Rocket Science, Default Risk and The Organization of Derivatives Markets

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Abstract Financial derivatives are traded on OTC markets and organized exchanges. Default risks are partially shared–"mutualized"–on exchanges through a clearinghouse. Default risks typically are not shared on OTC derivative markets. In the absence of private information and moral hazard, mutualization improves welfare by reducing the expected cost of default by exploiting scale economies scale economies. Although moral hazard and asymmetric information problems exist in both exchange and OTC markets, private information is more important in OTC transactions because valuation of OTC derivatives often requires the use of specialized, proprietary mathematical models. The lack of default risk mutualization in OTC derivatives markets and its presence for exchange derivatives is consistent with the greater importance of private information on OTC markets. Scale economies are exploited in OTC markets by the formation of large dealer firms rather than via mutualization. Moreover, private information and netting create scope economies that can make it economical to eschew mutualization of

default risks even for standardized OTC products.

1 Introduction

Derivatives–financial contracts with payoffs that are contingent on the prices of commodities or financial instruments–are traded on organized exchanges and in over-the-counter ("OTC") markets.[1] Derivatives include futures contracts, forward contracts, swaps, and options of various sorts. Derivatives are used primarily as risk management tools. A firm that wants to reduce exposure to interest rate, currency, or commodity price risk can off-set this risk exposure by entering into a properly structured derivatives position.

Exchange and OTC markets differ in a variety of ways. Exchange-traded derivatives are bought and sold at a central location in an auction process that takes place either on a trading floor or a central computer. In contrast, there is no centralized market for OTC products. These are typically traded by phone. Exchange traded products are highly standardized and cannot be customized, whereas OTC products can be customized at will. Perhaps most important, the arrangements for sharing default (credit) risk differ substantially between the two markets.

In particular, default risks of exchange traded derivatives are shared through the institution of the clearinghouse. Under the clearinghouse arrangement, default risk and market price risk are borne by different parties. In contrast, clearing on OTC markets is limited to less than a quarter of standardized transactions, and no non-standardized transaction. Instead, contracting parties in the OTC market bear both default risk and market

[1]Recently, so-called "event derivatives" with payoffs contingent on a non-price variable (e.g., a natural gas storage statistic or unemployment rate release) have been introduced into the marketplace, but price contingent contracts remain the primary form of derivative.

price risk on most transactions.

Why do OTC and exchange markets allocate default risk differently? Given the centrality of default risk to the operation of derivatives markets, the allocation cannot be accidental. There must be some considerations related to the characteristics of the products traded on these markets or the firms that trade on them that explains the differences in default risk sharing mechanisms.

Differences in the characteristics of the products traded in the two markets can explain the adoption of the different default risk allocation mechanisms. Exchange traded products are bought and sold in transparent, liquid markets and can be valued without specialized expertise. It is also a relatively straightforward task to quantify the risks inherent in exchange traded derivatives. Under these circumstances, default risk is readily measured by a third party, the clearinghouse. This facilitates the unbundling credit risks and market risk, which can improve welfare.

In contrast, many products traded on derivatives markets are unique and complex. As a result, specialized expertise is required to determine the value and the price risks of these instruments. Since evaluation of default risk requires an understanding of the price risks, those with the best understanding of price risks can measure default risk most accurately. OTC dealers invest in specialized valuation expertise to measure the risks inherent in the deals they execute. OTC dealers use "rocket scientists"–quantitative financial economists, physicists, and mathematicians–to develop proprietary models for valuing non-standard OTC derivatives. These models provide them with superior information about their default risk. This information asymmetry impedes the sharing of default risk. However, it is possible to exploit the economies of scale associated with default risk by the formation of OTC "megadealers" who serve in principals in a large number of transactions and who do not share risk across firm boundaries. Moreover, private information and the ability to net gains and losses across non-standardized and standardized OTC trades creates a scope economy that can make it more expensive to mutualize risk even on many standardized OTC contracts.

Although the formation of megadealers who do not mutualize default risks exploits scale economies and mitigates adverse selection costs, it incurs other costs. Specifically, dealers are fragile institutions (in the terminology of Diamond and Rajan, 2001) who may collapse in response to a sufficiently severe adverse shock.

Thus, differences in the characteristics of products traded OTC and on exchange create different degrees of information asymmetry. These differences in turn result in different default risk sharing arrangements.

The results of this article are novel. Several papers discuss various aspects of default risk and the implications of central clearing, but there is no systematic theory explaining why central clearing has been adopted in some instances, but not in others. Telser (1981) was the first to identify centralized clearing and mutualization of credit risk as the main factor distinguishing futures markets from OTC forward markets. Baer *et al* (1995) describe the mechanics of clearinghouses. Moser (1994) analyzes potential benefits of OTC clearing. Bergman *et al* examine the effect of close-out netting on default exposure. Knott and Mills (2002) note the potential importance of moral hazard that mutualization entails. Using simulation, Jackson and Manning (2005) estimate that centralized clearing can substantially reduce default costs, and that there are economies of scale and economies of scope in centralized clearing. Bliss and Kaufmann (2005) examine the implications of centralized clearing for systemic risk. Gibson and Murawski (2006) investigate the implications of default risk mitigation mechanisms on market, credit, and liquidity risk, and note that these mechanisms may be plagued by externalities that can actually reduce wealth. Many of these papers (Gibson-Murawski being an exception) suggest that mutualization of default risk through central clearing offers substantial cost savings, which begs the question: why has mutualization made only modest inroads into the OTC markets? This article attempts to answer this question using standard informational considerations that should be at the center of any analysis of risk sharing mechanisms. In a sense, it endogenizes the difference first emphasized by Telser based on the relation between information asymmetries and the costs of sharing risk.

