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**AN ANALYSIS OF INTERNATIONAL INTER-BANK
SETTLEMENT PROBLEMS AND RESPONSES**

by

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Abstract

Timely and adequate settlement of international inter-bank payments has always been a major concern for the banking industry. However the 1974 failure of Herstatt Bank, and the disruption which hit the financial markets, ushered in an era of heightened concern about the potential vulnerability of the international settlement systems.

The purpose of this paper is to analyse the encountered settlement problems and attempted solutions. Nowhere are these efforts more apparent than in the European attempt to create a single financial market.

One of the more interesting developments in this evolution towards regional and global payment markets has been the push towards real-time settlement systems with collateralisation.

Key words: Inter-bank settlement. Real-time settlement. Payment system risk.

Introduction

The 1974 failure of Herstatt Bank and the disruption which hit financial markets ushered in an era of heightened concern about the potential vulnerability of payments systems, especially the wholesale large-value systems, to systemic risk and other problems. Systemic risk - the likelihood that a problem in one institution will cause the insolvency of healthy institutions - through runs, the creation of liquidity problems, or other forces, has been a major policy focus {Kaufman (1994)}.

This concern has grown with the stock market crashes during 1987 and 1989, the problems in unwinding some of the contracts in the failure of bank of New England and for several other important reasons. First, the sheer growth in large volume payments has heightened the potential financial stakes, should a financial meltdown occur. Second, technology and technological change have had a major impacts on the kinds of transactions taking place, both increasing the speed and lowering the costs with which they may be completed. Third, technology has also permitted the unbinding and restructuring of transactions whose risk characteristics and cross institutional linkages are just now being understood. Complicated derivative transactions with notional values in the trillions did not exist as recently as five or six years ago. A recent *Wall Street Journal* article placed the amounts at more than \$35 trillion. {Smith and Lipin (1994)}. These new instruments and markets have introduced new and complex linkages across securities markets and domestic and world payments systems. Fourth, the globalization of financial markets has tied economies and markets together in ways that introduce new risks and concerns into the mechanisms by which traditional clearing and settlement take place.

Fifth, recent private sector and public sector developments in the way large-volume payments are cleared and settled, and more specifically, the introduction of bilateral and multilateral settlements procedures may affect systemic risks in important ways. Finally, the above developments have served simply to heighten both private and public sector concerns about the need to understand and control system vulnerability to systemic risks. Fortunately, private sector and public sector entities have paid a great deal of attention to these issues at both the domestic and international levels. The payment system risks and uncertainties are affected by the nature of the market infrastructure (e.g., the type of computer systems, software, backups, audit and control procedures that are in place), the legal structure governing asset ownership and settlement of claims in default, and market conventions (such as netting arrangements, the timing of the provision of good funds, by collateral and reserve provisions, by delivery conventions, and by time and distance). Both governments and private markets have sought to curtail payments system risks, and these risks are the focus of the remainder of this article. All have received intensive consideration and review by both regulators and market participants. The key types of risks are listed in table 1 (fraud risk and technology, e.g., hardware and software risk, seem to be self-evident and will not be examined further).

Great strides have been made in understanding the risks created by the rapid evolution of financial markets. Well-structured analyses of the risks and related problems have been underway for some time, and the outline, if not the details, of the public policy issues have been well delineated. In this context, it is difficult to carve out a contribution that might make a difference in this debate. What this article seeks to do is a bit more modest. It reviews recent concerns about risks in financial markets and attempts to synthesize what is known about the policy issues.

Finally, it seeks to explain why the recent evolution of more and more payments, clearing, and settlement systems, toward real-time gross settlement systems (RTGS) is taking place in the face of evidence and analysis that alternative systems employing bilateral netting and multilateral netting can, in the absence of uncertainty about the status of claims in bankruptcy, both reduce risk and be more efficient.

The central argument of this article is that despite the theoretical advantages of payments systems which incorporate various netting schemes and credit provisions, the movement towards real-time gross settlement systems is being driven by three main considerations which increasingly are reducing the advantages of netting-type clearing and settlement systems. {Kane (1991, 1988)}. The first is the problem of resolving uncertainties in the way defaults will be handled in payments systems at a fast enough rate to keep pace with the evolution of new instruments and markets. The second is the rapid decline in computing costs and increases in processing speed which are reducing the efficiency gains from netting arrangements. The third is the movement towards 24-hour trading which will make netting arrangements difficult to implement.

The rest of this article first lays out the nature of the systems that have evolved to clear and settle payments and asset transfers in very generic terms. It then discusses the risks associated with these systems. Finally, the evolutionary path that systems have taken are described and perhaps explained, with emphasis on the private-sector responses that have emerged to deal with risk control and financial system fragility.

Table 1. Risks in payments system relationships

- A. Legal risks
- B. Supervisory risks
- C. Settlement / credit risks
- D. Settlement / Liquidity risk
- E. Herstatt risk
- F. Fraud risk
- G. Technology risk

Asset and Payment Transfer System

The potential for fragility in the payments system has long been the source of public policy concern. In the U.S., an early source of instability was due to the fact that bank notes were issued with the promise to redeem their face amount in specie (gold and/or silver). Runs occurred when demands for note conversion exceeded the available supply of specie, creating both liquidity and solvency problems if, given sufficient time, enough good assets were not available to convert to specie to meet the demand.

