The Impact of a Dealer's Failure on OTC Derivatives Market Liquidity during Volatile Periods

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Federal Reserve Bank of Atlanta
Working Paper 96-6
June 1996

Abstract: This paper develops a model in which information losses may be an important part of the cost of an OTC derivatives dealer's failure. A dealer failure forces solvent counterparties of a failed dealer to seek replacement hedges with other dealers. However, by forcing good firms into the derivatives market, the failure provides camouflage for insolvent firms seeking to speculate with a dealer that does not know their credit status. The paper models this information loss and uses the model to quantitatively evaluate a range of scenarios. The results suggest that a market breakdown is unlikely but not quite impossible.

JEL classification: G28, E44

The authors thank Mark Flannery, Steve Smith, Jerry Dwyer, Andy Winton, Jim Moser, James Thomson, Joseph Haubrich, and participants at the Conference on Derivatives and Intermediation, FRB Cleveland, and the Atlanta Finance Workshop for helpful comments. The views expressed here are those of the authors and not necessarily those of the Federal Reserve Bank of Atlanta or the Federal Reserve System. Any remaining errors are the authors' responsibility.

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1. Introduction

While the volume of almost all derivatives markets has increased markedly during the last decade, the transactions volume of the over-the-counter (OTC) market for derivatives has grown especially rapidly. One of the most important OTC markets, the one for swaps (interest rate and foreign exchange rate) has increased over 600 percent from 1987 to a level of $14 trillion in 1995. The finance literature has identified a number of possible benefits that the OTC derivatives market provides to users.[1] Some underlying unease remains, however, about the rapid growth of these derivatives, an unease that stems in part from the complexity of analyzing many OTC and exchange traded derivatives contracts.

Probably the biggest concern in the OTC market is that some sort of problem will arise with catastrophic consequences for the overall economy. These concerns have been partially alleviated by the failures of several OTC derivatives dealers without disastrous consequences, including Bank of New England, Drexel Burnham Lambert, and Barings PLC. However, all of the existing cases of dealer failure occurred at dealers with small OTC market shares and in circumstances where there was no other major aggregate shock associated with these failures that could compound the problem. Thus, historical experience appears insufficient to rule out the potential for a systemic problem.

As a substitute for adequate historical experience, a number of policymakers have speculated about various scenarios in which OTC derivatives could have macro consequences, asserted without the benefit of formal economic models. The report by the Bank for International Settlements (1995) provides one enumeration of many of these concerns. Partially in response to fears expressed by regulators, the Group of Thirty (1993) listed a number of systemic risk concerns and provided a series of "best practices" designed to reduce the risks being taken by market participants. In a more formal treatment of one systemic concern, that exposure to derivatives could cause the failure of a dealer, Hentschel and Smith (1994) demonstrate that if dealers are hedging their derivatives activities then the risk of even a single dealer failing due to derivatives is small and the risk of multiple dealers failing is negligibly small.[2] Schneck (1995) also analyzes the risk of derivatives causing dealer failure in a more comprehensive model and reaches similar conclusions.[3] Thus, systemic risk issues have received considerable attention, albeit mostly without the benefit of a formal model. In particular, no formal models exist on a particular circumstance that may raise the specter of systemic risk: what happens to market liquidity following a dealer's failure during volatile periods.

Our paper exploits the idea long-standing in the banking literature that a bank failure results in a temporary loss of credit quality information on that bank's clients.[4] We apply Wall's (1993) intuition that information losses may be a key component of the costs of intermediary failure to the derivatives market. In particular, the dealer failure forces good, solvent firms of the failed dealer to seek hedges with other dealers. However, by forcing good firms to look for a new derivatives dealer, the dealer failure provides camouflage for insolvent firms looking to speculate with a dealer that does not know their credit status. That is, insolvent firms can mimic good firms because other dealers cannot quickly verify credit quality information to distinguish good from bad firms. If the firms could give the remaining dealers some time to analyze their credit quality then the dealers could separate the good firms from the insolvent ones. However, during periods of market turbulence a delay of a day (or even a few hours) in reestablishing the hedge could result in substantial losses to the good firm.[5] The resulting pooling equilibrium will impose at best additional costs (pooling losses) on the good firms but also may cause good firms to leave the market completely. Thus, there are costs imposed on derivatives users caused by the loss of credit information from the failure of their derivatives dealer, and these costs may be high enough to force a collapse of the market. The paper provides two contributions to the investigation of systemic risk in this market. First, this paper provides one of the first formal models of a scenario with potential macro consequences, that of a major derivatives dealer failing during a period of market turbulence. Second, we supply some calculations derived from a quantitative application of the model that suggests the potential costs imposed on small derivatives users when their derivatives dealer fails.

We propose a setting in which there are three risk-neutral derivatives dealers and N risk-neutral firms. Firms in the model may be solvent or insolvent, and the informed dealer can perfectly distiguish between these conditions. We introduce an incentive for solvent firms to hedge by incorporating costly financial distress. We restrict each firm to share financial information with only one dealer, giving one dealer for each firm an informational advantage in contracting with that firm over the other dealers. We show that in a benign environment (all dealers are solvent), the dealers contract with firms that they know to be solvent, and insolvent firms cannot speculate because the dealers know that only insolvent firms will be unable to contract with the dealer that "knows" them.

