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Identifying the Effect of Bank of Japan's Liquidity Provision on the Year-End Premium: A Structural Approach

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Abstract

To what extent did the Bank of Japan's liquidity provisions reduce the premium on money market rates over the year-ends in Japan? To answer this question, we propose a simple structural model that illustrates the year-end operations and the year-end interbank money markets. Based on the structural model, we identify the effects of the year-end operations as differences between the actual premium in the year-end money market and the counterfactual premium without the operations, and decompose the effects into two factors: the amount of liquidity supplied and the steepness of the banks' liquidity demand curve. We find that the operations over the year-end and the fiscal year-end of 2008 had the largest effects among those from 2006 to 2008, reflecting the fact that the Bank of Japan had significantly expanded liquidity provisions in response to the decrease in market liquidity under the financial turmoil.

Keywords: Money market operation; Year-end; Monetary policy

JEL classification: E50; E52; E58; G10

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1 Introduction

In Japan as well as other major countries, the premium on interbank money market rates arise over term-end periods as a result of the Japanese business practice of periodic settlement. In particular, settlements of funds between debtor and creditor institutions become intensive on the last business day of the term-end month.[1] This term-end premium, or the deviation of term-end money market rates from the expected path of the policy rate over the period, is considered to occur as market participants price the risk premium on the money market rates concerning the liquidity shortage over the term-end. This phenomenon is further amplified in term-end periods during the financial turmoil.[2]

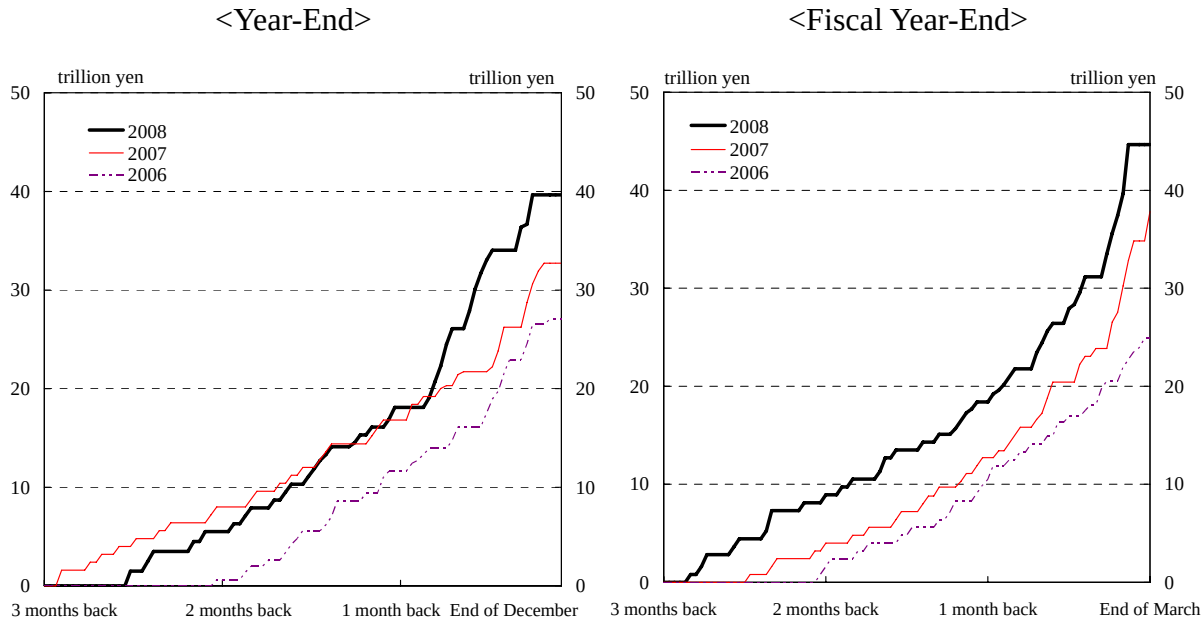
In response to the rise in the term-end premium, the Bank of Japan (BoJ) conducts funds-supplying operations, usually with a start-date one to two months before the term-end and an end-date beyond the term-end (term-end operations hereafter). The objective of term-end operations is to meet the liquidity demand of banks in the money market and mitigate the upward pressure on the term-end premium. The BoJ's operational desk increases the frequency and amount of funds supplied under the conditions where banks face considerable pressures in liquidity funding. For instance, in the face of the subprime mortgage problem which hit global financial markets in August 2007, the BoJ conducted more aggressive term-end operations in terms of timing of the first operation, frequency, and volume from autumn 2007 onwards than those toward the year-end of 2006 (see Figure 1).[3]

[1] According to Saito et al. (2001), Japanese firms tend to concentrate quarterly settlements largely during the last week, or especially the last business day of March (corresponding to the end of the fiscal year), September (the end of mid-fiscal year) or December (the end of the calendar year). Failure to settle is considered not only to damage the firm's credit but also jeopardizes the continuation of business with the firm's counterparty. Given such Japanese business practices, it has been noted in previous studies that firms voluntarily accumulate sufficient liquidity in advance of term-end settlements, as a result of tight credit conditions during the settlement month, and consideration of their counterparties' credit risk.

[2] Also, the term-end premium jumped during the period before the year-end of 1999 when the so-called Y2K problem was considered to be a risk event.

[3] For a comprehensive review of the recent operations conducted by the BoJ, see Bank of Japan (2008, 2009).

Figure 1: Total Amount Outstanding of Year-End Operations: 2006-2008



Notes: 1. Offer Date Basis.
2. Short-term funds-supplying operations (outright purchase of T-Bills, outright purchases of CP, and outright purchases of corporate bonds are not included).
3. In Japan, the fiscal year starts in April, and thus the fiscal year-end corresponds to the end of March of the following year.

This paper proposes a structural model to identify the effects of BoJ's funds-supplying operations over the year-end (year-end operations hereafter) on the premium for liquidity in the interbank money market over the year-end (year-end premium hereafter). The model characterizes a situation where a year-end premium exists as a result of an increase in demand not instantaneously met by any change in supply of liquidity in the year-end interbank money market. Then, under the assumption that the year-end interbank money market is highly integrated with the year-end operations market, a liquidity supply by the BoJ leads to a decrease in the year-end premium. Based on this model, we identify the effects of the year-end operations as differences between the actual premium in the year-end interbank money market and the counterfactual premium that would prevail without such operations.

The innovation of our approach lies in the identification of the unobservable counterfactual term-end premium without the operation from publicly available data on the operations and the term-end premium in the interbank money market. The counterfactual premium is identified through the following three steps.

