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Abstract

In this paper, we consider the case for an intraday market for reserves. We discuss the separate roles of intraday and overnight reserves and argue that an intraday market could be organized in the same way as the overnight market. We present arguments for and against a market for intraday reserves when the marginal cost of overnight reserves is positive. We also consider how reserves should be supplied when the cost of overnight reserves is zero. In that case, the distinction between overnight and intraday reserves becomes blurred, raising an important question: What is the role of the overnight market?

Key words: central bank reserves, money market

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1. Introduction

The institutional frameworks through which different central banks manage the supply of intraday and overnight reserves to banks share a number of features. Typically, intraday reserves can be obtained directly from the central bank. In contrast, overnight reserves are usually made available to banks through a market. This difference seems puzzling. If one method of providing liquidity works better than the other in one case, should it not work better in both cases?

Historically, many central banks provided overnight reserves directly to banks. Only after well-functioning markets for government debt developed did these central banks start to distribute reserves through a market. However, distribution of intraday reserves through a market was never adopted as a common practice. In this paper, we consider why this is so.

We start by describing the different roles of overnight and intraday reserves and provide important institutional details. In particular, we note that the costs of reserves, both intraday and overnight, are policy variables. Consequently, a market for reserves does not play the traditional role of information aggregation and price discovery. If fact, as we discuss, many demand-management features determined by central bank policy are intended to dampen price variability in the market for reserves. We investigate the possibility of designing a market for intraday reserves and conclude that such a market could be organized in a way similar to the market for overnight reserves.

Next, we consider arguments in favor of and against a market for intraday reserves under the assumption that there is an opportunity cost of holding overnight reserves. The monetary policy implementation framework used by most countries relies on such an opportunity cost. We review some academic literature that provides arguments in favor of a market. Freeman (1999) studies an environment in which providing liquidity through a market allows better risk-sharing, and higher welfare, than providing liquidity through a standing facility such as the central bank. Chapman and Martin (2007) study an

extension of Freeman's environment in which agents can exert effort to limit their exposure to risk. In that framework, supplying liquidity through a market provides better incentives.

We then provide some arguments suggesting that an intraday market may not function well. An intraday market may be more prone to delays than an overnight market because managing a bank's intraday reserve needs is considerably more difficult than managing its overnight needs. Recent research from the Federal Reserve Bank of Chicago provides some supporting evidence. Also, an intraday market may suffer from the central bank's inability to commit itself to not intervening in the event of a crisis. Indeed, payment delays can affect ancillary systems such as securities settlement, retail payments, or special-purpose foreign exchange settlement. This kind of spillover does not necessarily occur in the overnight market. We also argue that the benefits of an intraday market may be small.

Finally, we consider how reserves should be provided in an optimal system. Since the analysis in the first part of the paper applies if an optimal system requires a positive marginal cost of holding overnight reserves, we focus on the case where the marginal cost of reserves should be zero. Friedman (1969) provides an argument suggesting why such a policy would be optimal. We also discuss the case of New Zealand, where a new monetary policy implementation framework provides reserves both intraday and overnight at zero marginal cost.

When the opportunity cost of overnight reserves is zero, the distinction between overnight reserves and intraday reserves becomes blurred, as there is no need to economize on overnight reserves. Banks can hold enough reserves overnight to satisfy both their intraday and their overnight needs. One possible effect of providing overnight reserves at such a low marginal cost is that the overnight market may see reduced activity. This happened, for example, in Japan during the period of quantitative easing. The role of the market for reserves then becomes an important issue. Is anything lost if activity in this market is reduced when banks hold large amounts of reserves? We find that when

the opportunity cost of overnight reserves is zero, we may need to ask the following question: Should there be overnight money markets?

The remainder of the paper proceeds as follows. Section 2 provides some background on intraday and overnight reserves. Section 3 considers arguments for and against an intraday market when the opportunity cost of holding reserves overnight is positive. Section 4 focuses on the supply of reserves when the opportunity cost of money is zero. Section 5 concludes.

2. Some differences between overnight and intraday reserves

The deposits, or reserves, held by commercial banks at central banks play multiple roles in the monetary system. During the day, when the banking system is open, it is common for the quantity of reserves to increase dramatically. Then, at the close of the banking day, the quantity usually shrinks. This change hints at the different roles that "daylight" and "overnight" reserves play in the money and banking system. Not only do they play different roles, as this section will discuss, but they have different costs and they are supplied in different ways.

a. The role of overnight and intraday reserves

To understand the role of intraday and overnight reserves, it is useful to understand the institutional details. Banks use reserves held on a central bank account to make payments to each other and also to participate in ancillary systems such as securities settlement systems, retail payments systems, or special-purpose foreign exchange settlement systems. The large amount of reserves needed for these payments generates a demand for intraday reserves. In many countries, banks also hold reserves at the central bank overnight. These banks may need reserves to fulfill requirements, they may have voluntary agreements with the central bank to hold contractual reserves, or they may hold reserves for precautionary purposes. Any of these reasons can generate a demand for overnight reserves.

