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Asset Liquidity and Monetary Policy*

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We construct a parsimonious monetary search model and conduct empirical tests to examine the role of liquid assets as substitutes for money. The theoretical prediction suggests that nominal interest rates positively influence the market values of liquidity services, i.e., liquidity premia. Higher money holding costs increase the demand for liquid assets and, consequently, their prices. Consistent with this theory, the empirical tests show that short-term interest rates positively affect the liquidity premia of 91-day monetary stabilization bonds and three-year government bonds from 2011 to 2019. Additionally, the standing facility introduced in 2008 had a negative effect on these liquidity premia.

Key Words: Liquidity; Liquidity Premium; Nominal Interest Rate; Government Bond; Monetary Stabilization Bond.
JEL Classification Numbers: J21, J30, J31, J60, J62.

1. INTRODUCTION

Assets are priced for liquidity in addition to safety (default risk) and maturity in financial markets. Liquidity can be defined as the ability of assets to facilitate transactions. Assets can be used as collateral for loans or converted into more liquid assets, e.g., cash. Then these proceeds can expedite transactions that would have never occurred without assets. Importantly, since liquid assets as trade facilitators readily provide liquidity services as money does, the opportunity cost of holding money represented by nominal interest rates can directly affect demand for liquid assets as substitutes for money and thus asset prices, rather than demand for illiquid assets.

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In this study, we examine the effect of nominal interest rates on asset prices, more specifically, liquidity premia in Korean financial markets. An analysis about this effect is obviously important to not only participants in financial markets but also policymakers because central banks in many countries adjust their short-term interest rates which affect the prices or yields of financial assets. However, only a few studies measure liquidity premia of financial assets and investigate the effect of nominal interest rates on liquidity premia. To fill out this gap, we utilize Korean financial market data with unique institutional features in this study.

First, we build a parsimonious monetary search model to derive theoretical predictions about how liquidity premia could be measured, how nominal interest rates could affect the liquidity premia, and what economic mechanism behind it works. The model presents that yield differences between two different assets only in terms of relative liquidity can be used as a measure of liquidity premia and that nominal interest rates have a positive effect on liquidity premia. This is because an increase in nominal interest rates implies a higher money holding cost, and thus, demand for money is substituted into demand for liquid assets that can relatively easily provide liquidity services. This increased demand for liquid assets leads to higher liquidity premia, i.e., a wider yield spread.

To empirically test this theoretical finding, we use yield spreads between three-year AA-rated corporate bonds and government bonds and between 91-day certificates of deposit (henceforth, CDs) and monetary stabilization bonds (henceforth, MSBs) issued by the Bank of Korea as proxies of liquidity premia. We match the safety and maturities of each pair of financial assets to avoid a case where yield spreads include other types of premia such as default risk premia. AA-rated corporate bonds or CDs are considered as one of the safest assets in Korean financial markets. Also, each pair of financial assets has the same maturities−three years and 91 days, respectively. Following the theory, the difference between liquid and illiquid assets depends mainly on how easily they can be used as collateral or sold for cash. Obviously, it is even easier to sell government bonds and MSBs in secondary asset markets or to use them as collateral in loan markets than corporate bonds and CDs.

In empirical tests, we use the above yield differences as a dependent variable and short-term nominal interest rates−call rates−as the primary explanatory variable. In addition, we allow for control variables for default risk and bond supply for robustness check. Since AA-rated corporate bonds and CDs are almost as safe as government bonds, three-year credit default swap rates of Samsung Electronics are used as a control variable for default risk. The ratios of the monthly issued amount of government bonds and the outstanding amount of MSBs to nominal GDP are used to control the effects of supply on bond prices. Our primary regression analysis reveals that nominal interest rates have a significantly positive effect on the yield spreads. It is found that a one percentage point increase in call rates causes an increase of about 2.7 to 4.9 bps in the yield spread between CDs and MSBs and about 5.4 to 12.5 bps in the yield spread between AA-rated corporate bonds and three-year government bonds. Such a positive effect of call rates is robust across different specifications with control variables.

Additionally, the empirical test conducted to assess the impact of the Bank of Korea's standing facility, introduced in 2008, on liquidity premia as a novel economic event shows significant findings. It reveals that the facility had a negative effect on the liquidity premium of Monetary Stabilization Bonds (MSBs), particularly by reducing the impact of call rates on this premium. This suggests a diminished influence of call rates on liquidity costs, further substantiated by the broader empirical evidence presented. Consequently, this empirical analysis strongly supports the theoretical finding that the opportunity cost of holding money can positively affect liquidity premia, because liquid assets play a role as a substitute for money in transactions.

As for related literature, the monetary search model that we set up in Section 2 is based on Lagos and Wright (2005) and Rocheteau and Wright (2005). The present paper is a part of the growing literature on asset liquidity and prices. Notable papers include Geromichalos et al. (2007), Lagos and Rocheteau (2009), Aruoba et al. (2011) and Lee and Jung (2020). Similar to studies of Lester et al. (2012), Venkateswaran and Wright (2013) and Geromichalos et al. (2021), we do not study fundamentals that explain why some assets are liquid but others not. Instead we use the theoretical model to derive an appropriate guidance for empirical tests. Geromichalos et al. (2016) investigate why prices of assets used as collateral are higher than their fundamental values and how monetary policy affects their liquidity premia and thus prices. Geromichalos and Herrenbrueck (2016) study how secondary asset markets where assets can be liquidated for money affect asset prices. However, these papers do not empirically examine the effect of the opportunity cost of holding money, or nominal interest rates, on asset liquidity.

The empirical methodology used in the present paper is closely related to that used in studies of Longstaff (2004), Krishnamurthy and Vissing-Jorgensen (2012), Greenwood et al. (2015) and Nagel (2016) among others. They use yield spread data between two different types of financial assets in the U.S. to measure safety and liquidity premia and test effects of Treasury bills (and bonds) supply and federal funds rates on liquidity premia of Treasury bonds. They find negative effects of bond supply but positive effects of federal funds rates on liquidity premia. In addition, Lee (2020) presents a negative effect of money growth rate on liquidity premia of Treasury bills and suggests that liquidity premia can cause negative yields of government bonds in some advanced countries with developed financial markets. All of these use U.S. financial data and models with different fundamentals.

