

The Design of Wholesale Payments Networks: The Importance of Incentives

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MOST PEOPLE ARE FAMILIAR WITH RETAIL PAYMENTS SYSTEMS SUCH AS CHECKS AND CREDIT CARDS. LESS FAMILIAR ARE WHOLESALE PAYMENTS SYSTEMS, WHICH CONSIST OF ELECTRONIC NETWORKS THAT ARE USED FOR SENDING LARGE SUMS AMONG BANKS.¹ WHOLESALE PAYMENTS SYSTEMS SERVE TWO IMPORTANT PURPOSES. FIRST, BANKS OFTEN USE THESE SYSTEMS TO SETTLE TRANSACTIONS MADE USING RETAIL PAYMENTS SYSTEMS.²

Second, banks use these systems to clear and settle large-value transactions, primarily those associated with trading in the financial markets.³ Various wholesale payments systems employ different rules for settling payments. A feature common to all wholesale networks, however, is that they settle on the books of a central bank. That is, settlement is carried out by exchange of funds held in banks' reserve accounts at a central bank. The rules for settlement vary from network to network. Some networks operate under real-time gross settlement (RTGS). Under RTGS, payment messages cleared through the network are continuously settled by transfer of central bank funds from paying banks to receiving banks. Other networks operate under net settlement rules. That is, at some interval (usually the close of each business day) the value of all payments due to and due from each bank in the network is calculated on a net basis. Banks ending the day in a net debit position (banks whose due-tos exceed their due-froms) transfer

reserves to the network. The network, in turn, effects settlement by transferring these funds to net creditor banks.⁴

In many countries, banks participating in large-value payments systems have traditionally enjoyed access to significant amounts of virtually free intraday credit. In RTGS systems, such credit is granted when banks run "daylight overdrafts" on their reserve accounts.⁵ In net settlement systems, such credit is granted when a bank accumulates a large net debit position vis-à-vis other banks in the system. The allocation of intraday credit in wholesale payments systems is of policy concern, given the critical function of these systems in developed economies and given the very large flows that depend on the integrity of these networks. Combined daily payment flows on the two U.S. large-value payments systems, for example, average about \$2.6 trillion.⁶ A major disruption to the normal functioning of large-value payments systems could deny bank depositors access to

funds from already-completed transactions and could impair the operation of financial markets and the economy more generally. The Federal Reserve and other central banks have some special responsibilities in terms of ensuring the efficient operation of wholesale payments systems, as such systems are typically either operated by a central bank or settle on the books of a central bank.

Recent years have seen a number of efforts by central banks to more aggressively manage intraday credit in wholesale payments networks.⁷ First, central banks have required that wholesale systems that settle on a net basis employ certain risk-management controls. These rules include the setting of limits, or “caps,” on banks’ net debit positions. In addition, banks participating in net settlement networks are often required to undertake measures (in practice, to post collateral) in order to guarantee settlement of the network in case a participating bank fails. Second, central banks have tried to expand the use of RTGS, both through the introduction of new RTGS systems and through enhancement of existing RTGS systems. Under RTGS, all funds transfers must take the form of transfers of central bank funds. Banks receiving funds over an RTGS system thus have immediate full claim to central bank funds, whose value is backed by a sovereign government. Thus, the very act of payment over an RTGS system provides finality in the sense of favoring the receiver of the funds over other claimants on the bank. In contrast, payments over net settlement systems often take the form of private promises to provide funds at settlement time. Since under certain circumstances such promises may not come to pass, net settlement systems do not automatically offer the same degree of finality as RTGS systems. Third, central banks have taken a more cautious and deliberate approach to the allocation of intraday credit over RTGS systems. Central banks’ limitations on the use of intraday credit include collateralization requirements, caps on intraday credit, and charging interest on intraday overdrafts.

What is the best design for a wholesale payments system? Should it settle on a net or a real-time gross basis? Should preset limits or caps be placed on participants’ net positions (in net settlement systems) or intraday overdrafts (in gross settlement systems)? Or, instead of caps, should collateral be required to run net debit positions (or intraday overdrafts in gross settlement systems), or should interest be charged? These are some of the difficult policy questions facing both participants and regulators of wholesale systems. This article presents a framework for analyzing such questions.

The discussion begins by considering the trade-off between net and real-time gross settlement (with no intraday overdrafts). At the most basic level, this trade-off can be characterized as a trade-off between two distortions.⁸ Net settlement increases probability of defaults, or “abnormal settlements,” thereby raising the costs associated with potential defaults, and gross settlement increases the costs associated with holding reserves. The relative merits of the two types of settlement depend on the relative size of these two costs. Different weightings of these costs by bank regulators and banks can lead to different conclusions about the desirability of particular settlement rules and thus may explain the lack of consensus on this issue.