The remainder of this article is organized as follows. Section 2 describes the allocation of default risk on exchanges. Section 3 describes the allocation of default risk in OTC markets. Section 4 presents a simple model that demonstrates the existence of scale economies in the sharing of default risk, and argues that these economies can be exploited by either pooling risks across a large number of individual firms, or the consolidation of intermediaries to form megadealers. Section 5 shows that (1) the non-standard nature of OTC derivatives transactions creates information asymmetries that can preclude sharing of default risk across firm boundaries, and (2) these considerations are less important in standardized exchange transactions; this implies the consolidation solution is more likely in OTC markets, and clearing more likely in exchange traded markets with standard products. Section 6 shows that the default risk sharing mechanism in OTC markets may lead to periodic collapses of dealer firms; this is a cost of exploiting scale economies through consolidation. Section 7 summarizes the article.

2 The Allocation of Default Risk in Exchange Traded Derivatives

Futures contracts are promises to enter into a transaction at some future date. For example, a firm that buys a July, 2007 corn futures contract on the Chicago Board of Trade at a price of $2.30 per bushel is obligated to buy 5000 bushels of corn delivered to the Illinois River in July, 2006 at that price.[2] Traditionally, futures contracts have been traded on exchange floors via a double-sided "open outcry" auction in which buyers and sellers cry out prices at which they are willing to transact. Currently, the markets are undergoing a transition to electronic trading. In an electronic market, buyers and sellers submit reservation prices and quantities to a centralized computer which matches them using an algorithm based on price and time priority rules.

In an open outcry or electronic market, upon consummation of a transaction the buyer and the seller record the details of the deal (including commod-

[2]Futures market participants can off-set their position prior to delivery. For example, the buyer of a July, 2007 corn futures contract can subsequently sell a July, 2006 contract. By doing so, he terminates his obligation to take delivery. Most futures positions are off-set prior to delivery, so a relatively small percentage of contracts (roughly 2 percent) go to delivery.

ity, delivery month, quantity, price, and time). They submit these records to the exchange clearinghouse. The clearinghouse verifies that all information submitted by the buyer and the seller is in agreement. Once a trade is matched by the clearinghouse, the deal enters the clearing process.

Clearing replaces the contractual link between the initial transacting parties with another set of contractual connections. To understand the nature of this process, it is useful to present the "textbook" description of a clearing process even though this common description is not completely factual; I will subsequently flesh out the description to describe clearing more fully and accurately.

In the textbook description of the clearing process, the clearinghouse becomes the buyer to every seller and the seller to every buyer. For example, if S sells a corn futures contract to B, in this typical description once the trade is cleared B and S no longer have a contractual relation with one another. Instead, S has an a contract to sell corn to the clearinghouse, and B has a contract to buy corn from the clearinghouse. In this scenario, if S and B perform on their contracts, the clearinghouse has no exposure to market movements because it has bought and sold identical amounts. The clearinghouse's key role in this set-up is related to default risk. If S defaults on his obligation to deliver, the clearinghouse is obligated to make B whole by paying him the full contractual amount. Thus, in this case S and B bear risks due to price changes, but the clearinghouse bears the risk of default by S or B; default risk and market risk are unbundled.

Things are much more complicated in reality than this sketch would imply, although there is still in fact some separation of default and market price risk.

In actual practice, S and B trade through brokers who are (either directly or indirectly) members of the clearinghouse.[3] Once a deal is matched, S has a contract to sell to his broker, SB, and B has a contract to buy from his broker, BB. The clearinghouse enters the picture only if brokers do not have equal number of buy and sell contracts. For example, if SB has bought 500 contracts for customers and sold 1000 contracts for customers, the firm has a net position of 500 contracts sold. In this case, the clearinghouse becomes the buyer for the 500 contract net position of SB. The clearinghouse also has sold 500 contracts to all brokers other than SB. Thus, the clearinghouse's net position is always zero.

Contracts are collateralized in futures markets through the margin system. In a margin system, a broker collects money from customers when they open positions. This is called original margin. If prices move against the customer, the broker removes money from the customer's margin account in the so-called marking-to-market process. Thus, the customer has funds on deposit with the broker that can be used to cover his losses.

To illustrate this process, consider an individual who buys a corn futures contract on day t at a futures price of \$2.30 per bushel. The contract amount

[3]Some brokers belong to the clearinghouse. These are called clearing brokers. Other brokers are not members of the clearinghouse. Non-clearing brokers must have an account with a clearing member. Default by a non-clearing broker's customer is absorbed first by the broker and his other customers. If these resources are not sufficient to cover the amount owed by the defaulting party, the clearing broker is obligated to pay. If the clearing broker cannot cover the loss, some part of the obligation falls on the clearinghouse as described in the text. Frequently a non-clearing broker will execute an order on the floor of the exchange and then "give up" the contract to a clearing broker. In this process, one broker provides execution services, and another bears default risk. See Edwards (1983) for a full description of the process.

is 5000 bushels of corn. On day $t + 1$ the price rises to \$2.35 per bushel, generating a profit of \$250 for the buyer. This amount is paid into the individual's margin account at the end of $t + 1$. On day $t + 2$, the price falls to \$2.25 per bushel, generating a loss for the buyer of \$500. This amount is deducted from the individual's margin account. The individual need not post any additional monies into the margin account unless and until the balance in that account falls below the so-called "maintenance margin" level. In the case of the buyer of corn futures, his original margin may be \$2000 and the maintenance margin level may be \$1000. When the trader's account accumulates more than \$1000 in losses, he is obligated to send additional monies to his broker to restore the margin balance to the \$2000 level.

