for KORIBOR Bidding

<table>
<thead>
<tr>
<th>KORIBOR tenor</th>
<th>Interest rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 week</td>
<td>Call, Bank of Korea RPs, Inter-institutional RPs</td>
</tr>
<tr>
<td>1 month ~ 2 month</td>
<td>Call, Financial institution time deposits, CDs, IRS, MSBs (28-day), Bank debentures</td>
</tr>
<tr>
<td>3 month ~ 6 month</td>
<td>CDs, Bank debentures, Financial institution time deposits, MSBs, IRS</td>
</tr>
</tbody>
</table>

Table 6: State of Reference Rate Announcements

<table>
<thead>
<tr>
<th>CD rate</th>
<th>KORIBOR</th>
<th>Bank debenture rate</th>
<th>COFIX</th>
<th>Fund transfer rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twice a day (11:30, 15:30)</td>
<td>Once a day (11:00)</td>
<td>Once a day (17:00)</td>
<td>Once a month (announcement of weighted average interest rate of last month on 15th of current month)</td>
<td>No announcement</td>
</tr>
</tbody>
</table>

Table 7: Comparative Evaluation of Loan Reference Rates1)

<table>
<thead>
<tr>
<th>Desirable characteristics</th>
<th>CD rate</th>
<th>KORIBOR</th>
<th>COFIX</th>
<th>Bank debenture rate</th>
<th>Fund transfer rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Representativeness</td>
<td>✕</td>
<td>Δ</td>
<td>✕</td>
<td>Δ</td>
<td>✕</td>
</tr>
<tr>
<td>Fairness</td>
<td>✕</td>
<td>Δ</td>
<td>Δ</td>
<td>Δ</td>
<td>✕</td>
</tr>
<tr>
<td>Credit risk reflection</td>
<td>Δ</td>
<td>○</td>
<td>○</td>
<td>Δ</td>
<td>Δ</td>
</tr>
<tr>
<td>Ready availability</td>
<td>○</td>
<td>○</td>
<td>✕</td>
<td>○</td>
<td>✕</td>
</tr>
</tbody>
</table>

Note: 1) ○: High, Δ: Normal, ✕: Low
3. Empirical Analysis

3.1. Literature review

Existing studies examine the relationships of the reference rates with monetary policy in terms of i) the relationships between the reference rates and the monetary policy instruments, and ii) the roles of the reference rates for macroeconomic stabilization. Concerning the first issue, Ivrendi and Pearce (2014) use VAR to determine the relationships between expected monetary policy and LIBOR. Carpenter and Demiralp (2011) use single linear regression models to find evidence of the expectations hypothesis in the relationship between 3-month LIBOR and an appropriate measure of the expected federal funds rate. They also show that volatility in the federal funds market plays an important role in determining the LIBOR spread. There is also literature examining the prime rate as a reference rate in the US related to monetary policy.10) A traditional view is that the prime rate is less responsive to a change in the federal funds rate, and this lack of responsiveness becomes worse in periods of interest rate decline (Forbes and Mayne, 1989; Mester and Saunders, 1995; Dueker, 2000). However, recent studies by Kobayashi (2009) and by Friedman and Schacurove (2014) use menu cost models and VAR and find that the prime rate responds more to the federal funds rate since the mid-1990s, which improves monetary policy efficiency. Zhu, Chen and Li (2009) also show the prime rate becoming more responsive to money market changes since the mid-1990s.

Research has also been devoted to examining the role of reference rates related to macroeconomic and financial market stabilization, which offers insights as to the effectiveness of monetary policy transmission through reference rates. Sudo (2012) uses a dynamic stochastic general equilibrium model to find that (i) the reference rates mitigate informational frictions in the credit markets, leading to higher investment, output and inflation, (ii) it may contribute to economic

10) A survey carried out in 2005 found that about one-third of commercial loans extended by US banks were linked to prime rates, and that loans from small domestic banks and small business loans relied on the prime rates more than on LIBOR (FRB St. Louis).
stabilization by providing accurate economic forecasts, and (iii) it may bring about unintended consequences for monetary policy implementation by adding noise to the credit spreads. Muto (2013) shows theoretically that noise-free reference rates reduce the volatility of market interest rates, while the existence of noise weakens these effects when the market volume is small. Kawata et al. (2012) use their own small-size macroeconometric model to show that the existence of reference rates mitigates the volatility of financial and economic activities, and that the monetary policy transmission mechanism is weakened in the absence of reference rates.

On the other hand, however, an unusual jump in the LIBOR-OIS spread after the financial crisis in 2008 prompted interest in a role for monetary policy in stabilizing LIBOR. Taylor and Williams (2008), Szczepanik (2011) and Thornton (2014) find no evidence that the introduction of unconventional monetary policies such as the new term auction facility (TAF) has reduced the spread. Martin and Milas (2010) argue that the optimal monetary policy rule should include the determinants of the LIBOR-policy rate spread. Kobayashi (2012) claims that the rises in premiums of the reference rates due to the temporary surge in uncertainty recently have caused economic inefficiency, and an expert judgment could thus be allowed to some extent to reduce these premiums.

Although the relationships between reference rates and monetary policy have been widely studied, little attention has been paid to determining that relationship in the Korean economy. The existing literature focuses only on the relationship between the Bank of Korea’s policy rate and market interest rates or the loan/deposit rates. To the best of our knowledge, no research has studied the relationships with monetary policy of the reference rates used in the Korean economy.

3.2. Models

The purpose of our empirical analysis is to compare and evaluate the performances of the existing reference rates in terms of the resulting effectiveness of monetary policy. As discussed in the previous section, this requires strong relationships between the reference rates and the monetary instruments/
macroeconomic factors, together with reference rate robustness. To this end we conduct the following two empirical analyses: 1) measuring the effects of reference rate shocks on macroeconomic variables such as output, employment, prices, bank/nonbank loans, loan rates, etc., and 2) measuring the responses of the reference rates and their robustness to shocks from monetary policy, the real economy and inflation.