The first step is to identify the banks' liquidity demand in the year-end operations market from observables. We know that the total bid amount should be on the demand curve at the

base rate, or the minimum bid rate in operations. Given that a fixed offer amount is determined exogenously by the BoJ, the total offer amount should be also on the demand curve at the successful bid rate; namely, we identify another point on the banks' demand curve. Taking advantage of the fact that the total bid and offer amount are close, we obtain the linear demand curve for banks by connecting these two points.

Second, given the liquidity demand curve, we obtain the bid rate in the year-end operations market that would prevail without such operations. This can be done by simply extrapolating the bid rate through the demand function when the quantity of liquidity is zero.

Third, we assume that there exists a linear relationship between the bid rate in the year-end operations market and the year-end interbank money market rate. Then, we obtain the counterfactual term-end premium without the year-end operation from the counterfactual bid rate identified in the second step. Since we know the actual year-end premium with the year-end operations implemented, we can calculate the effect of year-end operations in our definition as the difference between the actual and counterfactual year-end premium.

Our structural model has two advantages in measuring the effects of term-end operations on the term-end premium; namely, the structural interpretation of the effects and the independence of the results from the econometric method.

The first advantage is that our model can decompose the effects of the operations into two factors: (1) the amount of liquidity supplied through the operations, or the "volume factor," and (2) the steepness of the banks' liquidity demand curve in the short term money market, or the "slope factor." Hence, referring to these factors allows us to structurally interpret the development of the operations' effects for each year-end.

The second advantage is that the results in our approach do not depend on econometric methods. In contrast to time-series econometric approach, our structural approach enables us to identify the effects cross-sectionally, period by period. In this respect, we can examine the effect of the operations with relatively small number of samples, while time-series econometric methods need sufficient number of samples at the risk of structural changes in the data generating process.

We use our model to empirically investigate the effects of year-end operations conducted by the BoJ on the premium for liquidity embedded in Japanese interbank money market rates for the (calendar) year-end period (from October to December) and the fiscal year-end period

(from January to March of the next year) since 2006.

First, we find that the term-end operations conducted over the year-end and fiscal year-end period of 2007 had notable effects in reducing the year-end premium. Second, we find that term-end operations conducted over the year-end and fiscal year-end of 2008 had much larger effects in reducing the year-end premium than those over the previous respective periods. Third, we find that after the fall of 2008, the large effects of the year-end operations are attributable to both the size of the volume factors and slope factors.

This paper is organized as follows. The next section presents a brief review of the existing literature on the term-end premium and the effectiveness of central bank liquidity provisions. In Section 3, we define the term-end premium, and show its movement for our sample period. Section 4 presents our analytical framework to identify the effects of the term-end operations. Section 5 extends our framework in order to identify the effects of BoJ's new liquidity facility implemented since January 2009. Section 6 explains the data used in our analysis. Section 7 reports our results on the effects of the term-end operations over the year-end and fiscal year-end periods since 2006. Section 8 is the conclusion.

2 Related Literature

A number of previous studies have noted the existence of a premium on the money market rate over the term-end. For example, Saito et al. (2001) examine the term structure of short term interest rates over the term-end in Japan and empirically show that the implied forward rates, calculated from term rates over the period of the term-end, have a tendency to over-value the spot rate of the term-end. They find that assets with a maturity that terminates exactly on the term-end will tend to be relatively dear compared to those assets with a maturity that terminates at a date beyond the term-end. They show that an increase in liquidity demand as a result of periodic settlements is met with an increase in the term-end premium.

For the United States, Griffiths and Winters (2005) show that the tendency of short term interest rates to rise over the year-end is attributable to the increase in liquidity demand over the year-end. Kotomin, Smith and Winters (2008), in light of Griffiths and Winters (2005), show that the increase in the term-end premium is not only observed in the U.S. dollar London Inter-Bank Offered Rates ("LIBOR"), but also in the Euro, Yen, Swiss Franc, and German Mark LIBOR rates. Furthermore, Downing and Oliner (2007) show that, in the U.S. commercial paper market over the year-end period, the one month commercial paper rate

deviates substantially from the corresponding one month average of the actual O/N commercial paper rate.

Central banks have played a key role in providing liquidity to mitigate funding pressures in money markets. There are several papers that discuss the effectiveness of central bank liquidity provisions. For example, Saito and Shiratsuka (2000) state that, under the situation of market dysfunction, liquidity provisions by the central bank may help the recovery of market liquidity. Sundaresan and Wang (2006) examine the effect of liquidity provision by the Federal Reserve Board (Fed) towards the year-end of 1999 when the so-called Y2K problem had been of particular concern as a risk event. They conclude that the Fed's response alleviated the market participants' concerns regarding liquidity funding, and thus contributed to the decrease in the liquidity premium over the year-end period.

In light of the recent global financial market turmoil, there has been active research in measuring the effectiveness of central bank liquidity provisions on short term interest rates, using a time-series econometrics approach. For instance, McAndrews, Sarkar, and Wang (2008), as well as Taylor and Williams (2009), investigate the effect of the Fed's Term Auction Facility (TAF) by regressing various indicators of counterparty risk and TAF dummy variables on the spreads between the LIBOR and the overnight indexed swap (OIS) rates in the U.S. dollar[4]. Christensen, Lopez and Rudebusch (2009) estimate an affine arbitrage-free term structure representation of Treasury yields, the yields on bonds issued by financial institutions, and term LIBOR rates. They conduct hypothesis testing and counterfactual analysis associated with the introduction of the Fed's liquidity facilities. Moreover, for the Euro area, Eisenschmidt, Hirsch and Linzert (2009) show that, during the current financial crisis, there is a tendency for European Central Bank's counterparties to show aggressive bidding behavior in liquidity operations.

3 Definition of the Term-End Premium

We start by defining and measuring the term-end premium on term-end interbank money market rates for our sample period. In Griffiths and Winters (2005) and Saito et al. (2001), term-end funds are defined as funds with a duration over the term-end, needed by firms and financial institutions in order to make periodic settlements before the term-end. In the case of

[4] Using a similar method, Wu (2008) estimates the effect of Fed's other facilities such as the Term Securities Lending Facility (TSLF) and Primary Dealer Credit Facility (PDCF).

Japan, the needs of these periodic settlements intensify during the last week before the term-end, especially on the last business day of the fiscal year-end (March), mid fiscal year-end (September), and the year-end (December). As a result of increased demand for term-end funds, the implied spot rate over the term-end, derived as a difference between the implied forward rate and the spot rate over this period, tends to show an over-valuation relative to the expected path of the policy rate over this period.