The next section shows that for the benchmark case in which bank asset quality is fixed and bank assets can always be liquidated at book value, some type of net

The Federal Reserve and other central banks have some special responsibilities in terms of ensuring the efficient operation of wholesale payments systems.

1. Throughout this article, bank is used as shorthand for any type of depository financial institution that is a settling participant of a payments network that settles on the books of a central bank.
2. When funds are transferred from one bank to another, an obligation is created from the paying bank to the receiving bank. Settlement refers to the process by which such obligations are discharged, or “settled.”
3. For surveys of large-value payments systems in the G-10 countries, see, for example, Bank for International Settlements (1993, 1997), Emmons (1997), or Folkerts-Landau, Garber, and Schoenmaker (1996).
4. Systems using net settlement are sometimes referred to as delayed net settlement (DNS) networks.
5. A daylight overdraft occurs when a bank overdrafts its reserve account during daylight hours but repays the overdraft by the close of business.
6. Data on daily payment volumes are 1997 averages for the Fedwire and CHIPS systems from Bank for International Settlements (1998). Fedwire is the wholesale payments system operated by the Federal Reserve System. CHIPS is a private wholesale payments system operated by the New York Clearinghouse Association.
7. Specifically, central banks have introduced a minimal set of standards, the “Lamfalussy standards,” for net settlement systems. The Lamfalussy standards were proposed in Bank for International Settlements (1990) and are discussed in Emmons (1997).
8. The term distortion is often applied to situations in which a loss of economic efficiency has occurred. The formal definition of the term is somewhat more specific but is too technical to discuss here. See Srinivasan (1987) for a discussion.

settlement always dominates real-time gross settlement. However, the optimal net settlement scheme may be one that necessarily involves some chance of default. Next, the discussion examines the case in which the quality of bank assets is a choice variable and finds that the potential costs of net settlement rise because of negative effects on bank asset quality. The article continues with a discussion of policy implications of the framework proposed. The final section discusses some of the limitations of this analysis and relates these to recent research on payments systems.

A Simple Model of Interbank Settlement⁹

Many of the critical differences between net and gross settlement systems can be illustrated using a simple example analyzing the incentives of a representative bank in an interbank payments network, in which the bank exists for only a single “trading day.”¹⁰ The bank can hold three types of assets: *A*, “earning assets”; *M*, “reserves”; and *DF*, “due-froms,” or payments received from other banks but not yet settled. It also holds two types of liabilities: *DT*, “due-tos,” or unsettled payments due to other banks; and *D*, “deposits.” Initially, the assumption is that reserves are non-interest bearing and that due-to positions cannot be collateralized.

A bank starts the day with only earning assets, *A*, and deposits, *D*. For convenience, initial holdings of reserves are set to zero.¹¹ During the course of the day, due-froms and due-tos will accumulate according to the demands of depositors. No delay in payments is permitted: as soon as a bank receives instruction from a depositor to make a payment, the payment message must be entered into the payments network.¹²

Consistent with real-world practice, the example assumes that banks are required to settle payments in central bank funds. For simplicity, there is no legal reserve requirement. Instead, banks will purchase or accumulate reserves as needed, according to the settlement rules of the payments system. Under RTGS, for example, banks continually pay off net due-tos as they are realized. Initially the case considered is one in which the bank’s assets have constant value over the trading day and can be exchanged for reserves at book value.¹³ However, the market for reserves is imperfect in the sense that reserves accumulated during the day cannot be exchanged for earning assets during the day but must be held overnight without receiving interest. The assumption that reserves cannot be reinvested during the day serves as a convenient approximation for the fact that in most countries there is no intraday market in reserve funds. The existence of such a market, combined with an absence of legal reserve requirements and an effective peg of the intraday interest rate, would imply that banks could end each day holding zero net reserves. In the absence of such a market, a “musical

chairs” situation is created whereby some banks end up holding reserves overnight since reserves can be created or destroyed only by the actions of the central bank.¹⁴ Note also that reserves accumulated during the day can be used to settle due-tos realized during the day.

The “social cost” of holding reserves is taken to be the implicit tax of $i > 0$ per dollar of reserves held at the end of the day, where i is the overnight interest rate. This specification in effect assumes that holding non-interest bearing reserves entails some welfare cost.¹⁵ The nominal rate times reserve holdings serves as a first-order approximation for the welfare costs of inflation that could be derived in a more complete model of the payments system.¹⁶ It is also assumed that the implicit tax on reserves is passed on to depositors.