Most of the empirical literature discussed above uses standard VAR, linear regressions, or small-size simultaneous equations. These methods are however not relevant to our analysis, for two reasons. First, it is well known that the standard VAR is subject to the so-called ‘price puzzle’ problem – a rise in the aggregate price level in response to a contractionary monetary policy shock, which contradicts what is predicted by mainstream theory. Any evaluations of the monetary policy implications will thus not be reliable if the price puzzle is present in the model. Second, our analysis requires fairly high dimensional models since its purpose is to examine the relationships between the candidate rates and a large set of macroeconomic and financial variables. Models with small sets of variables are thus not relevant. DSGE methods are also hard to apply to comparison of the relative performances of different reference rates, owing to the lack of a theoretical background for calibrating different parameters for different reference rates.

Considering this we employ the FAVAR proposed by Bernanke, Boivin and Eliasz (2005), and compute the impulse response functions. To examine the robustness of the reference rates’ responses in the second analysis, we also compare the stabilities of their responses using multiple conditional quantile analysis. We now briefly describe our empirical methodology.

11) A traditional interpretation of the puzzle is that central banks have better inflation forecasts, so that the changes in interest rates partially reflect policy responses to inflation pressures. In recent decades there have been many attempts to tackle the problem by eliminating the expected changes in the policy variables. One conventional way is to add a commodity price as an information variable; see Sims (1992), and Christiano, Eichenbaum and Evans (1996). In other efforts, Giordani (2004) proposes using the GDP gap instead of output growth, while Bernanke and Mihov (1998) suggest a linear combination of total reserves, non-borrowed reserves and the federal funds rate as a policy shock.
(1) Factor Augmented Vector Autoregression (FAVAR)

Let $Y_t$ be an $m \times 1$ vector of variables of interest, and let $F_t$ be a $k \times 1$ vector of unobserved factors that summarize additional information capturing macroeconomic activities and financial circumstances. The FAVAR model is given by

$$
\Phi_0 \begin{pmatrix} F_t \\ Y_t \end{pmatrix} = \Phi(L) \begin{pmatrix} F_{t-1} \\ Y_{t-1} \end{pmatrix} + \epsilon_t
$$

(1)

where $\Phi_0$ is the $(m+k) \times (m+k)$ matrix of coefficients, and $\Phi(L)$ is a conformable lag operator polynomial. Let $X_t$ be an $n \times 1$ vector of a large variety of time series that capture the dynamics of the macroeconomic and financial sectors. It is assumed that the unobservable factor $F_t$ can be inferred from $X_t$, which is described by the following regression:

$$
X_t = A^f F_t + A^y Y_t + u_t
$$

(2)

where $A^f$ is an $n \times k$ matrix of factor loadings, $A^y$ an $n \times m$ matrix, and $u_t$ an $n \times 1$ vector of error terms. Equation (2) thus captures that the common dynamics of $X_t$ are driven by $(F_t, Y_t)$. FAVAR has two benefits. First, it captures the information sets used by the financial sector, the central bank, and other economic agents. Bernanke, Boivin and Eliasz (2005), Bernanke and Boivin (2003), and Stock and Watson (2002) show that a small number of factors are able to summarize a large number of macroeconomic and financial time series. This mitigates the price puzzle problem, thus making monetary policy-related inferences valid. Second, using FAVAR we are able to obtain the impulse response functions of any variables included in $X_t$. Since we wish to analyze the effects of different candidate rates on a wide range of macroeconomic and financial variables, employing FAVAR will be appropriate for our purposes.

Bernanke, Boivin and Eliasz (2005) suggest two methods for estimating Equation (1): (i) estimating both Equation (1) and $F_t$ at one time using the joint
likelihood method implemented by Gibbs sampling, and (ii) estimating $F_t$ first using the principle component method, and then estimating (1) using the standard VAR estimation with $F_t$ replaced by $\hat{F}_t$. We choose the second method, because of their finding that the two methods provide similar results while the latter is computationally easier. Once the equations are estimated, we can compute the impulse response functions by using the standard method. The detailed procedure for estimation and computing of the impulse response functions is as follows:

Step 1) Obtain the first $k + m$ principle components of $X_t$.

Step 2) Estimate $F_t$, which is the part of the space of the principle components not covered by $Y_t$. Denote the estimator by $\hat{F}_t$.

Step 3) Replace $F_t$ in Equation (1) by $\hat{F}_t$ and estimate the equation using the standard VAR method. Compute the impulse response functions, denoted by $(\Delta \hat{F}_t^h, \Delta Y_t^h), h = 0, ..., H$.

Step 4) Estimate Equation (2) using $\hat{F}_t$, and compute the impulse response function of $X_t$ as

$$\Delta X_t^h = \hat{A}^F \Delta \hat{F}_t^h + \hat{A}^Y Y_t^h$$

(3)

where $\hat{A}^F$ and $\hat{A}^Y$ are the estimators of $A^F$ and $A^Y$ respectively.

(2) Quantile impulse response function

As noted in the previous section, the desirable reference rate should display stable and expected responses to any change in monetary policy. That is, the actual dynamics of the reference rate after economic shocks should not vary too far from the expected path, implying little chance of outliers after such shocks. To evaluate this performance we also examine the impulse responses of the reference
rates on the tails of their probability distributions, using the conditional quantile regression method. The $\alpha^{th}$ quantile of the distribution of each element of $X_t$ conditional on the information set $\Omega_t$, denoted by $q_{it}^\alpha$, is defined as satisfying

$$\text{Prob}(X_{it} < q_{it}^\alpha \mid \Omega_t) = \alpha, \quad 0 < \alpha < 1$$

(4)

where $X_{it}$ is the $i^{th}$ element of $X_t$. In other words, $q_{it}^\alpha$ is such that the conditional probability of $X_{it}$ being smaller than $q_{it}^\alpha$ is $\alpha$. Thus, $q_{it}^\alpha$ for $\alpha$ close to zero or one captures the dynamics of $X_{it}$ at the tails of the distribution. Analogous to the traditional impulse response function, the impulse response of the conditional quantile of $X_{it}$ against a shock $\varepsilon_{jt}$ can be defined as $\frac{\partial q_{it}^\alpha}{\partial \varepsilon_{jt}}$, $h = 0, \ldots, H$. An economic shock may not only shift the future expected paths of the variables but also change the uncertainty structure of economic activities, which is captured by the change in the probability distribution function. In this case the impulse response of $q_{it}^\alpha$ will be heterogeneous to the conventional impulse response, which is interpreted as the impulse response at the mean of the distribution. In this paper we examine the quantile dynamics at $\alpha = 0.05$ and 0.95.