In principle, the two types of demand for reserves are related since reserves held overnight can be used to make payments intraday. For example, suppose a bank's demand for reserves is perfectly predictable. In that case, if obtaining additional reserves during the day is more expensive than holding reserves overnight, then banks would choose to hold all their reserves overnight and not get additional daylight reserves. In contrast, if the cost of daylight reserves is lower than the cost of overnight reserves, then banks would hold only as many overnight reserves as they are required to and get daylight reserves to meet their demand. If the demand for reserves is not perfectly predictable, the demand for intraday and overnight reserves may change more smoothly with the relative prices of the two reserve types.

In practice, the two different demands are often largely independent because the marginal cost to the commercial bank of maintaining overnight reserves on deposit is typically positive, and most central banks provide intraday reserves to banks at a marginal cost very close to zero. As intraday reserves cannot be used to satisfy the banks' need for overnight reserves, they hold as little overnight reserves as they can and obtain large quantities of intraday reserves when they need it.

The provision of intraday liquidity by the central bank is associated with payments policy since it affects the ease with which banks can make payments to one another. The provision of overnight liquidity is associated with monetary policy since central banks often set monetary policy by targeting the overnight interest rate.

b. The marginal cost of intraday and overnight reserves

Another difference between intraday and overnight reserves is their marginal cost. A key feature of monetary policy in many countries is a positive marginal cost of reserves. With a positive marginal cost, the demand for reserves is downward sloping. The central bank can then choose the supply of reserves so that it intersects the demand at the desired

interest rate.[1] The marginal cost of excess reserves—reserves that exceed a bank's required or voluntary contractual level—is constant in channel systems such as that of the European Central Bank. In the U.S. system, it varies depending on the federal funds target. In the system of the Bank of England, the marginal cost of excess reserves changes between the last day of a maintenance period and other days. Because holding reserves is costly at the margin, banks try to economize on the reserves they hold overnight.

In contrast, banks have few incentives to economize on their use of reserves intraday because central banks typically provide intraday liquidity at a very low cost. Considerable research in payment economics has been devoted to understanding this pattern. In the remainder of this section, we describe three arguments from the academic literature suggesting that intraday liquidity should have a cost of zero, or very close to zero.

The first argument posits that lowering the cost of reserves during the day reduces banks' incentives to strategically delay sending payments, therefore improving the "liquidity" of the payment system. In most payment systems, banks face no pecuniary cost of delay. Hence, if it is costly to borrow intraday, participants will try to minimize their risk of having to do so. This can be done by delaying the sending of payments as much as possible. The hope is that such a delay will make it more likely that payments from other institutions will be received before payments need to be sent. But since all participants have the same incentives to delay payments, this strategy can create gridlock (Angelini 1998 and 2000, Bech and Garratt 2003, Kahn and Roberds 1999). Mills and Nesmith (2008) provide a model in which the incentives to delay disappear only if the cost of reserves is driven to zero. These models typically assume, at least implicitly, that the cost of overnight reserves is positive and that there is no intraday market.

The second argument is based on the idea that central banks can provide insurance against the risk of incurring large intraday overdrafts. Since the timing of payments

[1] See Keister, Martin, and McAndrews (2007) for a primer on monetary policy implementation.

received and sent by payment system participants is highly uncertain, two participants with identical reserve positions at the opening and closing of the market may have very different reserve demands throughout the day. For example, one institution might make a lot of payments early in the morning before it receives offsetting payments. Another institution might receive many payments before it needs to make any. If intraday borrowing is costly, these otherwise identical participants face potentially very different costs. The central bank has the ability to temporarily expand settlement balances at essentially no cost. By charging a very small price for intraday credit, it guarantees that payment system participants with high liquidity needs will not bear a heavy cost. Hence it provides insurance against the risk of having high payment needs (Green 1997, Kahn and Roberds 2001b, Martin 2004, Zhou 2000).[2]

The third argument is that a low cost of intraday liquidity can also be viewed as an application of the Friedman rule. Friedman (1969) argued that the return on money should be equal to the return on short-term, riskless assets so that there is no opportunity cost of holding money. For example, the returns on money and riskless assets would be equalized if the nominal interest rate on short-term, riskless assets is equal to zero. Alternatively, the opportunity cost of reserves will be close to zero if it is possible to borrow the reserves at little or no cost. In that case, banks will expend no costly resources in sequencing their payments to avoid the costs of borrowing reserves during the day, thus improving efficiency. It can be shown that the cost of intraday liquidity should be zero even in an environment in which the overnight cost of liquidity is strictly positive (Millard, Speight, and Willison 2006, Bhattacharya, Haslag, and Martin 2007).