The finality of reserves transfers will be the key to limiting the bank’s incentive to default.¹⁷ When a bank settles its due-to position by transferring reserves to other banks, doing so changes the priority of claims on the bank. The act of settlement is interpreted as irretrievably committing the bank to favor interbank claims on its assets over all others. This “irreversibility” feature of reserves transfers will be taken as a given institutional feature of the model environment.¹⁸

The bank’s default decision will be made on the basis of its profitability. The bank will have an incentive to default more often than is socially optimal. Two sets of assumptions underlie this excessive default rate: (1) that default allows the bank to increase the priority of the equityholders, at the expense of other participants in the network, and (2) that the social costs of default exceed the losses felt by the defaulting bank.¹⁹

The net worth of a bank if it does not default is the value of its assets minus its liabilities; that is,

$$NW = A + DF + M - D - DT. \quad (1)$$

Notional net worth at the beginning of the day, NW_0 , is simply the value of its assets minus its deposits, $A - D$, which is taken to be positive. If a bank defaults, by assumption it is forced into liquidation by a regulator. In this case its net worth is given by a fraction α times its assets, minus α times its deposit liabilities, minus a fraction β times its interbank liabilities or net due-tos $ND \equiv DT - DF$,

$$\begin{aligned} NW &\equiv \alpha(\text{assets}) - \alpha(\text{deposits}) - \beta(\text{net due-tos}) \\ &= \alpha(A - D) - \beta(ND), \end{aligned} \quad (2)$$

where $\alpha > \beta$. In other words, the cost of liquidation procedures diminishes the value of a bank’s assets, but it also allows the bank to partially shift priority away from other banks participating in the payments network. Under this assumption, liquidation disproportionately punishes holders of interbank claims, implying that

default is a tempting option for banks with a large net debit position relative to their capital.²⁰

End-of-day default under net settlement occurs if net worth after the default exceeds its net worth under normal settlement. In mathematical notation, this condition is the same as

$$\gamma ND(\text{end-of-day}) > NW_0, \quad (3)$$

where $\gamma \equiv (\alpha - \beta)/(1 - \alpha)$. Equation (3) says that a bank's incentive to default depends on the size of the bank's net worth, the parameter γ , and the size of its net debit position. The parameter γ measures the extent to which other banks' claims are at a disadvantage in case of default relative to the claims of depositors. A larger value of γ or a larger net debit position means that more capital is required in order to keep the bank from defaulting. The social cost of default is Ξ , where $\Xi \geq (1 - \alpha)A$. That is, the cost of default is at least as great as the value of assets lost from the defaulting bank. However,

the total cost of default may also include additional costs associated with abnormal settlement, such as the costs of legal proceedings.

In the next example, the day is divided into three periods, 0 (morning), 1 (noon), and 2 (close of business). The intraday evolution of net due-tos is random. It is assumed that there is an equal probability of depositors receiving an amount, Δ , in funds or wishing to send Δ in funds in the morning and again in the afternoon. Thus, under net settlement rules with no limits on the bank's net position,

$$ND(1) = \begin{cases} \Delta & \text{with probability } 1/2 \\ -\Delta & \text{with probability } 1/2 \end{cases} \quad (4)$$

$$ND(2) = \begin{cases} 2\Delta & \text{with probability } 1/4 \\ 0 & \text{with probability } 1/2 \\ -2\Delta & \text{with probability } 1/4. \end{cases} \quad (5)$$