To compute the quantile responses we impose an assumption similar to (2), that the conditional quantiles of $X_t$ for $\alpha = 0.05$ and 0.95 are described by the following quantile regression:

$$q_{it}^\alpha = A_i^{F\alpha} F_t + A_i^{Y\alpha} Y_t, \quad i = 1, \ldots, n$$

(5)

where $A_i^{F\alpha}$ and $A_i^{Y\alpha}$ are the $k \times 1$ and $m \times 1$ vectors of the coefficients respectively. The quantile impulse responses, denoted by $\Delta q_{it}^{a,b}$, can thus be calculated by

---

12) See Kim, Lee and Mizen (2015) for detailed explanation.
\[ \Delta q_{it}^h = \frac{\partial q_{it}^h}{\partial e_t} = \hat{\Lambda}_i^{F_o} \frac{\partial \hat{F}_t^h}{\partial e_t} + \hat{\Lambda}_i^{Y_o} \frac{\partial \hat{Y}_t^h}{\partial e_t} \]  

(6)

where \( \hat{\Lambda}_i^{F_o} \) and \( \hat{\Lambda}_i^{Y_o} \) are the estimators of \( \Lambda_i^{F_o} \) and \( \Lambda_i^{Y_o} \) respectively. We compare the relative degrees of robustness by examining the dynamics of the distances between the quantiles and the means after economic shocks. Note that (3) is defined as the impulse response of the mean. Thus, if an economic shock does not change the distribution of the reference rate, \( \Delta q_{it}^h \) for the reference rate is equivalent to \( \Delta X_{it}^h \), and the distance \( |q_{it}^h - X_{it}^h| \) is unchanged after the shock. If a distributional change occurs, however, then \( |q_{it}^h - X_{it}^h| \) changes over time. The increase in the distance and tails thereby farther from the center of the distribution indicates a spreading out of the distribution in that direction. This implies an increase in the possibility that the actual reference rates respond far below or above the central expectations. We will discuss this in more detail below.

### 3.3. Data

We examine the three existing reference rates: the CD rate, the KORIBOR, and the bank debenture rate. The COFIX and fund transfer rates are not considered because of a shortage of samples. We also include the Monetary Stabilization Bond (MSB) rate when analyzing the responses of the reference rates to various economic shocks. This is because, while it is not currently used as a reference rate, the MSB rate is being considered for use as an alternative reference rate in the interest rate swap market. The data used in the estimation are monthly observations spanning the period from November 2006 to November 2014, which is chosen based upon data availability. We consider two VAR models, of which the first is for measuring the effects of candidate rate shocks on the macroeconomic variables and the other for measuring the effects of macroeconomic shocks on the candidate rates. For the two models, \( Y_t \) is defined as follows:
Model I:  $Y_t = (\text{real growth, inflation, reference rate change})'$

Model II:  $Y_t = (\text{real growth, inflation, monetary policy change})'$

One may consider using a single VAR model by including both reference rate and policy rate. The main reason we split the model is because our purpose in the second VAR is to examine the quantile response of the reference rate. If the reference rate is in the VAR set-up, we have to construct the quantile relations in the VAR to examine the quantile responses of the reference rates. Unfortunately, the impulse response function in the quantile VAR set-up is not as simple as the conventional VAR and there is no agreement on the definition of the quantile impulse response function.\(^{13}\)

For the robustness check of the impulse response functions, we run the FAVAR model with various different measures of real growth and inflation. Real growth is measured by the rates of growth of industrial production, total employment and total shipments. The commodity consumer price index and the manufacturing producer price index are used to measure inflation. Changes in monetary policy are measured by changes in the overnight call rate.  $X_t$ contains 86 variables from real production, employment, wages, housing, prices, investment, monetary aggregates, finance and interest rates. The detailed data list and descriptions are provided in the appendix.

The current reference rates have five different maturities (1 week, 1 month, 3 months, 6 months, and 12 months), with the three-month maturity ones the most popular for use as reference rates. The three-month rates had been moving too closely to each other, however, since the CD rate had dominated the other rates at that maturity until implementation of the KORIBOR improvement plan in 2014. In addition, the powers of statistic tests are highly dependent on the distance between null and alternative spaces. Considering that all four interest rates perform as reference rates, it is natural that their movement would be similar so

\(^{13}\) See Kim, Lee and Mizen (2015) for details.
that the differences in the impulse responses are not fairly distinctive even though they present, which implies that the test would suffer from weak powers, and statistical significances are not very informative. Moreover, since we have separate VAR models with our different choices of reference rates, comparing the relative performances of the rates statistically is difficult. To tackle this problem we perform impulse response analyses at the various different maturities (1 week, 1 month, 3 months, 6 months, and 12 months), and examine whether the distinctive properties are consistent at all maturities. We also consider models with different numbers of factors (one and two), and with different proxies for price and output. We thus eventually run 60 different VAR models with diverse combinations of variables. Although the differences in performance among the three reference rates are moderate, we interpret a difference as meaningful if the results are consistent in all 60 different models. The optimal orders of VAR models based on AIC are all around 4 and we unify them to VAR(4).