We then consider the systemic implications of increased contracting costs due to the temporary information loss when one dealer fails in a period of market uncertainty. Firms that shared information with the failed dealer cannot immediately and credibly share its financial information completely with a new dealer. Solvent firms that previously dealt with the failed dealer cannot distinguish themselves from the insolvent firms that are not associated with the prospective dealer. The only insolvent firms that the prospective dealer can eliminate from this pool are those the dealer already knows. Note, however, that these insolvent firms can enter into the pool of the other solvent dealer. Thus, the failure of one of the three dealers provides an opportunity for some insolvent firms to enter into speculative forward contracts by mimicking the behavior of the good firms. The remaining dealers charge a premium over their typical spread for the resulting pooled contract because there will be some anticipated losses from insolvent firms who get a contract. We show that the size of the spread that the dealer requires depends on the proportion of good firms in the pool. The losses resulting from pooling may be so large that the resulting spread exceeds the gains that good firms obtain from hedging. In this case, dealers will not offer a pooling contract because only insolvent firms that want to speculate would accept the contract. This result alludes to a market breakdown that some consider a systemic policy issue.

The model of a market breakdown developed in this paper may not apply to large, well-known firms but may apply to many smaller firms. Large, multinational firms are likely to have publicly available credit ratings, established relationships with several OTC derivatives dealers, and may have the sophistication to use the standardized contracts offered by derivatives exchanges. However, many smaller firms are also actively hedged in the OTC derivatives market. Bodnar et al. (1995) report that of the firms responding to their survey: (1) 12 percent of the firms with market value below \$50 million report derivatives usage and (2) 30 percent with market value between \$50 million and \$250 million report derivatives usage. Smaller firms are less likely to have the sophistication in their treasury departments to combine standardized exchange contracts to meet their customized needs. Further, smaller firms are likely to have fewer banking relationships because of their smaller demand for credit and the relative lack of public information about their credit quality. Moreover, many of these relationships are likely to be with banks that are not active dealers given the relatively small number of OTC derivatives dealers and their geographic concentration. Further, our qualitative results do not depend on smaller firms having a relationship with only one dealer. What is required for the qualitative results is that one dealer have a substantial information advantage over the other dealers, which is a situation that is plausible for a significant number of small firms.

The paper is organized as follows: the following section contains the literature review, the third section presents the model and the main assumptions underlying the model, and the fourth section sets out the cases we analyze, the results, and the intuition behind those results. The last section presents some concluding remarks.

2. Model Assumptions

The model consists of N firms and three dealers, all of whom are risk neutral. The model includes a set of initial conditions and two subsequent periods in which developments occur. The following subsections describe the financial condition, the information set, and the contracting options of firms and dealers for each period. The time line is summarized in Table 1.

2.1 Initial Conditions

The firms in the model differ in three important respects during the initial period: (1) whether they are currently solvent, (2) whether their existing assets cause an inherent long or short exposure to the risk factor, and (3) which dealer they have an established hedge contract with. All firms have the same value of outstanding liabilities, L. The market value of the firm's assets M is indexed by $q \in \{b,g\}$. Bad firms have a market value of asset M_b less than their outstanding liabilities, whereas good firms have a market value of assets M_g in excess of their liabilities.

Every firm is exposed to a random, symmetric shock with realized value $S \in [S^+, S^-]$. Each shock has a 50 percent probability of taking place during period 3. Firms whose exposure from existing assets is inherently long have an $\alpha_l = 1$. The value of these firms increases by the value $\alpha_l S^+$ if the positive shock is realized and decreases by $\alpha_l S^-$ if the negative shock is realized. Those firms with an inherent short exposure have an $\alpha_s = -1$, and their value increases if S^- is realized and decreases if S^+ is realized. The analysis of firms with α_l is identical to that for firms with α_s except for the change in signs of the beneficial and adverse states; therefore, we shall focus on firms with an α_l for the remainder of the paper.[6]

Solvent firms that receive an adverse shock, S^-, are assumed to become financially distressed in the sense that the losses impair the firm's capital and reduce its ability to fund growth projects.[7] Financial distress results in a loss of firm value equal to some proportion θ of the firm's market value. Thus, the equity value of a good firm at period 3 after it has absorbed an adverse shock is

$$EQ_{g3} = \max\,(M_g - L + S^- - \theta M_g,\ 0)$$

where $0 < \theta < 1$.

The value of a firm that receives a positive shock is

$$EQ_{g3} = M_g - L + S^+$$

where

EQ_{g3} = equity value of the good firm at period 3.

Insolvent firms in the model gain from speculating because they are insolvent with either positive or negative shocks with the hedge, and we assume that, if unhedged, they return to solvency with a favorable shock:

$$EQ_{b3} = M_b - L + S^+ > 0.$$

Thus, insolvent firms have an incentive to unwind the hedge.

The shock may be hedged with a derivatives contract (for simplicity, a forward contract) arranged with one of three OTC dealers indexed by $i \in \{1, 2, 3\}$. The dealers have assets of M^i and liabilities of L^i. Firms and dealers engaged in a joint selection process so that every firm obtains a forward contract from exactly one dealer. The forward contracts provide for a regular exchange of financial information between the firm and the dealer. The information exchanged allows the dealer to infer the market value of the firm, its α, and thus the proper direction of the hedging contract, so that the dealer can distinguish between speculative and hedging behavior directly. The financial information, however, can be obtained only by a third party with a one period lag. This provides an informational advantage to the dealer with an ongoing contractual relationship with the firm.