Lacker (1997) has a different view. In his model, the intraday rate should be at least equal to the overnight rate or higher. This view is explained by an important feature of his model. Lacker assumes that there is no uncertainty about the arrival of intraday reserves; the uncertainty is about overnight reserves. Hence, once a bank has chosen the level of overnight reserves it wants to hold, it need not worry about intraday reserves. In contrast,

[2] It is possible to offer intraday liquidity at a low price only because an intraday loan cannot be rolled over into an overnight loan. Otherwise, the low price of intraday liquidity could conflict with other monetary policy goals.

the other models discussed in this section typically assume that there is uncertainty about the timing of intraday, but not overnight, reserves. In these models, a high cost of intraday reserves creates distortions.

In practice, central banks do not provide intraday liquidity at zero cost but at a very low cost. The cost may come from collateralization requirements or from a small fee for borrowing reserves intraday. These deviations from the Friedman rule can be justified by the fact that theoretical models do not take into account some features of the environment in which central banks operate, such as credit risk and cost recovery.[3] Overall, we view central bank practice and the prescription of economic theory to be broadly consistent.

c. The supply of intraday and overnight reserves

While both intraday and overnight reserves are supplied by the central bank, the process differs in important ways. Central banks typically supply intraday reserves directly to banks through a standing facility at predetermined terms. In contrast, most central banks provide overnight reserves through a market. In this section, we briefly describe these differences.

In the case of intraday reserves, the central banks typically receive requests from a bank and the terms are fixed in advance. There are two basic models. In the U.S., banks are allowed to incur uncollateralized daylight overdrafts, for which they are charged a small fee.[4] Most other central banks, including the European Central Bank, the Bank of England, and the Swiss National Bank, allow collateralized intraday borrowing at no cost.

In the case of overnight reserves, the central banks auction reserves to a group of institutions, called *primary dealers* in the U.S., and these institutions distribute the reserves to banks through the interbank money market. In this case, the quantity supplied

[3] See Mills (2006), for example.
[4] The fee is explained and determined by the Board of Governors' Payment System Risk Policy. See http://www.federalreserve.gov/paymentsystems/psr/default.htm for an explanation. The marginal fee per dollar of daylight overdraft is currently set at 36 basis points at an annual rate multiplied by the fraction of the day during which the dollar overdraft existed.

is at the discretion of the central bank and is usually chosen to meet a monetary policy objective. The interest rate at which the primary dealers lend the reserves is determined by a market process and can vary from bank to bank. In most countries there also exist standing facilities at which banks can obtain reserves at a fixed price over the monetary policy target, but the contribution of these facilities to the supply of overnight reserves tends to be relatively small in normal circumstances.

Some central banks also offer deposit facilities. Banks that deposit their excess reserves with the central bank can earn interest, albeit at a rate typically below the target rate. Systems with a lending and a deposit facility are sometimes called "channel" or "corridor" systems. The facilities reduce the fluctuation of the overnight rate by setting a floor and a ceiling on the rate. The overnight rate should never exceed the rate of the lending facility, since a bank needing reserves would likely prefer to obtain them from the central bank at the lending rate, rather than the (higher) market interest rate. Conversely, the overnight rate should never be below the rate of the deposit facility, since banks with excess reserves would prefer to deposit them at the facility rather than lend them in the market at the (lower) market rate.

It is interesting to note that, historically, overnight reserves were supplied mainly through a standing facility such as a discount window. Once interbank markets became sufficiently well developed, central banks modified the process through which they supplied liquidity. For example, the Federal Reserve did not start doing open market operations until the mid-1920s (see, for example, Chandler 1958). Hence there is at least a presumption that central banks favor supplying overnight reserves through a market rather than through the kind of standing facility used to supply intraday liquidity. In this context, it makes sense to ask the following question: Why are there no intraday money markets?

There is a related question as well: What would a private solution to the problem of supplying "liquidity" look like? Historical experience suggests that the private sector has relied on structures resembling clubs rather than markets. In particular, private netting

arrangements are often used. In such arrangements, the provision of "liquidity" is done on a non-priced, administered basis through interbank liabilities. Entry to such arrangements is restricted in order to control risk. In addition, bilateral and multilateral limits on interbank exposures may be enforced. Markets (in the sense of a price-discovery mechanism) do not appear to be a standard private-sector response to the problem of supplying "liquidity," at least not for very short terms.

3. An intraday market for money when the marginal cost of overnight reserves is positive

The question of whether there should be intraday money markets has received little attention from researchers. In this section, we consider arguments for and against such markets, taking as given the fact that overnight reserves have a positive marginal cost. We start by observing that an intraday market could be organized similar to an overnight market.

a. An intraday money market could be organized like an overnight market

In thinking about whether an intraday money market would be desirable, it is useful to first ask what such a market would look like. We argue that an intraday market for reserves would share important features with the overnight market, so the two markets could be organized in a similar way. Our argument rests on the observation that, in both cases, the market "price" is a policy choice and the supply is under the control of the central bank.[5] Let us look more closely at the organization of the overnight interbank markets.

Overnight markets for central bank reserves differ from other kinds of markets because the "price" the central bank targets on this market is a policy choice. Many central banks choose the target overnight rate of interest to achieve their policy goals. In particular,

[5] Wiseman (2007) makes a similar point.

this "price" does not aggregate information in the way other markets usually do.[6] In the market for cars, for example, the price would aggregate information about both the supply and the demand. A decrease in the market price would reveal either a decrease in the demand for cars or an increase in the supply. An increase in supply could come about because technological progress makes producing cars less costly, for example.