We follow previous studies in defining the term-end premium as the deviation of money market interest rates from the theoretical interest rates based on the expectations hypothesis on the term structure of interest rates. Specifically, we use Tokyo InterBank Offered Rates ("TIBOR") over the term-end period as the term-end interbank money market rates, and the OIS rate over the respective period as the expected path of the policy rate. The term-end periods of the year-end and fiscal year-end of 2006-2008 are analyzed in this paper. We measure the one month TIBOR-OIS spread over the term-end period, starting three months prior to the term-end, all the way up to the term-end[5]. For instance, in order to measure the term-end premium for the year-end period of 2008, we calculate the implied one month TIBOR-OIS spread over the term-end period from the three month TIBOR-OIS spread during October, the implied one month TIBOR-OIS spread over the term-end period from the implied two month TIBOR-OIS spread during November, and the one month TIBOR-OIS spread during December 2008. We consider the TIBOR rate as the suitable option for our purpose, although the use of the TIBOR rate is open for discussion[6].

Figure 2 shows the measured premium for the year-end and fiscal year-end periods from 2006. We note two features; first, the year-end premium is positive over all the periods, indicating that the expectations hypothesis on the term structure of interest rates does not hold, and second, the year-end and fiscal year-end premium in 2008 are much higher than those of previous respective periods. This implies that the liquidity demand for raising year-end funds was relatively high during these periods, despite the aggressive liquidity provision by the BoJ.

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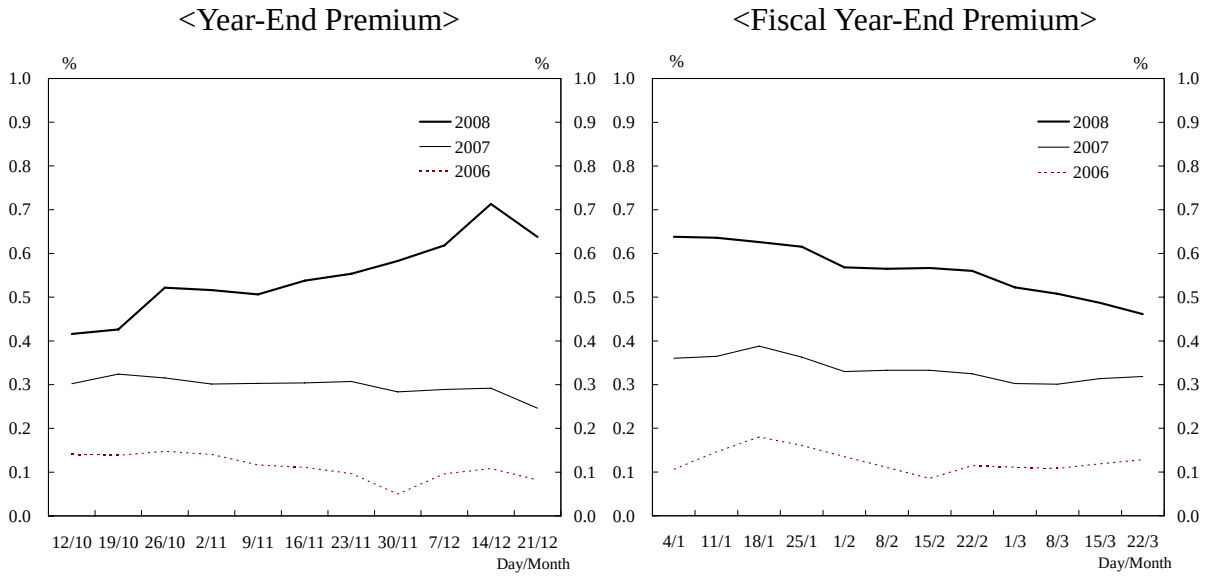
[5] We start the measurement of the term-end premium three months prior to the term-end because we note that term-end interbank money market rates start to deviate from the expected path of the policy rate from around this period, and because term-end operations start roughly two months prior to the term-end.

[6] TIBOR is an average of offered rates of panel banks, thus does not reflect actual rates. It is also used as the benchmark rate for bank lending, thus potentially reflecting the credit risk of borrowing firms. Nonetheless, we use TIBOR rates, because publicly available data on actual rates is limited in the Japanese short term money market, and because TIBOR rates on average are considered not to deviate much from the actual rates in the interbank money market. We do not exclude the possibility that the term-end TIBOR-OIS may be subject to both credit risk and term premium.

Figure 2: Term-End Premium in the Interbank Money Market



Note: The premiums are weekly averages calculated on an offer date basis. Rates with a start date after the term-end have been excluded.

4 Analytical Framework

This section presents our analytical framework in order to identify the effects of the term-end operations. In this paper, we measure the effect as the difference between the actual term-end premium and the counterfactual one that would prevail without the operations. The novel feature of our approach lies in the identification of the counterfactual term-end premium that is unobservable as a market data. To this end, we propose a structural model that illustrates the relationship between the year-end operations market and the year-end interbank money market. Based on our model, we show that we can identify the unobservables from available data.

In this section, we consider a single measure of the term-end operations under the conventional method of competitive rate auction in order to illustrate our framework. We extend our model to analyze the fixed-rate operation that the BoJ has conducted during the current financial turmoil in Section 5.

4.1 Mechanism behind the Term-End Premium

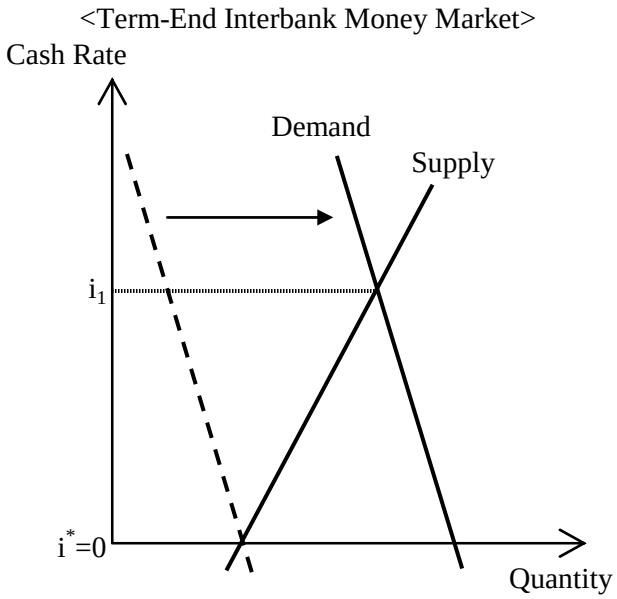
In order to construct our structural model, first we characterize the mechanism through which the term-end premium rises and falls. Figure 3 depicts the demand and supply relationship in the interbank money market, where the horizontal axis shows the quantity of

liquidity, and the vertical axis shows the term-end premium, or as explained above, the deviation of the money market rate from the OIS rate for that period.

Under the normal circumstance where, for instance, market participants do not anticipate the term-end premium, the equilibrium rate will always be close to the corresponding OIS rate. We describe the equilibrium as $i^* = 0$ for simplicity. This is because a rise in the cash rate due to an increase in liquidity demand will be offset simultaneously by the same increase in supply.