Margins are collected by brokerage firms and the clearinghouse. The brokerage firms collect margins from their customers. The clearinghouse collects margins from its member-brokers.[4]

This system determines the allocation of losses in the event of a default. To make things concrete, assume that S has sold corn futures contracts prior to a drought. When the drought occurs, corn futures prices rise, and S loses money. Prices rise so much on a particular day that S loses \$10 million.

[4]Some exchange clearinghouses, such as the Chicago Board of Trade Clearing Corporation, collect margins on the net position of clearing members. For example, a broker long 1000 contracts and short 500 contracts in customer accounts pays margin on the 500 net long position. Other clearinghouses, such as that of the Chicago Mercantile Exchange, collect margins on the gross position. In this case, the clearinghouse collects margin on the 1000 long contracts *and* the 500 short contracts. Edwards (1983) shows that the clearinghouse's guarantee obligation is the same under either net or gross margining. As long as the broker collects margins from his customers promptly and in full, and properly segregates customer and firm funds, the amount of margins collected are the same under the two systems. Gross margining reduces the probability that a broker will collect too little margins from customers.

He has \$1 million in his margin account, so he still owes \$9 million. If he cannot pay the \$9 million before the opening of the market the next day, he defaults. Assume that he defaults owing \$9 million. This means that there are those who have bought futures contracts who are owed \$9 million. Where will that money come from? It first comes from the pocket of S's broker SB. That is, SB is required to dip into its own capital (including any margin on deposit at the clearinghouse) to pay this sum. If SB's capital is less than \$9 million, then margin money held by SB for other customers is used to pay what is owed. If SB's capital plus the margin monies of other customers is less than \$9 million, the clearinghouse has an obligation to pay some or all of the remaining amount *if and only if* SB has a net position with the clearinghouse. The clearinghouse may not be required to pay all remaining losses.[5]

If the clearinghouse has an obligation because SB has insufficient funds to pay the losses incurred by a defaulting customer, it can pay this obligation out of a variety of sources. First, it can call on its own capital. The clearinghouse is owned by brokerage firms who contribute capital to join it. Second, if its own capital is insufficient to cover its obligations, in most cases the clearinghouse can require its members (the brokerage firms that own it) to

[5]For analyses of the operation of clearing systems, see Edwards (1983), Report of the Presidential Task Force, study VI (1988), Office of Technology Assessment (1990), and Jordan and Morgan (1990). The Board of Trade Clearing Corporation, which clears for the Chicago Board of Trade, has an "explicit right of offset" which effectively limits its exposure to the net position of any clearing member. Board of Trading Clearing Corporation (2001). Under Chicago Board of Trade rules, a customer whose position is off-set has a contract with a clearing member, not with the clearinghouse. Chicago Board of Trade (2001).

make additional contributions under so-called “good to the last drop” rules.[6] In most cases, the amount of contribution that the clearinghouse can demand from any member is proportional to capitalization and limited to some maximum amount. A clearinghouse can use this assessment authority to collateralize borrowings from banks, and in the aftermath of the 1987 crash many clearinghouses have purchased letters of credit precommiting banks to lend against the collateral provided by the assessment.[7] Thus, the cost of any payment by the clearinghouse to cover the obligations of a defaulter is shared by the owners of the clearinghouse. Third, some exchanges have established guaranty funds that can be drawn on to cover some customer losses.

This mechanism can result in a variety of different allocations of losses from default. Losses due to default are shared by the defaulter’s broker, the defaulter’s broker’s other customers, and other clearinghouse members, in that order. In some cases, the clearinghouse bears no loss from default. For example, consider a firm SB with a customer S has sold 1000 corn futures contracts and with other various customers $B_1, \ldots, B_N$ who have bought a total of 1000 corn futures contracts. Here, the firm’s customers have a zero net position, so SB has no position with the clearinghouse. If S de-

[6]The Chicago Board of Trade Clearing Corporation is an exception.

[7]Report of the Presidential Task Force, study VI (1987), Office of Technology Assessment (1990). Pirrong (1998) shows that borrowing by the clearinghouse can mitigate adverse selection problems that might occur during a market crash that casts doubt on the solvency of individual brokerage firms; there is less uncertainty about the solvency of the clearinghouse members collectively than there is about individual members. Thus, the clearinghouse can borrow when individual firms cannot. Precommitment through letters of credit further reduces the likelihood of an adverse selection problem that could force liquidation of solvent brokers.

faults owing \$10 million, and SB has a capital of \$5 million, other customers $B_1, \ldots, B_N$ lose \$5 million.[8] Conversely, if S is SB's only customer, the clearinghouse is obligated to pay the remaining \$5 million debt. Thus, sometimes the clearinghouse pays, sometimes it does not.