The identifying assumption for the FAVAR model is that the overnight call rate in Model 1 and the short-term interest rates in Model II are placed last in order, which implies that policy shocks and short-term interest rates respond almost contemporaneously to aggregate output and prices, but have no contemporaneous impacts on aggregate output and prices. When computing the responses to real growth and inflation shocks, we consider different orderings of the factors, growth and inflation, but find no distinctive changes. We thus present the results of the ordering as factors, growth and inflation. To ensure that the factors do not respond to the overnight call rate and short-term interest rates within one month, we follow Bernanke, Boivin and Eliasz (2005) but modify the fast-moving factors that are highly sensitive to contemporaneous shocks. This changes Steps 1) and 2) of the impulse response computation process as follows:

Step 1) Obtain the first \( k + m \) principle components of \( X_t \), denoted by \( \hat{C}_t \), and then obtain the first \( k \) principle components of the slow-moving factors of \( X_t, \hat{C}_t \) denoted by \( \hat{F}^x_t \),
Step 2) Estimate the following regression:

$$\hat{C}_t = b_P \hat{F}^S_t + b_Y Y_t + e_t$$  \hspace{1cm} (7)$$

where $e_t$ is the error term. $\hat{F}_t$ is then constructed from $\hat{C}_t - \hat{b}_Y Y_t$.

3.4. Empirical results

(1) Effects of reference rate shocks on macroeconomic and financial variables

Most of the results are robust and are not sensitive to the choice of variables, albeit with minor size differences, while the effects on the real economy are moderately unstable with shorter term interest rates (1-week and 1-month), and as expected the responses are not distinctive to the choice of reference rate at the three-month maturity. We consequently present selected results from the model with a single factor, along with growth in total employment, PPI inflation, and the 6-month reference rates.

Figure 6 shows the responses of lending rates. After the negative 0.5%p shock to the reference rates, the loan rate falls by about 0.4%p in six months, following which it rebounds and is stable thereafter. Among the three rates, the KORIBOR has greater effects on the lending rates than do the CD and bank debenture rates. Note that the KORIBOR dominates the others in terms of the market size that the
reference rate covers. This allows the KORIBOR to respond more effectively to changes in money market demand/supply, in credit risk, and in the funding costs of financial institutions. When using the KORIBOR financial institutions thus have less motivation to adjust the spreads between the reference rate and their lending rates, to make up for changes in the reference rate. This pattern is consistent for both household and corporate lending rates.

Figure 7 shows the responses of bank and non-bank loans. Non-bank loans increase after the negative shocks to all reference rates, although the sizes of increase are below 0.2% and thus not statistically significant. These weak responses are consistent with the previous finding of Kim and Jung (2012) that domestic loans depend more upon the business cycle and housing prices than on the lending rates. Even though the responses are relatively small, we find that the KORIBOR delivers the largest changes in all models. The responses of bank loans are smaller than those of non-bank loans, and in some models even show negative changes (i.e. reduced bank lending after declines in the reference rates). This is due to the fact that bank lending rates are generally lower than non-bank rates, and the loans depend more on non-interest rate-related factors such as regulation and policy-oriented loans. In the cases where bank loans increase, the patterns of the impulse responses are similar to those in the cases of nonbank loans.14)

14) We also analyzed the responses of household loans and corporate loans, dividing bank loans, but could not find any significant difference from those of bank loans.
Figure 8 shows the paths of the real variables after the shocks. From its left-hand panel, we find that industrial production increases by 0.5~1.5%, which is consistent with the mainstream theory that lower interest rates induce investment, which in turn boosts real output. We can conjecture that the lower reference rates contribute to increasing output through reductions in the opportunity costs for consumption and investment, even if their influences on lending are relatively small. The KORIBOR gives rise to the greatest increase among the three reference rates. Total employment on the other hand does not show any distinctive changes after the shocks, as shown in the right-hand panel. There is a large gap between output and employment since global financial crisis which may result in opposite response in our data set.15)

Figure 9 shows the reference rates’ influences on prices. The negative reference rate shocks cause both the CPI and PPI to rise. We interpret this response to be a result of the real market stimulation. Among the rates, the KORIBOR causes the prices to increase more than the other rates in all models.

In conclusion, the responses of macroeconomic variables to reference rate shocks are mostly consistent with mainstream theory in the cases of all three rates, so that the channels of monetary policy transmission will operate as expected. Among the three rates, the KORIBOR performs the best with regard to real output, prices and financial variables. Considering that the role of the reference

---

15) For example, there was a huge increase in employment rate even under sluggish economy.
rates in terms of monetary policy is the effective transmission of a policy shock via interest rate channels, we find the KORIBOR to be superior to the other rates.

(2) Effects of macroeconomic shocks on candidate reference rates

For each shock we present three different response graphs. The first graph represents the traditional impulse response functions as seen in the previous figures. Considering that the traditional impulse response is interpreted as the response in the mean, we also view that as the expected response (i.e. the response in the center of the probability distribution).

The second graph shows the quantile impulse responses of the KORIBOR at $\alpha = 0.05$ and 0.95, together with the mean responses. This shows how the stability of the candidate rate changes after a shock. Here we use the term ‘instability’ to mean the probability that the actual dynamics of the reference rate deviate greatly from the path expected. Increased instability thus implies a deterioration in robustness. The distance between the two quantiles indicates the range within which any change in the interest rate has a 90 percent probability of falling. A wider range after a shock thus indicates increased instability/uncertainty. In other words, after a shock there is a greater chance that the actual movement of the reference rate will differ largely from the expectation. Similar implications can be applied to the distance between the center and each quantile; that is, an increase in distance between the center and the 0.95th quantile implies an increased
possibility of the interest rate rising much more than expected. Consider for example the case where we are worried that the actual reference rate will be more than 1.5%p higher than the expected path. Suppose that the distance between the mean and the 0.95th quantile increases from 1.0%p to 1.5%p after a shock. This will mean that before the shock there was a 5% probability of the actual reference rate being 1%p or more greater than the expectation. Hence, the probability of an actual reference rate 1.5%p or higher than expectations should be strictly less than 5%. This probability increases to 5%p after the shock because the 0.95th quantile distance has widened to 1.5%p, which implies increased instability. We denote the distances between the mean and the 0.05th and 0.95th quantiles as “upside” and “downside” instability, respectively.