The central bank can influence the cost of overnight reserves because it is a monopoly supplier of those reserves. With a good knowledge of the demand for reserves, the central bank can choose the supply so that it intersects the demand curve at the interest rate specified by monetary policy. Estimating the precise supply of reserves can be difficult because autonomous factors, such as payments into and out of the Treasury's account, can be somewhat unpredictable. Available empirical evidence suggests that central banks do a good job of implementing their target rates.[7]

Central banks also affect the nature of demand for overnight reserves in many ways. For example, central banks often maintain a standing overnight collateralized lending facility above the policy rate. In addition, many central banks require banks to hold reserves, or they enter into agreements with banks to maintain a certain quantity of reserves on deposit. Many of these requirements and agreements specify a period over which the banks should maintain an average level of reserves, often called a *reserve maintenance period.* These features of reserve policy tend to make the demand for reserves by banks less volatile and more elastic.[8] In these and other ways, for example by restricting the type of institutions that may hold reserves with them, the central banks affect both the demand and the supply of reserves. The reserve policies serve to make demand more predictable and more elastic so that central banks can more precisely implement their desired target policy rate of interest when setting the supply of reserves.

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[6] The idea that prices aggregate information is often attributed to Hayek (1945).
[7] See, for example, Bartolini, Gudell, Hilton, and Schwarz (2005).
[8] Reserve maintenance periods tend to flatten the demand curve for reserves on all days except the last day of the period. Before the last day, banks can choose to hold reserves today or at some future date. Hence, if the price of overnight reserves is high today compared to the expected price later in the maintenance period, banks will want to sell reserves today at the high price, which will push the price down. Conversely, if the price of overnight reserves today is low, banks will want to buy reserves today, which will push the price up (see Whitesell, 2006, for a careful explanation).

The "price" of intraday reserves is also a policy choice. As noted above, many central banks choose to set the cost of intraday reserves very close to zero. Hence, just as with the overnight market, a hypothetical intraday market for reserves would not aggregate or reveal information in the way most other markets do, but instead would be designed to achieve the (intraday) policy rate determined by the central bank.

The desired prices for intraday and overnight liquidity are usually very different. In the U.S., the overnight target policy rate has fluctuated in recent years between 1 percent and 6 percent, while the marginal fee for daylight overdrafts is 36 basis points adjusted for the duration of the overdraft, as noted above. Nevertheless, the central bank can, in principle, achieve any interest rate it desires, provided it is between zero and the overnight rate. At least conceptually, nothing prevents a central bank from targeting and implementing an interest rate of zero in the overnight market. In practice, Japan in recent years has provided an example of an overnight market in which the cost of liquidity was very close to zero.

In the remainder of this section, we provide a brief description of how the overnight market for reserves functions in the U.S.[9] The Federal Reserve's main tool to control the supply of reserves in the overnight market is open market operations, which are carried out from the Open Market Trading Desk at the Federal Reserve Bank of New York. Such operations are performed on almost all days and, in rare circumstances, can occur several times in a day. The Trading Desk is authorized to conduct business with U.S. securities dealers and with foreign official and international institutions that maintain accounts at the Federal Reserve Bank of New York. The dealers with which the Trading Desk transacts business are called primary dealers. All open market operations transacted with primary dealers are conducted through an auction process. The Fed requires primary dealers to participate meaningfully in both the Fed's open market operations and Treasury

[9] This discussion borrows from the Board of Governors of the Federal Reserve System (2005), in which more details can be found.

auctions and to provide the Trading Desk with market information and analysis that are helpful in the formulation and implementation of monetary policy.

In principle, the exact same market structure could be used for an intraday market. The Fed would inject a massive amount of reserves early each morning and would need to take these reserves out of the system every night. The reserves could be auctioned to the primary dealers, who would pass them on to banks in the same way as is done for the overnight market. The Fed would have to supply enough reserves so that the market rate would be close to zero. Conceptually, achieving a very low intraday cost for reserves is similar to achieving a given overnight interest rate, so there should be no particular difficulty for the Trading Desk to supply the desired amount of reserves. Roberds (1993) describes a particular implementation of such a policy in which the central bank would distribute "electronic intraday cash" to banks in the morning and retire it at the close of the banking day.

To make such a market more manageable, a central bank would be expected to implement many of the same policies for influencing the demand for reserves as we see for the overnight market. The central bank could extend its standing lending facilities to operate on an intraday basis at some premium to the intraday target policy rate. In addition, the central bank could establish required levels of intraday reserves, or it could contract with banks to voluntarily maintain an average level of such reserves over some period (perhaps over the course of the day or on average over the course of several days). These demand-management devices would assist the central bank in its determination of the appropriate supply of reserves to deliver to banks in the morning. Because the demand for intraday reserves is quite variable across days, as high-payment-flow days (such as days on which calendar quarters come to an end) result in much higher payment volume and value than other calendar days, demand-management policies could be relatively more important for the intraday market than for the overnight market.

b. Arguments in favor of an intraday money market

In the next two sections, we provide arguments in favor of and against an intraday money market. We start with arguments in favor of a market. The academic literature does not provide much guidance concerning the benefits of a public supply of liquidity through a market versus direct access to the central bank at a fixed price. In most models, these two ways of supplying liquidity are not distinguishable.