9. The model presented below is a simplified version of that presented in Kahn and Roberds (1998a).
10. That is, the bank is liquidated at the end of the trading day. Hence a default by a bank simply changes the priority of end-of-day claims on bank assets. A more realistic setup would acknowledge the value of the bank as a going concern, which would tend to lessen the likelihood of default, *ceteris paribus*.
11. In practice, banks begin the day with some reserve holdings. Typically banks' reserve holdings are supplemented at some point during the day via overnight repurchase agreements with the central bank. Reserves obtained in this fashion are returned the following morning. This situation is approximated above by setting initial reserve holdings to zero.
12. The discussion below considers the costs that can arise when banks are allowed to delay payments.
13. In other words, the bank in the example presented is forced to fund liquidity needs through "reverse repos." In practice, banks in the United States can also obtain reserves by purchasing fed funds, that is, by taking out an unsecured loan of reserves from another bank. (Markets for fed funds and repos are discussed in, for example, Stigum 1990.) The existence of a fed funds market is ruled out here for purposes of tractability.
14. Lucas describes this outcome as follows: "[i]n a monetary economy, it is in everyone's private interest to try to get someone else to hold non-interest-bearing . . . reserves. But someone has to hold it all, so all of these efforts must simply cancel out" (1994, 30).
15. In other words, by holding non-interest-bearing reserves (or bank accounts in banks that must hold such reserves), people holding the reserves in effect pay a tax equal to the interest rate times the quantity of reserves that they hold. This amount represents the opportunity cost of holding a given quantity of reserves. Above, this private cost of holding the non-interest-bearing reserves is interpreted as the cost to society, though the cost to society will often be different from the private cost. In a standard money demand model, for example, the government gains back as tax revenue what reserveholders pay in implicit taxes. However, the government cannot recapture the full value of what reserveholders lose through the implicit tax because taxing reserves reduces the quantity that people are willing to hold. Hence, the nonpayment of interest on reserves imposes a welfare loss, or net social loss, when the value of the gains and losses are added up across different members of society. See, for example, Lucas (1994) for a standard treatment of the welfare costs of inflation.
16. See, for instance, various papers that analyze general equilibrium models of the payments system, including Freeman (1996a, 1996b, 1999), Green (1997), Kahn and Roberds (1998b), and Lacker (1997).
17. There are many definitions of the term finality. The one used here is one of the most succinct, provided by Corrigan (1990): a transfer of money is final if "the money in question is 'good money,' even if at the next instant the sending institution goes bust" (131).
18. This assumption is consistent with institutions in most countries. In the United States, transfers of reserves via Fedwire immediately become liabilities of the Federal Reserve System; see, for example, Federal Reserve Bank of New York (1995, 11).
19. It could also be the case that the bank might default less often than is socially optimal. While this situation is more difficult to model, similar welfare losses would result. For example, this situation would increase the incentives of the bank to shift risks to other network participants or governmental guarantors, as discussed in the next section below.
20. Note that banks need not literally have positive net worth in the default state in order for this incentive to exist. A similar incentive could exist if default favored a select group of bank creditors. Such inequities in priority could result from political considerations—for example, if the failing bank is based in one country while the payments network is based in another—or from statutory provisions favoring certain depositors over other creditors.

Parameter values are chosen so that a bank with 2Δ in net due-tos finds it advantageous to default, but a bank with Δ in net due-tos does not, so that

$$\gamma(2\Delta) > NW_0 = (A - D) > \gamma\Delta. \quad (6)$$

Under RTGS without intraday overdrafts, banks must pay off net due-tos as they are realized.²¹ They do so by selling earning assets in return for reserves. Hence, if the bank incurs a net due-to position of Δ in period 1, it must immediately liquidate Δ worth of earning assets. This requirement implies that the bank's maximum net due-to position in period 2 will be Δ , which in turn

implies that the bank will have no incentive to default in either period (the evolution of the bank's net position under RTGS is shown in Chart 1).

Since, as Chart 1 shows, there is no possibility of strategic default under real-time gross settlement, the expected social costs under RTGS are simply the implicit costs associated with holding reserves (the overnight interest rate)

times expected reserve holdings at the end of period 2.²² In evaluating this cost, there are four equally likely possibilities. If the bank pays out to other banks in each of the two periods, it holds no reserves in the final period. If the bank receives funds in each of the two periods, it holds reserves in an amount equal to 2Δ in the final period. If it receives funds in the first period and pays in the second, it holds zero reserves. Finally, if it pays in the first period but receives funds in the second period, it holds reserves equal to Δ . Thus, the expected level of reserve holdings is $(3/4)\Delta$, and social costs are $(3/4)\Delta i$.

Under net settlement without net debit caps, the bank ends up with a period 2 net debit position of 2Δ with probability $1/4$ (see Chart 2). In this case the bank will default under assumption (6). With probability $1/4$ the bank ends up with a period 2 net credit position of 2Δ , and with probability $1/2$ the bank ends up with a zero net position. The social costs of this settlement system are therefore given by the social cost of default, Ξ , times the probability of default, $(1/4)$, plus the cost, $2\Delta i$, of holding reserves at the end of the day times the probability of ending the day in a net credit position, that is, $1/4$. The total social cost of net settlement is therefore given by the sum of these two costs, $\Delta i/2 + \Xi/4$.

