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Risk Management by Securities Settlement Agents

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RISK MANAGEMENT BY SECURITIES SETTLEMENT AGENTS

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A securities settlement system is the combination of a securities transfer mechanism and funds transfer mechanism for accomplishing security purchase and sale agreements. By providing for the efficient and safe exchange of assets for funds, settlement systems reduce the costs of securities transactions, thereby promoting capital formation.[1] Especially for developing countries seeking to facilitate aggregate capital formation through the establishment of organized exchanges, well-defined settlement infrastructures are of critical importance.

This article explores the management of the risks endemic to the settlement process. We begin with a discussion of the primary types of risk facing settlement-system participants. Next, we explore whether settlement risk management is justified in the context of the theory of value-maximizing organizations. We conclude by explaining why, in the absence of appropriate forward-looking *measures* of risk, conventional settlement risk control mechanisms such as position limits may be inefficient and result in significant misallocations of capital.

SETTLEMENT IN SECURITIES MARKETS

After a securities purchase or sale agreement has been consummated—whether on an organized exchange or over-the-counter—the transaction enters the "settlement cycle," beginning with a confirmation of trade terms and ending with the transfer of security ownership and funds.[2] To achieve final settlement, both the securities and funds transfers must be "irrevocable" and "final."[3]

A "settlement system" is the mechanism by which securities and funds transfers discharge the obligations created by securities trading. To accomplish this, settlement systems include an operational infrastructure (consisting of, among other things, computer systems for processing settlement instructions) and a set of "rules" governing the functioning of the system (such as those governing the timing of settlement instruction processing). Virtually all industrialized countries have at least one settlement system for each of their major national markets.

In most developed countries, settlement occurs on a "rolling" basis in which trades settle several days following the trade date.[4] The number of days by which

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1. *See* David A. Walker, "Costs, Benefits and Beneficiaries," in *Proceedings of a Conference on Clearance and Settlement Systems* (The Group of Thirty, March 1990).

2. For a more detailed discussion of the settlement cycle, *see* Morgan Guaranty Trust Company of New York, "Cross-border Clearance, Settlement, and Custody: Beyond the G30 Recommendations" (June 1993) (hereinafter "MGTCNY"), and Christopher L. Culp and Andrea M.P. Neves, "Risk Management by Delivery-Versus-Payment Agents in Securities Settlement Systems," Working Paper, Graduate School of Business, The University of Chicago (June 1997).

3. For a discussion of finality in funds transfers, *see* Hans J. Blommestein and Bruce J. Summers, "Banking and the Payment System," and Paul Van den Bergh, "Operational and Financial Structure of the Payment System," both in *The Payment System: Design, Management, and Supervision*, B.J. Summers, ed. (1994), and Bank for International Settlements, "Payment Systems in the Group of Ten Countries" (1993).

4. For a discussion of rolling settlement and other settlement regimes, *see* The Group of Thirty, "Clearance and Settlement Systems in the World's Securities Markets" (March 1989) (hereinafter "G30").

final settlement follows trading is *fixed*, resulting in settlements occurring on every business day. For example, if a system specifies rolling settlement within five business days of the trade date (hereafter referred to as "T+5"), participants will issue securities and funds transfer instructions on date T+5 for the settlement of trades made on date T. This way, trades on Monday are settled the following Monday, trades on Tuesday are settled the following Tuesday, and so on.[5]

Types of Settlement Risk

In a rolling settlement system, the time lapse between trade date and final settlement creates "settlement risk." Losses can occur if one party to a trade defaults *after* the trade date but *before* final settlement. In this case, there are three major types of settlement risk: principal, replacement cost, and liquidity risk.[6]

Principal Risk. Principal risk is a type of credit risk arising from the possibility of a loss of principal on a transaction, either on the funds or securities side. No matter how long the settlement cycle, principal risk occurs only at the actual time of final settlement. Specifically, a loss may occur if a non-defaulting firm makes an irrevocable and final securities delivery (payment) but receives no corresponding funds (securities) transfer. In other words, the solvent broker discharges its own obligation, but its counterparty defaults *before* paying or delivering securities.[7]