Early private sector responses resulted in extensions of credit and liquidity to the affected banks by other banks or through local clearing houses which had been organized to clear and return notes to the issuing banks within a region. Alternatively, banks experiencing runs either suspended convertibility or went out of business. Suspension of convertibility prevented the spread of the demand for money to other institutions whose reserves would not be depleted to meet the demand for converting assets into specie by the institutions experiencing the run {Kaufman (1986) & Bryant (1980)}. Suspension did however result in loss of purchasing power by the holders of the non-convertible notes, which were often only accepted at deep discounts in exchange for goods or services at redeeming banks {Einsenbeis (1987)}. Since note holders ultimately bore much of the costs of non-convertibility, they had incentives to worry about banks solvency. Indeed, the evidence is that they did; the result was that banks during this period typically has significantly higher capital ratios than in the post deposit insurance era {Kaufman (1986)}. The first public sector regulatory actions to ensure convertibility were to establish maximum ratios of notes to specie.

With the growth of deposits and importance of cheques as a medium of exchange, liquidity concerns changed from focusing on specie convertibility to the ability to meet demands for withdrawal of currency or payments of cheques to other banks. This was accomplished by maintaining sufficient volumes of reserves balances, demand notes, (which could be recalled at any time), government securities, or other marketable assets. Again, clearing house often required maintenance of reserve assets as collateral to meet cheques-clearing houses demands, and the clearing houses also were sources of emergency funds from time to time. Many states also imposed minimum reserve requirements as a condition for being granted a charter.

Not all regulatory responses, however, were stabilizing; in fact, some even proved to be an important source of systematic risk. An example of this in the U.S. was the reserve requirement feature of the National Banking Act 1864. Under this act, legal reserves to meet liquidity needs included not only cash vault but also deposits held at Reserve City and Central Reserve City Banks. During this period, most payments were made by cheques drawn on demand deposits with the remainder being made in currency. Demand deposit were the dominant from the banks liability to fund loans. There were not close substitutes for bank liabilities or transactions functions they performed, nor were financial markets sufficiently deep that there were ready markets for the assets on bank balance sheets. Within that structure, protecting the payments mechanism meant preventing the cumulative collapse of the money supply when runs to currency occurred and the supply of demand deposits contracted cumulatively {Gorton (1991) & Wilson (1993)}. Since the money supply consisted chiefly of currency and demand deposits, protecting the payment system meant that eliminating bank failures and ensuring banks soundness would prevent the destruction of demand deposits. This is key feature of the U.S. banking system was largely true of systems in other countries as well (e.g. Canada, Australia). Currency and demand deposits were the prime medium of exchange.

Today, payment systems are larger, inherently more complex, have many more components—both private and public—and are subject to different risks than in the past. The cheques/demand deposit system, which most currently regulatory systems and central banks sought to protect, is relatively small in terms of the value of payments and financial transactions made {BIS (1993c)}. In the U.S., for example cash payments account for less than .5% of the transactions made {Furash and Company (1994)}.

Corrigan (1990), Junker, Summers and Young (1991), and Mengle (1992) have detailed the complexity of modern-day payment systems. They lay out the relationships among the various types of financial-asset transfer, clearing, and settlement systems within the U.S., concentrating on large dollar or wholesale payments. In characterizing the U.S. system, Corrigan (1990) describes an inverted pyramid set of relationships with over-the-counter and pit-trading dealer and parties at the top. In these markets, trades are negotiated, and then delivery takes place at agreed upon times. Payment and settlement take place in different markets altogether. The next layer are those markets with netting relationships as part of their trading, such as securities, futures, and options clearing operations. Here, buy-and-sell transactions are cumulated through the course of the day and are netted to determine the amount to be settled, usually at the end of the business day. These systems settle through other financial institutions, which in turn clear and settle through clearing houses, private settlement systems such as U.S. CHIPS or U.K. CHAPS, which in turn ultimate settle through (in the case of the U.S.) Fedwire. At the foundation or bottom, of Corrigan's inverted pyramid is the central-bank clearing and settlement system. In the U.S., this is Fedwire, where interbank clearings are settled, and ownership of book entry securities are exchanged. With a little modification—self imposed caps, their discussions apply to how the systems most countries operate today.

With few exceptions throughout the world, private sector arrangements handle all aspects of payments transactions, except perhaps for final settlement (or payment), which usually requires exchange of ownership on an agent basis of central-bank money. Hence the system for exchanging ownership of central bank deposits—the so-called wholesale market—underpins the clearing and settlement activities in other markets. It is the potential for disruptions in these other markets to suddenly impact each other and ultimately and unwittingly transmit problems to the large-value payments markets that has become a major source of concern.

In nearly every one of these markets, each part of the transaction process is often broken into several parts, with different intermediaries often interjecting themselves in the middle between the transacting parties. For example, in the case of the sale of book-entry Treasury securities, the buying agent instructs his bank or broker to purchase a security. The receiving institution's bank takes possession of the security and transfers that ownership to the buyer. Time delays and clearing arrangements may dictate exactly when the selling institution's bank and the seller receive and give use of funds and when the buyer and its agent bank ultimately settle. For example, the two intermediary banks may have several securities transactions with each other during the course of the day, with only the net difference owned actually being transferred at the end of the day.