Note that the effects on stability of the variables are generally asymmetric. In other words, while a positive shock increases overall instability/uncertainty, a negative shock decreases it. A positive shock may also cause increased upside instabilities while the downside risk remains unchanged or even declines. And a negative shock has the opposite effects. We thus present the responses for both positive and negative shocks, so that we can capture whether there is increased instability on either the upside or the downside for each shock. We present the responses for the KORIBOR only, for simplification purposes, since all four interest rates are similar in terms of their patterns of decreased/increased instability.

The third graph captures the dynamics of the mean-quantile distances of all four reference rates after each shock, so that we are able to compare the differences in patterns among the four. Recall that if a shock does not affect the degree of uncertainty, and the distributions of the reference rates are thus unchanged, then the distances remain the same even after the shock. An increased distance on the other hand implies an expansion in instability, i.e. a higher possibility that the reference path is far from expectations. We compute \((q_{it}^{0.95,h} - X_{it}^{h})\) and \((q_{it}^{0.05,h} - X_{it}^{h})\), the values of which are positive and negative respectively. Increased instability is thus indicated by a higher \((q_{it}^{0.95,h} - X_{it}^{h})\) and a lower \((q_{it}^{0.05,h} - X_{it}^{h})\). If the \((q_{it}^{0.95,h} - X_{it}^{h})\) of a reference rate is higher than those of the others, then that rate’s upside instability becomes the largest after the shock, with the lowest \((q_{it}^{0.05,h} - X_{it}^{h})\) having the same implication. Note that
examining and comparing the relative instabilities is of greater importance when instability has risen after a shock. We thus draw the graphs only for responses to shocks that cause increases in instability. To compare the differences in response coefficients between equations (2) and (6), we compute the 90% confidence intervals conditional on $(\Delta \hat{F}_{t}^{h}, \Delta Y_{t}^{h})$.

Figure 10-A shows the effects of an expansionary monetary policy shock on the mean paths of the reference rates. After a negative 0.25%p policy rate shock, the overnight call rate is expected to drop by about 0.75%p in total within one year, and all four references rates decrease by similar amounts. This pattern of over-response is due to the pattern of the overnight call rate, which also shows a decrease of around 0.75%p after the initial shock. We interpret this over-response as resulting from the huge drop in the policy rate during the sample period.16)

Figure 10-B illustrates the quantile responses of the KORIBOR against a negative and a positive shock. We observe that both the upside and the downside instabilities are increased after a decline in the overnight call rate. For example, in the case of a policy rate decrease the width of the range within which the KORIBOR lies with a 90% probability is originally about 1.5%p (from -1.0%p to 0.5%p). It expands to 2.3%p three years after the initial shock, however. A tightening of monetary policy causes the opposite effects on uncertainty, where the width of this range narrowed to 0.7%p after the shock. The increased upside instability after a policy rate cut is consistent with the existing findings that reference rates are less responsive to policy rate cuts (Mester and Saunders, 1995;

16) The overnight call rate experienced a huge drop from 5.25% to 2.00% in five months (October 2008 ~ February 2009), which causes an overshooting in the impulse response function. We find no clear differences in responses among the four rates, and they are all inside the 90% confidence interval of the KORIBOR path.
Dueker, 2000). An increase in downside instability after a policy rate cut may be counterintuitive. We conjecture that this result is due mainly to the sharp decline in interest rates in late 2008. Note that the 0.05th quantile represents a large unexpected drop, given the previous path. The 0.05th quantile responses are thus determined mostly by the period of sharply declining interest rates. We find that the reference rates fell by more than the overnight call rate during this time, which causes the increased instability in our sample period. The results of estimation of Equation (5), which are given in Tables 1 and 2 in Appendix 1, show this over-response, where the coefficients of the overnight call rate at the 0.05th quantile are significantly higher than 1 for all reference rates, with those for the bank debenture rate and the CD rate the highest. The results are similar for all other candidate rates, although the MSB rate, which is rarely used as a reference rate, responds more weakly than the others.

Figure 10-C shows the quantile responses of all four reference rates after negative call rate shocks at $\alpha = 0.05$ and 0.95. The lefthand panel shows that the 0.95th quantile of the bank debenture rate stays higher than those of the other rates, indicating a greater increase in the possibility of upside instability, and is outside the 90% confidence interval of the KORIBOR. The CD and MSB rates show patterns similar to that of the KORIBOR. The bank debenture rate also displays the largest increase in downside instability, as shown in the righthand panel. The market size for the debenture rate is small compared to those for the other reference rates. This causes the debenture rate to be more sensitive to credit risks, which increases the possibility of volatile responses. Unlike the case with the upper quantile, the other three interest rates differ moderately, with the CD rate having the largest increase in downside risk among the three, and the MSB rate the smallest.

17) Intuitively, one may conjecture that the quantile impulse response increases as the standard deviation of an interest rate increases. Actually, during our sample period (November 2006–November 2014), the standard deviation of bank debenture rate is the largest among the four candidate reference rates. However, it is not necessarily true in that the quantile impulse response is the conditional concept, different from the standard deviation which is unconditional.

<table>
<thead>
<tr>
<th></th>
<th>KORIBOR</th>
<th>CD</th>
<th>Bank debenture</th>
<th>MSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>standard deviation</td>
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<td>1.13</td>
<td>1.15</td>
<td>1.11</td>
</tr>
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</table>
Figure 10: Responses to Policy Rate Shocks

A. Reference Rate Responses to Monetary Policy Shocks

Note: 1) Dotted line indicates 90% confidence interval of KORIBOR.

B. Upside and Downside Instabilities of Reference Rates to Policy Rate Shocks

Note: 1) Based on KORIBOR.

C. Quantile Responses of Reference Rates to Policy Rate Decrease Shocks

Note: 1) Dotted lines indicate 90% confidence intervals of KORIBOR.
Figure 11-A shows the effects of an employment shock. After an initial 1% increase in total employment, all four references rates are expected to rise by about 1% after three years. This pattern coincides with the mainstream theory that a positive supply shock boosts aggregate demand, which in turn increases interest rates. But there are no clear differences among the candidate rates.