Sometime after entering into the forward contract but still during period 1 a firm may become insolvent due to its normal business operations.[8] As a result each dealer will have some insolvent firms with whom they have an existing forward contract. Insolvent firms will want to unwind hedges with its known dealer and will attempt to speculate in a contract with an unknown dealer. We will demonstrate below the circumstances that allow firms to speculate. In the presence of potential credit losses, each dealer requires a premium in the form of a spread between the dealer payment and the firm payment in order to cover potential credit losses from firms that subsequently become insolvent during period 1. This spread, γ_t^i, may be interpreted as the spread paid as a proportion of the contract's terminal payout for contracts with dealer i at time t.[9] We assume that all firms arranging a hedge contract at time 1 with dealer i have the same size forward contract, TH_1^i. Given the size of the hedge and the dealer's spread, the change in the value of the fully hedged firm in period 3 for realized shock S is

$$S_3 + TH_1^i - \gamma_1^i |TH_1^i| . \tag{1}$$

Note that the spread is paid for both positive and negative shocks, implying that the spread is deducted from any payments made by the dealer to the firm and added to any payments from the firm to the dealer, TH_{g1}^{i+} and TH_{g1}^{i-}, respectively.

For our purposes, we restrict the value of the forward contract to be the same in periods 1 and 2. This restriction is made to ensure that our results depend solely on the information loss due to a dealer failure. One consequence of the assumption is that an insolvent firm would desire to unwind a hedge rather than either extract a payment from the dealer or pay the dealer to unwind the hedge.

In general, the number of firms going to dealer i and seeking long forward contracts need not equal the number seeking short contracts. Dealers may hedge their exposure to the forward contracts by costlessly taking offsetting positions in the market for the underlying asset (which we do not model). Effective use of the market in the underlying asset requires a fixed initial investment to cover the costs of developing skilled staff and meeting any market requirements.[10] Hence, although the marginal cost of using this market is zero to established dealers in period 1, the costs would be large to firms seeking to begin operation in the market. Dealers are given the incentive to hedge their positions fully because the regulatory authorities will tax away any ex post gains from speculative positions.[11]

2.2 Period 2

The description of the first period sets up the initial conditions for the analysis of the derivatives market and likely contract structure. Upon entering the second period, firms may seek to unwind their existing forward contracts, they may seek to enter into new forward contracts with another dealer, or both. For simplicity, we can categorize the likely contracts for the two types of firms. Insolvent firms will unwind existing hedges and seek to speculate. Solvent firms will maintain their forward contract at the optimal hedge size. Further, some firms may find their forward contracts terminated due to the failure of a dealer.

Dealer 1 may become insolvent during period 2.[12] If an insolvency occurs it will not be because of any losses the dealer incurs in the derivatives market.[13] The dealers neither would suffer any credit losses from their counterparties failure during period 2 nor would dealer 1's failure impose losses on its counterparties because we assume that the value of the forward contract remains at zero during period 2.

The solvency status of a firm may be important to a dealer when considering a firm's request to unwind an existing forward contract or to enter into a new contract. While dealers do not know the financial status of individual firms that they do not have a relationship with, nevertheless dealers do know the number of counterparties served by each of the other dealers.[14] Further, the proportion of good and bad firms is the same for all firms. Thus, each dealer can correctly infer the number of good firms that are customers of dealer i, g^i, and the proporation of bad firms that are customers of dealer i, b^i.

Individual firms know their individual solvency, their α, and learn of the respective g^i, b^i values for each of the three dealers. Firms also learn of the solvency status of individual dealers. Individual firms also know what is in the dealer's information set and dealers know what is in the firm's information set.

Firms may seek to enter into new forward contracts or to close out their existing contracts in period 2. In those cases where firms would seek a new forward agreement, the dealer must determine the minimum spread γ required to cover its expected credit losses and the firm must determine the maximum spread that it would be willing to pay.

2.3. Period 3

The realized value of the exogenous risk factor results in a shock to individual firm values of S^+ or S^-. A firm becomes financially distressed if

$$M_q - L + S^- < Z$$

where

Z = the minimum level of firm equity to avoid financial distress.

The firm does not need to fail in this model to incur costly financial distress; a firm will bear some costs so long as its market value net of liabilities and the shock is less than Z.[15]

On the other hand, a firm is not subject to financial distress if the firm is hedged. We assume that if a firm chooses to hedge, the firm hedges sufficiently to avoid completely the costs of financial distress.

$$M_q - L + S^- + H_g^i \geq Z$$

where we define H_g^i as the minimum amount of inflow in the bad state (after accounting for the spread payment) to keep the good firm out of financial distress:

$$H_g^i = \sum_{i=1}^{3} (TH_1^i - \gamma_1^i |TH_1^i| + TH_2^i - \gamma_2^i |TH_2^i|). \tag{3}$$

Hence, we view the hedge as sufficient to prevent financial distress if the cash inflow in the bad state is H_g^i.

If a firm or dealer is insolvent in period 3 then it is liquidated and the proceeds are distributed to the creditors. We assume that the treatment of forward contracts in bankruptcy follows standard practice in the market for over-the-counter derivatives. If the solvent party to the contract owes a payment to the insolvent party, then full payment is made. If, however, the insolvent party owes the payment then the solvent party becomes a general creditor of the firm. However, in this model we assume the firms' and dealers' other debts (respectively, L and L^i) are senior to their forward obligations and, hence, neither insolvent firms nor dealers will make a payment under their forward contract.