There are several ways to categorize these payments systems in terms of the types of customers they serve, the types of transactions involved, the size of typically transactions that are exchanged, the frequency of the transactions, the types of participants, etc. For example, retail checks and European giro systems handle large volume of relatively small paper and electronic transactions as individuals engage in day-to-day exchange.

Paper cheques systems in the U.S. have traditionally been focus of regulatory and supervisory concerns and provided the rational for much of the financial regulatory and infrastructure in place today. Large-value payment systems are largely electronic inter-bank markets and account for the vast majority of the value of payments in developed economies. Such systems tend to be the entry point for central bank implementation of monetary policy. They also generally involve urgent intra-day transfers of claims which may be reused several times during the course of the day before they are settled. Participants in these markets may be direct, indirect, or customers. Table 2 {from BIS (1993)} provides a categorization of participants in inter-bank fund transfer systems and their responsibilities. Direct participants usually own the systems or are specifically authorized members who settle accounts directly with the system or its other direct participants. Indirect participants clear and settle through the accounts of the direct participants who act as their agents. Finally, customers usually are the initiators and ultimate recipients of value resulting from the purchase and sale of assets. They work through agents who may be either direct participants in the payments systems—and who are ultimately responsible for settlement—or through indirect participants who settle with the direct participants.

Table 2. Classification of participants in IFTS

Participants	Responsibility					
	Identified by IFTS	Identified with a system or SWIFT address and permitted to send payment orders	Exchange of payment	Responsibility for intra-system	Responsibility for fulfillment of standards &	Share expenses
Direct	Yes	Yes	Yes	Yes for its own operations.	Yes	Yes or No
Indirect	Yes or No	Yes or No	No	Yes or No	Yes or	Yes or No
Customers	No	No	No	No	No	No

Source: BIS (1993), p.10.

Literally hundreds of different markets exist to facilitate the exchange of financial assets (not to mention real assets), such as government securities, mortgage-backed securities, stocks and bonds, options and futures, short-term debt instruments such as commercial paper, and foreign exchange contracts. Transactions in these assets often take place on organized exchanges while others do not. Some of the exchanges are privately owned (e.g. privately placed bonds) while others are publicly owned (e.g. commercial-bank loans). Regardless, the transaction has several aspects which need to be managed for it to be completed. These include notification of the intent for two parties to enter a transaction and the terms of that transaction, the delivery of the asset to the ultimate purchaser, and finally the payment and settlement of the transaction in an acceptable medium.

The simplest of these markets is the cash market, where currency (government fiat money) is exchanged for goods and services. Notification, clearing, and settlement takes place simultaneously. No major markets, however, use currency to accomplish trades; transportation costs, security concerns, and the sheer volume of currency required make settlement in currency impractical {Mengle (1992)}.

Once a transaction concludes to be a spot transaction, with instantaneous delivery and settlement in cash government fiat money, it is either paid for using a paper check or some other method of transferring value, such as electronic transfer of funds. Any such transaction has two main components that must be discharged: clearing and settlement. During clearing, which can be done by any number of different parties (both banks and non-banks alike), information is transferred from the payer to payee concerning the transaction which establishes the terms and parties to the transaction. The final transfer of value, or settlement, however, is almost always done through banks. Thus, banks and inter-bank payments systems are at the heart of all these markets.

Value can be transferred in several ways. If the payer and payee both have accounts at the same institution, then the payer's account can be debited and the payee's account credited. Clearing and settlement take place through the exchange bank debt, with no governmental involvement. If the contracting parties have accounts at different institutions, then similar transfers can be made by debiting and crediting clearing house accounts. Alternatively, value can be conveyed by settling through the central bank by exchanging ownership of central bank deposits.

The institutional arrangements for completing the clearing and settlement functions have grown extremely complex. Most clearing is done in the private sector, while settlement takes place in both the private sector and through central banks. The specifics of the settlement arrangements differ widely across the various systems, both within the United States and across and banking systems throughout the rest of the world {BIS, (1993c)}. These range from gross settlement systems, such as Fedwire in the US, through which each transaction results in a debt or credit to a settlement account, to various types bilateral and multilateral netting arrangements. Table 3 details some of the netting and related features of both retail and large value payments systems in G-10 countries. They include both government and privately owned systems. Most are netting systems, but several are real-time gross settlement systems. Some have open membership; others are restricted.

Under bilateral netting arrangements, which occur in many derivative, foreign exchange, securities, and equity markets, two institutions mutually agree to cumulate transactions during a specified period of time, with only the net amount being settled for value, usually through the banking system, at the end of the business day or several days thereafter. Under multilateral netting, an institution agrees to cumulate transactions involving several parties, and settle the amount either owned or to be received collectively from the other parties to the arrangement through a single agent, usually a clearing house. Examples of multilateral netting systems are CHIPS (Clearing House Inter-bank Payments Systems) through which most of the world dollar payments are settled or CHAPS (Clearing House Automated Payment System) in the U.K. Interestingly, CHAPS has recently indicated its intention to move to 100 percent collateralization and real-time gross settlement {Bank of England and APACS (1994)}.