The quantile responses of the KORIBOR presented in Figure 11-B show that a positive shock reduces the overall instability of the reference rate, while a negative shock increases it. This result is consistent with the common expectation that a negative shock in the real economy causes rising economic uncertainty, which results in increased reference rate instability.

Figure 11-C shows in its lefthand panel that the bank debenture rate sees the largest increase in upside risk after a negative employment shock. From the righthand panel it can be seen that the CD and bank debenture rates have the largest increases in downside risk; that is, the probabilities of the CD and bank debenture rates plunging relative to their expected changes rise more than those of the KORIBOR and the MSB rate.

Figure 12-A shows the results of inflation shocks. We observe that, after a positive inflation shock, all four reference rates show initial rises in the first seven months followed by moderate declines thereafter. In the structural VAR set-up, an inflation shock is often interpreted as a demand shock. Our results can thus be interpreted as the short-term increases in interest rates after a positive demand shock, with the effects not lasting more than a year. Among the four rates, the MSB and bank debenture rates respond to greater extents than the CD rate and the KORIBOR, and their responses are outside the 90 percent confidence interval of the KORIBOR. The KORIBOR and the CD rate respond similarly to both PPI and CPI inflation shocks.

As Figure 12-B shows, during the initial period of an increase in CPI inflation there is a large decline in reference rate instability, while with a negative shock overall instability/uncertainty rises significantly for all four rates. This is related to the theoretical expectation of a positive demand shock leading to reduced overall uncertainty.
Figure 11: Responses to Employment Shocks

A. Reference Rate Responses to Employment Shocks

Note: 1) Dotted line indicates 90% confidence interval of KORiBOR.

B. Upside and Downside Instabilities of Reference Rates to Employment Shocks

Note: 1) Based on KORiBOR.

C. Quantile Responses of Reference Rates to Employment Decrease Shocks

Note: 1) Dotted lines indicate 90% confidence intervals of KORiBOR.
Figure 12: Responses to Inflation Shocks

A. Reference Rate Responses to Inflation Shocks

(PPI Increase)  (CPI Increase)

Note: 1) Dotted lines indicate 90% confidence intervals of KORIBOR.

B. Changes in Upside and Downside Reference Rate Instabilities in Response to Inflation Shocks

(CPI Increase)  (CPI Decrease)

Note: 1) Based on KORIBOR.

C. Quantile Responses of Reference Rates to Deflation Shocks

(0.95th Quantile, CPI)  (0.05th Quantile, CPI)

Note: 1) Dotted lines indicate 90% confidence intervals of KORIBOR.
The quantile responses of the bank debenture rate at \( \alpha = 0.95 \) are quite different from those of the other rates, and from Figure 12-C, it appears highly possible that the bank debenture rate’s movements will deviate greatly from the central bank’s expectations. The quantile responses of the other three rates are fairly similar to each other. There are also no clear differences in the quantile responses of these three rates at \( \alpha = 0.05 \).

In conclusion, the KORIBOR shows stable performances in response to various economic shocks including from monetary policy. The bank debenture rate has serious stability issues in the face of most economic shocks. The MSB rate also performs well in terms of its stability against shocks, while the CD rate shows increased downside instabilities. We also examine the case of an industrial production shock, but find no distinctive differences among the four reference rates.

4. Conclusion

This paper uses traditional impulse response and conditional quantile impulse response analyses based on FAVAR to study the influences of various reference rates on real economic and financial market variables in Korea, and the robustness of each candidate reference rate to monetary policy or macroeconomic shocks.

In terms of its influences on real economic and financial market variables, the KORIBOR delivers the strongest responses, which can be explained by the fact that this rate reflects various fund raising costs and market interest rates and so includes more information about the real economy and the financial markets than do the other candidate reference rates. This implies that usage of the KORIBOR as a reference rate should be expanded in order to boost monetary policy effectiveness. To increase usage of the KORIBOR, sales of KORIBOR-related loans should be encouraged and the credibility of the KORIBOR should be improved. To improve KORIBOR credibility as a rate keeping in step with global trends, we can consider converting the rate into a KORIBOR+, with its transaction base
enlarged\(^{18}\) so as to lessen the need for depending upon expert judgments in the process of its calculation.

In analyzing the dynamic responses of the reference rates to monetary policy shocks, we find that monetary policy tightening (a policy rate hike) causes a decline in reference rate instability, while monetary policy easing (a policy rate cut) increases it. This means that the reference rates are more likely to deviate from the path expected by the monetary authority in the case of monetary easing, so that central banks should be more cautious when conducting expansionary monetary policies.

In response to macroeconomic shocks for example to employment and prices, the levels of the reference rates respond pro-cyclically while their volatilities respond counter-cyclically. These results coincide with the general economic theory that an upswing in the real economy pushes interest rates up by increasing aggregate demand. It implies as well that an economic downturn can lead to increased uncertainty as to macroeconomic variables overall, resulting in reference rate instability and aggravated difficulties in monetary policy conduct.

Assessment of the quantile impulse responses of the reference rates finds the bank debenture rate to be most vulnerable to monetary policy and macroeconomic shocks. In other words, the possibility of a reference rate fluctuation deviating from market expectations is biggest in the case of this rate. This is because the bank debenture rate is most likely among the four candidate rates to be swung by changes in credit risk.

In an environment in which expectations of monetary policy easing and disinflation are strong, the possibility of reference rates showing unexpected changes increases. This means a weakening of the effectiveness of monetary policy through traditional channels such as the interest rate and credit channels. The necessity of considering complementary monetary policy measures thus increases to an equal extent.

\(^{18}\) FSB (2014) suggests that the set of transactions include funding obtained overseas, and corporate sector funding as well as interbank funding in the domestic money market.
References


FSB (2014), “Reforming Major Interest Rate Benchmarks.”


<Appendix 1: Quantile Regression Estimates>

The following tables show regression results of equations (2) and (5) for selected elements of $X_t$.