The objective function for the firm is to maximize equity value of the firm during period 3. The firm's equity value consists of its initial net equity (total assets minus liabilities), the impact of the shock on firm value and any losses due to financial distress. The impact of the shock on firm value is

$$SI_3^i = \left[S_3 - \sum_{i=1}^{3}(TH_1^i + TH_2^i - \gamma_1^i|TH_1^i| - \gamma_2^i|TH_2^i|)\right] + FD_g \tag{4}$$

where

SI_3^i = shock's impact on firms that are customers of dealer i, including the impact of any forward contracts, and

FD_g = costs of financial distress to good firms.[16]

The impact of the shock in Equation (4) depends not only on the shock's direct impact but also on any forward contracts that the firms have with the dealers. The first two terms in the summation are the payments that depend on the shock and the last two are the spread paid by the firm to the dealer.

The costs of financial distress arise if the shock is not adequately hedged against the risk factor. A firm enters into a hedge contract to avoid the costs of financial distress. If the firm is hedged, then the firm avoids the costs of financial distress. On the other hand, if the firm is unhedged, the firm has a 50 - 50 chance of being exposed to financial distress. In this case, the firm suffers distress costs that reduce its going concern value:

$$FD_g = -\theta M_g \quad \text{if } H_g^i \text{ is zero and } S^- \text{ is realized, and}$$

$$FD_g = 0 \qquad \text{if } H_g^i \text{ is the optimal hedge size or } S^+ \text{ is realized.} \tag{5}$$

The first issue is to determine whether the firm is hedged; if hedged, the firm avoids financial distress. We assume that the firm will hedge up to the point at which it is insulated fully from the costs of financial distress.[17]

Given the impact of the shock on firm value and the potential costs of financial distress, the firm's objective function takes the form

$$\max E[\max((M_q - L + SI_3^i - FD_g), 0)]. \tag{6}$$

The remainder of the paper focuses on specific scenarios for firm and dealer solvency and uses versions of this objective function that focus on the specific scenario.

3. The Model

Our focus is on the conditions that would lead to a market breakdown, where the value of a hedge to good firms is less than the cost. Thus, we determine the minimum price that a dealer must charge to break even and the maximum that a firm will pay for the hedge. There are numerous pricing issues that may arise in this setting, such as which party gets the larger share of potential rents, but these issues are tangential to the main point of this paper.

3.1 Case 1: No dealer fails

Good firms with an existing hedge at the start of period 2 would not obtain any additional gains from another hedge. In order for them to benefit from obtaining a new agreement they must reduce the net spread they are paying to the dealer. Their existing dealer will demand compensation for its loss of spread payments due to unwinding. Hence, if there are to be any gains it must come from the new dealer accepting a negative spread. However, the new dealer has no incentive to offer a negative spread. Therefore, good firms with hedges will not be in the market since they cannot improve on their existing hedges.

The decision of bad firms is straightforward during period 2; they seek the maximum speculative position possible. Hedged bad firms will first seek to unwind their existing forward and to speculate by magnifying their inherent exposure to the risk factor. Each dealer knows the financial condition of the firms with which it has period 1 hedges by previous assumption. In having an existing hedge with insolvent firms, the dealer has a 50 percent chance of making payments to the insolvent firm and has a 50 percent chance of receiving nothing from the failed firms (according to the payment assumptions). Thus the dealer will agree to unwind the contracts because the outstanding deals with insolvent firms have negative expected value to the dealer. After the firms with period 1 forward contracts successfully unwind their deals, they will then seek to enter into new speculative forward contracts during period 2. But absent dealer 1 failure, each dealer knows that no good firm will apply for a new forward contract. Thus, dealers will not offer a contract to unknown firms because only the bad (insolvent) firms will accept it.

3.2 Case 2: One dealer fails

Consider the case where dealer 1 fails in period 2. The only group of firms that will be unambiguously unaffected by the failure is that of good firms that have existing hedges with dealers 2 or 3. These firms have no incentive to contract in the forward market in period 2. All other firms face potential changes in the availability of forward contracts in period 2.

Good firms that are known only by dealer 1 will have lost their hedge due to the failure and will seek to establish new hedges with dealer 2 or 3 in period 2. Bad firms (known by any dealer) with outstanding hedges will unwind their contracts, either due to the failure of dealer 1 or by mutual consent. Moreover, the bad firms known by each of the three dealers may gain an opportunity to contract that they would not otherwise have had. If the good firms known by dealer 1 may obtain a contract from the remaining dealers, then so can the bad firms known by dealer 1. Neither of the remaining dealers can distinguish the good firms associated with dealer 1 from the bad firms associated with dealer 1 nor the other solvent dealer. Thus, all bad firms get the opportunity to mimic the behavior of the good firms from dealer 1 and speculate using the contract offered to the good firms when dealer 1 fails.

Although dealers 2 and 3 will retain the business of the firms they know, dealer 1's good firms will still be looking to replace a hedge. Thus, dealer 2 or 3 may also offer a pooled contract intended to attract dealer 1's good firms.

The first step in determining the equilibrium is to analyze the two dealers in isolation. The minimum acceptable spread such that dealer 2 earns nonnegative profits is

$$0 = \gamma_{2p}^{2}|TH_2^{i}|(g^{1}) - [.5(TH_2^{2} - \gamma_{2p}^{2}|TH_2^{i}|) + .5(0)](b^{1} + b^{3}).$$

The first term refers to the dealer's receipt of the premium from the good firms; the forward positions cancel because the expected value of the hedge payments in the positive state is exactly offset by the expected value of the payments in the negative state. The second term reflects the outflow from the dealer to the insolvent firms. This relationship can be reduced to

$$\gamma_{2p}^{2} \geq (1-G^2) / (1+G^2), \tag{7}$$

where

γ_{2p}^{2} = the pooling spread charged by dealer 2 in a hedge contract offered in period 2 to the firms previously hedged with the failed dealer 1.