Two exceptions are Freeman (1999) and Chapman and Martin (2007). Both papers rely on the framework introduced in Freeman (1996), which incorporates enough microeconomic details to distinguish open market purchases from discount window lending. In Freeman (1999), supplying liquidity through a market provides better risk-sharing than a discount window and thus higher welfare. In Chapman and Martin (2007), markets provide higher welfare because they induce better incentives for agents to monitor risk.

The key friction in Freeman (1996) is that different agents may not have access to the market at the same time and thus may be unable to trade with one another. We believe that this kind of friction is at least as important intraday as it is overnight since intraday liquidity needs are more difficult to predict (see McAndrews, 2006, for a discussion of frictions related to the need for daylight reserves).

The environment is similar in both models. The economy is populated with overlapping generations of two types of agents, called creditors and debtors, who live for two periods. The sequence of meetings between different types of agents and the preferences of these agents are such that money is essential, debt arises endogenously, and debt is repaid with money.[10] Moreover, there can be a shortage of liquidity in the secondary market for debt, leading debt to trade below its face value.

The debtors wish to consume goods when they are young, but they do not have money at the time of the trade. They pay for goods by writing short-term debt contracts. Later, the debtors acquire the money they need to repay their debt. In their second period of life,

[10] See Mills (2004) for a discussion of the essentiality of money in this model.

debtors meet creditors in a central meeting place and can redeem their debt with the money. However, there is a mismatch in the timing of arrivals and departures at the central meeting place. A fraction of the debtors arrive after some of the creditors have had to leave. Creditors who must leave early and hold unredeemed debt can sell the debt to late-leaving creditors on a secondary market.

The price of debt on the secondary market depends on the amount of money available. If there is enough money, competition will drive the price of debt up to its face value. However, the amount of money available in the market will depend on the fraction of late-arriving debtors, and the quantity of debt that needs to be sold on the market depends on the fraction of early-leaving creditors. If many debtors arrive late and many creditors leave early, there will not be enough money in the secondary market for all the debt that needs to be redeemed to trade at face value. In that case, early-leaving creditors will have to accept a discount on the debts they sell in the market. A liquidity shortage in the secondary market reduces welfare because it creates risk for risk-averse agents. Ex-ante, identical agents will consume different amounts in case of a liquidity shortage while they would consume the same amount otherwise.

Freeman (1999) extends this original framework by assuming that, with some probability, a default shock occurs and some of the debt is not repaid. The probability of the default shock is exogenous, so the central bank's policy does not have any effect on it. In this context, Freeman contrasts two types of liquidity provision policies by the central bank. The first policy resembles a standing facility in that the central bank provides liquidity at a predetermined price against collateral. The second policy resembles an open market purchase because the central bank buys unredeemed debt in the market.

Freeman shows that the central bank should absorb losses associated with default to spread the risk among different types of agents. This is optimal because the central bank policy does not affect the probability of default. The policy resembling an open market purchase provides better risk-sharing than the policy resembling a standing facility because the central bank absorbs more risk when it purchases the debt outright than when

it makes collateralized loans. Hence Freeman's model can be viewed as supporting liquidity provision through a market.

Freeman's assumption that central bank intervention does not affect the probability of default may not apply in all situations. Indeed, moral hazard seems to be an important concern for central banks (see, for example, Coleman, 2002, or Madigan and Nelson, 2002). Chapman and Martin (2007) consider an environment similar to that in Freeman (1999) in which creditors can exert costly effort to reduce the probability of default of the debt they take on. The amount of effort exerted by a creditor is assumed to be observable to other creditors but not to the central bank. This is a way of modeling the fact that market participants may have better information about one another than does the central bank.

If the moral hazard problem is sufficiently severe, the central bank wants to avoid absorbing losses associated with default. Chapman and Martin show that a liquidity provision policy resembling a standing facility either creates moral hazard or will be underutilized. By assumption, the cost of liquidity at a standing facility is set in advance and cannot incorporate any default information available to market participants. Hence, if the cost of liquidity is sufficiently low, creditors have few incentives to monitor debt since they can obtain liquidity from the central bank in case of default. But if the cost of liquidity is high, then not enough liquidity is provided when no default occurs.

In contrast, providing liquidity to a market allows the price of liquidity to reflect information available to market participants, even if the central bank itself does not know this information. The model suggests that the central bank should provide liquidity directly to a small number of market participants, who redistribute the liquidity to other banks in the market. This key insight is that, to limit moral hazard, most banks should have to obtain liquidity from a market participant, who is informed about the quality of the available debt, rather than the central bank, who is less informed.