Table 3. Attributes of G10-retail and large value payments systems (1992)

Country System	Type	Settlement	Membership	Number of transactions (thousands)
Belgium				
Clearing House of Belgium (CH)	Large value & retail	Multilateral netting	Open	24666
Centre for Exchange of Operations to be Cleared (CEC)	Retail	Multilateral netting	Open	695200
Canada				
Inter-bank International Payment Systems (IIPS)	Large value		Restricted	1560
France				
Paris Clearing House (CH Paris)	Large value & retail	Multilateral netting	Restricted	761969
Clearing House of Provinces Système Interbancaire de Telecom- pensation (SIT)	Retail	Multilateral netting	Open	3121268
	Retail	Bilateral netting	Restricted	301800
Transferts Banque d France (TBF)	Large value	Real time gross settlement	Open	11000
Germany				
Eiliger Zahlungsverkehr (EIL-ZV)	Large value	Real time gross settlement	Open	71865
Elektronische Abrechnung Filetransfer (EAF)	Large value	Multilateral netting	Restricted	7774
Italy				
Local clearing	Large value & retail	Multilateral netting	Open	292129
Electronic Memoranda (ME)	Large value	Multilateral netting	Open	1804
Interbank Society for Automation (SIPS)	Large value	Multilateral netting	Open	2780
Japan				
Foreign Exchange Yen Clearing	Large value	Multilateral netting	Restricted	6119
Bank of Japan Financial Network System (BOJ-NET)	Large value	Real time gross settlement	Restricted	3710

Table 3. continued

Netherlands				
(Bank-Giro Centre (BGC-CH))	Retail	Multilateral netting	Open	1043.7
8007-SWIFT	Large value	Multilateral netting	Open	1.8
Sweden				
Clearing and Interbank System (RIX)	Large value & retail	Real time gross settlement	Restricted	79
Data-Clearing	Retail		Open	141436
Switzerland				
Swiss Interbank Clearing (SIC)	Large value & retail	Real time gross settlement	Restricted	64279
DTA/LSV	Retail	Multilateral netting	Restricted	56704
United Kingdom				
Clearing House Automated Payment System (CHAPS)	Large value	Multilateral netting	Restricted	9000
Checks Clearing and Credit Clearing (Cheque/credit)	Retail	Multilateral netting	Restricted	2577000
United States				
Fedwire	Large value	Real time gross settlement	Open	67600
Clearing House Interbank Payment System (CHIPS)	Large value	Multilateral netting	Restricted	39073

Source: BIS (1993c), Table 10a.

Netting arrangements can drastically reduce the number of payments that have to be settled, can reduce the need for liquidity, and also have significant implications for risk exposure of the parties involved {Gilbert (1992), BIS (1990, 1993a), and Mengle (1990, 1992)}. The orders of magnitude of the payments reductions can be dramatic. For example, if an institution has 100 transactions with each of 10 institutions, then 1000 individual transactions have to be settled under a real-time gross settlement system. The institution must maintain sufficient liquidity to be able to settle each transaction as it flows through the payment system. In contrast, under bilateral netting $\frac{10 \times 9}{2}$ or only 45 transactions need to be settled. Under multilateral netting, a maximum of only 1 transaction per institution in the netting arrangement has to be settled. In general, if m is the number of transactions and n is the number of institutions, then the limits on the number of transactions to be processed are:

m for gross settlement systems,

$n(n-1)/2$ for bilateral systems, and

$\text{Max}(n)$ for multilateral netting system with n participants.

The benefits of netting to liquidity management are also clear. Netting arrangements obviate the need to assure that funds are available to settle each transaction. The risk implications of the various systems are discussed in the next section.

The breaking up of clearing/settlement process into component parts results in a tiring of markets. Securities, futures and options, derivatives and other markets clear under one arrangement, but largely settle in the interbank markets. Moreover, as a result of this separation, seemingly unrelated markets and institutions are linked together in ways that both create and may transfer risks in one market to participants in other markets. There are four generally accepted generic types of risks that have been identified and have been the focus of much attention. These are discussed in the next section

Payment system risk

Payments system risks have been well explored in the literature. They include operational, legal, credit, and liquidity risks {Gilbert (1992), Mengle (1992), Saunders (1996)}. Conceptually, it is easy to identify these risks separately, but in reality they tend to be interrelated, and the realization of one can lead to occurrences of the others.

Operation risks arise from possible breakdowns in the computer systems or problems with accounting, physical delivery, internal controls, or other process elements associated with clearing and settling transactions. Numerous examples of such process risks have occurred and have been the source of both considerable embarrassment and consternation. One of the most glaring was the overloading of the government securities clearing system of the Bank of New York in 1985. When the processing capacity of the computer program was exceeded, instead of stopping the system or sending an error message, the system simply continued to accept delivery of securities with the corresponding debiting of the bank's reserve account through Fedwire at the Federal Reserve Bank of New York. But the system did not then complete the rest of the transaction by forwarding the securities to the ultimate purchaser and receiving payment. The deficit in the bank's reserve account exceeded \$22 billion by the close of the business day {BIS (1989), (1990), (1993)}. This created a liquidity risk—that is, a temporary inability to settle transactions at the agreed upon date. Bank of New York clearly was not insolvent, but was neither able to liquidate assets to meet the demand for funds nor to obtain needed funds by completing the delivery of the securities, thus replenishing its funds from the delivery proceeds. In this case, the problem was solved when the central bank provided an overnight loan from the discount window. Given the amount of funds needed, it is doubtful that the other historic way that solvent but illiquid institutions met the demand for funds, that is, by borrowing from a clearing house or other banks, could have been accomplished.