Replacement Cost Risk. A second type of credit risk, known as replacement cost risk, stems from the possibility that a default may deprive the solvent firm in a transaction of any unrealized gains that have occurred since the time of trading. The replacement cost of a security is the price at which a trade can be replaced in the market if the original transaction goes into default. This cost is equal to the *difference* between the original trade price and the price at which the non-defaulting firm can re-establish its position if a counterparty defaults. The *buyer* of a security faces replacement cost risk only after a price *increase*; in that event, the buyer must enter into a new purchase agreement at a higher price than it would have paid for the security in the original transaction. Conversely, the *seller* faces replacement cost risk only after a price *decline*.

Unlike principal risk, replacement cost risk depends on the length of the rolling settlement window. A longer settlement cycle not only implies a longer period over which unrealized gains may accumulate, but also more open, unsettled positions in the settlement cycle. In a T+1 system, for example, positions are open and unsettled for only one day. A T+5 system, by contrast, involves six days worth of trades in the settlement cycle on any given day. Long settlement cycles thus are associated with greater replacement cost risks.[8]

Liquidity Risk. Liquidity risk originates from a party's lack of funds or securities *at the time they were anticipated*. This may be caused by an actual credit default (*i.e.,* the failure of a counterparty to discharge fully its obligations on a transaction) *or* by a "failed transaction." A failed transaction occurs when a counterparty does not settle funds or delivery obligations *on time*, although the transaction may be settled in full later. Failed transactions often occur for purely operational reasons—for example, a funds transfer instruction is not processed because funds are on deposit in the wrong account of a broker's settlement bank.[9]

Liquidity risk can affect both the non-defaulting firm and the perpetrator of a failed transaction. Problems can arise for the solvent broker when it needs securities or funds at a specific time and does not receive them. This may precipitate defaults or failures on other transactions, resulting in a domino effect that ends with real financial losses—even if the original settlement failure occurred for purely technical reasons.[10]

5. In 1989, The Group of Thirty issued an important report with several recommendations for improving settlement in major national securities markets. One recommendation was that all markets adopt rolling settlement by T+3 no later than 1992. *See* G30, cited previously. For reviews of how major markets around the world have responded to the G30's report, *see* The Group of Thirty, "Clearance and Settlement Systems Status Reports" (Autumn 1992).

6. Other risks in the settlement process are described in MGTCNY, cited previously, and Culp and Neves, cited previously.

7. Principal risk is sometimes called "Herstatt risk," named for the large foreign exchange losses that occurred when Bankhaus Herstatt failed in Germany in 1974. *See, for example,* The Group of Thirty, "Global Institutions, National Supervision, and Systemic Risk" (1997).

8. Because rolling settlement spreads out settlements across all business days, settlement congestion is ameliorated and, hence, *principal* risk is less in such systems than in settlement schemes where trade settlement is concentrated at particular times and on particular days. The tradeoff, however, is greater *replacement cost* risk. *See* G30, cited previously.

9. A settlement bank is a bank that maintains funds accounts on behalf of brokers and settles their funds transfers when required.

10. Such liquidity risk may be especially problematic on "back-to-back" transactions in which a party agrees to buy securities from one counterparty in order to sell them to another counterparty. In that case, a failure of the first counterparty to deliver stock will make it impossible for the intermediary firm to honor its obligation on the stock sale to the second counterparty unless the firm in the middle of the back-to-back transaction has an inventory of that particular stock issue on hand. *See* MGTCNY, cited previously.

For the perpetrator of a failed transaction, liquidity risk may result even if the firm is solvent. If its counterparties cannot distinguish an operational problem from a potential insolvency, the responsible party could experience a confidence crisis in which other firms stop trading with it because they fear the firm *might* be insolvent. Credit-sensitive transactions with call or early termination provisions may be automatically declared in default after a failed transaction, even when the perpetrator still is financially viable.[11] In that manner, a liquidity crisis can turn a sound company into an unsound one rather quickly.