We now consider the case where an increase in liquidity demand is not instantaneously met by any change in liquidity supply due to the concern of intensive settlements toward the year-end. Then, the cash rate will rise and the term-end premium will be determined at i_1. The term-end premium is further heightened under financial turmoil when the counterparty risk is highly concerned and the precautionary demand for liquidity increases.

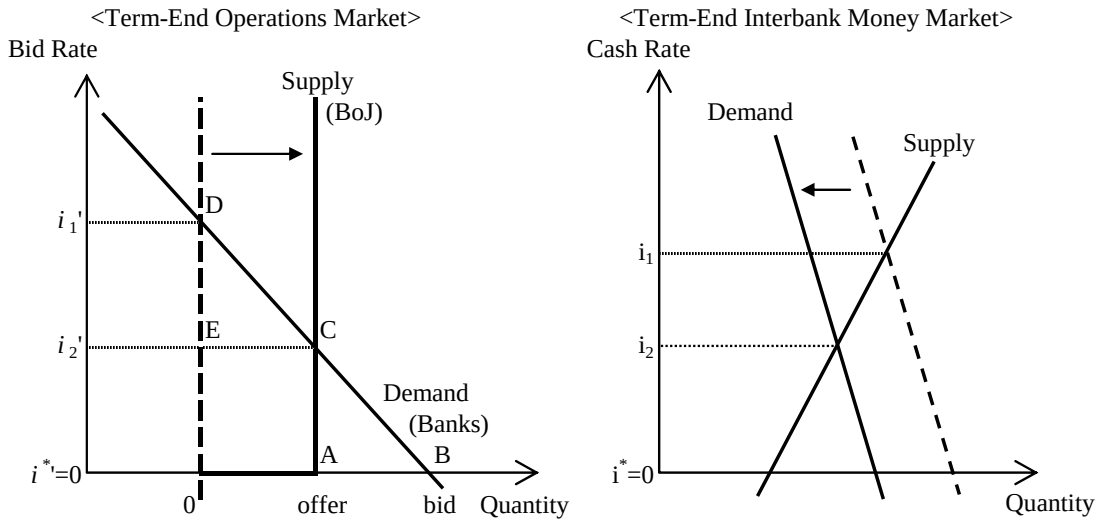
Figure 3: Mechanism behind the Term-End Premium



4.2 The Model

The model consists of two markets: the term-end operations market and the term-end interbank money market. Figure 4 depicts the demand and supply relationship in each market in terms of quantity of liquidity and the interest-rate spreads between the market rates and the corresponding OIS rates. We will explain the details of each diagram in turn below.

Figure 4: Demand and Supply Relationships in the Term-End Operations Market and the Term-End Interbank Money Market



First, in the term-end operations market, banks' behavior is characterized by the downward-sloping demand curve. Operation counterparties (Banks hereafter) have an incentive to bid along the demand curve up to the point where $i^{*'}=0$. Therefore, the total bid amount of Banks will be denoted by the point B.

On the other hand, the supply curve of the BoJ is depicted as the vertical line since the quantity of liquidity supply is exogenously set by the BoJ, irrespective of any bid rates. Without any liquidity supplying operation, the supply curve is vertical at the quantity zero. Suppose that the BoJ offers a certain amount of term-end funds, which is characterized by the rightward shift in the vertical supply curve above $i^{*'}$ up to the amount offered, denoted by the point A[7]. Banks decide whether to bid or not in the operation, referring to the implied term-end premium $i_1^{'}$, i.e., the counterfactual rate without the operation. When $i_1^{'}$ is positive, they have an incentive to bid in the operation. The equilibrium in this market is determined at point C, the intersection of the demand and supply curves, where the successful bid rate is determined at $i_2^{'}$.

Second, we consider how the term-end operation has effects on the supply and demand conditions in the term-end interbank money market. For simplicity, we postulate that there will be no effect of a liquidity supply of term-end funds on the slope of the demand curve and

[7] In reality, the total offer amount and total allotment amount can slightly differ. For simplicity, we assume that these amounts are equal.

the slope and position of the supply curve in the money market. Under the assumption that there is substitutability between the collateralized term-end funds in the operation and the uncollateralized term-end funds in the money market, the liquidity supply in the term-end operations market leads to the leftward shift of the demand curve in the term-end interbank money market, as a result of the fulfillment of liquidity demand. Consequently, the term-end premium in the term-end interbank money market falls from i_1 to i_2. According to our definition, the effect is measured as the difference between i_1 and i_2.

4.3 Identification of the Effect of the Term-End Operations

Given the framework described above, we will now show how we identify the effect of the term-end operation on the term-end premium. First, assuming the linearity of the demand and supply curve in the term-end operations market, we notice in Figure 4 that ΔABC is similar to ΔECD since the supply curve is vertical. Thus, we have the following relationship:

$$(bid - offer) : offer = i_2^{'} : (i_1^{'} - i_2^{'}) . \quad (1)$$

Next, we assume a linear relationship between the bid rate spread $i^{'}$ and the term-end premium i, or:

$$i = \gamma i^{'} . \quad (2)$$

Then, we have:

$$i_2^{'} : (i_1^{'} - i_2^{'}) = i_2 : (i_1 - i_2) . \quad (3)$$

Combining Equations (1) to (3) gives an expression for the effect of the term-end operation on the term-end premium:

$$i_1 - i_2 = i_2 \frac{offer}{bid - offer} . \quad (4)$$

Equation (4) allows us to calculate the effect of the term-end operation, by using the actual term-premium and publicly available bid and offer amounts in the term-end operations.

4.4 Decomposition of the effect of term-end operations

One of the advantages of our approach is that we can structurally examine what factors determine the effect of term-end operations. Substituting Equation (2) into (4), we obtain:

$$i_1 - i_2 = \gamma i_2^{'} \frac{offer}{bid - offer} . \quad (5)$$

Equation (5) shows that the effect of the term-end operation is the product of the following two factors: $offer$ and $\gamma i_2^{'} /(bid - offer)$, given the value of γ.

First, $offer$ is the amount of liquidity supplied through term-end operations, which determine how much liquidity demand in the short term money market is replenished. We call this term the "volume factor." We can see in Figure 4 that a larger shift of the amount offered in the term-end operations market, *ceteris paribus*, gives rise to a larger shift of the demand curve in the term-end interbank money market, and consequently a larger fall in the term-end premium.