Although the allocations of losses from default can vary, the important thing to note is that default risks are shared. If S and B execute a deal in the pit, once a deal enters the clearing process, the risk of loss from default that B bears does not depend on S's wealth; instead, it depends on the capital of S's broker, and the resources of other members of the clearinghouse. Also note that brokerage firms and clearinghouse members can lose due to defaults even if they have no net market exposure to price changes. For example, the clearinghouse never faces market price risk because it always has a zero net position, but the clearinghouse can suffer losses if a market participant defaults. Thus, default risk and risk of loss from changes in market prices (assuming all parties perform their obligations) are not bundled.

Although default risks are shared, they are not pooled completely as would be the case under the textbook description of the clearinghouse in which the clearinghouse (and thus its members) share the costs of any default. As noted earlier, the broker of a defaulting customer absorbs the cost of default up to the amount of its capital. The broker's other customers may also bear some of the default costs. These limitations on risk sharing with other brokers are clearly intended to mitigate moral hazard problems. With incomplete risk pooling the broker has an incentive to monitor the creditwor-

[8] Customers of two brokerage firms, Volume Investors and Griffin Trading, suffered sizeable losses when a large customer defaulted.

thiness of his customers. Similarly, customers have an incentive to monitor both the creditworthiness of the broker, and his diligence in monitoring other customers. Such incentives would be absent if the clearinghouse operated in a truly textbook fashion.

3 The Allocation of Default Risk for OTC Derivatives

OTC derivatives transactions are negotiated and executed by spatially dispersed traders via telephone or through electronic dealing platforms, rather than on a centralized trading floor or computerized exchange. In a traditional OTC trade, after agreeing to the details of the transaction by phone, the transactors exchange deal confirmations by facsimile or teletype transmission.

Until very recently all OTC transactions have been exclusively principal-to-principal transactions with no central clearing. Even now only a small fraction OTC transactions are cleared; as will be discussed in detail shortly, a clearinghouse for some OTC transactions was established in 1998.[9] That is, unlike in exchange traded markets, for most OTC deals each original transactor is at risk to the default of their counterparty for the life of the transaction. Thus, if S sells an OTC forward contract to buyer B, B bears the entire loss if S defaults. Recall that in exchange traded markets, the original transactors are not at risk to default by the party with whom they *initially* transact. In the exchange, once the deal enters the clearing system default

[9] Energy is somewhat of an exception.

risk is reallocated according to the rules of the exchange and its clearinghouse. This reallocation of default risk does not occur in most principal-to-principal OTC transactions.[10]

Although OTC clearing has made some inroads since its introduction in 1998, as of 2006 (a) far less than half of all standardized OTC interest rate derivatives trades are cleared, (b) no currency or equity OTC derivatives are cleared, and (c) virtually no exotic, non-standardized OTC trades are cleared. According to Bank of International Settlements data, the total notional amount of interest rate swaps and FRAs outstanding at the end of 2004 was $163.4 trillion. At the end of 2004, SwapClear, an OTC swap clearing service operated by LCH.Clearnet was clearing approximately $40 trillion in standardized OTC interest rate swaps. Since non-standard instruments accounted for some of the total outstanding swap notional, approximately one-quarter of standardized interest rate swaps were cleared at the end of 2004. To place things in perspective, one bank, JPMorganChase had $37 trillion in notional value of interest rate swaps on its books at the end of 2004. Moreover, although at the end of 2004 there were $29.6 trillion in notional amount of OTC currency swaps and forwards and $4.4 trillion in OTC equity swaps outstanding, none were cleared. Similarly, none of the

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[10]There are some default risk sharing mechanisms in the OTC market. For instance, insurance companies will sometimes issue surety bonds to back OTC derivatives transactions. The insurance company issuing the bond is obligated for performance in the event that the relevant principal defaults. Similarly, third parties will sometimes "sleeve" a principal to an OTC deal. The party "sleeving" the deal is obligated for performance if the principal he "sleeves" defaults." Both sleeving and surety bonds differ substantially from default risk sharing through clearinghouses. In a clearinghouse, default risk is spread among a larger number of parties. Moreover, whereas a clearinghouse necessarily has a zero exposure to market risk, the same is not true in sleeving or surety transactions.

$27.1 trillion in interest rate options, $6.1 trillion in currency options, or $3.6 trillion in equity options traded OTC were cleared.

Although centralized clearing has made only limited penetration into the OTC markets, the potential costs of default have nonetheless exerted a decisive influence over the structure of OTC derivatives transactions. Virtually all OTC derivatives transactions are entered pursuant to so-called Master Agreements that set out the basic terms governing all OTC transactions between the parties of the Master Agreement. In particular, the Master Agreement establishes procedures governing default on any OTC transaction.

One of the most important features of standard Master Agreements is that obligations are netted to limit exposure to default by a given counterparty. For example, assume that B and S have executed three OTC transactions, deals 1, 2, and 3. As of date t, B owes $1 million on deal 1, and $3 million on deal 2, but as of t, S owes B $2 million on deal 3.[11] Under netting, B owes S $2 million. Thus, in the event of a default by B at time t (occasioned by B's declaration of bankruptcy, for instance), S is a creditor of B to the amount of $2 million. This arrangement prevents B from defaulting on the $4 million it owes on deals 1 and 3 and taking action to force S to pay the $2 million owed on deal 3.