G^2 = the maximum proportion of good firms in a pool that seek a pooled contract from dealer 2 where the potential pool of good firms consists of the good (previously) hedged firms of dealer 1.

$G^2 = g^1 / [g^1 + b^1 + b^3]$.

Similarly, the minimum pooling price dealer 3 requires to offer a pooled contract to dealer 1's good firms is

$$\gamma_{2p}^{3} \geq (1-G^3) / (1+G^3), \tag{8}$$

where

γ_{2p}^{3} = the pooling spread charged by dealer 3 in a hedge contract offered in period 2 to the firms previously hedged with the failed dealer 1.

G^3 = the maximum proportion of good firms in a pool that seek a pooled contract from dealer 3 where the potential pool of good firms consists of the good (previously) hedged firms of dealers 1.

$G^3 = g^1 / [g^1 + b^1 + b^2]$.

Given the minimum γ_{2p}^{2}, γ_{2p}^{3} and the gain from hedging, good firms known by dealer 1 will only accept the forward contract from either dealer 2 or dealer 3 if the gains exceed the spread paid on the forward contract. There are gains from hedging if the expected value of the hedged firm exceeds the expected value of the unhedged firm, as shown below:

$$.5[(M_g - L + S^+ + TH_2^{i+} - \gamma_{2p}^i|TH_{g2}^i|) - (M_g - L + S^+)] +$$
$$.5[(M_g - L + S^- + TH_2^{i-} - \gamma_{2p}^i|TH_{g2}^i|) - (M_g - L + S^- - \theta M_g)] > 0.$$

This relation can be reduced to

$$.5\theta M_g > \gamma_p^i \,|\, TH_2^i \,|. \tag{9}$$

The minimum requirement for either dealer to offer a forward contract is that the good firms known by dealer 1 would accept the contract. If either dealer could not offer contracts acceptable to the dealer 1's firms then that dealer would not offer the pooling contract (or equivalently, require a spread γ_{2p}^i equal to one). If neither remaining dealer could offer a contract acceptable to dealer 1's good firms then no pooling contract is offered. We suggest that this circumstance corresponds to the market breakdown scenario in popular discussions in which good firms seeking to replace hedge positions lost by the failure of its dealer are unable to do so.

4. The Economic Significance of a Dealer Failure

Our analysis above shows that informal speculation about a possible market breakdown can be supported by a simple model of the derivatives market. Additional insight about the economic significance of this scenario is obtained by using the model to evaluate a range of specific scenarios. Two variables are particularly significant in this model: (1) the minimum spread that the dealer must charge to at least break even given the pooling losses to insolvent firms and (2) the maximum spread that good firms will pay so that their cost of hedging does not exceed the gains from hedging.

The minimum spread that the dealer must charge to break even in the model, equation (7), is uniquely determined by the ratio of good firms to the total number in the pool applying for a forward contract. Table 2 shows the relationship between the percentage of good firms and the spread, γ. For example, if the ratio of good firms to all firms in the pool is 90 percent, then the minimum spread required by the dealer is 0.0526.

At first glance, most of the spreads required by dealers in Table 2 appear to be huge relative to observed spreads in the OTC derivatives market. For example, spreads on simple or plain-vanilla swaps are generally in the range of 5 basis points (0.0005). However, market spreads are quoted in terms of the notional principal rather than the size of the shock. Since October 1979, there have been only five instances of daily price drops of the 30-year Treasury bond in which this bond lost more than 3 percent (but never more than 4 percent) of its face value.[18] To create a realistic threat of insolvencies, perhaps on the order of a few percent of the total population of end-user counterparties, we imagine a much more severe market stress equivalent to, say, a 10 percent loss on this bond. If, in this circumstance, the proportion of good firms is 95 percent, with a minimum spread in Table 2 of 0.0256, a 10 percent shock would result in a spread payment of 25.6 basis points relative to notional principal. Thus, while many of the spreads in Table 2 appear to be unbelievably large compared with actually quoted market spreads, the model-based spreads are still somewhat large, but not completely unrealistic, as a proportion of a short-term OTC forward or swap contract's notional principal.

The maximum spread that good firms would pay to enter into a swap, equation (9), is given in Table 3. The amount of hedging required to avoid financial distress, H_g^i, stated as a percentage of the value of the firm's assets, varies with each of the rows.[19] The cost of financial distress, (θ), again stated as a percentage of the firm's assets, varies with each of the columns in Table 3. For example, if a firm is hedging a shock that is equal in value to 50 percent of the firm's assets and the loss in going concern value from not hedging this shock is 5 percent of firm value, then the firm would be willing to pay a spread of 0.056. Recall, this spread is an indifference point where the gains from hedging exactly equal the costs of not hedging. Thus, if the dealer charged a spread of 0.055 then the firm would benefit from entering into a swap but it would be paying almost 2.5 percent of firm value to obtain the protection.[20] The squares in the lower right-hand portion of the table reflect "not meaningful" (NM) results because these states imply that the equity holders could lose over 100 percent of the market value of the firm's assets.[21]

Table 3 provides two intuitively appealing results. First, the spread that firms are willing to pay increases with the cost of financial distress. Second, the maximum spread the firm will pay decreases as the size of the hedge increases. This result is intuitive because the fixed gains from hedging decrease as a proportion of the derivative contract as the contract grows in size. As a consequence, the smallest spreads that firms will pay are in the lower left-hand corner of Table 3 and the biggest spreads are in the upper right-hand corner.