Second, the term $\gamma i_2^{'} /(bid - offer)$ characterizes the slope of the liquidity demand curve in the term-end operations market and, given the value of γ, that in the term-end interbank money market. We call this term the "slope factor." A steeper slope of the demand curve implies that the banks' demand for liquidity is less elastic to the change of the interest rate. As shown in Figure 4, given the amount offered, if the slope of the demand curve in the term-end operations market is steeper, the difference between $i_1^{'}$ and $i_2^{'}$ becomes larger. Since we assume that the interest rate spreads in the term-end operations market and the term-end interbank money market are linearly dependent with each other, a larger difference between $i_1^{'}$ and $i_2^{'}$ leads to a larger difference between i_1 and i_2, or a larger effect of the operation in our definition. An intuitive explanation for this mechanism is that banks whose funding position is short recognize a more severe supply and demand condition in the term-end interbank money market, and are willing to pay a higher cost to raise additional liquidity from the central bank. In such a case, the contribution of the liquidity provision to suppressing the term-end premium would be larger.

5. Identifying the Effect of the Operation over the Fiscal Year-End of 2008: An Extension of the Analytical Framework

The current financial turmoil, triggered by the U.S. subprime mortgage problem, developed into a global financial crisis from the fall of 2008. The BoJ as well as other central banks in major economies responded to this situation, not only by reducing the policy interest rate, but also by expanding the tools of money market operations to undertake aggressive liquidity provision in financial markets. One of the policy measures newly introduced is the

special funds-supplying operation (the special operation hereafter), which has been implemented to facilitate corporate financing since January 2009.

The special operation provides one- or three- month liquidity for an unlimited amount against the value of corporate debt submitted to the BoJ as collateral at an interest rate equivalent to the target for the uncollateralized overnight call rate. We consider the special operation over the term-end to be one of the term-end operations, taking account of its term and role.

Because the BoJ has conducted the conventional term-end operations and the special operations simultaneously since January 2009, and the features of the special operations are different from that of the conventional one, we need to extend our framework to identify the respective effects of these operations.

5.1 The Extended Model

There are two identification issues to investigate the effects of the special operation in addition to the one by competitive rate auction.

One issue is that both operations simultaneously contribute to reducing the term-end premium, and hence we need to decompose the effect into each contribution of these two operations.

Another issue is that the special operation is conducted for an unlimited amount (within the range of corporate debt submitted to the BoJ as collateral) at a fixed loan rate. In identifying the effect of the operations based on the previous framework, it is crucial to infer the slope of banks' demand curve from the observables. However, under the special operation, irrespective of the amount of bid and offer, the successful bid rate remains the same at the policy rate. Hence, we cannot obtain the information to conjecture the slope of the demand curve.

To overcome these issues, we introduce two additional assumptions.

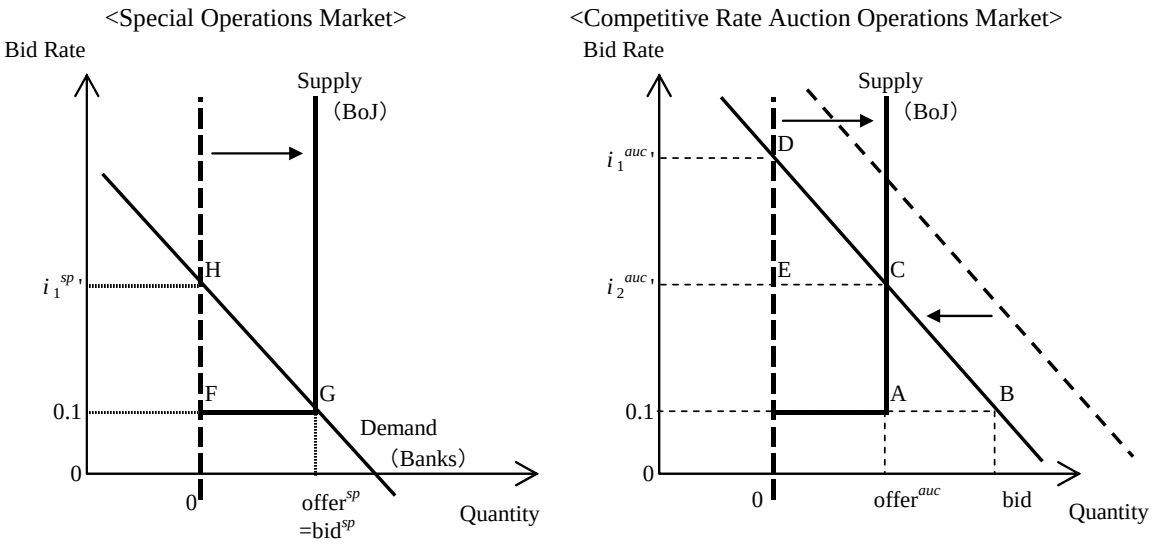
First, we assume that banks determine their bids in the special operation prior to those in the conventional term-end operations. This assumption takes into consideration the banks' funding cost and availability. From a bank's view point, bidding in the special operation is the better way to raise funds in terms of cost and availability since it offers an unlimited amount

with a fixed loan rate equivalent to the policy rate, and the dates of the operations are known to the public beforehand. On the other hand, the other operations are conducted by competitive rate auction, and hence the successful bid rates are slightly above the base rate, or the policy rate. Also, banks do not know in advance the exact amount allotted to them or the offer dates of the operations.

Second, we assume that the slopes of the liquidity demand curves for both operations are the same. This assumption takes account of the similarity between the liquidity obtained in the two operations. Both operations are collateralized operations with a fixed duration and have the same purpose of supplying liquidity to replenish liquidity demand for term-end funds.

Figure 5 is a graphical representation of the market for the two operations, reflecting the two assumptions made above. In contrast to Figure 4, the bid rates are represented in terms of their own level, not in terms of their spreads, for explicit treatment of the fixed loan rate in the special operation and the successful bid rate in the competitive rate auction.

Figure 5: Special Operation and Operation by Competitive Rate Auction



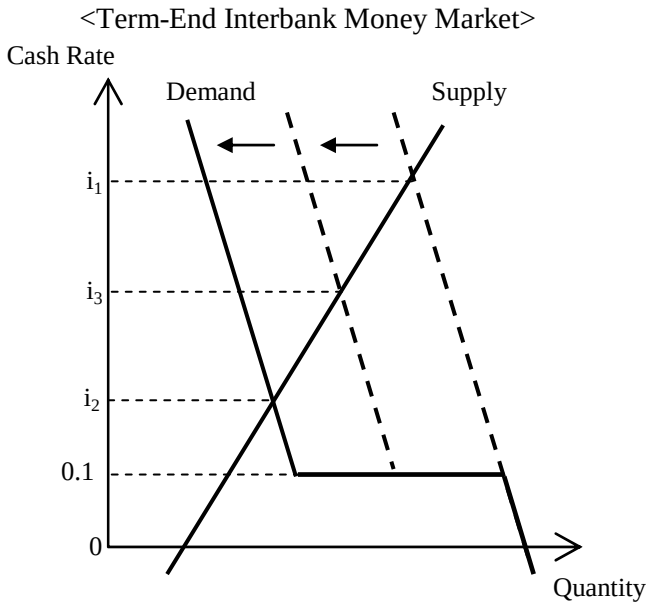
The implementation of the special operation is described by the rightward shift in the vertical supply curve to the total amount bid at the policy rate (0.1 percent as of March 2009).[8] Given the banks' demand curve with the slope assumed above, $i_1^{sp'}$ is the implicit cost of funds without the operation.