Master Agreements also typically specify that OTC transactions are ex-

[11]The degree of netting can vary. Some master agreements limit netting to contracts in the same commodity and currency. In this case, a loss on a gas contract would not be netted against a gain on a power contract, nor would a US dollar gas contract loss be netted against a Canadian dollar gas contract gain. Cross-product netting is also possible, in which case the hypothetical power-gas gains and losses can be offset against one another. The Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 provided a legal safe harbor to cross product netting.

empt from the automatic stay provision of Federal bankruptcy law. In the event of a default occasioned by the bankruptcy of one of the parties, the counterparty usually has the right to liquidate all outstanding OTC deals with the bankrupt party. Upon liquidation, the defaulter is obligated to pay the net amount due on OTC transactions and cannot use the bankruptcy process to escape or delay payment.

The structure of the OTC market also reflects the primacy of default risk. In particular, most OTC derivative transactions are intermediated by dealers. That is, most OTC transactions have a large dealer as one of the parties. For instance, a corporation that wants protection against rising interest rates sells an interest rate swap to a dealer. Another firm that wants protection against falling rates buys an interest rate swap from a dealer.

Dealers are typically large, well capitalized banks with AA credit ratings. Due to the creditworthiness of these dealer-banks, counterparties who wish to hedge price risks are highly confident that the dealers will not default on their obligations. Derivative holdings are highly concentrated in these large banks. At the end of 2004, the top 3 banks in the US, JP Morgan Chase, Bank of America, and Citibank, held 86 percent, 93 percent, and 87 percent of all notional value of OTC forwards, swaps, and options, respectively, held by US banks . The Herfindahl index of derivatives notional value holdings across all US commercial banks was 2708, 3650, and 3270 for OTC forwards, swaps, and options, respectively.[12] Therefore, these are very highly concentrated markets, and have become more concentrated in recent years. In 1998, for

[12] All data from OCC (2004). Similar data are unavailable for non-US institutions and for investment banks.

instance, the top 7 banks accounted for 90 percent of the notional value of OTC derivatives held by US banks, whereas as of the end of 2004 the top three banks account for 90 percent of this notional value.

In essence, in OTC markets a dealer's equity capital is used to reduce the probability that its counterparty will suffer loss from a default. Put differently, for the most part the dealer's equity holders self-insure the default risk. The dealer typically participates on both sides of the market. The dealer is the buyer in some transactions, the seller in others. If one of the dealer's counterparties (firm A) defaults, the dealer's other transacting partners (say, firm X) will receive what the dealer owes them as long as the dealer is solvent. If the dealer has substantial equity capital he will almost surely be solvent. In contrast, if a firm X had dealt with A directly without intermediation from the dealer, X would be at risk to A's default.

The importance that market participants place on reducing default risk is further illustrated by the fact that investment banks have largely failed to make major inroads as derivatives dealers despite concerted efforts to do so. Several major investment banks, including Merrill Lynch and Soloman Brothers, established seperately capitalized AAA derivative dealer subsidiaries (Derivative Products Companies, or "DTCs")) in an attempt to capture OTC derivatives business from AAA rated commercial banks. Despite these efforts, investment banks largely failed in this object because of the perception that a AAA rating for a subsidiary of an investment bank rated less than AAA is not as desirable as a AA rating for a commercial bank such as J. P. Morgan.[13]

In sum, default risk is allocted differently in OTC and exchange markets. The original transactors continue to bear default risk throughout the life of most OTC derivatives transactions. The original transactors typically also continue to bear market price risk throughout the life of the transaction. Thus, price risk and default risk are largely integrated ("bundled") in OTC markets. In contrast, market price and default risks are unbundled in exchange markets. Default risk for exchange traded products is shared among market participants according to a complex set of rules. This raises the question: What explains the differences in default risk sharing on exchanges and in OTC markets.

4 Economies of Scale in Default Risk

A simple model of default risk and default risk sharing demonstrates that there are economies of scale in bearing default risk. These economies of scale provide a motive to create risk pooling mechanisms, such as a clearinghouse. They may also induce the formation of large dealers who do not share risks through a clearinghouse, and induce substantial concentration in dealer activities. This raises the question–addressed in section 5 below–of which means of exploiting economies of scale will be adopted.

In the model, there are several dealers. At time 0 dealer i enters into a set of derivatives transactions with customers $j = 1, \ldots, N$. These deals all mature (expire) at time 1. The time 1 contractual payoff to dealer i in his

[13] See Kroszner (1999) for a detailed discussion of DTCs.

transaction with customer j is given by the random variable $\tilde{v}_{ij}$. If $\tilde{v}_{ij} > 0$, the customer owes the dealer money; if $\tilde{v}_{ij} < 0$ the dealer owes the customer. At time 1, customer j has equity (gross of his obligations to dealer i) equal to the random variable $\tilde{V}_j \geq 0$. The dealer receives the entire contractual payment on the derivative only if $\tilde{V}_j \geq \tilde{v}_{ij}$. If $\tilde{V}_j < \tilde{v}_{ij}$, the customer cannot pay what he owes, so the dealer receives $\tilde{V}_j$ instead of the full contractual payment. Thus, the payoff to the dealer in his dealings with customer j is $\min[\tilde{v}_{ij}, \tilde{V}_j]$.

Note that the payoff to the contract with customer j is an option. More specifically, it is the option on the minimum of two risky assets.[14] The value of this option depends on the joint probability distribution of the no-default value of the claim, $\tilde{v}_{ij}$, and the equity value of the counterparty, $\tilde{V}_j$.