The forward market breaks down in this model (i.e., dealers do not offer contracts) if the minimum spreads the dealers require exceed the maximum that good firms will pay. The combinations of parameters that could cause such a breakdown may be obtained by combining Tables 2 and 3. Such a combination shows that no market breakdown would occur *for the sets of parameter values presented in the two tables* if the proportion of good firms is 95 percent or better. This result obtains because the lowest γ that firms are willing to pay is 0.0270 (for H = 0.9 and FD = 0.05) whereas the smallest spread that dealers will charge with 95 percent good firms is 0.0256. However, if the proportion of good firms is only 80 percent (implying a minimum dealer spread of 0.1111) then the market will break down in a variety of cases, for example if H = 0.5 and FD = 0.1 (implying the maximum spread the firm will pay is 0.091).

Tables 2 and 3 (equations (3), (7), and (9)) are combined to obtain the minimum proportion of good firms required to avoid a market breakdown, and the results are presented in Table 4. Our reading of Table 4 is that a market breakdown is unlikely but not impossible given "reasonable" parameter values. The parameter where we have the strongest intuition is that of H, the size of the shock to be hedged as a proportion of the firm's total assets. Our own guess is that few firms need to hedge shocks that would exceed 40 percent to 50 percent of their asset value. This implies that the market breakdown will occur only if the pool contains less than 91 percent good firms even if the deadweight loss is only 5 percent of firm value and that the proportion of good firms must fall sharply as the deadweight losses increase. The proportion of good firms in the pool will depend in large part on the overall state of the economy at the time of a dealer's failure. One reason why the proportion of good firms may be small is that the dealer's failure could be an adverse signal about the average credit quality of its customers. Another reason is that every insolvent firm that could successfully mimic a good firm will seek to do so. Thus, if the market contains 10 equal-size dealers and bad firms are 2 percent of each dealers' book, then the proportion of good firms in the pool would be approximately 85 percent.[22]

While these "back of the envelope" calculations based on the model may provide some intuition, policymakers may want to consider "real world" reasons why these figures may overstate or understate the problem. We see at least four reasons why the figures may understate the problem. First, we assume that dealers are risk neutral and will engage in swaps at break-even pricing. In practice, neither of these assumptions is likely to hold, implying that our minimum spreads are biased down. Second, we rule out a "market for lemons" type problem by assuming that all firms have the same hedging requirement, H, and the same costs of financial distress, FD. A continuum of values for H and FD would result in some good firms being willing to pay high spreads and other good firms being willing to pay only minimal spreads.[23] Those good firms willing to pay only small spreads may drop out of the pool, which will reduce the proportion of good firms and force dealers to charge an even higher spread. That higher spread in turn may induce more good firms to drop out, repeating the cycle.

A third reason why our analysis may understate the problem is that we focus on market breakdown. Even if good firms are willing to pay a spread equal to 2.4 percent of firm value, this does not imply that they will happily accept this fate. Policymakers should not be surprised if good firms with contracts with the failed dealer lobby aggressively for a bailout of the dealer.

Finally, our analysis focuses exclusively on market problems related to the loss of information when a dealer fails. Other potential problems such as the credit losses arising from the failure of the dealer could also contribute to a market breakdown.[24]

The one reason why our analysis may overstate the problem is that we assume that firms pay nothing on their OTC derivative if they fail. In practice, derivatives will generally not be junior to all other claimants. Also, violations of the absolute priority rule often occur when U.S. firms become bankrupt.[25] Hence, even bankrupt firms are likely to pay at least part of whatever obligations they owe under an OTC derivative contract.

5. Conclusion

The current debate about the systemic risk associated with OTC derivatives is dominated by informal discussion of possible disaster scenarios. These policy discussions illuminate potential problems and possible solutions to scenarios involving derivative contracts. However, the probabilities of a "bad" scenario and the costs of such a scenario are difficult to assess without formal models—even careful analysis without a model may fail to uncover unstated assumptions or internal inconsistencies. Thus, given our (fortunately) limited experience with OTC derivatives problems, we feel that there is a need for formal models to analyze different scenarios, models that allow explicit evaluation of assumptions, a clear confirmation of internal consistency, and quantitative analysis of the scenario.

This paper proposes a formal economic model for analyzing one possible scenario for a breakdown of the market for OTC derivatives. The central problem is the loss of information about firms' financial condition when a dealer fails. If no dealer fails then the financial condition of every firm is known by one of the dealers. In this case all good firms obtain hedges and no bad (insolvent) firm is able to enter into a forward contract. The paper shows that a market breakdown is theoretically possible. The quantitative analysis of the model further suggests that such a breakdown in the event of a dealer failure would be unlikely but not impossible.

Our purpose in laying out this model is neither to demonstrate a "fatal" flaw in the derivatives market nor to show that the OTC derivatives market is not subject to systemic risk.[26] Rather, our purpose is to provide a reasoned basis for discussing the likelihood and potential costs of one possible scenario that could concern policymakers should an OTC derivatives dealer fail during a period of market volatility. If such a discussion leads to the conclusion that the costs of such a scenario are low then policymakers may be more likely to let a dealer fail without a public bailout.[27] If, on the other hand, the likelihood and costs are perceived to be high then perhaps steps may be taken before a crisis that would reduce the costs of a dealer failure and perhaps avoid the need for a government bailout.

Given the partial equilibrium nature of our model, we are reluctant to speculate on the optimal policy response if the costs of a dealer failure were unacceptable. However, a public policy of attempting to shrink the derivatives markets via some combination of regulation and taxation is unlikely to prove optimal in the context of our model. The damage from a derivatives problem in our model arises precisely because derivatives are valuable hedges. A policy response designed to shrink the derivatives market would have the counterproductive effect of reducing valuable hedging in our model.