[8] In the fixed-rate operation, since the total amount offered is determined by the banks, the total amount bid equals the total amount offered.

The other operation by competitive rate auction is depicted similarly to Figure 4. Notice that, according to the assumption on the ordering of banks bidding behavior, the demand curve has been shifted leftward since the banks have already partially replenished their liquidity demand in the special operations market, before bidding in the present operation. The successful bid rate and the counterfactual rate without the operation are $i_2^{auc'}$ and $i_1^{auc'}$ respectively.

Figure 6 illustrates the shift of the demand curve in the term-end money market, reflecting the conduct of liquidity provisions by both operations in the same period of time.

Figure 6: Effect of Term-End Operations on the Term-End Interbank Money Market



First, the special operation shifts the banks demand curve leftward, and lowers the term-end premium from i_1 to i_3. Next, the other operations by competitive rate auction cause the additional shift of the demand curve, and hence the premium falls from i_3 to i_2. Thus, the cumulative effect on the term-end premium is calculated by:

$$i_1 - i_2 = (i_1 - i_3) + (i_3 - i_2). \qquad (6)$$

5.2 Identification of the Effects of the Two Operations

Given the analytical framework described above, we proceed to quantify the effects of the special operation and the operation by competitive rate auction on the term-end premium. Note that we return to exploit the interest rates in terms of spread to apply Equation (4) for

identifying the effect of each operation.

First, we rewrite Equation (4) for calculating the effect of the operation by competitive rate auction.

$$i_3 - i_2 = i_2 \frac{offer^{auc}}{bid^{auc} - offer^{auc}}, \tag{7}$$

where the superscript auc denotes the variables associated with the operation by competitive rate auction.

Next, we identify the effect of the special operation. As we have assumed that the slope of the liquidity demand curve in the special operation is the same as that in the operation by competitive rate auction, we have the following relationship:

$$(i_1 - i_3) : (i_3 - i_2) = offer^{sp} : offer^{auc}, \tag{8}$$

where the superscript sp denotes the variables related to the special operation. Note that the total offer amount for the special operation is equal to the total bid amount by banks, and therefore the total allotment amount of this operation.

Given the effect of the operation by competitive rate auction $i_3 - i_2$, rearranging Equation (8) gives an expression for the effect of the special operation $i_1 - i_3$ as:

$$i_1 - i_3 = (i_3 - i_2) \frac{offer^{sp}}{offer^{auc}}. \tag{9}$$

Therefore, by combing Equation (7) and (9) through Equation (6), we can express the cumulative effect of the two operations $i_1 - i_2$ as:

$$i_1 - i_2 = \gamma i_2^{'} \frac{offer^{auc} + offer^{sp}}{Bid^{auc} - offer^{auc}}. \tag{10}$$

In Equation (10), the term $offer^{auc} + offer^{sp}$ represents the volume factor, whereas $\gamma i_2^{'} / (bid^{auc} - offer^{auc})$ corresponds to the slope factor.

In the subsequent analysis, we measure the effects of term-end operations for the year-ends and fiscal year-ends before December 2008 using Equation (4), and those for the fiscal year-end of 2008, after the implementation of the special operation in January 2009, using Equation (10). We decompose the effects into the volume and slope factors by Equation

(5) and (10).

6 Data

The data used for our empirical analysis consists of the year-end and fiscal year-end premium described in Section 2 and the amounts of offer and bid in the respective year-end operations.

The term-end operations consist of all funds-supplying operations conducted by the BoJ that have an end date over the year-end and fiscal year-end, except for the outright purchases of CPs, corporate bonds and long-term JGBs.[9] The data for the bid and offer amounts of these operations are publicly available from the BoJ's website. The daily data are aggregated on a weekly or monthly basis.

In the actual operations, the amount of offer and that of successful bid can slightly differ, since the former is the amount offered in the conventional auction while the latter is the amount actually provided to the successful bidders on a pro rata basis. However, we do not distinguish between the two, but we exploit the term "the amount offered" throughout the paper. For our empirical analysis below, we use the data on the amounts of successful bid as the amounts offered so that we can take account of the actual transaction of liquidity.

7 Results

In this section, we first report the results of the total effect of the year-end operations on the year-end money market. We next proceed to decompose the total effect into the volume and slope factors, and give an interpretation for the results.

7.1 The Effects of Year-End and Fiscal Year-End Operations

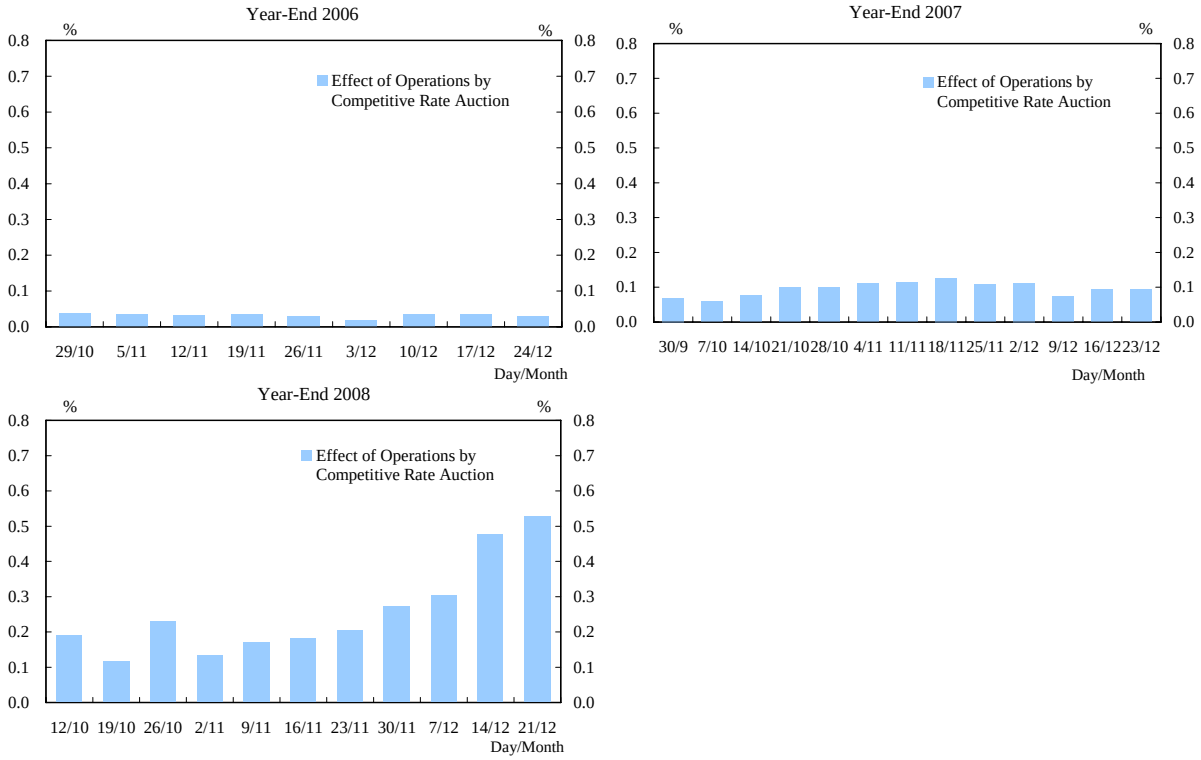
In what follows, we report the effects of the year-end and the fiscal year-end operations in turn.