Settlement Agents and the Delivery-Versus-Payment Principle

Virtually all settlement systems around the world are operated by a settlement system "provider." Examples of settlement system providers include the National Securities Clearing Corporation, which clears U.S. corporate securities,[12] CRESTCo., which settles London Stock Exchange-listed equities, and CEDEL and Euroclear, which clear cross-border securities transactions.

More than just enterprises that supply technology to facilitate the processing of funds and securities transfer instructions, such settlement system providers typically act as settlement *agents* to implement the "delivery-versus-payment" ("DVP") principle. Under the DVP principle, some entity acts as a third-party transfer agent in all securities transactions, ensuring that security ownership does not change until payment has been effected by the buyer of a security.[13]

Settlement agents may play one of two DVP roles in a settlement system. In some systems, the DVP agent acts only as a transfer agent and assumes no legal responsibility for the discharge of trading obligations. In other schemes, the settlement agent acts as a central counterparty, assuming the obligations of both sides of all transactions.[14]

Risk-Bearing and Loss Allocation. The main purpose of a DVP agent is to minimize *principal* risk by ensuring that payment occurs only after securities are delivered, and vice versa. Replacement cost risk and liquidity risk, however, are not eliminated by the presence of a DVP agent. Even a central counterparty-based settlement system must specify a "loss-sharing" mechanism, or a scheme by which any clearing and settlement losses initially borne by the DVP agent are eventually allocated across various participants in the settlement system.

In central counterparty arrangements, the DVP agent that guarantees all trades assumes all credit risk. A default to the DVP agent thus does not remove the settlement agent's obligation to honor the other sides of the defaulted transactions.[15] How the DVP agent allocates credit losses, however, depends on the particular system. In some cases, the DVP agent absorbs the loss using some combination of shareholder equity, a participant pay-in capital fund, and soft-capital insurance policies. In other cases, the DVP agent may adopt more of a "futures-like" loss-sharing arrangement in which all participants in the system bear a *pro rata* share of any credit losses.[16]

WHY SHOULD THE DVP AGENT MANAGE RISK?

For the remainder of this article, we consider settlement systems in which DVP agents act as central counterparties in the settlement process.[17] Most such DVP agents are corporations owned by the exchange(s) on which transactions settled and guaranteed by the DVP agent occur. In other cases, ownership lies with the settlement banks that maintain brokers' funds accounts and provide the associated funds transfer services in the settlement process. DVP agents thus are "financial mutuals"—that is,

11. Derivatives contracts typically include early termination features which can give rise to this type of liquidity risk following a failed transaction. *See* the detailed discussion in Christopher L. Culp and Barbara T. Kavanagh, "Methods of Resolving Over-the-Counter Derivatives Contracts in Failed Depository Institutions: Federal Banking Law Restrictions on Regulators," *Futures International Law Letter* Vol. 14 Nos. 3-4 (May/June 1994):1-19.

12. In the United States, the Depository Trust Company also plays a role in providing a settlement system. Nevertheless, 95 per cent of corporate security trades between brokers and dealers are cleared and settled by NSCC. *See* David M. Kelly, "USA III," in *Proceedings of a Conference on Clearance and Settlement Systems* (The Group of Thirty, March 1990).

13. *See* Bank for International Settlements, "Delivery versus Payment in Securities Settlement Systems" (September 1992) (hereinafter "BIS").

14. *See* G30, cited previously, and BIS, cited previously.

15. In principle, the assumption of all *credit risk* by the DVP agent also eliminates the possibility of most *liquidity risk*, as well, unless the DVP agent itself becomes cash constrained.

16. Futures-style loss-sharing mechanisms are reviewed in William J. Hanley, Karen McCann, and James T. Moser, "Public Benefits and Public Concerns: An Economic Analysis of Regulatory Standards for Clearing Facilities," Working Paper, Federal Reserve Bank of Chicago WP-95-12 (September 1995). *See also* G30, cited previously.

17. Actually, much of what we say does not depend on this assumption and also applies to DVP agents acting purely as transfer agents. We make this assumption just to keep the discussion clear.