At time 1 dealer i has equity value (gross of profits or losses on derivatives deals) equal to the random variable $\tilde{E}_i$. At time 1, the dealer owes payments to counterparties on deals such that $\tilde{v}_{ij} < 0$. (Note that $\min[\tilde{v}_{ij}, \tilde{V}_j] = \tilde{v}_{ij} < 0$ for such deals.) All counterparties the dealer owes will receive full payment if and only if:

$$\tilde{Z}_i = \sum_{j=1}^{N} \min[\tilde{v}_{ij}, \tilde{V}_j] + \tilde{E}_i \geq 0 \tag{1}$$

If this inequality does not hold, the dealer defaults. In this case, all customers with $v_{ij} < 0$ receive less than the full contractual payment.

Note that the distribution of $\tilde{Z}_i$ depends on the joint distribution of $\tilde{E}_i$, $\{\tilde{v}_{ij}\}_{j=1}^{N}$, and $\{\tilde{V}_j\}_{j=1}^{N}$. Thus, knowledge of this joint distribution is required to evaluate the distribution of losses due to a default by dealer i.

[14] If the deal with j is itself an option, the dealer's payoff is a compound option–an option on an option. Things are even more complex if the trade is an exotic option.

Consider another dealer h who transacts with customers $k = 1, \ldots, K$ at time 0. This dealer does not default if:

$$\tilde{Z}_h = \sum_{k=1}^{K} \min[\tilde{v}_{hk}, \tilde{V}_k] + \tilde{E}_h \geq 0 \tag{2}$$

Dealers i and h could enter into a default risk sharing arrangement (likely through the establishment of a clearinghouse) whereby i covers any payments owed to h's customers in the event that h would otherwise default, and h covers any payments owed to i's customers in the event that i would otherwise default. Alternatively, i and h could merge. In either case, no customer of h and i (or the combined entity) loses from a default if:

$$\sum_{j=1}^{N} \min[\tilde{v}_{ij}, \tilde{V}_j] + \tilde{E}_i + \sum_{k=1}^{K} \min[\tilde{v}_{hk}, \tilde{V}_k] + \tilde{E}_h \geq 0 \tag{3}$$

It is readily evident that there are some states of the world (i.e., some possible realization of $\{\tilde{v}_{ij}, \tilde{v}_{hk}, \tilde{V}_j, \tilde{V}_k, \tilde{E}_i, \tilde{E}_h\}$) such that (3) holds, but (1), (2), or both do not, i.e., (1) and (2) are sufficient, but not necessary, for (3) to hold. In essence, default costs are subadditive. Therefore, customers lose from defaults in fewer states of the world if default risk is shared than if it is not. Equivalently, sharing of default risk would reduce the amount of equity capital required to generate the same expected customer loss from dealer default that would be observed absent default risk sharing. It is straightforward to show that increasing the number of dealers participating in the risk sharing arrangement, or the number combining to form a single "megadealer," would reduce even further default risks (or equivalently the amount of equity required to hold the expected customer losses to default constant).

This analysis demonstrates the existence of economies of scale in default risk sharing.[15] If customers are risk averse, the reduction in the risk of default makes them better off. Alternatively, a reduction in the amount of dealer equity required to hold the risk of default constant is beneficial because equity capital is costly due to asymmetric information and moral hazard problems (Merton, 1993; Jensen and Meckling, 1973).

Since these economies of scale can be exploited either through mutualization or the formation of large dealers, to understand which will occur in practice requires consideration of the costs and benefits of these alternatives. I focus on two salient considerations that can explain key features of the organization of derivatives markets: information asymmetries that impede risk sharing across firms via mutualization, and the risks of dealer collapse that arise largely due to the ability of a dealer to take exposure to market risks. I discuss the first consideration in the next section, and the second issue in Section 6.

5 Transaction Characteristics and the Choice of Default Allocation Rules

5.1 Information Asymmetry and Default Risk Sharing for Non-Standardized Products

Mutualization of default risk implies that this risk is shared across firm boundaries. In contrast, exploitation of scale economies through the formation of megadealers who do not mutualize implies that default risk is not so transferred. Therefore, the existence of costs to transferring risk across

[15]Jackson and Manning (2005) quantify other sources of scale economies.

firm boundaries tend to disfavor mutualization.

Information asymmetries between firms raise the costs of mutualizing default risk. If information asymmetries are sufficiently severe, mutualization mechanisms may fail to develop.[16] Specifically, in the notation of the prior section, inter-firm risk sharing may break down if dealer i has substantially better information about Z_i than does h, and dealer h has substantially better information about about Z_h than does i.

Information asymmetry is most acute when dealer i has better information about the joint distribution of the $\{\tilde{v}_{ij}\}_{j=1}^{N}$ and $\{\tilde{V}_j\}_{j=1}^{N}$ than dealer h. Due to the nature of many OTC derivatives transactions, it is likely that these asymmetries are in fact severe. Many OTC derivatives transactions are unique and non-standard, and are customized to suit the needs of a particular client. For example, there are a variety of "exotic" options such as "knock (or barrier) options" and "Asian options" that are routinely traded on OTC markets. These products are not traded on transparent markets.