<table>
<thead>
<tr>
<th>$\gamma$</th>
<th>0.05th quantile (Eq. 5 with $\alpha=0.05$)</th>
<th>0.95th quantile (Eq. 5 with $\alpha=0.95$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KORIBOR</td>
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</tr>
<tr>
<td>C</td>
<td>coef</td>
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</tr>
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<td></td>
<td>(se)</td>
<td>$(0.0004)$</td>
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<tr>
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<tr>
<td></td>
<td>(se)</td>
<td>$(0.0018)$</td>
</tr>
<tr>
<td>growth</td>
<td>coef</td>
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<tr>
<td></td>
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<td>$(0.3203)$</td>
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<tr>
<td>inflation</td>
<td>coef</td>
<td>$0.0101$</td>
</tr>
<tr>
<td></td>
<td>(se)</td>
<td>$(0.1301)$</td>
</tr>
<tr>
<td>policy</td>
<td>coef</td>
<td>$1.7468$</td>
</tr>
<tr>
<td></td>
<td>(se)</td>
<td>$(0.2310)$</td>
</tr>
<tr>
<td>Pseudo $R^2$</td>
<td></td>
<td>$0.5490$</td>
</tr>
</tbody>
</table>

Notes: 1) Standard errors of quantile regression coefficients are calculated using bootstrap method.  
2) Mean regressions do not contain constant terms because variables are all mean deviated.  
3) growth=employment growth, inflation=PPI inflation, policy=call rate change
## Estimation Results with $Y_t$: (industrial production growth, PPI inflation, call rate change)

### 0.05th quantile (Eq. 5 with $\alpha = 0.05$)

<table>
<thead>
<tr>
<th></th>
<th>KORIBOR</th>
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<th>BD</th>
<th>MSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.0027</td>
<td>-0.0031</td>
<td>-0.0035</td>
<td>-0.0023</td>
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<td>(0.0006)</td>
<td>(0.0005)</td>
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<td>factor</td>
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<td>-0.0013</td>
<td>-0.0032</td>
<td>-0.0007</td>
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<tr>
<td>(se)</td>
<td>(0.0016)</td>
<td>(0.0020)</td>
<td>(0.0021)</td>
<td>(0.0011)</td>
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<tr>
<td>growth</td>
<td>-0.0050</td>
<td>-0.0630</td>
<td>0.0296</td>
<td>-0.0266</td>
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<tr>
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<td>(0.4233)</td>
<td>(0.0316)</td>
<td>(0.0207)</td>
</tr>
<tr>
<td>inflation</td>
<td>0.0153</td>
<td>0.0179</td>
<td>-0.0024</td>
<td>0.1277</td>
</tr>
<tr>
<td>(se)</td>
<td>(0.1104)</td>
<td>(0.1847)</td>
<td>(0.1630)</td>
<td>(0.1069)</td>
</tr>
<tr>
<td>policy</td>
<td>1.7673</td>
<td>2.0731</td>
<td>2.1290</td>
<td>1.3938</td>
</tr>
<tr>
<td>(se)</td>
<td>(0.2520)</td>
<td>(0.3423)</td>
<td>(0.3335)</td>
<td>(0.1751)</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.5815</td>
<td>0.5335</td>
<td>0.5685</td>
<td>0.6400</td>
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### Mean (Eq. 2)

<table>
<thead>
<tr>
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<th>BD</th>
<th>MSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>factor</td>
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<td>0.0013</td>
<td>0.0016</td>
<td>0.0005</td>
</tr>
<tr>
<td>(se)</td>
<td>(0.0008)</td>
<td>(0.0009)</td>
<td>(0.0011)</td>
<td>(0.0006)</td>
</tr>
<tr>
<td>growth</td>
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<td>0.0151</td>
<td>0.0346</td>
<td>0.0151</td>
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<tr>
<td>(se)</td>
<td>(0.0136)</td>
<td>(0.0160)</td>
<td>(0.0189)</td>
<td>(0.0106)</td>
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<tr>
<td>inflation</td>
<td>-0.0396</td>
<td>-0.0667</td>
<td>0.0083</td>
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<tr>
<td>(se)</td>
<td>(0.0590)</td>
<td>(0.0697)</td>
<td>(0.0820)</td>
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<td>policy</td>
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<td>1.1103</td>
<td>1.1279</td>
<td>1.0122</td>
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<tr>
<td>(se)</td>
<td>(0.1160)</td>
<td>(0.1370)</td>
<td>(0.1612)</td>
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<tr>
<td>Pseudo R²</td>
<td>0.5142</td>
<td>0.4588</td>
<td>0.4380</td>
<td>0.6562</td>
</tr>
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</table>

### 0.95th quantile (Eq. 5 with $\alpha = 0.95$)

<table>
<thead>
<tr>
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<th>KORIBOR</th>
<th>CD</th>
<th>BD</th>
<th>MSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.0024</td>
<td>0.0024</td>
<td>0.0032</td>
<td>0.0018</td>
</tr>
<tr>
<td>(se)</td>
<td>(0.0003)</td>
<td>(0.0005)</td>
<td>(0.0005)</td>
<td>(0.0002)</td>
</tr>
<tr>
<td>factor</td>
<td>0.0025</td>
<td>0.0035</td>
<td>0.0023</td>
<td>0.0018</td>
</tr>
<tr>
<td>(se)</td>
<td>(0.0016)</td>
<td>(0.0019)</td>
<td>(0.0021)</td>
<td>(0.0009)</td>
</tr>
<tr>
<td>growth</td>
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<td>0.0203</td>
<td>0.0235</td>
<td>0.0043</td>
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<td>(se)</td>
<td>(0.0242)</td>
<td>(0.0311)</td>
<td>(0.0338)</td>
<td>(0.0136)</td>
</tr>
<tr>
<td>inflation</td>
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<td>-0.0383</td>
<td>0.2268</td>
<td>0.1971</td>
</tr>
<tr>
<td>(se)</td>
<td>(0.1175)</td>
<td>(0.1266)</td>
<td>(0.1465)</td>
<td>(0.0699)</td>
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<td>policy</td>
<td>0.6359</td>
<td>0.7840</td>
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<tr>
<td>(se)</td>
<td>(0.2087)</td>
<td>(0.2547)</td>
<td>(0.3113)</td>
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<tr>
<td>Pseudo R²</td>
<td>0.1164</td>
<td>0.1233</td>
<td>0.1248</td>
<td>0.2822</td>
</tr>
</tbody>
</table>

**Notes:**
1) Standard errors of quantile regression coefficients are calculated using bootstrap method.
2) Mean regressions do not contain constant terms because variables are all mean deviated.
3) growth=industrial production growth, inflation=PPI inflation, policy=call rate change.
<Appendix 2: Data Description>

The following series describe the elements of $X_t$, the set of data that capture the dynamics of the macroeconomic and financial sectors. The factor $F_t$ for FAVAR model is obtained from $X_t$ using the principal component method.