Several points can be immediately made from this simple example. First, changing the rules of a payments system from real-time gross to net settlement necessarily (though perhaps, weakly) increases the risk of a settlement failure. Second, the social costs of a net settlement system may be less than under gross settlement, even though net settlement can increase the risk of a default. This risk can increase because net settlement reduces the costs associated with holding the reserves necessary for settlement. Obviously, if strategic default were unavailable, then net settlement would always dominate gross settlement since net settlement would lessen liquidity costs without increasing default risk. Strategic default as modeled here is merely the simplest form of moral hazard problem. More complicated forms of moral hazard, such as choosing riskier investment, offering depositors early payment, and the like, will generate similar costs as long as interbank liability is diminished in cases of default.

Finally, it is noted that a system of net settlement with a cap $C > 0$ on the typical bank's net debit position offers the possibility of some economization on reserve balances with reduced default probability. For this example it is easy to show that a net debit cap of NW_0/γ decreases expected reserve holdings while eliminating the possibility of strategic default. Thus, for this example net settlement with a net debit cap dominates gross settlement, and, indeed, if default costs are greater than some critical level, NW_0/γ is the optimal net debit cap. For a more general case, Kahn and Roberds (1998a) show that the optimal net debit cap need not be set at a level that precludes default. The optimal net debit cap also decreases as the ratio Ξ/i increases. In other words, if the cost of a default rises relative to the cost of holding reserves, then caps on banks' net debit positions should fall.

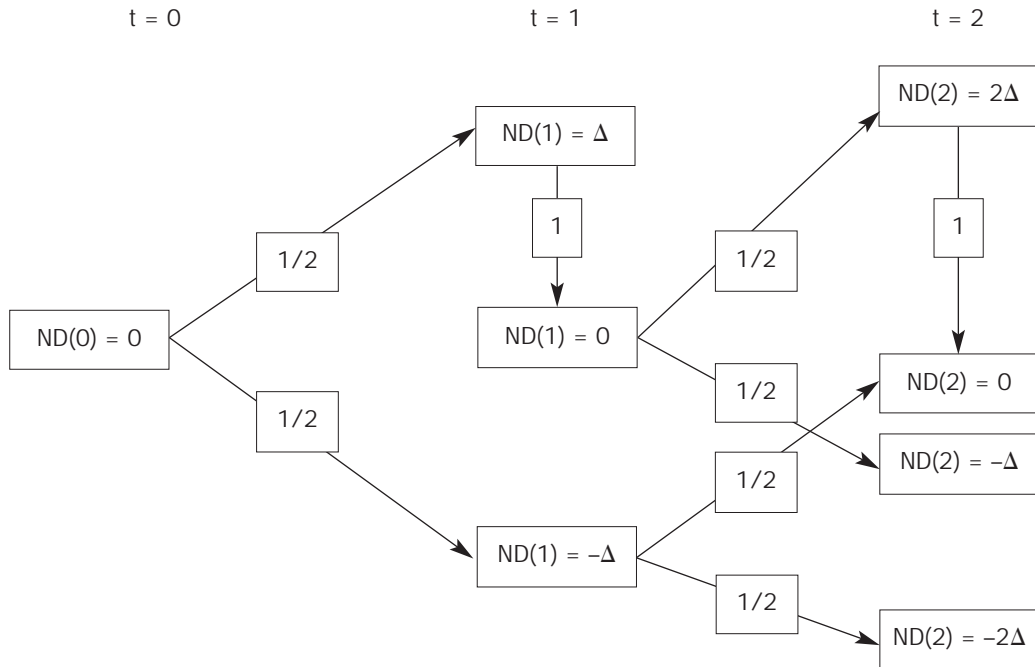
Settlement Rules and Bank Portfolio Choice

One of the limitations of the model the previous section presents is that it ignores the interaction between the settlement rules of the payments system and the bank's decisions concerning its investment portfolio. To see why such interactions might be important, consider the following example.

Suppose that the bank can invest in only two types of investments: safe bonds that yield zero real return and risky projects that yield a positive real return some of the time and negative real returns at other times. Will the settlement rules of the payments system have an impact on the bank's division of its assets between the two types of investment?

The answer to this question is yes.²³ To see why, suppose that the payments system operates as a net settlement system with a fairly large net debit cap. Then, at least some of the time, the obligations of the bank would

In many countries, banks participating in large-value payments systems have traditionally enjoyed access to significant amounts of virtually free intraday credit.



be shifted away from its own depositors and toward the other banks in the payments network. If the bank were to simultaneously experience a large loss due to the failure of a risky investment, the default condition (3) could be satisfied and the bank would default.