This example illustrates that the four categories of risk are not independent, and that a settlement or operational risk can create credit risk, or, in this case, lead to a liquidity crisis which could expose system participants to large, unanticipated losses. Whether the system exposure to Bank of New York would have caused liquidity or solvency problems at other institutions is unclear, and no scenarios have been put forth to indicate how problems might have spread. Nevertheless, it is this uncertainty which creates the specter of financial fragility (the realization of large risks in certain states of the world)

Similarly, during the 1987 crash of the stock market, transactions ran far ahead of the ability of the electronic clearing system to process transactions. The breakdown disrupted the orderly flow of prices to the market place. Limit, stop, and other orders flows were disrupted by the sheer volume of transactions and the inability of existing computer system to handle them. As a result, many traders were either not made or were made at prices that participants would not have accepted had they had full information. The market responses to such problems have been (1) to expand capacity, which generates an interesting side issue of how much idle capacity a market should maintain to deal with an infrequent peak load problem, (2) to build in redundancy by providing backup computer and other systems, not unlike the arrangements made by public utilities to reroute electricity or telephone calls, (3) to perform process audits, and finally (4) to engage in disaster scenario planning and simulations in order to identify risks and build in appropriate protections. But unanticipated circumstances, such as the disruptions caused by the World Trade Center bombing, show that even unlikely events can both occur and have significant ripple effects through markets {Newland (1994)}.

The difference between a liquidity problem and credit risk, as it relates to settlement, is largely one of degree rather than kind. Credit risk arises when an institution defaults by failing to settle on any or all of its obligations.

Credit risk can occur at any step of the payments process, affecting customers, direct and indirect market participants. For example, if a customer initiates a transaction ordering a bank to purchase an assets, but then cannot accept delivery, the institution is faced with several alternatives. Credit can be provided to the customer until funds are received. Alternatively, the transaction can either be canceled, or it can be completed by the bank, which then takes possession of the assets (or the customer's available collateral) . Finally, in the extreme, the bank can default on its own obligation to settle if settlement time has not yet occurred. If the buyer has good collateral and a sound credit rating, then extension of credit may be the best alternative. Canceling the transaction may not be an option, especially if delivery has already taken place.

Settlement failure in the above example can be controlled if the bank puts a hold on the buyer's funds at the time the transaction was ordered, effectively collateralizing the transaction. For good customers, however, this may not be necessary, practical or efficient, especially if both the probability of default and the expected loss are small relative to the bank's resources. This suggests that diversification, control of credit concentrations, and maintenance of adequate capital are key management tools in limiting settlement/credit risk exposure.

The lack of a hold -policy illustrates that an institution's vulnerability to credit risk often results from the underlying conventions and structure of the markets involved, rather than from the realization of performance risks associated with the underlying projects and investments. For example, under Fedwire, which is a gross settlement system in which an institution's reserve account is debited or credited on a transactions-by-transactions basis, the Fed has chosen not to prohibit transactions when an institution does not have good funds in its reserve account. Subject to limits, the Fed permits an institution to make and accept transfers continuously throughout the day, but only requires that the institution close out its account at the end of the day, either by transferring in good funds or by borrowing from the discount window.

Since delivery conventions on various securities transactions, federal funds, and commercial paper vary considerably across markets, it is not uncommon for major dealer and correspondent banks to be in net deficit reserve positions for a large portion of the business day. When this happens, the Federal Reserve become a lender, providing credit to the institution with daylight overdraft. Not only is the Federal Reserve, and hence the US taxpayer, a creditor, but also, until April 1994, this credit was provided free of charge, which had implication for risk-management incentives within the payments system and individual institutions {Gilbert (1992)}.

The historical roots of this convention lie partly in the Federal Reserves' technical inability to monitor continuously the flows of funds into and out of all banks' reserve accounts, and hence to prevent overdrafts form arising {Summer and Young (1991)}. Also, this free credit helped offset the other burdens of Federal Reserve membership, which was, up until the Monetary Control Act of 1980 mandated holding of reserves against transactions accounts, eroding at a rate sufficient to cause the Federal Reserve to believe that it might be losing its ability to implement monetary policy.

Another structural feature of the Fedwire system—the fact that the system provides finality—increases the likelihood that credit will be extended. This is, once a Fedwire transaction is initiated and accepted by the Federal Reserve into the system for electronic processing, the receiving bank is granted immediate use, and an irrevocable claim, on the funds (regardless of whether the sender ultimately defaults). In this respect the Fed interposes itself between the two parties to the transaction, as do many other clearing and settlement institutions such as futures and options exchanges, increasing its exposure to credit risk.

Not all payments systems have finality; some of those that do, do not necessarily have absolute credible finality (only central banks can create riskless money assets in unlimited amounts). Again, a useful example can be taken from the United States. The other major wholesale dollar clearing system in the U.S. is CHIPS, the large-dollar clearing and settlement system owned by major New York money center banks and operated by the New York Clearing House Association. Until recently, CHIPS did not provide finality. Failure to settle on the part of a system member meant that transactions involving the defaulting party would have to be unwound, and in the extreme, potentially all transactions would have to be unwound. Because of the extreme number and volume of transactions which flow through CHIPS every day, unwinding the failure of a participant to settle could put other institutions in extreme deficit positions which might not easily or quickly be settled. The result could unwittingly transmit a problem in one institution to others in the system, resulting in a systematic risk problem. The only recourse to affected institutions would be to seek emergency loans or to discount assets with the Federal Reserve. This makes the Federal Reserve the backup source of liquidity and lender of last resort to CHIPS, even though it does not run or is not directly involved with CHIPS, except to allow settlement through a reserve account at the Federal Reserve Bank of New York {Clair (1991)}.