In the model, the participants to which the central bank provides liquidity directly are chosen at random. In that way, any participant has a very small probability of receiving liquidity directly and thus a very limited opportunity to engage in opportunistic behavior. This is what limits the moral hazard problem. In practice, a central bank can choose a small number of institutions that have few incentives to engage in opportunistic behavior, maybe because their value as a going concern is higher than the potential immediate benefit from engaging in morally hazardous activities.

This model can also be interpreted as supporting liquidity provision through a market. Moreover, it provides a justification for the particular structure of the overnight reserves market that is typically observed. As we have noted, an intraday market could, in principle, be structured in the same way as an overnight market. Hence the benefits of a market discussed by Chapman and Martin would apply to an intraday market.

c. Arguments against markets

Arguments against a market typically fall under the general idea that the absence of a market may be preferable to a poorly performing one. In this section, we review two reasons why an intraday market for money may not perform well: 1) it could be subject to delays, and 2) it may not be possible for the central bank to commit to a policy of not intervening in the case of a crisis. We also provide arguments as to why the benefits from an intraday market may be much smaller than the benefits from an overnight market.

i. Delays

Precise timing is much more important for intraday reserves than for overnight reserves, so delay costs are higher intraday. This makes an intraday market inherently more expensive to operate than an overnight market. With a shorter period for interest to accrue, this establishes a higher hurdle rate—like a fixed cost—for an intraday loan to make sense.

More precise timing of funding is needed during the hours of payment systems' operation because banks face a variety of deadlines to make payments during the day. These payments need to be made to ancillary systems, such as securities settlement, automated clearing houses, and special-purpose foreign exchange settlement, each of which has its own deadline. In contrast, a bank's overnight reserves, whether to satisfy requirements or a precautionary demand, are needed only by the close of the banking day.

An intraday market for funds would need to overcome the factors that lead banks to delay payments. However, recent evidence suggests that even when banks are contractually obligated to make timely payments, it is difficult to enforce compliance with the contract. As a result, it is likely an intraday market would face significant challenges in assuring parties that funds would be delivered in a timely fashion; such a problem could lead to a breakdown of a market.

Recent evidence is provided by a study conducted at the Federal Reserve Bank of Chicago, which examined settlement payments among banks participating in a major derivatives exchange. While the banks agree in advance to provide necessary settlement payments within one hour of having been notified of their obligation amount, banks regularly delay the delivery of these funds.[11] As noted in the study, "a substantial percentage of these interbank balancing payments were made late, as determined by the relevant agreements between the clearing members and the clearinghouse. A nontrivial percentage was made exceptionally late (3 to 9½ hours). Furthermore, we find that the payments associated with the biggest delays tend to have the largest dollar value."

ii. Lack of commitment by the central bank

One factor that may make it difficult for an intraday money market to function efficiently is a commitment problem on the part of the central bank. As noted by Goodfriend and Lacker (1999), commitment is an important problem for central banks. Interbank

[11] See the Public Comments by the Federal Reserve Bank of Chicago on the Consultation Paper on Intraday Liquidity Management and Payment System Risk Policy [OP-1257]: http://www.federalreserve.gov/SECRS/2007/April/20070410/OP-1257/OP-1257_19_1.pdf

payments are important enough for the functioning of financial markets that it may be difficult for a central bank to resist pressures to step in and intervene in case of trouble.

This commitment problem exists both intraday and overnight. Consider the commitment problem facing a central bank in the overnight market. A bank may face difficulty in obtaining funds in the overnight money market. The central bank can require the bank in question to post high-quality collateral and to approach the central bank through a standing discount window facility that lends to the bank at a penalty rate of interest. One commitment problem is that the central bank may decide to reduce the cost to the bank by relaxing the collateral requirement or reducing the interest rate. It could choose to do so because otherwise the bank might either fail or have an overnight overdraft at the central bank. In banking crises, when many banks face potential funding problems because the interbank market is not functioning well, central banks have tended to supply funds on more liberal terms than is usual, suggesting that central banks do face a commitment problem in that, at the least, they would choose to have a discretionary state-contingent policy at their disposal.

Now consider the central bank's commitment problem were it to rely on an intraday market to distribute funds. A failure by one bank to obtain funds in a timely way via the intraday market could have much wider effects than the failure by a bank to obtain funds for required or precautionary purposes by the end of the day. The failure to deliver funds during the day may prevent the settlement of some ancillary payment or settlement system, causing a more general, market-wide problem, essentially forcing the central bank to intervene. This suggests that the central bank's commitment problem would be larger intraday.

iii. The benefits of an intraday market may be very small

As noted above, the benefits of a market are often thought to be related to the fact that market participants may have better information than the central bank. For example, the funding to a troubled bank may be curtailed by the market, while the central bank may

have provided excessive liquidity to that same bank if its only tool were the discount window. In particular, the central bank may not be aware of the quickly deteriorating situation of a bank. The level of liquidity provided to that bank may have been very safe while it was sound but excessive under the new circumstances.