In some systems, the DVP agent acts only as a transfer agent and assumes no legal responsibility for the discharge of trading obligations. In other schemes, the settlement agent acts as a central counterparty, assuming the obligations of both sides of all transactions.

organizations whose residual claimants are *also* the primary customers/users of the enterprises.[18] As Eugene Fama and Michael Jensen have argued about mutuals, it makes sense to view DVP agents as value-maximizing corporations.[19]

Under the assumptions of the Modigliani-Miller ("M&M") capital structure irrelevance propositions, risk management is an activity to which residual claimants of value-maximizing companies should be indifferent.[20] At least one M&M assumption thus must be violated to justify formal risk management by a value-maximizing DVP agent. As explained below, the M&M assumption of costless and symmetric information is routinely violated in settlement systems.

Asymmetric Information and Risk Management

Informational asymmetries suggest that risk management by central counterparty DVP agents is appropriate for several reasons. Most obviously, the DVP agent has unique access to information about *all* participants in a settlement system—and, hence, to the risk exposures of participating brokers. With proper risk measurement and monitoring, the DVP agent has a bird's-eye perspective on the aggregate exposures of all participants that any single broker may be lacking.[21] In addition, liquidity risk is inherently *correlated* across participants, requiring a perspective beyond the firm-level for monitoring and risk control. The DVP agent thus has some comparative advantage in information acquisition and analysis, making it a natural "delegated monitor" of credit and liquidity risk within a settlement system.

Additionally, the mutualization of transaction-specific losses in central counterparty systems implies that brokers participating in such systems have limited incentive to analyze judiciously the credit risk of their trading counterparties. Without risk management undertaken by the DVP agent, the securities settlement process can be plagued by the same moral hazard and adverse selection problems that arise as a matter of course in virtually all insurance markets.[22] Moral hazard stems from the fact that participants in the process are assured that all losses will be borne *jointly* by all participants, thus discouraging any particular broker from engaging in costly bilateral credit risk evaluations. Similarly, adverse selection occurs as firms with higher-than-average credit risk opt into the loss-sharing scheme to take advantage of the cross-guarantee.

Common Risk Mitigation Mechanisms

To mitigate moral hazard and adverse selection problems, DVP agents today adopt standards and risk mitigation policies that apply to all firms with access to their settlement systems. These include capital and collateral requirements, and exposure limits.[23]

Capital Requirements. Minimum levels of capital adequacy may be specified by the DVP agent for participating firms, thus mitigating credit risk by restricting entry into the system.[24] In addition, central counterparty DVP agents often create "guaranty funds" intended both to provide a temporary liquidity support facility *and* to absorb and allocate actual credit losses across brokers. Although such guaranty funds may be supplemented with soft capital facilities (such as insurance policies), pri-

18. We are here following the terminology of Eugene Fama and Michael Jensen, who pioneered a system of classifying organizations based on the structure of their residual claims and the separation of their ownership from control. Financial mutuals are one of Fama and Jensen's four types of organizations; the others are "open corporations," "closed corporations," and "non-profits." *See* Eugene F. Fama and Michael C. Jensen, "Agency Problems and Residual Claims," *Journal of Law and Economics* Vol. 26 (1983):327-49; Eugene F. Fama and Michael C. Jensen, "Separation of Ownership and Control," *Journal of Law and Economics* Vol. 26 (1983):301-25, and Eugene F. Fama and Michael C. Jensen, "Organizational Forms and Investment Decisions," *Journal of Financial Economics* Vol. 14 (1985):101-119.

19. *See* Fama and Jensen, cited previously, and Eugene F. Fama, "The Effects of a Firm's Investment and Financing Decisions on the Welfare of Its Security Holders," *American Economic Review* Vol. 68 No. 3 (1978):272-84.