Concern for the systematic risks inherent in the structure of CHIPS lead participants to institute payments finality. To provide the necessary resources to make the promise of finality credible, loss-sharing arrangements among members were instituted in the form of posting of collateral sufficient to cover an institution's maximum net debt exposure. On the one hand, the result is to use finality to avoid the need to unwind transactions in the event of a settlement failure, but it also ties the fate of all member institutions to the overall health of the system, and potentially increases the member institutions' exposure to catastrophic systematic risk, to the extent that posted collateral may not be sufficient to cover actual losses. The effects of this change on member incentives to limit risk or to engage in moral hazard behavior to shift even greater burdens to the Federal Reserve remains to be seen.

Whether CHIPS finality is credible, is open to question; it is inconceivable that the member institutions would, in the extreme, all go out of business to meet their commitments. Rather, the more likely scenario is that institutions facing default would turn to the Federal Reserve as lender of last resort. It is this problem that makes central banks the lenders of last resort to all payments systems, and raises the issue of whether and to what degree they are subject to moral hazard and adverse selection behavior during times of crisis and fragility.

As markets have become increasingly global, timing differences and differences in clearing and settlement conventions can add temporal and other dimensions to credit risks not always found in domestic markets. This was clearly demonstrated in 1974, when Herstatt bank failed and was closed by German authorities. The bank had entered into agreements to exchange marks for dollars. The mark leg of the transactions were settled, but the dollar portions were not settled in New York at the time Herstatt was closed, since the deadline on CHIPS for final settlement was about 4:30 PM Eastern Standard time. {Walmsley (1985)}. This left the counter-parties to the foreign exchange transactions thinking that they had more funds than they did. When the dollar transactions failed to settle, large losses to counter-parties resulted. This temporal dimension to credit/systemic risk has come to be known as "Herstatt Risk" and can be vary large. A more recent example is provided when BCCI (Bank of Credit and Commerce International) was closed in 1991. The industrial Bank of Japan had paid 44 billion yen into BCCI's branch in Tokyo, for which payment was to be received in New York from BCCI's New York Branch. When BCCI was closed, the dollar portion of the transaction was never completed, Industrial Bank of Japan became creditor for \$30 million {BIS (1993a,b,c)}. To some, this may look like ordinary credit risk, which indeed it is. But its incidence is determined by the intervention policies pursued by the regulatory authorities, whose actions cannot be easily predicted or priced. Simmers (1991) indicates that settlement of foreign exchange transactions originating in the Far East may be delayed in settlement through CHIPS by as much as 14 hours and amount to as much as \$425 billion dollars.

The losses to dollar counterparties in the Herstatt case were the consequence of the German authorities' timing of the closure of the institution rather than to the realization of estimable default risk. Had the authorities waited until the U.S. dollar markets had settled, then the losses to those expecting dollar transfers would not have occurred. Such exposure is better characterized as settlement uncertainty rather than settlement risk, since it is not possible to reliably estimate and cost out the implications of regulatory actions and policies.

Herstatt-type risk can also be involved in solely dollar clearing system. In Asia, through its Tokyo branch, the Chase Manhattan Bank operates a dollar clearing and settlement service which offers finality and limited overdrafts and is guaranteed by Chase. Participants are permitted to settle these overdrafts in New York across the Tokyo/New York business day. Furthermore, Tokyo balances at the end of the day may be transferred to New York, either through the New York offices of Chase or Tokyo banks or through CHIPS. In this case, problems in this satellite settlement and clearing system, quickly have the potential to transmit liquidity and credit risk from Asia to New York, and ultimately to the Federal Reserve, if it affects either CHIPS, Chase, or significant New York correspondents. A failure to settle in New York on payments guaranteed in Japan by Chase would create a form of Herstatt risk that would end up having to be resolved in New York. How problems in this system might be handled is uncertain. Moreover, there has been little discussion of how the problem of the failure of one institution to settle would cause a ripple effect across many institutions. At present, concern flows from the sheer size of the potential losses rather than from an understanding of well-articulated scenarios. Furthermore, regulatory agencies have sometimes played on the fears that these potential losses represent in seeking to increase their regulatory scope.

Many other significant sources of uncertainty can also be identified in the clearing and settlement processes in modern financial market. For example, when clearing and settlement of financial assets are separated, a given country's rules usually establish the exact point in time that a transaction has been completed. The issue centers around transaction finality and the legal criteria for when debts are discharged and who bears the losses in the event of default. Finality usually occurs when the party selling the assets actually has "good funds," and may or may not correspond to the time that the sender has actually settled. For example, because Fedwire provides finality, acceptance of payment order "guarantees" the receiver "good funds" and discharges the debt, since the sender's reserve account is debited and the receiver's bank's account is credited, even though the sender's bank may default on the settlement of its reserve account with the Fed at the end of the day. When the institutions are located in two separate countries, then transactions can sometimes be governed by the laws of two separate countries, and, if transactions involve clearing houses, the laws where they are located.