Few studies present evidence about determinants of liquidity premia and the effect of nominal interests on liquidity in Korean bond markets, which have many similar institutional features with those in the other advanced countries but also have different operational features as follows. Compared with the other advanced countries such as the United States and the United Kingdom, the number of financial institutions and trade volume in bond markets is even smaller, and the variety of financial assets (with investment-grade) is narrow.[1] Hence, it matters to present whether interest rates, i.e., the opportunity cost of holding money, positively affect liquidity premium and also its substitution effect between liquid and illiquid bonds exists in the Korean financial market, as in the U.S. financial market which is considered as the most efficient financial market.

In particular, there are the unique characteristics of the Korean monetary policy and financial system. First of all, the central bank in Korea, called Bank of Korea, issues central bank bonds with positive interest payments unlike central banks in other advanced countries such as the United States, the United Kingdom, and the European Central Bank.[2] These bonds are called Monetary Stabilization Bonds in Korea. Since 1961, the Bank of Korea has been using these Monetary Stabilization Bonds as one of the monetary policy tools to adjust market liquidity from the mid and long-term perspective. That is, the Bank of Korea conducts monetary policy by adjusting not only prices (the BOK base rate) but also quantities of funds available to financial institutions.[3] The Monetary Stabilization Bonds are currently issued in two different interest payment types: discount bonds and coupon bonds. The discount bonds are relatively short-term bonds whose maturities are 91 days and 182 days. The maturities of coupon bonds are 1 year and 2 years. Notice that government bonds are issued in three-, five-, ten-, twenty-, thirty- and fifty-year maturities. Compared with Monetary Stabilization Bonds, government bonds are relatively issued in long terms such that their maturities are not overlapped with those of Monetary Stabilization Bonds.[4] According to Kim, Choi, Kim, and Choi (2016), the outstanding amount of Monetary Stabilization Bonds is 184.9

[1] According to Kim, Choi, Kim, and Choi (2016), the average daily trade volume is estimated to around 17.5 billion dollars in the Korean bond market and 778.3 in the U.S. bond market. The U.S. market is approximately 44.6 times larger.

[2] According to Gray and Pongsaparm (2015), there were 42 of 125 countries whose central banks issue their bonds as a liquidity adjustment tool.

[3] Obviously, currency (Korean Won) and reserves are also the liabilities of the Bank of Korea, but do not pay any positive interest.

[4] In the United States, the maturities of government bonds are more diversified. The short-term bonds include four-week, thirteen-week, twenty six-week, fifty two-week, and they are called Treasury Bills. The long-term bonds include two-, three-, five-, seven-,

trillion won as of June in 2016 and 11.6% of the total outstanding amount of all different types of bonds.

Relatedly, previous studies that are relatively close to our work include Jang and Kim (2009), Jang et al. (2012), and Shin and Kim (2015). Jang and Kim (2009) examine how credit spread is determined and how monetary policy shocks affect credit spread to explain its dynamics in Korea. Jang et al. (2012) present a new measure of liquidity in the Korean stock market by constructing a market and liquidity factor model to explain stock returns from 1987 to 2010. Shin and Kim (2015) use a reduced form of empirical specification to analyze changes in liquidity and credit risk in the Korean corporate bond market during the global financial crisis. All things considered, our study contributes to the literature by providing a tractable theoretical model for empirical tests and empirically testing the effects of nominal interest rates on liquidity premia in the Korean bond markets.[5]

The rest of the paper is organized as follows. In Section 2, we construct a theoretical model to derive theoretical predictions to be tested in Section 3. Section 3 demonstrates the data that will be used in empirical analysis and tests theoretical predictions. Section 4 concludes this paper.

2. MODEL

2.1. Environment

We build a parsimonious monetary search model, which is based on Lagos and Wright (2005), to lay the foundation for empirical analysis in Section 3. Discrete time continues forever, $t = 0, 1, 2, \ldots$. Agents discount the future between periods, not sub-periods, at a rate of $\beta \in (0, 1)$. Each period is divided into two sub-periods, when different economic activities occur. In the first sub-period, a decentralized market opens and a centralized and

ten- and thirty-year. Thirty-year government bonds are called Treasury Bonds and the rest of them are called Treasury Notes.

[5]If a money-in-the-utility function instead of a monetary search model were used to derive the main theoretical predictions of the paper, we should assume that holding assets itself generates utility. This kind of assumption makes it ambiguous how such utility is generated. For example, it can come from asset safety, liquidity, maturity preference, or personal preference. However, a monetary search model can clarify that the utility comes from liquidity services of assets, i.e., an ability of assets to facilitate transactions; otherwise would not occur. Assets are used to increase consumption, which leads to a higher utility. Fundamentally, agents feel happy not just because they hold assets, but because they can increase consumption by using assets in transactions. This is exactly how liquidity services are valued in the monetary search model in the paper. Moreover, it makes the results from the monetary search model more empirically relevant: this theoretical feature leads us to pick up more precise data to empirically measure liquidity premia and to test the theoretical predictions from the model. Liquidity premia are measured by the yield spreads between two assets are explicitly different only in liquidity services, in safety, maturity, and for forth.

competitive market follows. The decentralized market is characterized by anonymity and limited commitment among agents.

There are two types of agents, buyers and sellers, who live forever. Their identities are fixed and determined by their roles in the decentralized market, where buyers cannot produce but want to consume goods, whereas sellers can produce but do not want to consume goods. These goods are divisible and perishable. The measure of each type of agents is normalized to one. The preferences are given by

$$\begin{aligned} \text{Buyers}: \ \mathcal{U}(X_t, H_t, q_t) =& u(q_t) + X_t - H_t, \\ \text{Sellers}: \ \mathcal{V}(X_t, H_t, q_t) =& -c(q_t) + X_t - H_t, \end{aligned}$$

where q_t is the amount of decentralized market goods that buyers consume, X_t is the amount of centralized and competitive market goods that both types of agents consume, H_t is hours worked for the centralized and competitive market goods production, and $c(q_t)$ is the cost of producing q_t. The utility function, $u(\cdot)$, is twice continuously differentiable with $u'(\cdot) > 0, u''(\cdot) < 0, u(0) = 0, \lim_{q_t \to 0} u'(q_t) = \infty$, and $\lim_{q_t \to \infty} u'(q_t) = 0$. Without loss of generality, we assume that $c(q_t) = q_t$ for simplicity. One unit of labor can be transformed into one unit of goods. Let $q^* \equiv \{q : u'(q) = 1\}$ in order to denote the optimal consumption level in the decentralized market.