**Real output**

Index of industrial production:
Manufacturing (4, SA), Capital goods (4, SA), For manufacturing equipment (4, SA), Electric power (4, SA), For telecommunication and broadcasting (4, SA), Transport equipment (4, SA), For agriculture (4, SA), Construction (4, SA), Office equipment (4, SA), Intermediate goods (4, SA), For manufacturing (4, SA), For construction (4, SA), Fuel and electric power (4, SA), Consumer goods (4, SA), Durable consumer goods (4, SA), Nondurable consumer goods (4, SA), Services (4, SA)

**Employment**

Unemployment:
Less than 3 months (2, SA), 3～6 months (2, SA), 6～12 months (2, SA), 6 months and above (2, SA), 12 months and above (2, SA)

Employment:
Total (4, SA), Agriculture (4, SA), Mining and quarrying (4, SA), Manufacturing (4, SA), Construction (4, SA), Agriculture (4, SA), Private services (4, SA), Electricity and water supply (4, SA), Wholesale and retail trade (4, SA)

**Wages**

All industries (4, SA), Mining and quarrying (4, SA), Manufacturing (4, SA), Electricity and water supply (4, SA), Wholesale and retail trade (4, SA), Accommodation (4, SA)

**Housing Indexes**

Nationwide housing sales price (4), Seoul city housing sales price (4), Six major cities housing sales price (4), Nationwide housing lease price (4), Seoul city housing lease price (4), Six major cities housing lease price (4)

Prices
Producer price index:
Total (4, SA), Merchandise (4, SA)

Consumer price index:
Total (4, SA), Merchandise (4, SA), Durable goods (4, SA), Textiles (4, SA), Medicaments (4, SA), Services (4, SA)

Inventory and Shipments
Industry inventory (4, SA), Manufacturing inventory (4, SA), Mining inventory (4, SA), Industry shipments (4, SA), Mining and manufacturing shipments (4, SA), Mining shipments (4, SA)

Monetary Aggregates, Deposits and Loans
Monetary Base (4, SA), M1 (4, SA), M2 (4, SA), Liquidity aggregates of financial institutions (4, SA), Liquidity aggregates (4, SA), Deposits at deposit money banks (end of period) (4, SA), Deposits at non-bank financial corporations (end of period) (4, SA), Loans at deposit money banks (end of period) (4, SA), Loans at non-bank financial corporations (end of period) (4, SA)

Stock Index and Exchange Rates
KOSPI (4), Dividend rate (1, SA), Price-earnings ratio (1), Won/Dollar exchange rate (4, SA), Won/Yen exchange rate (4, SA), Won/Euro exchange rate (4, SA), Won/Yuan exchange rate (4, SA)

Interest Rates
Commercial paper rate - 3 months (3), Corporate bond yields - 3 years, AA- and BBB+ (3), Korea Treasury Bond rates - 3, 5 and 10 years (3), Call rate (3), Repurchase agreement rate (3), Interest rate on bank deposits (newly extended basis) (3), Interest rate on bank loans (newly extended basis) (3), Interest rate on bank household loans (newly extended basis) (3), Interest rate on bank business loans (newly extended basis), KORIBOR - 1 week, and 1, 3, 6 and 12 months (3), Certificate of deposit rates - 1 week, and 1, 3, 6 and 12 months (3), Monetary Stabilization Bond rates - 3, 6 and 12 months (3), Bank debenture rates - 3, 6 and 12 months (3)
한국의 지표금리와 통화정책 유효성

정홍순*, 이동진**, 권태효***, 윤세진****

본고는 한국의 통화정책 유효성과 관련한 지표금리의 역할을 실증적으로 분석하였다. 바람직한 지표금리는 거시경제변수와 밀접한 연계성을 지녀야 하며 예상되는 경로로부터 크게 벗어나지 않는 강건성(robustness)을 지닐 것이 요구된다. 먼저 전자와 관련하여 한국에서 주로 활용되고 있는 지표금리를 대상으로 공통요인 부과 벡터자기회귀모형(FAVAR)에 기초한 충격반응분석을 실시하였다.

분석 결과 거시경제변수의 반응은 모든 지표금리에서 유사한 패턴을 보였으나 상대적으로 KORIBOR의 경우에서 가장 큰 것으로 나타났다. 다음으로 지표금리의 강건성 비교를 위해 복수의 조건부 분위수준에서 지표금리의 충격반응 정도를 산출하고 실제 반응이 시장의 기대치에 이탈할 확률을 분석하였다. 분석 결과 이탈확률은 통화정책 완화 충격 후 증대되며, 지표금리별로는 KORIBOR의 강건성이 비교적 양호한 반면 은행채금리는 충격에 가장 취약한 것으로 나타났다. 부(-)의 생산 및 물가 충격 또한 경기위축에 따라 지표금리의 불안정성을 증대시키며 지표금리별 반응결과는 통화정책 충격시와 유사한 것으로 나타났다.

핵심주제어: 공통요인 부과 벡터자기회귀모형, 충격반응함수, 통화정책 유효성, 분위충격반응, 지표금리

JEL Classification: C32, E44, E52, E58

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**** 한국은행 금융시장국 자금시장팀 조사역

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