20. The M&M propositions are an immediate implication of equilibrium in a perfect capital market. For a discussion, *see* Fama, cited previously, and Merton H. Miller, "The Modigliani-Miller Propositions After Thirty Years," *Journal of Economic Perspectives* Vol. 2 No. 4 (Fall 1988):99-120. The relations between perfect capital market assumptions, the M&M propositions, and corporate hedging are explored in Christopher L. Culp, Dean Furbush, and Barbara T. Kavanagh, "Structured Debt and Corporate Risk Management," *Journal of Applied Corporate Finance* Vol. 7 No. 3 (Fall 1994):73-84.

21. The main reason that the M&M assumptions imply the irrelevance of risk management by corporations is that shareholders can diversify away risks on their own. That assumes, of course, that shareholders *know* the risks to which they are exposed, which is not usually the case for residual claimants on central counterparty DVP agents.

22. Michael Rothschild and Joseph Stiglitz, "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information," *Quarterly Journal of Economics* Vol. 90 (1976):629-50.

23. Other risk control mechanisms (*e.g.*, real-time monitoring of trading activities and periodic resettlements of open positions) are discussed in Culp and Neves, cited previously.

24. Several recent regulatory initiatives around the world have attempted to mandate "equal access" for all brokers to settlement systems. This will *greatly* restrict the ability of financial exchanges and DVP agents to control default risk by restricting entry using minimum capital or other requirements, making the other risk mitigation mechanisms discussed here even more relevant.

mary funding typically comes from deposits of capital or guarantees by broker participants in the settlement system. Consequently, the temptation is removed for firms to incur huge risks and "walk away" from their losses (a form of moral hazard) or to exploit the cross-subsidy of the loss-sharing regime (adverse selection).[25]

Collateral Requirements. Most settlement systems involve some collateral requirements imposed on participants either by the DVP agent or by settlement banks. Such requirements result when the settlement system involves an extension of credit (securities or funds) by the DVP agent, settlement banks, or other lenders. The amount and type of credit inherent in a securities settlement system depends on the timing of security and funds transfers. Some settlement systems involve simultaneous securities and funds transfers (whether in real time or batched periodically),[26] whereas others involve intra-day security transfers and end-of-day funds settlement. [27] Also relevant is the "netting scheme" of the system. Netting refers to the means by which multiple funds or securities transfer obligations between brokers are offset. In a gross settlement system, each transaction is settled separately, whereas a net settlement system may involve the netting of funds and/or securities settlement obligations.[28]

Extensions of securities and funds credit are common in two particular types of settlement regimes. When gross settlement in securities and funds occur at the same time and at the end of the settlement day, the DVP agent or a settlement bank may extend credit to promote liquidity and mitigate the number of failed transactions. Without such extensions of funds and securities credit, firms selling securities would have to maintain positive *intra-day* securities holdings and purchasing brokers would have to "pre-fund" all their sales. Otherwise a transaction could fail because of a net debit in securities or funds accounts at the time the settlement instruction is issued. Although loans are useful for mitigating such failed transactions, the resulting credit risk must be addressed through mechanisms such as collateral requirements.[29]

Collateral requirements also are commonly used in systems where finality for funds transfers is earlier in the day than finality for securities transfers. In that case, *next-day funds* must be used to settle securities transfers instead of *same-day funds*. In other words, settlement banks effectively extend overnight credit to brokers purchasing securities and allow those brokers to take ownership of securities before payment finality is achieved. In such situations, collateral is often required against the overnight extension of credit.

Position and Net Debit Limits. Limits can be an effective risk mitigation mechanism in settlement systems and may include open position limits or securities and cash net debit limits. Position limits are directed at the securities transaction level and are intended to ensure that defaulting firms do not accumulate positions that may end up unsettled. The larger the position of a defaulting firm in a particular security, after all, the larger the credit risk associated with the failure of the firm.[30] Such limits also help ensure that failing firms do not establish large amounts of proprietary positions in a desperate act to save themselves—the *classic* illustration of moral hazard.

Net debit limits are intended to prevent the DVP agent from incurring large *intra-day* or *overnight* obligations either in securities or in funds. In systems for which next-day funds are used to settle securities purchases, net debit caps often accompany or replace collateral requirements on overnight extensions of credit.