There are two types of assets: money and a one-period real asset. Both of them are divisible and storable between periods. A monetary authority adjusts the supply of money, which follows the rule: $M_{t+1} = (1+\mu)M_t$. We assume that $(1 + \mu) > \beta$ for the existence of monetary equilibria. Money is injected (if $\mu > 0$) or withdrawn (if $\mu < 0$) through a lump-sum transfer (T_t) in the centralized and competitive market. Money is accepted as a medium of exchange in all transactions. One unit of real asset delivers one unit of consumption goods, or numeraire, in the next period's centralized and competitive market. Real assets are divided into two groups: liquid and illiquid. Liquidity depends on how easily assets help facilitate transactions in the decentralized market. Liquid assets can be easily used as collateral for loans or converted for money. On the other hand, illiquid assets can be also used as collateral or sold for cash but they incur more costs for liquidation than liquid assets. As a result, illiquid assets are less useful in transactions than liquid assets.[6] For example, government bonds can be regarded as liquid assets and corporate bonds as illiquid assets. It is well known that it is easier to find buyers or lenders in order to sell government bonds for cash in secondary asset markets or to use them as collateral for new loans than corporate bonds. The supplies of liquid and illiquid real

[6]Terms ‘liquid’ and ‘illiquid’ are used to represent relative liquidity of assets. The term ‘illiquid’ does not mean ‘impossible to liquidate.’ Note that even if it is costly, illiquid assets can be used as collateral for loans or converted to cash.

assets are fixed at $B^l > 0$ and $B^i > 0$, respectively. Agents can purchase any amount of money (m_t), liquid (b^l) and illiquid assets (b^i) at prices, ϕ_t, ψ_t^l, and ψ_t^i in the centralized and competitive market, respectively. In other words, they choose an asset portfolio that they will bring into the forthcoming decentralized market. All agents can work to produce and consume goods in the centralized and competitive market.

In the decentralized market, buyers meet a seller in a pairwise meeting. Buyers make a take-it-or-leave-it offer to the seller to determine terms of trade, i.e., the quantity and the price of decentralized market goods that they will trade. Due to anonymity and limited commitment among agents, a medium of exchange is necessary for transactions. Money and assets can be used as a means of payment. All money balances can be used as a medium of exchange, whereas only a fraction θ^l (θ^i) of liquid (illiquid) assets can be used as a medium of exchange because they incur costs for liquidation. We assume $1 > \theta^l > \theta^i > 0$.[7] θ^l and θ^i represent liquidity parameters of how useful assets are as a means of payment in transactions.

2.2. Value Functions and Optimal Choices

First, we describe the value functions in the centralized and competitive market. Buyers make a decision of their portfolio that they will use in the next decentralized market. The value function of buyers is given by

$$W^B(m_t, \mathbf{b}_t) = \max_{X_t, H_t, m_{t+1}, \mathbf{b}_{t+1}} \left\{X_t - H_t + \beta V^B(m_{t+1}, \mathbf{b}_{t+1})\right\} \tag{1}$$
$$\text{s.t.} \quad X_t + \phi_t m_{t+1} + \psi_t \mathbf{b}_{t+1} = H_t + \phi_t m_t + \mathbf{b}_t + T_t,$$

where $\mathbf{b}_t = (b_t^i, b_t^l)$ and $\psi_t' = (\psi_t^i, \psi_t^l)$. V^B denotes the buyers' value function in the next period decentralized market. Buyers can work and use their real balances to purchase a new portfolio, $(m_{t+1}, \mathbf{b}_{t+1})$ for the next decentralized market transactions. The value function of sellers is given by

$$W^S(m_t, \mathbf{b}_t) = \max_{X_t, H_t} \left\{X_t - H_t + \beta V^S(0, \mathbf{0})\right\} \tag{2}$$
$$\text{s.t.} \quad X_t = H_t + \phi_t m_t + \mathbf{b}_t,$$

where V^S represents the sellers' value function in the next period decentralized market. Notice that sellers do not bring money or assets for decentralized market transactions because they do not want to consume in the decentralized market.[8] In particular, only if $1+\mu > \beta$, i.e., the opportunity

[7]The relative size of θ^l or θ^i can be determined by financial development in an economy. For instance, if financial markets develop, using financial assets other than money as collateral or exchanging for money will not be costly. This would imply high θ^l and θ^i in the model. However, if there are no existing financial markets and thus assets are only used as a store of value, then $\theta^l = \theta^i = 0$.

[8]Rocheteau and Wright (2005) present a detailed proof for this.

cost of holding money is positive, sellers do not have an incentive to hold money.

Next, the value functions of buyers and sellers in the decentralized market are given by

$$V^B(m_t, \mathbf{b}_t) = u(q_t) + W^B(m_t - p_t^m, \mathbf{b}_t - \mathbf{p}_t), \tag{3}$$

$$V^S(0, \mathbf{0}) = -q_t + W^S(p_t^m, \mathbf{p}_t), \tag{4}$$

where $(p_t^m, \mathbf{p}_t)$ is the amount of money and assets exchanged for decentralized market goods, q_t. The terms of trade are determined by bargaining, where a buyer makes a take-it-or-leave-it offer to a seller. Then, the bargaining problem in decentralized market meetings is expressed by

$$\max_{q_t, p_t^m, \mathbf{p}_t} \left\{u(q_t) + W^B(m_t - p_t^m, \mathbf{b}_t - \mathbf{p}_t) - W^B(m_t, \mathbf{b}_t)\right\} \tag{5}$$

$$\text{s.t.} \quad -q_t + W^S(p_t^m, \mathbf{p}_t) - W^S(0, \mathbf{0}) = 0,$$

and the budget constraints, $p_t^m \leq m_t$ and $\mathbf{p}_t \leq \theta \mathbf{b}_t$, where $\theta = (\theta^i, \theta^l)$. Buyers maximize their surplus given the sellers' participation constraint and the budget constraints. Assets are not as liquid as money, and thus only a fraction θ of them can be used in transactions.