Due to the customization of many OTC products, transactions price data for them are not readily available. As a result, it is not possible to utilize

[16]Information asymmetry creates the potential for adverse selection. If parties have the option to clear a trade or not, a dealer may prefer to keep the low risk trades and clear the high risk ones. Mandatory clearing of all deals would eliminate adverse selection, but it is unlikely that this mandate could be enforced economically as it would require the comparison of all of a dealer's trades against those submitted for clearing. Although random monitoring could mitigate monitoring costs, monitoring is still likely to be expensive. Moreover, the cleverness of financial engineers makes it extremely difficult to monitor compliance. It is possible to financially-engineer products that are functionally equivalent to derivatives but which are characterized as loans or securities, and *vice versa.* Thus, a rule that requires clearing of all derivatives trades could be readily circumvented by engineering derivatives trades into loans or securities. It is cheaper to monitor submission of trades consummated in a centralized exchange market for clearing than is the case for decentralized OTC markets.

publicly available transaction price information to determine the value of one of these deals on a continuous or even regular basis. Moreover, non-standard OTC products frequently have highly non-linear exposures to underlying risks. For example, the value of a knock-in option on the yen is a highly non-linear function of the yen-dollar exchange rate. This non-linear exposure also makes it difficult to hedge and to quantify the risk inherent in a position in such an instrument.

Since (1) transactions price quotations for non-standard OTC instruments are not widely available, and (2) non-standard instruments generate complex risk exposures, OTC dealers develop proprietary models to value such instruments. To develop and implement these models, dealers employ financial economists with specialized valuation expertise. They also employ numerous mathematicians, physicists, and computer scientists to solve the complex mathematical and programming problems inherent in valuing and hedging complex derivatives. These individuals are often called "quants" or "rocket scientists."

The models that rocket scientists develop are intended to allow the dealer to value and hedge specialized derivatives more accurately. For instance, using finance theory and various mathematical and computational methods, it is possible to estimate how the value of the aforementioned knock-in option varies with the yen-dollar exchange rate, the volatility of the exchange rate, time to option expiration, and other factors. Given this knowledge, it is possible to determine the appropriate price to charge for the option and to understand its risk profile. This information also allows the dealer to determine a dynamically adjusted position in the yen that offsets the risk inherent in the option position.

The reliance on specialized valuation expertise contributes to information asymmetries for a variety of reasons.

First, investments in pricing model expertise reduce the dealer's cost of evaluating the risk exposure posed by a particular instrument. A dealer i with special model to determine the value, behavior, and risks of a particular financial instrument has better information on the distribution of $\tilde{v}_{ij}$ than someone who lacks such a model.

Second, dealers offering derivatives tailored to suit the needs of a particular counterparty learn about the latter's business operations. A customer seeking a particular type of derivatives trade, or seeking advice on how to structure a trade to manage a particular risk, provides valuable information about his risk management needs and financial condition to the dealer with whom he contracts. That is, the process of structuring a deal with counterparty j gives dealer i information about the distribution of $\tilde{V}_j$.[17]

Third, these factors interact. A dealer with special knowledge of the behavior of a particular kind of instrument and the risk exposure of his counterparty better understands how this particular instrument will affect this particular counterparty under specific market conditions than someone who lacks specialized pricing expertise and knowledge of the counterparty's risk exposure and financial condition. That is, the combination of specialized modeling expertise and close contact with customers provides valuable information on the joint distribution of $\tilde{v}_{ij}$ and $\tilde{V}_j$.

[17] A banker-dealer with a lending or deposit relationship with j has access to additional information about j.

Fourth, dealer i may enter into some derivatives transactions to hedge others. In particular, a dealer may enter into simple derivative contracts (forwards, swaps, and basic options) to hedge exposures inherent in exotic derivatives trades. The dealer must adjust positions in simple derivatives in a dynamic fashion in order to maintain a hedge of the exotic trade. The appropriate dynamic hedge position for an exotic is determined by the sensitivity (the mathematical derivative) of the exotic to changes in underlying basic risk variables. The dealer utilizes proprietary pricing models to determine these sensitivities. Due to a variety of factors (such as, the fact that the hedge cannot be adjusted instantaneously, transactions costs, imperfect market liquidity, and modeling error), no hedge is "perfect." That is, even a dynamically hedged position has some residual risk. This residual risk contributes to the probability that the dealer will default (i.e., the probability that $Z_i < 0$). The performance of the dealer's dynamic hedges depends on his models and the skills of his traders. The dealer can evaluate and monitor this performance more effectively than outsiders. This further contributes to an information asymmetry between the dealer and others with whom he could share default risk through mutualization.[18]

The foregoing implies that dealer i is likely to possess proprietary information about the distribution of $\tilde{Z}_i$. This asymmetry is compounded if dealer i has more information about $\tilde{E}_i$, as is likely especially if the firm is a bank, which due to the nature of its assets (a loan portfolio) has a somewhat opaque balance sheet.

[18] Green and Figlewski (1999) show that "model risk" can be large.

The existence of this information asymmetry can make it too costly for dealers to share default risk. This raises the question of whether it is economic to take actions to reduce the degree of information asymmetry. Possible mechanisms include the voluntary transfer of proprietary pricing information from dealers to a third party clearing organization, or the development of exotic derivative price modeling expertise by the clearer.

For a variety of reasons it is unlikely that these mechanisms are economic. In particular, it is costly to transfer information from the dealer to the clearinghouse. Moreover, the third party clearer cannot have as strong an incentive as the dealer to develop accurate pricing models.