The issue can quickly become murky, however, when one starts to examine the problems involved in settlement failures in bilateral and multilateral netting arrangements—especially those involving forward dated contracts, such as foreign exchange, derivatives, other cross-border markets. Final disposition of the liability depends critically on the legal rules governing the disposition of debts and transaction in the event of a default or bankruptcy {Mengle (1990)}. For example, if two institutions have entered into a bilateral netting arrangement, then completion of all the transactions subject to the arrangement depends upon settlement of the net position. If one of the parties fails to settle because of a bankruptcy, then all the gross transactions subject to netting may have to be undone, depending upon the legal rules affecting the markets in which the transaction was settled. Since the legal rules may differ depending upon where settlement takes place, and this may be beyond the receiver's control, significant settlement uncertainty may exist.

The exact status of these transactions, therefore, depends upon several sets of laws: those governing bilateral netting arrangement, those governing the particular settlement market involved, and the bankruptcy provisions and other related laws of the country of the failed institution (and/or the laws of the resident country if the transaction is recorded on the books of a branch of the failed bank). For example, netted transactions may, or may not be regarded as discharged. Thus, the bankruptcy court may decide to unbundle netted transactions, demanding payment for debts owned and disavowing liabilities to creditors. In addition, country bankruptcy law may give creditors the right to offset their liabilities to a failed entity against their claims on that entity. Thus, debts owned on foreign exchange may be discharged with debts on securities, loans, or any other assets. Not only do these bankruptcy laws affect the losses, but also how the losses may be apportioned across various creditors. The legal situation in multilateral netting arrangements introduce complexities several orders of magnitude greater than those affecting bilateral arrangements { Juncker, Summer, and Young (1991)}.

There is considerable variation across countries in the treatment of transactions; and thus uncertainty exists about how particular bankruptcies will be treated. This uncertainty undermines the risk-reducing potential of bilateral and multilateral netting arrangements, and creates the very real possibility that systemic risks could be heightened rather than reduced when the laws governing netting are uniform across countries {BIS (1990), Cohen and Roberds (1993)}. The uncertainties associated with their resolution make it virtually impossible in today's environment to reliably assess the likely outcome of a default scenario for many transactions {Knight (1971)}.

Private sector responses to risk and uncertainty

Private sector entities have responded to the increased uncertainties, market risks and evolving market technologies in many interesting ways. The responses involve (1) contract design, (2) the micro market structure of exchanges and their rules governing transactions, (3) private proposals to change laws governing transactions, and (4) suggestions to increase governmental cross-border cooperation in financial rules, regulation and supervision {Smith and Lippin (1994), Kane (1991)}.

Given the complexity of financial transactions and their inter-relationships, there are significant problems in measuring, monitoring, and pricing what institutions' true risk exposures are to each other and how risks flow directly and indirectly through relationships with related customer groups. For example, customer *X* may have several relationships with its primary bank (bank A). This might include a loan, a swap, a deposit account, and several foreign exchange transactions, etc. Customer *X* may also have similar relationships and transactions outstanding with bank B. In addition, bank A may also have made loans in the form of advancing fed Funds to bank B. If customer *X* fails, the entirety of its net position with bank A across all the relationships and transactions represent its net direct risk exposure. Bank A may also be indirectly exposed through bank B, if the customer's default causes bank B to default on its Federal Funds obligations to A's primary bank. Measuring and monitoring these interrelated exposures across the world and across different markets is truly a daunting modeling and monitoring problem, made even more so by the dynamic and continual evolution of new instrument and markets.

The private sector responses to these risk measurements and monitoring of payments risk-exposure have attempted to substitute rules and other mechanisms to control customer risk-taking incentives. Actions have involved cooperatively owned clearing and settlement systems and responses by individual participants as well. Control mechanisms include maintenance of adequate capitalization, reliance upon contract design to allocate risk and losses, collateralization of transactions, use of outside guarantees and bonding, pricing, imposition of system membership requirements, and other limits on risk exposure to individual and related parties. These responses may be viewed as attempts to limit uncertainty and to provide incentives for member institutions to control their own risks exposures.

For example, a great deal of attention has been paid to the process concerning the structure of payment orders and to contract design as methods of reducing payment system uncertainty regarding the legal status of various transactions in the event of default. In netting arrangements, especially when dealing with customers with large numbers of transactions and different types of credit and other relationships with a bank or other payment system participant, institutions have employed rules to define rights of setoff, defining collateral in the case of collateralized transactions. Netting by notation, for example, is one contract feature that explicitly specifies that parties discharge all their obligations to each other by transferring only the net amount due. Netting by notation replaces two existing contracts for delivery of an asset on the same day with a single net contract for that date. Similarly, another contract provision that has evolved is a close-out provision. A closeout provision becomes effective in bankruptcy and defines a formula which will convert outstanding transactions into an immediately payable amount. This would include all future date futures, options, forwards, and other future liabilities. So important are these contract provisions and their design for netting arrangements, that Gilbert (1992) notes that in the U.S., a private sector firm provides legal advice and communications specifically addressing netting arrangements. (and many laws firms provide similar services as well.)

While attention to contract design is necessary, without defaults and continual testing of contract features in the courts, reliance upon contract design to provide needed risk control and protection may tend only to mask the true uncertainties and losses for which members are potentially liable.