Figure 7 shows the measured effects of the term-end operations on the year-end interbank

[9] The outright purchases of CPs and corporate bonds are intended to respond to a significant decline in market functioning of corporate financing instruments, which will expire at the end of 2009. The outright purchase of long-term JGBs is to facilitate money market operations by providing long-term liquidity. The objective of these operations is not to mitigate the upward pressure of year-end premium in the money markets.

money market following the equations (4). The effects are calculated on a weekly basis.[10]

Figure 7: Effects of Term-End Operations for the Year-End Periods: 2006-2008

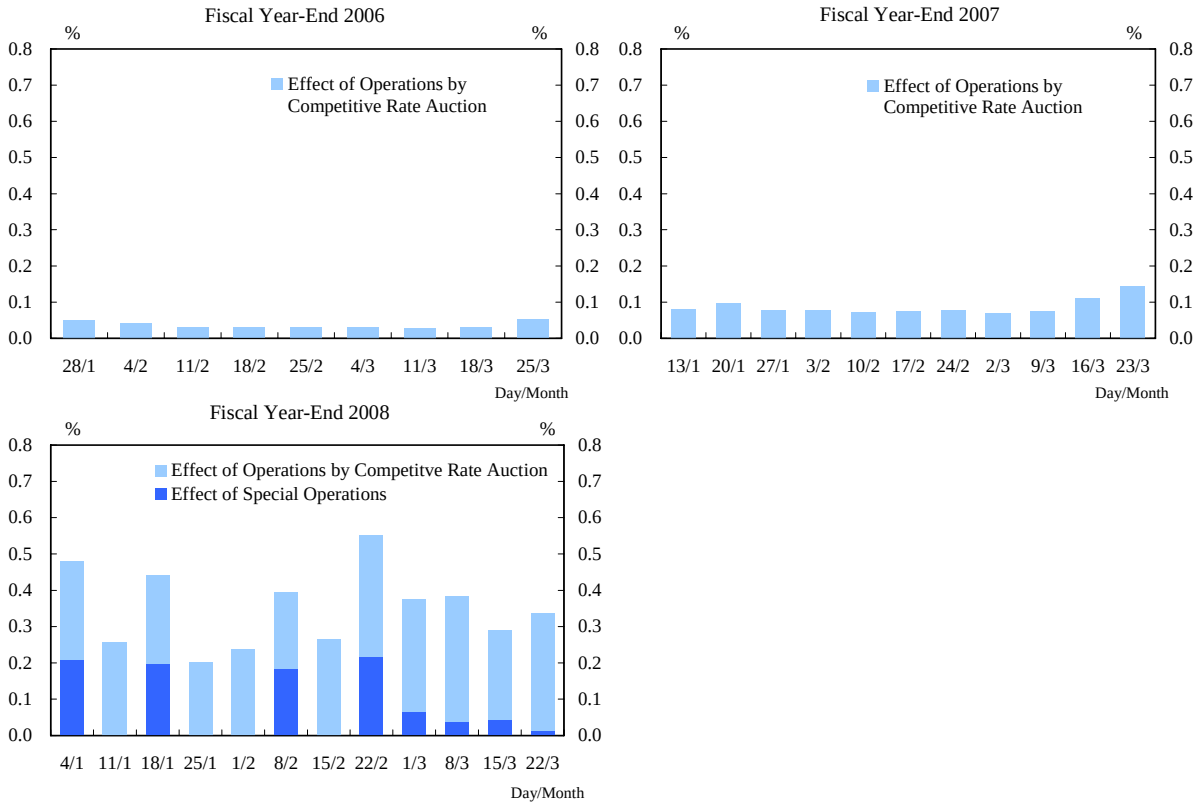


For the year-end period of 2006, the effect of term-end operations on the term-end interbank money market is limited to the range from 2 to 4 basis points. However, the effect increases to around 10 basis points for the year-end period of 2007. This coincides with the upward pressure on the term-end premium stemmed from the dysfunctioning of the interbank money market in Japan as a result of the global financial turmoil. This result also provides the evidence that BoJ's response to amply supply term-end funds contributed to suppressing the rise of the term-end premium. For the year-end period of 2008, there is a notable increase in the size of the effect. From mid-October to mid-November, the term-end operation had an effect of lowering the term-end premium by the range of 12-23 basis points. After November 2008, we can see a further rise in the effect, up to 53 basis points toward the year-end.

Figure 8 shows the effects of the term-end operations over the fiscal year-end (from January to March of the next year), measured by the equations (4) and (10).

[10] The total offer amount is aggregated on a weekly basis. The term-end premium is averaged weekly.

Figure 8: Effects of Term-End Operations for the Fiscal Year-End Periods: 2006-2008



For the fiscal year-end of 2006, the effect was only approximately 3-5 basis points, increasing to 7-15 basis points for the fiscal year-end of 2007. The largest effect is found for the period over the fiscal year-end of 2008 (from January to March 2009). We observe that the effect in January jumped to 48 basis points, as the result of an ample supply of liquidity through the special operations as well as the operations by conventional auction. After January, the effect remained high around 20-55 basis points toward the end of March.

The effects observed in these figures indicate that the liquidity supply of term-end funds helped reduce the term-end premium and alleviate the pressure in the term-end interbank money market. One of the advantages in our structural approach is that we can decompose the effects into two factors: the volume of the operations and the steepness of banks' demand curve. In the following subsection, we decompose the effects of the term-end operations and elucidate the background of our results.

7.2 Decomposition of the Effects of Year-End and Fiscal Year-End Operations

First, we decompose the effect of year-end operations of 2006-2008 according to Equation (5). Table 1 shows the decomposition of the effects of year-end operations on a monthly basis.