Thus, participation in a wholesale payments system operating under net settlement can increase banks' incentives to make excessively risky investments by setting up a "heads I win, tails you lose" situation. That is, a bank undertaking risky investments will be able to keep the profits from such investments when they are successful. When these investments are unsuccessful, under net settlement banks will sometimes be able to shift a portion of their losses to other participants in the payments network. Hence, a lower net debit cap will be called for when this effect is considered.

In contrast, participation in an RTGS system (without intraday overdrafts) cannot create an incentive to overinvest in risky assets because under this system banks' due-to positions are extinguished as soon as they arise and banks are unable to shift any losses to other participants in the payments system. This advantage may not be enough, however, to compensate for the lower liquidity costs associated with net settlement systems.

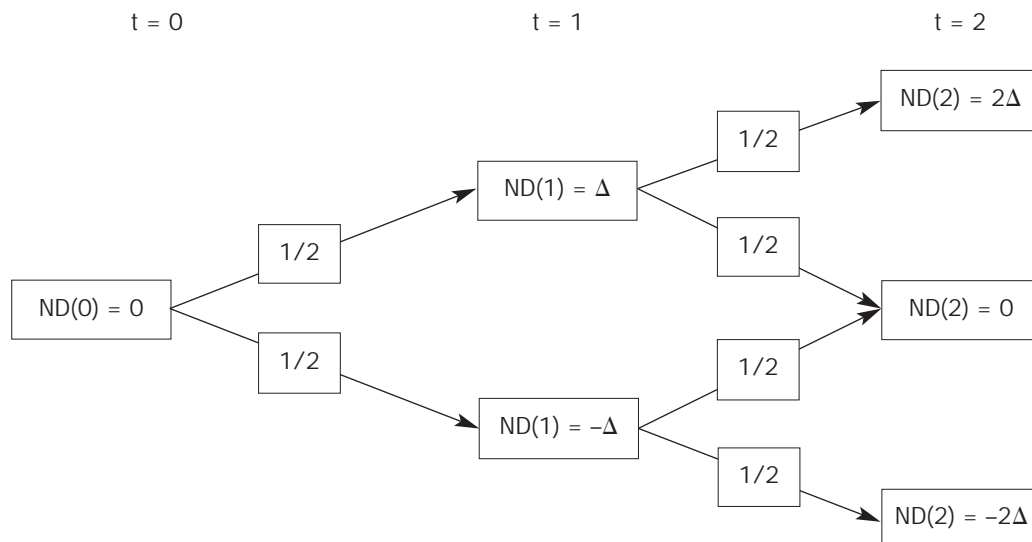
Policy Implications

What are the implications of the model in the previous section for the questions posed in the introduction?

Should payments systems operate under net settlement or real-time gross settlement? In the model discussed first, net settlement with a cap on net debit positions dominates RTGS. However, the next section shows that the advantage of net settlement is diminished somewhat when its effect on banks' investment incentives is taken into account. This finding suggests that net settlement systems are more appealing in situations in which the amount of risk in participants' portfolios is known to other participants or can be controlled by regulation, mutual monitoring, or some other means.

Should there be limits on banks' intraday positions? In the model, limits (caps) on banks' intraday positions are desirable for two reasons. First, caps lower the incidence of default. Given that any default brings with it certain unavoidable costs, such as legal costs, a reduction in the incidence of such costs can improve economic efficiency. A second reason for imposing caps is to improve productive efficiency by discouraging

21. The implications of allowing RTGS with intraday overdrafts are considered below.
22. Default is strategic in the model of this section since a default results from the efforts of a leveraged bank to shift priority away from the claims of other banks, thereby increasing the value of its own equity.
23. This finding is shown rigorously in Kahn and Roberds (1998a), propositions 5 and 6.



excessive risk taking on the part of the banks participating in the network.

It should be emphasized that caps should be set at the “correct” level. Since there are efficiency losses in the direction of either too generous or too stringent provision of intraday credit, caps set at the wrong level may be as bad as a cap of zero or no cap whatsoever.

Instead of caps, should collateral be required to run net debit positions, or should interest be charged? To consider the advantages and disadvantages of collateral requirements, first consider the role of collateral in the model discussed first. If the bank must post collateral to the payments system in order to run a net debit position, then the effect on the bank’s default incentive is similar to requiring that the bank settle on a real-time basis. The bank is unable to shift priority away from other payments system participants in case of default. An advantage of collateralization over RTGS is that the bank need not actually liquidate assets every time it runs a net debit position. Since there is some chance that the net debit position will decrease or even be extinguished by the end of the day, the bank can wait until later in the day to determine the amount of reserves it needs for settlement. Hence, net settlement with collateralization reduces banks’ demand for costly reserves relative to RTGS while preserving the positive incentive effects of RTGS. So, for this model, full collateralization of banks’ net debit position makes sense.