The next lemma summarizes the solutions to the bargaining problem.

Lemma 1. *The solutions to the bargaining problem depend on the real money and asset balances of buyers:*

(i) If $\phi_t m_t + \theta \mathbf{b}_t \geq q^*$, $q_t = q^*$, and $(p_t^m, \mathbf{p}_t)$ can be any pair that solves the following equation: $\phi_t p_t^m + \mathbf{p}_t = q^*$.

(ii) If $\phi_t m_t + \theta \mathbf{b}_t < q^*$, $q_t = \phi_t m_t + \theta \mathbf{b}_t$, $p_t^m = m_t$, and $\mathbf{p}_t = \mathbf{b}_t$.

Proof. See Appendix A.1. ▌

The solutions imply that if buyers hold real balances enough to purchase the first-best amount of decentralized market goods: $\phi_t m_t + \theta \mathbf{b}_t \geq q^*$, sellers produce q^* and buyers pay money, liquid assets and illiquid assets whose real value is equal to q^*. Only if the real value of the paid portfolio, $(p_t^m, \mathbf{p}_t)$, equals q^*, buyers can pay any combinations of money and assets. On the other hand, if the real balances are not enough to buy the first-best amount: $\phi_t m_t + \theta \mathbf{b}_t < q^*$, buyers will hand over all of their money (m_t) and assets $(\theta \mathbf{b}_t)$ available to sellers in order to purchase as many goods as possible. Sellers will produce the amount of decentralized market goods whose real value is equal to the real balances allowing for liquidity parameters: $q_t = \phi_t m_t + \theta \mathbf{b}_t$.

Now, the optimization problem of buyers in (1) is simplified as follows.

$$\max_{m_{t+1},\mathbf{b}_{t+1}} -\phi_t m_{t+1} - \psi_t \mathbf{b}_{t+1} + \beta V^B(m_{t+1}, \mathbf{b}_{t+1}). \tag{6}$$

The first two terms stand for the cost of purchasing money and assets in the centralized and competitive market, i.e., their competitive market prices times quantities. The third term represents the continuation value of the purchased portfolio in the next period's decentralized market. We use the solutions in Lemma 1 to solve the maximization problem. Then, the Euler equations for money, liquid assets and illiquid assets are given by

$$\phi_t = \beta u'(q_{t+1})\phi_{t+1}, \tag{7}$$
$$\psi_t^i = \beta\left\{u'(q_{t+1})\theta^i + (1-\theta^i)\right\}, \tag{8}$$
$$\psi_t^l = \beta\left\{u'(q_{t+1})\theta^l + (1-\theta^l)\right\}. \tag{9}$$

Each Euler equation has a standard economic interpretation. The left-hand side of each equation is the marginal cost of purchasing a unit of money or assets, whereas the right-hand side is the marginal benefit from the purchased money or assets. For example, if a buyer purchases one unit of liquid asset, its marginal cost is equal to its unit price, ψ_t^l, and the marginal benefit is the utility from using it as a medium of exchange in the next decentralized market. Since only a fraction, θ_t^l, of the liquid asset can be used in transactions, the marginal utility from decentralized market consumption is equal to $u'(q_{t+1})\theta^l$ and the rest $(1-\theta_t^l)$ of the asset delivers $(1-\theta_t^l)$ units of centralized and competitive market goods that the buyer can consume in the next centralized and competitive market. At the optimum, the sum of these benefits must be equal to the marginal cost.

2.3. Equilibrium and Liquidity Premium

In a steady state equilibrium, agents implement identical consumption and portfolio strategies and their real portfolio balances are constant over time. It means that $\phi_t M_t = \phi_{t+1}M_{t+1}$ and thus $1+\mu = \frac{M_{t+1}}{M_t} = \frac{\phi_t}{\phi_{t+1}} = 1+\pi$, where π denotes the inflation rate.

Definition 2.1. A steady state equilibrium is a list $\{\psi_t, q_t, \phi_t M_t, \phi_t p_t^m, \psi_t \mathbf{p}_t\}$, where q_t represents the amount of goods traded in the decentralized market, $\phi_t M_t$ the real money balances, $\phi_t p_t^m$ the real money balances paid for decentralized market trade, and $\psi_t \mathbf{p}_t$ the real asset balances paid for decentralized market trade. The equilibrium objects are determined such that:

(i) Given prices, ϕ_t and ψ_t, a representative buyer solves the individual optimization problem (1).

(ii) The terms of trade in the decentralized market follow Lemma 1.
(iii) Each market clears: $m_{t+1} = (1+\mu)M_t$ and $(b_t^i, b_t^l) = (B^i, B^l)$.

Given the market clearing conditions, agents optimally choose the real money and asset balances in the centralized and competitive market. Such chosen balances then determine trade volumes and prices in the decentralized market as described in Lemma 1. At the same time, the prices of liquid and illiquid assets are determined in the centralized and competitive market. We use (7), (8), and (9) in equilibrium to examine how asset prices and liquidity premia are determined and how they respond to changes in nominal interest rates. Without loss of generality, we assume that asset supply is scarce in the sense that the real balances available in the decentralized market are not enough to consume the first-best amount of goods, q^*: $\phi M_t + \psi_t \mathbf{B} < q^*$, where $\mathbf{B} \equiv (B^i, B^l)$. Otherwise, purchasing one more unit of assets does not generate additional benefit and thus it will be the trivial case that asset prices are equal to the fundamental value, β and there do not exist liquidity premia.

Then, plugging (7) into (8) and (9) yields the following equations for asset prices in equilibrium:

$$\psi^i = \beta \left\{ (1+\iota)\theta^i + (1-\theta^i) \right\}, \tag{10}$$

$$\psi^l = \beta \left\{ (1+\iota)\theta^l + (1-\theta^l) \right\}, \tag{11}$$

where ι represents a nominal interest rate of an asset which is used only as a store of value. If we set $\theta^i = 0$ or $\theta^j = 0$ in either (8) or (9), the real price of an asset used only as a store of value is equal to β. Then, its gross nominal interest rate, $(1+\iota)$, equals $(1+\pi)\frac{1}{\beta}$ by the Fisher equation, which equals $u'(q_t)$ according to (7).