This problem is likely to be smaller in the case of intraday liquidity. In the U.S., for example, a daylight overdraft that is not repaid by the end of the day automatically turns into an overnight overdraft and is assessed a high penalty charge. Hence, the Federal Reserve quickly receives a signal of a bank's potential trouble if it is unable to repay an overdraft. While it is possible that a bank's situation can deteriorate very quickly, problems cannot be hidden very long if banks have access to intraday reserves, but they could be hidden for much longer if banks have easy access to overnight reserves at a discount window.

4. How should central banks supply reserves optimally?

Whether an optimal system to supply intraday and overnight reserves should specify a positive marginal cost of overnight reserves is a difficult question. We do not believe that economic theory can conclusively answer this question yet. Nevertheless, it is interesting to think about the benefits and costs of either case. If it is desirable to set a positive marginal cost of overnight reserves, then the type of analysis presented in the previous section will determine the features of an optimal system. However, if it is desirable to set the marginal cost of overnight reserves to zero, then the analysis changes profoundly. We consider this case next.

a. Supplying overnight liquidity at zero marginal cost

The case where the marginal cost of reserves is zero is particularly interesting because it is related to the logic of Friedman's (1969) argument. This argument can be restated as follows. Central bank reserves can be created at almost no cost. If such reserves are valuable, they should be supplied until the marginal cost to society from supplying these

reserves equals the marginal benefit to society. In this case, most of the benefit to society can be associated with the benefits to banks. Banks will demand reserves until their private marginal benefit equals their private marginal cost. So lowering the marginal cost to banks will lead them to increase their demand for reserves. If this marginal cost is very close to zero, then the marginal benefit of reserves for banks, and by extension to society, will be very close to zero. This is the same argument as the one justifying the provision of intraday reserves at a very low cost.

To supply reserves at a marginal cost close to zero while maintaining the interest rate on such reserves close to its target, a central bank can choose to pay interest on reserves. As we describe below, this is what the Reserve Bank of New Zealand has been doing since October 2006. The rate of interest paid on reserves puts a floor on the market price of those reserves. Then, provided it is large enough, the supply of reserves has little influence on that price. For that reason, banks should be indifferent between holding reserves on their balance sheet and lending them in the interbank market. This indifference gives the central bank much greater flexibility in its choice of supply for the quantity of overnight reserves.

This flexibility has important consequences for the supply of intraday reserves. If the supply of overnight reserves is no longer tied to the setting of the central bank's target rate, it can be used to satisfy other objectives. One possible objective is to reduce or eliminate the supply of intraday reserves, which would reduce the central bank's credit exposure associated with the supply of intraday reserves.

b. The case of New Zealand

In July 2006, the Reserve Bank of New Zealand began the transition from a symmetric channel system to a floor-target channel. As part of this move, the Reserve Bank has increased the total supply of reserve balances to roughly 400 times its previous level. This section, which draws on Nield (2006), describes the transition from one regime to the other and the reason for the changes.

Prior to the changes introduced in 2006, the New Zealand system was a symmetric corridor system with no reserve requirements. The Reserve Bank targeted a supply of reserves of NZD 20 million overnight. Reserves at the deposit facility earned interest at a rate 25 basis points below the official cash rate (OCR), the Reserve Bank's target rate. Payment system participants could borrow reserves overnight against collateral at the overnight reserve repurchase facility (ORRF), at a rate 25 basis points above the OCR. Finally, participants could obtain reserves intraday, against collateral, at an interest rate of zero at a facility called Autorepo.

The decision to modify the liquidity management regime in New Zealand followed signs of stress in the money market. These signs included delayed payments between market participants as the government securities available to pledge in the Autorepo facility were scarce. For the same reason, there had been an increase in the levels of underbid open market operations and, consequently, in the use of the Reserve Bank's standing facilities at the end of the day. Finally, the implied New Zealand dollar interest rates on overnight credit in the foreign exchange swap market, the primary market by which banks in New Zealand traded overnight, were volatile and often significantly above the rate consistent with the monetary policy objective. The Reserve Bank of New Zealand conducted a review of its liquidity management regime in 2005 and issued a consultation document in March 2006.

Under the new system, the target supply of reserves has been vastly increased to a level currently in the region of NZD 8 billion. Reserves now earn the OCR. It is still possible to obtain overnight funds at the ORRF but at a rate 50 basis points above the OCR, which keeps the width of the channel at 50 basis points. Finally, it is no longer possible to obtain intraday funds from the central bank.

The bulk of the transition occurred in fours steps over a twelve-week period, between July 3 and October 5, 2006. During that time, the target supply of reserves increased gradually to its current level. At each step, the rate earned on reserves and the rate at

which funds could be borrowed at the ORRF were increased relative to the OCR in increments of 5 basis points up to their current levels. The set of securities eligible as collateral for Autorepo was reduced until Autorepo was discontinued on October 5.