In the model discussed next, collateralization may impact banks’ portfolio decisions. If the payments system allows only low-risk assets such as government bonds to be posted as collateral, banks may be induced to underinvest in riskier but higher-yielding assets such as loans. Therefore, in this model the positive incentive

effects of collateralization must be balanced against its potentially negative effects on banks’ portfolio decisions. A compromise policy would be to require partial collateralization of net debit positions.

To consider the effects of charging interest on intraday net debit positions, again consider the first model in the case of net settlement with no caps on the bank’s position. The model also supposes that the interest rate on intraday positions is well below that of the overnight interest rate, i . If interest on intraday positions is collected only at the close of business, then charging interest on intraday decisions would actually increase a bank’s incentive to default by diminishing its net worth. Charging intraday interest would also be costly to non-defaulting banks. Hence, the model suggests that a policy of charging interest on banks’ intraday net debit positions would be inferior to imposing caps or collateral requirements on these positions.

Complications

The models presented above are useful for considering some of the issues associated with different designs of wholesale payments networks. Because these models are relatively simple, however, they cannot come close to capturing all of the policy trade-offs that must be considered. The discussion below considers some additional issues not addressed by the models and relates these, where possible, to recent research in this area.

Additional Issues with Net Settlement Systems. A limitation of the model of the previous section is that it does not formally distinguish between net settlement systems and RTGS systems that grant intraday credit. The representative bank’s incentives to default are the same, irrespective of whether the bank’s due-tos are

due to other banks participating in the payments network (as under net settlement arrangements) or to the central bank (as under RTGS with intraday overdrafts). This feature of the model masks some costs of net settlement systems.

A potentially important distinction between net and gross settlement systems is that in many countries other than the United States the legality of a netting agreement may be questionable in cases of bankruptcy.²⁴ If a bank defaults on its net settlement obligation and declares bankruptcy, this action might result in all transactions of the network in question being “unwound” for that day. While such a rule could have the desirable effect of limiting a bank’s incentives for strategic default, it could also have undesirable side effects. One of these might be contagion or systemic risk whereby the unwinding would result in failure of other banks arising from unanticipated last-minute changes in interbank obligations. Freixas and Parigi (1998) show that the likelihood of contagion is increased when one considers the possibility that depositors in failing banks will try to transfer their deposits to other banks before the actual failure takes place. Rochet and Tirole (1996) note that a factor counteracting these negative effects, however, would be the increased incentive of all banks participating in a net settlement system to monitor each other’s portfolios, thereby lessening the risks associated with abnormal settlement. In addition, members of a net settlement system would have a strong incentive to exclude poor credit risks from participating in the system.

Concerns about contagion have led net settlement systems to take measures guaranteeing settlement should members default. The reduction of systemic risk that such guarantees offer must be weighed against their costs, including the costs resulting from the associated incentive effects. As a practical matter, most net settlement systems in developed countries must be able to guarantee settlement, at least to the extent that normal settlement can occur if there is a failure of the participant with the largest net debit position.²⁵ In the case of CHIPS, this requirement is implemented by a loss-sharing agreement, which is backed by a collateral requirement.²⁶ The loss-sharing agreement thus functions something like a partial collateral requirement on a bank’s intraday position (see discussion above), and, since the costs of the settlement guarantee are spread

across all participants in the network, the loss-sharing agreement also increases incentives for participants to monitor one another and to enforce strict requirements for membership.

For some net-settlement wholesale payments systems, the possibility of contagion is entirely excluded because settlement is guaranteed by a central bank, as in the case of Canada (Dingle 1998).²⁷ A more common approach to the containment of systemic risk, however, has been for central banks to make intraday credit available over their respective RTGS systems.

Additional Issues with RTGS Systems.

Modern RTGS payments systems can eliminate the possibility of contagion by effectively interposing the central bank as a counterparty in all transactions between payments system members. Every bank in a due-to position can be thought of as sending funds to the central bank, whereas every bank in a due-from position can be thought of as receiving

funds from the central bank. As explained above, RTGS can also lessen the incidence of defaults and create incentives for efficient portfolio allocations. These advantages must be balanced against the costs associated with holding the additional reserves needed to operate in a gross settlement environment.