Net debit limits may be enforced for net debits to the DVP agent and/or may apply to *bilateral* counterparty and settlement bank credit exposures. Intra-day limits on net debits in securities and funds accounts with the DVP agent are intended to mitigate intra-day credit risk borne directly by the DVP agent. Bilateral net debit limits, by contrast, are designed to control principal and liquidity concentrations between any two brokers or settlement banks.

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25. Walk-aways are further discouraged by segregating common capital pools into broker-specific tranches. If Broker A fails, for example, the capital in Broker A's tranche is applied *in full* to the funds deficit or to the security purchase by the DVP agent that the default has necessitated. Other brokers' tranches are then accessed on a *pro rata* basis to cover the *remainder* of the funds deficit or to fund the *residual* amount of the defaulted securities *after* Broker A's tranche is exhausted.

26. Even simultaneous securities and funds transfers may not be *truly* simultaneous, however, because payments finality is not achieved in most countries until the end of the day when settlement banks' central bank balances are debited and credited. *See* Blommestein and Summers, cited previously, and Van den Bergh, cited previously.

27. For a discussion, *see* BIS, cited previously.

28. *See* Bank for International Settlements, "Report on Netting Schemes," (February 1989).

29. *See* Group of Thirty, cited previously, and MGTCNY, cited previously.

30. Larger obligations to the settlement agent do *not* necessarily imply greater liquidity risk, however, because the broker may have offsetting exposures in other settlement systems or in off-exchange contracts.

The goal of risk management is to ensure that the risks to which a settlement agent and its residual claimants *are exposed* are those risks to which the agent's shareholders *think they are* and *want to be* exposed.

THE DESIGN OF RISK MANAGEMENT PROGRAMS AT DVP AGENTS

The biggest problem with extant capital and collateral requirements and limits is that they often are *set* based on relatively arbitrary criteria that may have no relation to the actual replacement cost, principal, or liquidity risk of the transaction, portfolio, or participant on which they are imposed. This highlights a major shortcoming in the current state of risk management at DVP agents. Specifically, most DVP agents today do not have *integrated, comprehensive* risk management processes that emphasize and rely on forward-looking *measures of risk* for individual brokers and across brokers.

Risk Measurement in a Comprehensive Risk Management Process

The process of risk management is a dynamic one in which various risks are identified, measured, monitored, and controlled. The goal of such a process is to ensure that the risks to which a settlement agent and its residual claimants *are exposed* are those risks to which the agent's shareholders *think they are* and *want to be* exposed.[31]

As noted, the identification and control of risks by DVP agents is accomplished principally through *ex ante* requirements concerning participants' capital, collateral, and net debit positions. To the extent such requirements are linked to risk measurements, DVP agents usually look only at *current* exposures of settlement system participants—that is, the value of a default if that default occurs *precisely at the time the exposure is measured.* In the absence of explicit links between a more *forward-looking* measure of risk and risk control, however, the settlement process actually may distort the capital formation process that settlement systems are intended to promote.

At one extreme, central counterparty DVP agents may set capital requirements and limits so high that losses are virtually impossible. In consequence, however, far more capital is required than justified by the risk of actual exposures, resulting in a misallocation of that capital.[32,33] At the other extreme, requirements that are too liberal may encourage moral hazard and adverse selection, again resulting in a capital misallocation.[34]

Risk measurement is the quantification of credit and liquidity risk facing the DVP agent's shareholders or participants in the settlement process and loss-sharing mechanism. Any well-designed risk measurement system should be capable of measuring risk using a means that can be linked meaningfully to risk control mechanisms such as limits. Rather than just quantifying *current exposures*, risk measures thus must characterize the *potential* exposure of the DVP agent over a particular period of time.