While it is too early to judge all the effects of the changes with great confidence, it appears that the transition went smoothly, despite occasional signs of stress attributable to the learning process the Reserve Bank of New Zealand and the payment system participants are undergoing.

There are some positive signs that the liquidity of the interbank market has improved. Notably, payments have been settling significantly earlier since the transition began, suggesting that the constraints previously suffered from the scarcity of the collateral available to pledge in the Autorepo facility have been reduced. In addition, the implied New Zealand dollar interest rates in the foreign exchange swap market are now much less volatile and are well within the 50-basis-point band between the OCR and the ORRF. Finally, the open market operations of the Reserve Bank of New Zealand are conducted far less frequently, and they are no longer subject to the underbidding that had previously led to excessive use of the overnight facilities.

c. Impact on the overnight market for reserves

One likely consequence of providing a large amount of overnight reserves at zero marginal cost is a decline in the overnight market activity. Banks may prefer to hold extra precautionary reserves, since it is very inexpensive to do so, rather than have to trade with other banks often. An example of this phenomenon was observed in the Japanese market under the "quantitative easing" policy. From March 2001 to March 2006, the Bank of Japan engaged in a policy of supplying so many reserves that the marginal cost of holding overnight reserves was almost zero. Because the supply of overnight reserves was so high, the activity on overnight money markets decreased markedly. The Bank of Japan reports that the amount outstanding in the uncollateralized call market fell from ¥29.3 trillion at the end of 1995 to ¥7.6 trillion at the end of 2005.

Similarly, the Euro-Yen swap market decreased from ¥23.6 trillion at the end of 1995 to ¥2.9 trillion at the end of 2005.[12] It appears that banks preferred to hold onto large quantities of reserves to meet their needs rather than potentially have to borrow these reserves from other banks.

In an extreme case, it is possible to imagine that the overnight market for money could disappear completely. Understanding the benefits of the overnight market, and the potential cost of a reduction or disappearance of activity in that market, is therefore important to evaluate the desirability of providing overnight reserves at a very low cost. Some observations can be made.

One benefit often attributed to the overnight market is that it provides potentially valuable information about banks. This information can be used by the central bank to manage its exposure when it provides intraday liquidity, for example. While this benefit may be lost if the market activity is much reduced, it should also be noted that the central bank may no longer need to provide intraday liquidity, so this particular risk exposure can be eliminated completely. One may also ask whether there are other ways to obtain the information provided by the overnight market for reserves.

In systems where reserves are costly at the margin, banks typically try to economize on their holding of reserves and hold interbank liabilities on their balance sheets as a substitute. The interbank market facilitates the transfer and distribution of these liabilities. In contrast, in a system where reserves are not costly at the margin, banks may choose to hold reserves on their balance sheets. These reserves could allow them to meet payments shocks over a few days.

Activity in the money market can be viewed as an efficient way to allocate reserves and to impose some market discipline on banks. An alternative view holds that reserves need not be scarce since the central bank can supply as much as it wants. Under this view,

[12] See the Financial Markets Report "Issues Regarding Money Markets After the Conclusion of the Quantitative Easing Policy," published by the Bank of Japan and available at http://www.boj.or.jp/en/type/ronbun/mkr/mkr0608.pdf

activity in the money market is a waste of resources. Which one of these views is correct has important implications for central banking arrangements.

The study of the case where the central bank supplies overnight reserves at a marginal cost of zero leads us to the maybe surprising conclusion that the overnight money market could be relatively unimportant. Hence, instead of asking why there are no intraday markets for money, maybe we should be asking this question: Why are there overnight markets for money?

5. Conclusion

Why are there no intraday markets for money? While this paper does not directly answer that question, we have examined a number of relevant facts and ideas. To understand the potential costs and benefits of an intraday market for reserves, one should understand in some detail the reasons why demand is usually different for intraday reserves and for overnight reserves. An important point that arises from looking at overnight and intraday reserves separately is that the institutions necessary for the emergence of an overnight market could be set up to give rise to an intraday market. These institutions include features that manage the variability and unpredictability of demand as well as specific institutions to inject the supply of reserves.

Because an intraday market is feasible does not necessarily mean that it is desirable. We consider a number of arguments for and against an intraday market. A market may be able to provide better risk-sharing and better incentives for market participants to control their risk. On the other hand, the market may not work efficiently because participants have incentives to delay intraday payments and the central bank may have incentives to intervene when the market does not function properly. Weighing these arguments against each other is difficult, and we do not provide an answer to whether an intraday market is desirable. However, we believe these are the main arguments that must be considered.

We also consider how reserves should be supplied if the marginal cost of overnight reserves is zero, as advocated by Friedman (1969). In this case, the distinction between overnight reserves and intraday reserves becomes blurred. Indeed, if the cost of overnight reserves is zero, there is no need to inject additional reserves intraday, as these same reserves can be held overnight at no cost. If the marginal cost of holding reserves is zero, however, it is not clear that there is much of a role for a reserves market. Banks may prefer to hold rather than trade for the reserves they need. A key question then becomes that of the role of the reserves market—or if such a market has a role at all.

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