PROPOSITION 1. *If $\theta^i \neq 0$ and $\theta^j \neq 0$, asset prices are greater than their intrinsic values, β, as stores of value. Moreover, their values increase in ι.*

The proof is straightforward and so omitted. Equations (10) and (11) present that the prices of liquid and illiquid assets increase in a nominal interest rate, ι. The economic mechanism behind this positive effect of a nominal interest rate on asset prices is that since an increase in a nominal interest rate implies the higher opportunity cost of holding money, the demand for assets as a substitute for money increases. This increased demand for assets causes higher asset prices at the end because it increases the prices of liquidity services that assets provide, i.e. liquidity premia. Notice that the liquid asset price in (11) more sensitively responds to changes in a nominal interest rate. This implies that liquid assets are preferred to illiquid assets as a substitute for money because the former can be more useful in transactions. Furthermore, the nominal yields of illiquid and liquid bonds are expressed as follows:

$$1+i=(1+\pi)\frac{1}{\psi_t^i}=(1+\pi)\left\{(1+\iota)\theta^i+(1-\theta^i)\right\}^{-1}, \quad (12)$$

$$1+l=(1+\pi)\frac{1}{\psi_t^l}=(1+\pi)\left\{(1+\iota)\theta^l+(1-\theta^l)\right\}^{-1}. \quad (13)$$

The spread between nominal yields of liquid and illiquid assets can then be used as a proxy of liquidity premia, because these two assets are different only in terms of liquidity. They have the same maturity and safety. The log difference between (12) and (13) shows that liquidity premia can be approximately measured by the following equation:

$$lp=i-l\approx\log\left[(1+\iota)\theta^l+(1-\theta^l)\right]-\log\left[(1+\iota)\theta^i+(1-\theta^i)\right]. \quad (14)$$

COROLLARY 1. *The spread between nominal yields of liquid and illiquid assets increases in ι.*

It is straightforward to find a positive effect of a nominal interest rate on liquidity premia by taking a derivative of lp, i.e., (14) with respect to ι. In the next section, we will present empirical evidence of whether this theoretical finding is supported by Korean financial market data.

3. EMPIRICAL EVIDENCE

In this section, we will empirically test the positive effect of nominal interest rates on liquidity premia of liquid bonds such as MSBs and government bonds. All interest rates are monthly averages of daily closing annualized yields from January 2011 to December 2019.[9] The economic statistics system of the Bank of Korea provides the data except for credit default swap rates and the issued amount of government bonds, whose data sources are Bloomberg and Korea Treasury Bond, respectively. The frequency of all the data used in empirical tests are monthly.

3.1. Data

To measure liquidity premia, we need to first find pairs of assets that are different in terms of liquidity but the same in terms of other characteristics

[9]We focus on the period before the COVID-19 pandemic to avoid the distortion of results by atypical data and ensure the generalizability and accuracy of the findings, as these events can significantly alter normal economic behaviors and trends, which the model in Section 2 presents.

such as maturity and safety (or default risk). We consider 91-day MSBs and three-year government bonds as liquid assets, whereas 91-day CDs and three-year AA-rated corporate bonds as illiquid assets. First, MSBs are bonds with positive interest which the central bank in Korea, i.e., the Bank of Korea, issues in order to generally adjust midterm and long-term liquidity in financial markets.[10] Obviously, MSBs are as safe and liquid as government bonds in the sense that the central bank guarantees payment of the principal and interest. In addition, it is easy to find trading partners without a large cost when MSBs need to be sold for cash. On the other hand, CDs and AA-rated corporate bonds are almost as safe as government bonds but less liquid.[11] It is relatively hard to find trading partners when they need to be sold, compared with MSBs and government bonds. Lastly, the maturities of CDs and MSBs are 91 days, and the maturities of AA-rated corporate bonds and government bonds are three years. There is no maturity difference in each pair of assets. Consequently, the yield spreads between CDs and MSBs, and between AA-rated corporate bonds and government bonds can be used as appropriate proxies to measure the liquidity premia of MSBs and government bonds, respectively.

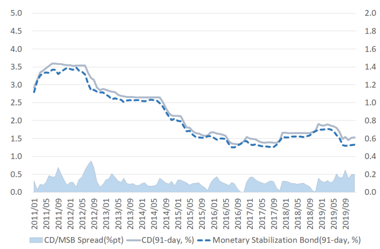

FIG. 1. CD & MSB Rates

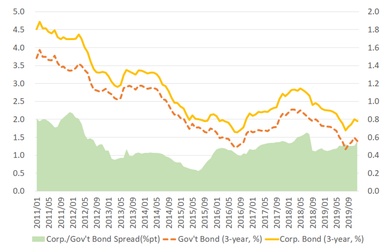

FIG. 2. Corp. & Gov't Bond Rates

Figures 1 and 2 demonstrate the interest rates of the four assets explained above and their yield spreads. All the interest rates tend to move in the

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[10]The Bank of Korea implements security transactions mainly through repurchase agreements (RP) transactions with 7-day maturities to adjust the short-term liquidity. Eligible securities for RP transactions include government bonds, government-guaranteed bonds, and securities selected by the Monetary Policy Board. MSBs are the only bonds eligible for RP transactions that the Monetary Policy Board selects. Source: https://www.bok.or.kr/eng/main/contents.do?menuNo=400027.

[11]Of course, private liabilities such as CDs and AA-rated corporate bonds are almost as safe as government bonds, but not 100%. Hence, a control variable for default risk will be considered in regressions. This helps us isolate the effect of nominal interest rates on liquidity premia and to control risk premia that the yield difference may include even if it is small.

same direction and their overall levels decrease during the sample period from 2011 to 2019. In addition, the yield spreads between AA- corporate bonds and Gov't bonds are wider than those between CDs and MSBs. This seems to be because liquidity services of government bonds are relatively high valued in financial markets. That is, government bonds are easily used in transactions.

Table 1 presents the summary statistics of the yield spreads that we use in empirical tests. The averages of the CDs/MSB spread and the AA- corporate bond/Gov't Bond spread are 12.0 basis points and 50.2 basis points, respectively. The standard deviation of the AA- corporate bond/Gov't Bond spread is 15.3, which is greater than that of the CDs/MSB spread. The larger spread and variation of the AA- corporate bond/Gov't Bond spread make sense because the relative liquidity of long-term government bonds to AA- corporate bonds is greater than that of short-term MSBs to CDs.