Endnotes

1. See Smith and Stulz (1985) for a discussion of the benefits of hedging by firms. See Smith, Smithson, and Wakeman (1988), Arak et al. (1988), Wall (1989), Campbell and Kracaw (1991), Titman (1992), and Froot, Scharfstein, and Stein (1993) for a discussion of the benefits of the interest rate swap market and Usmen (1994) for a discussion of currency swaps.

2. Gorton and Rosen (1995) provide some evidence from commercial bank's financial statements that the banks have been taking an aggregate net short position in swaps, i.e., on average these banks paid floating and received fixed. However, they provide some tentative evidence that most of this risk is hedged.

3. Although it does not specifically focus on the derivatives market, Eisenberg's (1994) network analysis of failure also may provide interesting insights into the potential for a domino-like problem in the OTC derivatives market.

4. Bernanke (1983) suggested that bank failures could have macroeconomic consequences as a result of the temporary loss of information about the creditworthiness of some borrowers. Sharpe (1990) provides theoretical support at a micro level for a bank obtaining an information advantage in its long-term dealings with its customers. Empirical support for a bank's information advantage is provided by Slovin, Sushka, and Polonchek (1993) and Petersen and Rajan (1995).

5. By market turbulence, we want to distinguish ordinary times when the ex ante expected cost of going unhedged for a short period of time is small from the relatively rare times when the ex ante expected cost of going unhedged could be very large. Examples of turbulent market

times would include the period after the change in Federal Reserve operating procedures in 1979 and the collapse of the European Exchange Rate Mechanism in 1992.

6. While the results of the analysis from the firm's perspective are independent of α, the same need not hold from the perspective of dealers who must hedge any imbalances in their derivatives portfolio. However, the assumptions below give dealers costless access to an external hedging market, which eliminates any complications introduced by the dealers' need to hedge their exposure.

7. A shock may reduce the value of growth opportunities by forcing the firm to raise additional funds to finance the project in external markets where it may have to pay a premium for asymmetric information and possible agency costs. It may also raise the cost of funds by reducing the firm's debt capacity and forcing it to raise relatively more expensive equity rather than issue debt.

8. The term "normal business operations" refers to losses that could not be hedged by the derivatives contract considered in this model or any other derivatives contract. For example, the firm's managers may not be efficient producers of their product or they may not be good at marketing the product.

9. γ_t^i is the spread on a forward contract in period t paid to the dealer i.

10. Such as undergoing a credit check by other market participants or having available assets that are acceptable collateral in the market.

11. This assumption is made to prevent dealers from taking unhedged positions in the forward market. An example of this could occur if a regulator found that a commercial bank was taking large, unhedged positions in the derivatives market and it was hit with a cease and

desist order. The costs to management could be large and the dealer could be forced out of the marketplace due to adverse reputational effects.

12. This assumption that dealer 1 fails rather than dealer 2 or 3 is arbitrary but results in no loss of generality.

13. Examples of derivatives dealers that failed due to losses outside the derivatives market include Drexel Burnham Lambert and Bank of New England. Dealers could incur losses in two ways as a result of movements in the forward market. First, the dealer could have been speculating and the market moved against the dealer's position. The potential for dealer speculation is not included in the model because that would be inconsistent with our assumption of regulatory penalties that effectively deter dealer speculation at time 2 in the model. More fundamentally, we do not consider dealer speculation because we believe that the workings of the interdealer hedge market are sufficiently complicated and important to merit a separate paper.

    Second, dealers could fail due to losses from transactions with derivatives counterparties. This issue could easily be incorporated into the model in this paper if the model allowed the value of the forward contract to change from the initial conditions to time 2. Under this alternative assumption, firms would also suffer credit losses when their dealer failed. We do not allow the value of the forward contract to change, however, because that confounds the interpretation of our results—mixing in both credit losses and information losses.

14. This assumption is a reasonable first approximation of reality given that dealers, especially commercial bank dealers in the United States, regularly publish the size of their derivatives book in their financial statements.

15. Equity holders would not benefit from hedging at time 2 if bankruptcy costs were the only costs of not hedging. The equity holders would not bear any of the deadweight costs of bankruptcy because we assume the firm will not be recontracting its outstanding debt at time 2. This assumption follows almost automatically from our prior assumption that time 2 lasts no longer than 2 or 3 days. That is to say, most firms can avoid refunding most of their outstanding debt if financial markets are very turbulent.

16. The equity holders of the bad firms would not suffer any costs of financial distress. The bad firm is bankrupt if (1) it is unhedged and S^- is realized or (2) it is hedged.

17. There are no gains to increasing hedge positions because the firms could only increase the size of their hedge with dealers that do not know them. Their own dealer could detect any deviation from optimal hedge positions. Given that any additional contract would involve pooling losses, the firms would not gain from the added hedge contract.

18. Fred Vogelstein and Laura Jereski, "Jarred by Jobs: Investors Stunned as Bonds Plunge, Rates Top 6.7%," *Wall Street Journal*, March 11, 1996, pp. C1 and C18.

19. The value for H_{j2}^{i} is determined by solving equation (3) for TH_{j1}^{i}.

20. If the spread is equal to 0.056, then that would imply that the firm would lose 5 percent of firm value when the adverse shock occurs, which is 50 percent of the time. Hence, the expected value of the unhedged loss is 2.5 percent of firm value.