Table 1: Decomposition of the Effect of Year-End Operations: 2006-2008

	2006			2007			2008		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Year-End Effect of Operations (%) (a)	0.04	0.04	0.03	0.07	0.11	0.09	0.16	0.17	0.37
Volume Factor (trillion yen)	0.60	10.41	16.01	7.21	9.61	16.71	5.51	10.60	23.54
Slope Factor (shown 100 times larger)	5.95	0.34	0.17	1.04	1.19	0.56	2.91	1.62	1.59
Year-End Premium (%) (b)	0.14	0.12	0.08	0.31	0.30	0.27	0.44	0.53	0.62
Counterfactual Year-End Premium without operations (%) (a + b)	0.18	0.16	0.11	0.38	0.42	0.37	0.60	0.70	0.99

Note: Term-end operation data are monthly aggregates while term-end premium data are monthly averages.

The "year-end effect of operations" in Table 1 is the cumulative effect $i_1 - i_2$, which is the product of the volume factor and the slope factor. In Equation (5), the volume factor corresponds to $offer$, and the slope factor is the term $\gamma i_2^{'} / (bid - offer)$.

The year-end effect of operations in 2006 was limited to 3-4 basis points. Decomposing this effect, we see that the volume factor rose from October to December, while the slope factor declined during this period. The intuition behind the change of these factors is that, as liquidity demand for term-end funds became replenished as a result of the liquidity provisions by the BoJ, the banks became less willing to raise funds at higher costs than the policy rate.

The effect in 2007 was 7-11 basis points, and higher than that in 2006. The decomposition of this effect shows that it is attributable to the volume factor, as the BoJ supplied more funds much earlier toward the end of 2007 than toward the end of 2006. The slope factor in November and December of 2007 remained higher. This coincides with the observation that foreign banks had high liquidity demand in the Japanese interbank money market at the time whereas domestic banks, who normally function as net suppliers of liquidity, refrained from supplying liquidity to these institutions.

In 2008, the year-end operation exhibits the remarkable effect up to the range from 16 to 37 basis points. According to the decomposition, both factors contributed to this result. One of the reasons behind the slope factor remaining quite high despite ample liquidity provision by the BoJ, is that during the same period, Japanese banks increased their lending to firms who had difficulty issuing corporate bonds and commercial papers, and therefore were reluctant to provide liquidity in the money market. As a result, the demand and supply condition in the year-end money market remained quite tight. Against the background of the condition in the money market, the BoJ responded by supplying ample liquidity consecutively toward the end of December.

Next, we proceed to decompose the effect of fiscal year-end operations of 2006-2008. The results are shown in Table 2.

Table 2: Decomposition of the Effect of Fiscal Year-End Operations: 2006-2008

	2007			2008			2009		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Year-End Effect of Operations (%) (a)	0.04	0.03	0.03	0.09	0.08	0.11	0.34	0.36	0.34
Volume Factor (trillion yen)	2.40	7.51	15.01	4.00	8.71	25.12	8.92	9.48	26.26
Slope Factor (shown 100 times larger)	1.83	0.47	0.23	2.13	0.88	0.42	3.77	3.81	1.29
Year-End Premium (%) (b)	0.14	0.11	0.12	0.37	0.33	0.29	0.63	0.56	0.48
Counterfactual Year-End Premium without operations (%) (a + b)	0.18	0.15	0.15	0.45	0.41	0.40	0.97	0.93	0.82

Note: All Term-end Operation data are monthly aggregates. All term-end premium data are monthly averages.

The effect of operations for the end of fiscal-year 2006 (from January to March of 2007) was small, around 3-4 basis points. As is the case in the year-end of 2006, the decomposition indicates that the slope factor became smaller, i.e., the banks' demand curve became flatter from January to March, as a result of a cumulative increase in liquidity supply by the BoJ during this period.

The effect for the fiscal year-end of 2007 (from January to March of 2008) was 8-11 basis points. With regards to the factors, the same explanation can be made as the previous fiscal year-end, but we note that the slope factor remained relatively higher compared to the

previous fiscal year-end.

Toward the fiscal year-end of 2008 (from January to March of 2009), the effect was substantially high up to 34-36 basis points. This is attributed to the large values of both the volume and slope factors. During this period, severe strains were apparent in the term-end money market, in light of market participants' concerns of an event risk occurring. However, as shown in the decrease in the slope factor, the strain could have somewhat eased in March following financial institutions fulfilling a large share of the necessary procurement of term-end funds.

8 Conclusion

In this paper, we have evaluated the effect of term-end operations on the term-end money market in Japan. For this purpose, we have presented a structural model that relates the operations market to the term-end money market. Based on our model, we can measure the effect of the term-end operation as the difference between the actual term-end premium and the counterfactual premium that would prevail without the operation. We have shown that, under some plausible assumptions, our framework enables us to identify the effect from available data.

Our results on the year-end and fiscal year-end periods from 2006 to 2008 show that the operations conducted during the year-end and fiscal year-end period of 2008 had the largest effect of lowering the term-end premium, compared to the two previous years. Furthermore, according to the decomposition of the term-end effect based on our structural model, the large effects during this period were attributable to both the large volume of liquidity supplied by the BoJ and the steep demand curve of banks reflecting the tight supply and demand condition in the money market.

While our structural approach has two advantages in measuring the effect of term-end operations, i.e., the structural interpretation of the effect and the independence of the results from the econometric methods, we should note several limitations in our analysis that depends on the model specification and the assumptions.

First, our partial-equilibrium approach does not take into account arbitrage between the term-end interbank money market and financial markets other than the term-end operations market.

Second, we only focus on the effect of the term-end operation through the liquidity supply. For example, the effect of alleviating concerns of market participants as a result of offering term-end liquidity earlier than previous years is not examined. Also, analyzing the effect of a forward start operation[11] just over the term-end, which is considered to stabilize the market's expectations for the term-end premium in advance, is beyond the scope of this paper.

Third, our analysis rests on several strong assumptions. We exclude the possibilities of a change in the slope of the demand or supply curve and a shift in the supply curve in the term-end interbank money market. We have also assumed that the relationship between the bid rate and the term-end interbank money market rate is linear, and that the collateralized term-end operations market and the uncollateralized term-end interbank money market are substitutable.

However, in an economy where term-end premium exists, or when market functioning is deteriorated, our partial equilibrium approach might be appropriate in approximating the market structure. We believe that our approach can be applicable to examine the effects of various liquidity provisions conducted by central banks during the financial turmoil.

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[11] The majority of term-end operations have a start date one or two business days after the offer date. However, for the year-end and fiscal year-end periods of 2008, the BoJ offered forward start operations with more than two business days between the offer and start dates. For details, see Bank of Japan (2009).

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