Any useful summary risk measure must have its roots in probability theory. Measures of risk useful for facilitating risk control thus must associate particular adverse market outcomes with the likelihood those outcomes will occur. In addition, risk must be measured consistently across different types of financial instruments and participants in the settlement process. Risk measurement also should facilitate both system-wide and firm-specific analyses of risk.[35]

Some contend that measuring and monitoring firms' exposures is of no real value, because the monitor (for example, the DVP agent) has access

31. This goal of risk management is affected by externalities. If a settlement failure results in costs borne by those *other than* residual claimants of the DVP agent, for example, the residual claimants may choose a suboptimally low "level" of risk management. This is frequently thought to necessitate government regulation to bring risk management up to a more "socially efficient" level.

Specifically, "systemic risk" often is said to emanate from the possibility that a large brokerage failure will affect the whole financial system rather than just the counterparties to the broker. We urge caution in interpreting such claims as evidence of any negative externality that warrants political regulation, however. No empirical evidence suggests that the failure of one firm—even a firm active in multiple settlement systems—would somehow create a liquidity shock *across* settlement systems that is "uncontainable" through judicious risk management programs *by each individual settlement system provider.* Cautionary notes about abuses of externality theory resembling those leveled by proponents of "systemic risk" justifications for regulation are presented in the collection of Ronald H. Coase's essays reprinted in *The Firm, The Market, and The Law* (1991). *See especially* "The Problem of Social Cost" and "The Lighthouse in Economics."

32. In a M&M world, capital requirements should not affect firm value. The same informational asymmetries that make risk management consistent with value maximization, however, also may affect the traditional capital structure irrelevance propositions of Modigliani and Miller. In addition, capital requirements can involve deadweight costs at the implementation level alone. For a discussion, *see* Fischer Black, Merton H. Miller, and Richard A. Posner, "An Approach to the Regulation of Bank Holding Companies," *Journal of Business* Vol. 51 No. 3 (1978): 379-412, and Merton H. Miller, "Do the M&M Propositions Apply to Banks?" *Journal of Banking & Finance* Vol. 19 (1995):483-89.

33. The same distortion to capital formation may occur through inappropriately set "margin requirements." *See, for example,* Board of Governors of the Federal Reserve System, "A Review and Evaluation of Federal Margin Requirements" (1984).

34. Particularly in the form of investment in high-variance, negative-NPV projects. For a discussion of this problem, see Michael Jensen and William Meckling, "Theory of the Firm: Managerial Behavior, Agency Costs, and Capital Structure," *Journal of Financial Economics* (1976), pp. 305-360.

35. For liquidity risk measurement, this can indeed be a problem for DVP agents—*viz.,* how will the DVP agent know the liquidity impact of a settlement default on a broker unless the DVP agent knows the broker's *consolidated* funds and securities positions?

only to positions negotiated in that settlement system; and thus the *net* exposure of any broker—inclusive of transactions in other settlement systems and off-exchange—is likely to be unknown. For credit risk measurement by a central counterparty, however, risk monitoring is clearly important. Replacement cost and principal risk are a function *exclusively* of the broker's net obligations to the DVP agent; off-exchange exposures and positions in other settlement systems *do not affect what the DVP agent has to replace in the event of a default.*

Risk Horizons. In order to measure risk properly, the DVP agent first must define a time horizon, called the *risk horizon*, over which changes in the values of participants' settlement obligations are considered. The risk horizon for *credit risk* measurement depends on the length of time in the settlement cycle. In a T+4 system, for example, the failure of a single firm would involve possible replacement cost losses to a central counterparty DVP agent for positions negotiated on any of the last four trading days plus final settlement day. Summary measures of risk for replacement cost thus should include estimated changes in the value of open positions on all those trading days.

In measuring *liquidity* risk and *principal* risk, the DVP agent must consider the same-day (that is, final-settlement day) exposures of settlement banks and brokers. The resulting computations of risk indicate the amount by which unsettled positions in the settlement cycle may change in value over the upcoming day in order to help the DVP agent identify dangerously excessive exposures. Daily liquidity and principal risk measurement also can help the DVP agent identify *aggregate* liquidity risks associated with principal credit defaults. The gross impact of the failure of a broker or settlement bank on the cash and securities balances *of other participants* then can be identified, facilitating the DVP agent's designation of potential credit lines and guarantees required to smooth liquidity crises.[36] Liquidity risk measurement can be used to impose bilateral settlement limits on participants with large settlement obligations due to complete the settlement cycle on the same day.