A relatively simple means of lowering the liquidity costs of an RTGS system is for its associated central bank to pay interest on some portion of banks’ reserve accounts. Payment of interest on reserves has become more common in recent years (Borio 1997). In the United States, the Federal Reserve System does not pay interest on banks’ reserve accounts, but banks are allowed to set up interest-bearing clearing accounts. Despite these developments, central banks generally find it necessary to impose some interest penalty on at least some portion of funds held in reserve accounts in order to maintain control over money market conditions (Borio 1997). That is, at least some of banks’ reserve holdings will bear less than

The allocation of intraday credit is of policy concern, given the critical function of wholesale payments systems in developed economies and the very large flows that depend on the integrity of these networks.

24. In the United States, the legal status of netting agreements among financial institutions is strongly supported by provisions of the Federal Deposit Insurance Corporation Improvement Act (FDICIA) of 1991. See Emmons (1997, 39–41) for a discussion of the legality of netting arrangements under U.S. law.

25. This is the fourth requirement of the Lamfalussy standards. See *Bank for International Settlements (1990)*.

26. More detailed information on the CHIPS arrangements is available at the Web site www.chips.org.

27. As noted by Mengle (1990) and many others, net settlement systems are often perceived as having an implicit guarantee of settlement, even in cases where no explicit guarantee exists.

the market rate on overnight funds and will thus carry a positive opportunity cost. This condition suggests that it is not possible to entirely eliminate the liquidity costs associated with RTGS by paying interest on reserves.

Central banks can also ease the liquidity constraints imposed by RTGS by extending intraday credit to participants in RTGS systems. This credit can be set up on a collateralized or uncollateralized basis. The model presented earlier illustrates that an RTGS system that allows for uncollateralized intraday overdrafts may create incentive problems similar to those that exist with net settlement systems. The only difference is that this risk is now shifted from other banks participating in the payments system to the central bank. As is the case with net settlement systems, default incentives can be limited by the use of caps or collateral requirements.

Much of the recent work in the payments area has focused on more closely identifying the costs associated with RTGS payments systems. Angelini (1998) identifies one potential cost that arises when banks can delay outgoing payments. Under RTGS with strict limits on intraday credit, banks may find it less costly to settle payments by waiting for incoming payments than to send payments out immediately during the day. If all system participants delay outgoing payments, however, the result can be that banks have to hold more reserves, at a greater cost, to settle a given volume of payments. Banks and their customers are also inconvenienced by the settlement delays. This situation, in which Bank A is waiting for Bank B to settle first, and vice-versa for Bank B, is often referred to as payments gridlock. The problem of gridlock is also analyzed by Kobayakawa (1997), who notes that this problem can be solved if intraday credit is available on a collateralized basis (as in most RTGS systems) but that collateralization also imposes costs. One means by which central banks have sought to minimize the effects of delay in RTGS is the use of queuing arrangements, which match up or reorder banks' outgoing pay-

ments before they are settled.²⁸ Many of these arrangements are designed to organize outgoing payments in a way that lowers both the system's overall need for reserves and the chances of gridlock.²⁹

Experience has shown that the use of collateralized intraday credit and queuing arrangements can substantially reduce the delays associated with RTGS systems. Eliminating delays under RTGS is not the same as eliminating costs, however. A number of recent studies have developed models of RTGS systems and found that the cost of RTGS is not necessarily manifested in the delay of payments.³⁰ Instead, the costs arise from credit constraints. The credit constraints appear under strict forms of RTGS, when payments system participants are in effect denied credit for incoming payments that they anticipate but that have not yet arrived. The costs of these credit constraints can be manifested in queuing or delay of payments but could also result in changing patterns of payments over the day or in some payments simply not being made. As pointed out by Lacker (1997), these costs could also motivate banks to route payments away from RTGS systems and through net settlement systems.

Conclusion

The design of a wholesale payments system must take into account numerous policy trade-offs. The most critical trade-off, however, is the one between the costs of liquidity versus the costs of default (and related types of moral hazard costs). The availability of net settlement systems, or real-time gross settlement systems that offer low-cost intraday overdrafts, lowers liquidity costs but may increase default costs. Imposing caps or collateral requirements on intraday positions lowers the costs of potential defaults but makes intraday liquidity more expensive. Achieving the correct balance between these two costs will be the subject of future research.

28. See *Bank for International Settlements (1997)* for a survey of different designs for queuing arrangements.

29. A potential problem with such systems, however, is that banks may feel the need to extend credit to customers for queued but unsettled payments. If such credit is commonly granted, the result could be a payments system that resembles a net settlement system in many respects.

30. See references in footnote 16 above.

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