21. For example, if an unhedged firm suffered losses equal to 70 percent of its market value, shareholders would not care if the costs of financial distress were equal to 70 percent of the firm's assets (if such losses were even possible) because the most the shareholders could lose is an amount equal to 100 percent of the value of the firm's assets.

22. Assume each dealer had 100 OTC counterparties and that each dealer had 2 insolvent counterparties. Each dealer would know the 2 firms on their books that were bad but would not know the 2 firms on the other nine dealer's books who are bad. Thus, the pool facing each of the solvent dealers would contain 18 bad firms (two bad firms for each of the other nine dealers). The failure of one dealer would leave 98 good firms looking for contracts and a total pool of 116 firms seeking OTC contracts. Thus, the ratio of good firms to the total pool is 98/116, or 84.5%.

23. If any good firms will accept the contract then the gains to bad firms are sufficient to induce them to mimic good firms.

24. Among these problems are: (1) credit losses on OTC derivatives incurred by other firms due to the failure of the dealer, (2) dealer's incentives to speculate rather than hedge, and (3) problems that dealers may have in hedging any exposure they incur in providing derivatives contracts to the firms. All of these issues deserve further consideration before we can confidently say that the failure of a dealer would (or would not) pose a systemic risk. We exclude these problems from this analysis in order to highlight that our results depend solely on the loss of information about customer quality.

25. For example, see Weiss (1990).

26. Or that the only possible source of systemic risk is that of bad government regulation.

27. We think that such a bailout would be bad not only for the taxpayers but also for the OTC derivatives market. Any public bailout designed to protect participants in the OTC derivatives market is likely to be accompanied by a substantial increase in government regulation.

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Table 1
TIME LINE

PERIOD 1: INITIAL CONDITIONS

- Firms establish hedges with one of the dealers.
- Some firms become insolvent.

PERIOD 2

- Firms may seek to unwind their existing hedges.
- Dealer 1 may become insolvent.
- Both solvent and insolvent firms may seek to enter into new forward contracts.

PERIOD 3

- A shock to the exogenous risk factor is realized.
- Solvent, hedged firms are unaffected by the shock.
- Solvent, unhedged firms receive gains if the shock is favorable.
- Solvent, unhedged firms suffer direct losses plus costs of financial distress if the shock is unfavorable.
- Insolvent firms that remain hedged fail.
- Insolvent firms that are unhedged and receive an adverse shock fail.
- Insolvent firms that are unhedged and receive a favorable shock are made solvent.
- Firms that are solvent after the shock fully honor their outstanding forward contracts.
- Firms that are insolvent after the shock receive payment under their outstanding forward contracts (if any) if the dealer owes them.
- Firms that are insolvent after the shock do not make any payment under their outstanding forward contracts (if any) if they owe a payment to the dealer.

Table 2
MINIMUM SPREAD REQUIRED BY DEALERS
AS A PROPORTION OF THE SHOCK

Proportion of Firms That are Good	Minimum Spread
99.0%	0.0050
97.5%	0.0127
95.0%	0.0256
90.0%	0.0526
85.0%	0.0811
80.0%	0.1111
70.0%	0.1765
60.0%	0.2500
50.0%	0.3333
40.0%	0.4286

Table 3
MAXIMUM SPREAD THAT GOOD FIRMS WILL PAY AS A PROPORTION OF THE SHOCK

Required Firm Hedge Ratio (H)	Costs of Financial Distress as a Percentage of the Market Value of the Firm's Assets (θ)									
	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%
10%	0.200	0.333	0.500	0.600	0.667	0.714	0.750	0.778	0.800	0.818
20%	0.111	0.200	0.333	0.429	0.500	0.556	0.600	0.636	0.667	NM
30%	0.077	0.143	0.250	0.333	0.400	0.455	0.500	0.538	NM	NM
40%	0.059	0.111	0.200	0.273	0.333	0.385	0.429	NM	NM	NM
50%	0.048	0.091	0.167	0.231	0.286	0.333	NM	NM	NM	NM
60%	0.040	0.077	0.143	0.200	0.250	NM	NM	NM	NM	NM
70%	0.034	0.067	0.125	0.176	NM	NM	NM	NM	NM	NM
80%	0.030	0.059	0.111	NM	NM	NM	NM	NM	NM	NM
90%	0.027	0.053	NM	NM	NM	NM	NM	NM	NM	NM

NM = Not meaningful.

Table 4
MINIMUM PROPORTION OF GOOD FIRMS REQUIRED TO PREVENT MARKET BREAKDOWN

Required Firm Hedge Ratio (H)	Costs of Financial Distress as a Percentage of the Market Value of the Firm's Assets (θ)									
	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%
10%	0.667	0.500	0.333	0.250	0.200	0.167	0.143	0.125	0.111	0.100
20%	0.800	0.667	0.500	0.400	0.333	0.286	0.250	0.222	0.200	NM
30%	0.857	0.750	0.600	0.500	0.429	0.375	0.333	0.300	NM	NM
40%	0.889	0.800	0.667	0.571	0.500	0.444	0.400	NM	NM	NM
50%	0.909	0.833	0.714	0.625	0.556	0.500	NM	NM	NM	NM
60%	0.923	0.857	0.750	0.667	0.600	NM	NM	NM	NM	NM
70%	0.933	0.875	0.778	0.700	NM	NM	NM	NM	NM	NM
80%	0.941	0.889	0.800	NM	NM	NM	NM	NM	NM	NM
90%	0.947	0.900	NM	NM	NM	NM	NM	NM	NM	NM

NM = Not meaningful.