Summary Measures of Risk. DVP agents must choose and implement appropriate risk measurement methodologies, all of which involve a common approach: namely, the systematic generation of portfolio returns for participants's open positions over the settlement risk horizons, and the calculation of summary measures of liquidity and credit risk using the resulting potential return distributions for both individual brokers and in the aggregate.

The first step in risk measurement is the computation of the contract prices for all the open, unsettled trades that were initiated the prior trading day. This gives the DVP agent an estimate of the *current exposures* of all unsettled transactions. Next, the DVP agent must calculate the *potential exposure* on all participants' unsettled transactions over the risk horizon. Mechanically, this is accomplished by simulating a return on the assets to be delivered and summarizing a "worst-case" return for each asset (for example, 5th or 95th percentile return, depending on whether a broker is net long or short the issue). At the broker level, worst-case returns then can be aggregated using appropriate estimates of correlation across all open positions and taking into consideration the relevant netting scheme. A similar aggregation can be performed at the *system-wide* level to quantify correlated default exposures.

The settlement system provider *also* should measure the same-day liquidity and principal risk of open transactions due to settle that day. The basic methodology is the same as replacement cost measurement: simulate possible worst-case price movements over the day, and aggregate those movements using appropriate statistical methods. Unlike the replacement cost risk measure, however, this same-day risk measure is *added to* the contract prices for all open assets along with any price moves that already have occurred since trade date T in the rolling settlement window.

The actual summary risk measure used by the DVP agent for risk monitoring and control is not as important as the methodology used to generate that risk measure. [37] Many such risk measures will serve the settlement agent's purposes, including "value at risk" (or "VaR"), "below-target risk," "below-target

36. Because the *net* consolidated exposure of brokers is unknown to the DVP agent, gross liquidity exposure measurement may overstate the DVP agent's funding requirements.

37. *See* Christopher L. Culp and Kamaryn T. Tanner, "Relations Between Investment Management and Risk Management," Arthur Andersen LLP White Paper (1996).

38. For discussions of these concepts, *see* Kamaryn T. Tanner, "An Asymmetric Distribution Model for Portfolio Optimization," Working Paper, Graduate School of Business, The University of Chicago (November 1996), Christopher L. Culp, Kamaryn T. Tanner, and Ron Mensink, "When and How Should Pension Plans Measure Risk?" Working Paper, Graduate School of Business, The University of Chicago (July 1997), and Culp and Tanner, cited previously.

Most DVP agents today do not have *integrated, comprehensive* risk management processes that emphasize and rely on forward-looking *measures of risk* for individual brokers and across brokers.

probability," and "downside semi-variance."[38] All these measures are ways of summarizing distributions of simulated asset returns for risk measurement, and all can be linked explicitly to risk limits and to capital and collateral requirements.[39]

CONCLUSION

As financial mutuals operating in an environment characterized by highly asymmetric information, value-maximizing delivery-versus-payment agents have the incentive and comparative informational advantage to monitor, measure, and manage risks inherent in the securities settlement system. Unfortunately, most DVP agents have accomplished this to date by the cumbersome use of position and net debit limits, capital requirements, and collateral requirements that are *not explicitly linked* to any forward-looking measure of actual risk facing settlement participants.

As developing countries search for ways to promote capital formation through the establishment of organized exchanges, attention to comprehensive risk management in the settlement process is crucial. Moreover, to the extent settlement agents in the *developed* world have failed to integrate sound risk measurement with comprehensive risk management, developing countries should focus their attention more on the *correct* approach to settlement risk management than simply on the *current* approach. Otherwise the distortions in capital allocation created by a poorly defined settlement system may overwhelm the benefits of organized securities trading.

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39. For a measure of risk more directly aimed at capital allocation, *see* René M. Stultz, "Rethinking Risk Management," *Journal of Applied Corporate Finance* Vol. 9 No. 3 (Fall 1996):8-24.

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