TABLE 1.

Summary Statistics: Yield Spreads

	Obs	Mean	Std. Dev.	Min	Max
91-day CDs/MSB Spread	108	12.0	6.0	0.0	35.0
3-year Corp. Bond(AA-)/Gov't Bond Spread	108	50.2	15.3	22.4	88.0

Notes: The spreads reported above are expressed in terms of basis points of annual rates. Source: ecos.bok.or.kr.

Call rates, which are used as an explanatory variable in regressions, represent nominal interest rates, ι, in the above theoretical prediction because they are an appropriate measure of the opportunity cost of holding money. Call rates in Korea are overnight loan rates among financial institutions such as commercial banks and security companies. These overnight interest rates are equivalent to federal funds rates in the United States in the sense that the Bank of Korea implements open market operations in order to prevent call rates from deviating significantly from the reference policy base rate.[12]

We allow for control variables for default risk and bond supply in regression analysis. Three-year credit default swap (henceforth, CDS) rates of Samsung Electronics are used as a control variable for default risk. Lastly, control variables for supply effects are the ratios of the outstanding amount

[12] The reference policy rate is so-called the "BOK Base Rate" in Korea because the rate is applied in transactions between the Bank of Korea and financial institutions.

of MSBs and the monthly issued amount of three-year government bonds to nominal GDP.[13]

3.2. Empirical Test

Based on the theoretical prediction, we use the yield spreads between illiquid and liquid assets as the dependent variables and call rates as the primary explanatory variable in regressions. Table 2 presents the main empirical result that interest rates, i.e., the opportunity cost of holding money, have a positive impact on the liquidity premia of liquid assets.

In Regressions (1) to (4), the dependent variable is the yield spread between CDs and MSBs. The coefficients of *Call Rate* turn out to be significantly positive and the positive sign is robust across different specifications. A one percentage point increase in Call Rate results in an increase of around 2.7 bps in the liquidity premium in Regressions (1) and (2) and around 4.9 bps in Regressions (3) and (4). The reason for the greater coefficients of Call Rate in (3) and (4) seems to be due to a control variable, *MSB/GDP*, for the bond supply effect. Adding MSB/GDP increases the R-squared values. Moreover, the coefficients of MSB/GDP are about negative 16.0 at the significance level of 5%, and robust across different specifications. The negative sign of MSB/GDP is economically intuitive because an increase in the MSB supply decreases the relative scarcity of assets that provide liquidity services. Regressions (2) and (4) have a control variable for default risk, *CDS Rate*, in common. However, the coefficients of CDS Rate turn out to be not statistically significant. This implies that CDS rates do not have a meaningful effect on the CD/MSB spread. This insignificance makes sense because commercial banks that issue CDs have never defaulted since the Asian financial crisis of the late 1990s. CDs are regarded as one of the safest assets to investors in Korean financial markets. This safety of CDs leads to the insignificant coefficients of CDS Rate in Regression (2) and (4).

In Regressions (5) to (8), the dependent variable is the yield spread between AA-rated corporate bonds and government bonds. The coefficients of Call Rate and *Gov't Bond/GDP* turn out to be positive and negative as in Regressions (1) to (4) and have the same economic meanings. A one percentage point increase in Call Rate leads to an increase of around 5.4 bps to 12.5 in the liquidity premium of government bonds across regressions, whereas a one percentage point increase in Gov't Bond/GDP causes a decrease of around 14.75 on average. The positive effect of call rates is larger than that on the yield spread between CDs and MSBs. When the bond supply effect is considered by including Gov't Bond/GDP in the regressions, R-squared increases, and the coefficients of Call Rate tend to be

[13]The outstanding amount or the monthly issued amount of MSBs by maturity is not available to the public in Korea, and thus we use the total outstanding amount of MSBs.

greater. Unlike in Regressions (2) and (4), however, the coefficients of CDS Rate appear significantly positive 0.45 and robust for these two different specifications even if its magnitude is small. This results from the fact that AA-rated corporate bonds would not be perfectly default-free even if their default risk is very low. Furthermore, they would be sensitive even to tiny changes in nominal interest rates or default risk levels of financial markets because their maturity is three years, which is longer than the maturity of 91-day MSBs.

Consequently, the empirical test results strongly support the theoretical prediction that an increase in interest rates should cause higher liquidity premia of liquid assets, as expressed in Equation (14). The opportunity cost of holding money increases the demand for liquid assets, i.e., assets that provide liquidity services as collateral or can be easily converted into cash, and thus their prices. In other words, the demand for money is substituted into that for liquid assets and this substitution leads to an increase in the yield spreads between illiquid and liquid assets, i.e., liquidity premia.

TABLE 2.

Impact on Liquidity Premia of MSBs and Government Bonds

Dependent Vars	CD/MSB spread				AA- Corp Bond/Gov't Bond spread			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Call Rate	2.742^{**}	2.765^{**}	4.919^{***}	4.830^{***}	10.18^{***}	5.375^{**}	12.53^{***}	7.714^{***}
	(1.366)	(1.336)	(1.666)	(1.676)	(3.657)	(2.671)	(3.557)	(2.554)
CDS Rate		-0.00218		0.0172		0.455^{***}		0.449^{***}
		(0.0481)		(0.0491)		(0.0722)		(0.0558)
MSB/GDP			-15.82^{**}	-16.49^{**}				
			(7.422)	(7.496)				
Gov't Bond/GDP							-14.98^{***}	-14.45^{***}
							(4.874)	(4.278)
Constant	6.399^{**}	6.431^{**}	21.98^{***}	22.40^{***}	29.34^{***}	22.81^{***}	44.81^{***}	37.84^{***}
	(2.651)	(2.942)	(8.114)	(8.072)	(7.057)	(5.926)	(7.180)	(6.523)
Observations	108	108	108	108	108	108	108	108
R-squared	0.821	0.821	0.832	0.832	0.934	0.954	0.942	0.961
Adjusted R-squared	0.105	0.105	0.158	0.160	0.223	0.452	0.320	0.542

Notes: Coefficients are estimated by Newey-West estimators with 3 lags and their standard errors are presented in parenthesis. The dependent variable of (1) to (4) is the yield spread between CDs and MSBs, and that of (5) to (8) is the yield spread between AA-rated corporate bonds and government bonds, which are measured in a basis point. The primary explanatory variable is call rates. A control variable for default risk on illiquid assets is CDS rates. Control variables for supply effects are the ratios of the outstanding amount of MSBs and the monthly issued amount of three-government bonds to nominal GDP. MSB/GDP and Gov't Bond/GDP denote the former and the latter, respectively. CDS rates are measured by the monthly average of the daily closing annualized three-year credit default swap rates of Samsung Electronics. Source: BOK ECOS, Korea Treasury Bond and Bloomberg. *** indicates $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. The further robustness check of the empirical results is relegated to Appendix A.2.