Second, private sector contracting activities also focus on apportioning risks, defining performance, and allocating losses among participants in a payments system or exchange in the event that a default occurs. These provisions can take many forms. For example, in CHIPS, unwinding was a way of apportioning losses ex post other participants in the system. Agreements are executed, however, that make system participants liable for portion of losses if problems arise. CHIPS has abandoned unwinding as a loss apportionment mechanism and has substituted apportioning losses through collateralization of exposures. Such collateralization provides incentives for members to control and monitor their own exposure to other clearing house members so as to protect their collateral.

Third, private sector entities also impose various types of memberships and participation requirements. In futures exchanges, for example, members are required to post collateral in the form of maintenance margins and initial margins. Additional constraints include membership requirements, minimum capital requirements, and collateralization and backup lines of credit. All of these rules impose costs on members which attempt to internalize the costs of risk to the system and its members.

Finally, recognized accounting rules can impact the ease of information transfer and reduce monitoring costs. Most futures exchanges require that transactions be marked to market and that any deficiencies in coverage as the result of price or interest rate movements be made up with immediately available funds. Again, for systems which operate continuously, this is equivalent to requiring that good funds be posted continuously. Uniform accounting, especially market-value reporting, increasingly have become recognized as an important component of effective risk control systems {Gilbert (1992), Cohen and Roberds (1993)}.

Conclusions: Responses to risk and uncertainty

Perhaps one of the more interesting developments in this evolution of regional and globalized payments markets in both the public and private sectors has been the push towards real-time gross settlement systems with collateralization. This applies to both private systems and publicly run systems. Nowhere are these efforts more apparent than in Europe where the struggle to create a single financial market place has focused attention and generated analyses of the underlying issues, with the Group of Ten, and EC central banks spearheading much of this work (BIS 1990, 1993a, 1993b).

At the market level, the process of financial integration suggests that as the barriers to real production within Europe break down and as financial institutions operate branches throughout Europe, more and more of the domestic payment and financial markets will have cross-border attributes. Hence, the EC central banks have paid particular attention to the structure and operations of cross-border and multi-currency netting and settlement schemes. Table 4 lists the key attributes that the EC committee have put forth. It is interesting the Committee gives heavy weight to getting "legal situation" right. Yet, the evidence and analysis suggests that infrastructure differences from different legal environments are of paramount importance in introducing uncertainty in payments system operations.

Casual empiricism suggests several reasons why the systems are evolving in this direction, despite considerable analysis suggesting that netting arrangements are both more efficient and involve less potential risk. The first reason is that systems, instruments, and financial markets are evolving faster than the political entities can harmonize or bring their various rules and regulation into harmony {Kane (1991)}.

Second, harmonizing systems to control effectively the systemic risk (such as Herstatt risks) inherent in non-synchronized clearing and settlement systems, such as foreign exchange markets, even if all the legal rules are in place, requires complete international coordination and cooperation when payment system principals enter bankruptcy. That is, unless all markets are open 24 hours, Herstatt risk will still be an important consideration. Such coordination and cooperation is far from certain, and is clearly not in place.

Third, central banks realize that regardless of the explicit rules governing exchanges, they still may be thrust into the role of the 'lender of last resort,' should major participants get into financial difficulties which threaten to bring down settlement and clearing systems. This potential exposure is not only large, but also often outside of central bank jurisdiction and control. For example, in the U.S., despite all the cross guarantees, etc., the Federal Reserve is the residual bearer of risk for CHIPS participants. Interestingly, while the Fed can examine domestic banks many of the CHIPS members and indirect participants are foreign institutions, over which the Fed has no authority or jurisdiction. These institutions can potentially, through default, shift CHIPS system problems to the Fed. This potentially exists across all major markets in which U.S. banks participate, and carries the same types of implications for the Fed and U.S. taxpayer.

Finally, the movement towards expanding the overlapping hours that exchanges are open will increasingly make the operation of net settlement systems more difficult. For example, in the extreme, as markets evolve towards 24-hour operations, agreement upon the exact number of times and when net settlement will be posted becomes an arbitrary, and essentially unnecessary, complication vis-a-vis real-time gross settlement systems. In addition, as the pace of technology continues to expand computer storage and processing capacities, the costs/benefits to netting become less and less. With billions of transactions being moved at virtually the speed of light, the marginal benefits of netting seem to be declining at an exponential rate.

Table 4. Minimum standards for the design and operation of cross-border and multi-currency netting and settlement schemes

Attributes
I. Netting schemes should have well-founded legal basis under all relevant jurisdictions.
II. Netting schemes participants should have a clear understanding of the impact of the particular scheme on each of the financial risks affected by netting process.
III. Multilateral netting systems should have clearly defined procedures for management of credit and liquidity risks which specify respective responsibilities of the netting provider and participants. These procedures should also ensure that all parties have both the incentives and capabilities to manage and contain each of the risks borne, and that limits are placed on the maximum level of credit exposure with the largest single net-debit position.
IV. Multilateral netting schemes should, at the minimum, be capable of ensuring the timely completion of daily settlements in the event of an inability to settle by the participant with the largest single net-debit positions.
V. Multilateral netting schemes should have objective and publicly disclosed criteria for admission which permit fair and open access.
VI. All netting schemes should ensure the operational reliability of technical systems and the availability of backup facilities capable of completing daily processing requirements.

Source: BIS 1993b

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