3.3. Extension: Effects of Standing Facilities

In this section, we investigate the effects of a standing facility introduced by the Bank of Korea in March 2008 on the liquidity premia analyzed above. This standing facility aimed to strike a balance between market performance and the stability of the call rate. Specifically, it provides financial institutions holding reserves at the Bank of Korea with overnight loans and deposits, termed "Liquidity Adjustment Loans and Deposits," respectively. The interest rates for these Liquidity Adjustment Loans and Deposits are set at +100 basis points (bps) and −100 bps relative to the Bank of Korea Base Rate, respectively.

Note that even if the interest rate of the Liquidity Adjustment Deposits is 100bps lower than the Bank of Korea Base Rate, the Bank of Korea still pays positive interest on reserves when the Base Rate exceeds 1%. This is a significant event because, prior to this, there was no deposit facility in Korea that offered positive interest on excess reserves. Therefore, this deposit facility can reduce the money holding costs for financial institutions, such as commercial banks, that maintain reserves. This change suggests that the deposit facility may diminish the effects of nominal interest rates on liquidity premia. Consequently, this institutional change allows us to study and provide additional evidence supporting the theoretical results.

The sample period for this empirical analysis is extended back to September 2006, due to the implementation of the deposit facility in March 2008. Notably, the interest rates of 91-day Monetary Stabilization Bonds are not available before September 2006. We consider two dummy variables in our analysis. The first is for the Global Financial Crisis (henceforth, GFC), which spans from 2008 to 2010, a period during which the average Credit Default Swap rates reaches 109.9, exceeding the overall average of 45.4 for the entire period. The second dummy variable is for the standing facility implemented in March 2008. Additionally, our analysis primarily focuses on the effects of this facility on the liquidity premium of MSBs, rather than on three-year government bonds, due to the insufficient availability of supply data for the latter before 2008.

The following regressions include an interaction term between call rates and the deposit facility to assess how the introduction of the deposit facility affects the impact of call rates on the liquidity premia of MSBs. Table 3 presents the regression results, confirming the negative effect of the deposit facility. In Regressions (1) to (3) in Table 3, the dependent variable is the yield spread between CDs and MSBs. Similar to the regression results in Table 2, the coefficients of *Call Rate* and *CDS Rate* are significantly positive, while *MSB/GDP* is negative. Additionally, this analysis suggests that the coefficient of the Global Financial Crisis dummy positively affects the liquidity premia of MSBs. This is economically intuitive because, during a crisis, demand for liquid assets can increase, leading to higher pricing for asset liquidity than in normal times. Most importantly, Regression (3) reveals a negative sign for the interaction term between call rates and the deposit facility. This indicates that the introduction of the deposit facility reduces the impact of call rates—i.e., the money-holding cost—on the liquidity premia of MSBs, which is consistent with theoretical predictions and provides further empirical evidence.

TABLE 3.

Effects of the Deposit Facility on Liquidity Premia of MSBs

	(1)	(2)	(3)
Call Rate	1.389^{*}	3.302^{**}	4.251^{***}
	(0.802)	(1.430)	(1.617)
CDS Rate	0.225^{***}	0.218^{***}	0.229^{***}
	(0.0439)	(0.0412)	(0.0420)
MSB/GDP		-16.87^{**}	-24.11^{***}
		(6.949)	(8.472)
Call Rate × Standing Facility			-2.186^{*}
			(1.124)
GFC Dummy	14.67^{***}	16.49^{***}	17.77^{***}
	(3.993)	(3.938)	(3.927)
Constant	1.448	19.58^{***}	30.46^{***}
	(2.567)	(6.208)	(8.798)
Observations	160	160	160
Adjusted R-squared	0.683	0.694	0.703

Notes: Coefficients are estimated by Newey-West estimators and their standard errors are presented in parenthesis.
Source: BOK ECOS, and Bloomberg. *** indicates $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4. CONCLUSION

Our study constructs a parsimonious monetary search model to derive theoretical predictions about how liquidity premia can be measured and how the opportunity cost of holding money, which is represented by nominal interest rates, affects liquidity premia. Then we implement empirical tests with Korean financial market data in order to find empirical evidence to support theoretical prediction.

According to the theory, the yield spreads between illiquid and liquid assets with the same maturities and default risks can be used as an appropriate proxy of liquidity premia, and nominal interest rates increase liquidity premia. The economic mechanism behind this is that an increase in nominal interest rates implies the higher opportunity cost of holding money, and thus that demand for money is substituted into demand for liquid assets, which provide liquidity services as money does, and thus their prices of liquidity services, i.e., their liquidity premia.

To empirically test the theoretical predictions, we utilize Korean financial data. The yield spreads between 91-day CDs and MSBs and between three-year AA-rated corporate bonds and government bonds are used as measures of liquidity premia. In addition, call rates are used to represent the opportunity cost of holding money and thus the main explanatory variable in empirical tests. The regression results demonstrate that call rates significantly have a positive effect on the yield spreads. Such positive effects are robust across different specifications with control variables for the default risk of CDs and corporate bonds as well as supply effects of MSBs and government bonds.

Additionally, the empirical analysis conducted to assess the impact of the Bank of Korea's standing facility, introduced in 2008, on liquidity premia shows significant findings. It reveals that the facility had a negative effect on the liquidity premium of Monetary Stabilization Bonds (MSBs), particularly by reducing the impact of call rates on this premium. This suggests a diminished influence of call rates on liquidity costs, further substantiated by the broader empirical evidence presented. Consequently, liquid assets play a role as substitutes for money in providing liquidity services, and thus the higher opportunity cost of holding money leads to an increase in demand for liquid assets and higher liquidity premia.

APPENDIX A

A.1. PROOF OF STATEMENTS

Proof. Proof of Lemma 1.

First, plugging H_t into the value function, W^B, of buyers in (1) yields

$$W^B(m_t, \mathbf{b}_t) = \phi_t m_t + \mathbf{b}_t + \gamma_t^B, \tag{A.1}$$

where $\gamma_t^B \equiv T_t + \max_{m_{t+1}, \mathbf{b}_{t+1}} \left\{-\phi_t m_{t+1} - \psi_t \mathbf{b}_{t+1} + \beta V^B(m_{t+1}, \mathbf{b}_{t+1})\right\}$. The value function in the centralized and competitive market is linear in choice variables, m_{t+1} and $\mathbf{b}_{t+1}$, and thus the optimal choice of buyers does not depend on the state variables, m_t and $\mathbf{b}_t$. Similarly, the value function, W^S, of sellers in (2) can be expressed as a function of the state variables as follows.

$$W^S(m_t, \mathbf{b}_t) = \phi_t m_t + \mathbf{b}_t + \gamma_t^S, \tag{A.2}$$

where $\gamma_t^S \equiv \beta V^B(0, \mathbf{0})$. Substituting (A.1) and (A.2) into (5) simplifies the bargaining problem as follows. participation constraint

$$\max_{q_t, p_t^m, \mathbf{p}_t} \{u(q_t) - \phi_t p_t^m - \mathbf{p}_t\} \tag{A.3}$$

$$\text{s.t.} \quad -q_t + \phi_t p_t^m + \mathbf{p}_t = 0, \tag{A.4}$$

and the budget constraints, $p_t^m \leq m_t$ and $\mathbf{p}_t \leq \theta \mathbf{b}_t$, where $\theta = (\theta^i, \theta^l)$. Substituting (A.4) into (A.3) yields

$$\max_{q_t} \{u(q_t) - q_t\}$$

subject to $q_t = \phi_t p_t^m + \mathbf{p}_t$, $p_t^m \leq m_t$ and $\mathbf{p}_t \leq \theta \mathbf{b}_t$. If $\phi_t m_t + \theta \mathbf{b}_t \geq q^*$, the optimal choice of q_t will be the first-best quantity q^*: $q_t = q^*$. Then $(p_t^m, \mathbf{p}_t)$ can be any pairs whose real balances are equal to q^*. If $\phi_t m_t + \theta \mathbf{b}_t < q^*$, the budget constraint is binding and thus the optimal choice of q_t is equal to the real money and asset balances, $\phi_t m_t + \theta \mathbf{b}_t$. Buyers will hand over all their money (m_t) and assets ($\theta \mathbf{b}_t$) available to sellers in order to purchase as many goods as possible. Sellers will produce the corresponding decentralized market goods to the real balances that buyers will pay: $q_t = \phi_t m_t + \theta \mathbf{b}_t$. ▌

A.2. ROBUSTNESS OF THE EMPIRICAL ANALYSIS

We test the robustness of the empirical results in Section 3 by including macroeconomic variables such as Industrial Production Index and Consumer Price Index (CPI) as control variables. These macroeconomic indicators are standard variables that can affect bond demand. As found in Table 4, it turns out that the positive effects of nominal interest rates on liquidity premia are robust to the macroeconomic indicators. The coefficients of "Call Rate" are statistically significant at the 1% level across the regressions and furthermore remain at the similar magnitudes. For instance, the coefficients in Regression (1) to (4) with control variables appear to be 4.6∼4.8. A one percentage point increase in Call Rate results in an increase of around 4.6∼4.8 bps in the liquidity premium of MSBs, which are similar to the results in Table 2. Consequently, the macroeconomic variables that we consider for robustness check have virtually no effect on the coefficients of the call rate, and also the MSB/GDP and Gov't Bonds/GDP ratios.

TABLE 4.

Robustness for the Impact on Liquidity Premia

Dependent Vars	CD/MSB spread				AA- Corp Bond/Gov't Bond spread			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Call Rate	4.682^{***}	4.598^{***}	4.826^{***}	4.747^{***}	14.02^{***}	10.33^{***}	12.18^{***}	7.478^{***}
	(1.501)	(1.510)	(1.497)	(1.493)	(3.112)	(2.148)	(2.625)	(1.969)
CDS Rate		0.0168		0.0156		0.471^{***}		0.443^{***}
		(0.0470)		(0.0488)		(0.0456)		(0.0449)
MSB/GDP	-18.48^{***}	-19.11^{***}	-15.86^{**}	-16.47^{**}				
	(6.746)	(6.778)	(6.302)	(6.422)				
Industrial Production	-0.0928	-0.0918			0.280	0.538^{**}		
	(0.128)	(0.129)			(0.302)	(0.252)		
CPI			1.661	1.627			6.455^{*}	5.432
			(2.003)	(2.027)			(3.888)	(3.315)
Gov't Bond/GDP					-12.85^{***}	-10.35^{***}	-15.21^{***}	-14.65^{***}
					(4.399)	(3.529)	(3.770)	(3.296)
Constant	35.22^{*}	35.47^{*}	22.02^{***}	22.39^{***}	10.57	-28.21	45.04^{***}	38.11^{***}
	(18.32)	(18.38)	(6.727)	(6.685)	(36.86)	(29.77)	(5.421)	(5.013)
Observations	108	108	108	108	108	108	108	108
Adjusted R-squared	0.163	0.165	0.167	0.168	0.326	0.566	0.339	0.556

Notes: Coefficients are estimated by Newey-West estimators with 3 lags and their standard errors are presented in parenthesis. The dependent variable of (1) to (4) is the yield spread between CDs and MSBs, and that of (5) to (8) is the yield spread between AA-rated corporate bonds and government bonds, which are measured in a basis point. The primary explanatory variable is call rates. A control variable for default risk on illiquid assets is CDS rates. Control variables for supply effects are the ratios of the outstanding amount of MSBs and the monthly issued amount of three-government bonds to nominal GDP. MSB/GDP and Gov't Bond/GDP denote the former and the latter, respectively. CDS rates are measured by the monthly average of the daily closing annualized three-year credit default swap rates of Samsung Electronics. Source: BOK ECOS, Korea Treasury Bond, Statistics Korea, and Bloomberg. *** indicates $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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