With regards to the first point, note that (1) proprietary pricing information is valuable to the dealer because it may confer a competitive advantage in servicing clients, (2) it would be difficult for the dealer to protect his property right in specialized pricing expertise if he were to transmit this information to a third-party such as a clearinghouse, (3) it is costly to ensure accurate revelation of pricing and counterparty risk exposure information by the dealer, and (4) it is difficult for the dealer to articulate some information about the creditworthiness of counterparties. All of these factors combine to make it costly to transfer valuation expertise from the dealer to the clearinghouse.

With regards to the second point, although an OTC clearinghouse could in theory develop expertise in pricing non-standard instruments to facilitate the quantification of the default risk exposure inherent in a dealer's portfolio, this entails substantial additional costs. Specifically, it involves redundant investment in pricing expertise. Furthermore, dealers typically have stronger incentives to develop superior pricing expertise. The dealer internalizes any gains to superior price modeling attributable to more effective hedging of derivatives positions, reduced pricing error risk, *and* reduced default risk. In contrast, a third-party clearer would internalize only those gains attributable to better measurement of default risk because the clearinghouse does not bear pricing, market, or hedging risk. Thus, one expects the dealer to develop a more accurate and robust model. This tends to reduce the dealer's effective cost of measuring counterparty credit risk relative to the cost incurred by a third-party.

This analysis implies that the non-standard nature of some OTC derivatives creates the potential for information asymmetries. The various impediments to default risk sharing in OTC markets are present in exchange markets, but they are clearly less severe. Valuation of exchange transactions is far simpler. The market prices of exchange traded instruments can be determined whenever the market is open; in an increasingly electronic world, markets are open for all but a few hours each day. The markets are competitive and transparent. Large numbers of transactions take place on exchanges, so recent transactions prices are reliable barometers of current value. Therefore, a third party that wishes to determine the value of any particular transaction can do so by referring to the readily available market price; no specialized valuation expertise is required.[19]

Moreover, although exchange traded derivatives are frequently quite risky,

[19] Brokers are likely to have private information about the financial condition of their customers. This information asymmetry may preclude complete sharing of default risks through a clearinghouse, and incomplete sharing is the rule as I have already demonstrated.

their risks are readily understood and quantified using fairly straightforward statistical techniques. No specialized valuation models are required to evaluate risk exposure.

In contrast to circumstances in the OTC market, the values of the standardized claims that are traded on exchanges are typically linear functions (or relatively simple non-linear functions) of these risk factors. Far more specialized valuation expertise is required to understand the distribution of non-linear functions of these risk factors than is needed to understand the distribution of the risk factors themselves. This implies that information about the default risks inherent in exchange traded derivatives is much more widespread and much cheaper to obtain. This in turn implies that it is cheaper to implement default risk mutualization in exchange markets than OTC markets because information asymmetries are not as severe in the former as the latter.

Therefore, the information asymmetry-related costs costs of unbundling default risk and market risk are higher for non-standardized OTC transactions than standardized exchange transactions. The fact that all exchange transactions are centrally cleared, whereas non-standard OTC trades are not, is consistent with this analysis of cost differences.

5.2 Why Aren't Default Risks for Standardized OTC Products More Widely Shared?

Although all derivatives transactions that are centrally cleared are standardized, not all standardized transactions are centrally cleared. Many OTC transactions are highly standardized. For example, highly standardized "vanilla" interest rate swaps and forward rate agreements (FRAs) are widely traded in the OTC market.[20] Moreover, price quotations for such products are widely available on information sources such as Bloomberg. Nonetheless, as documented in section 3, the majority of transactions in the largest OTC markets, such as those for dollar and Euro denominated interest rate swaps and FRAs and major currency swaps, are not centrally cleared; nor are equity and currency OTC trades. The lack of clearing of currency swaps is of particular interest because default costs are typically higher for these instruments due to the fact that principal is at risk in these transactions, whereas it is not for interest rate, commodity, and equity swaps.

Although standardization mitigates some of the informational asymmetries that raise the cost of mutualization, it does not eliminate them. In particular, one key factor that impedes mutualization of default risk on standardized instruments traded by dealers who also trade non-standard products is that the exposure of the mutualization mechanism to default by any member is determined by that member's overall position across all instruments; this is evident in (1) and (2). The default risk on a standardized transaction therefore cannot be evaluated in isolation; it depends on the riskiness of the dealer's entire position. For instance, a dealer that suffers a huge loss on a series of exotic option transactions may default on a vanilla swap obligation.

[20] Notional value of US dollar interest rate swaps outstanding at the end of 2004 was $61 trillion. The notional value of exchange traded US dollar interest rate futures outstanding at the end of 2004 was $10 trillion. Since swaps typically have tenors of more than three months, but Eurodollar futures have a tenor of only three months, $1 trillion of swap notional value is equivalent to several trillion in Eurodollar futures notional value. For example, a five year $1 million notional swap is equivalent to a bundle of 20 Eurodollar futures contracts, so $1 million in 5 year swap notional value is equivalent to $20 million in Eurodollar futures notional value.

To determine the expected cost attributable to such events, a clearinghouse that assumes default risk on the vanilla swap must understand the value and risks of the dealer's entire portfolio. As noted earlier, superior pricing expertise gives the dealer an information advantage over the clearinghouse. This impedes sharing of default risks even on standardized transactions.

The relative unimportance of central clearing arrangements for standardized OTC derivatives is therefore consistent with the information asymmetry explanation for bundling of default and price risks in OTC markets when dealers trade both standard and non-standard products. This analysis does suggest, however, that there is an advantage to mutualizing default risks on standardized instruments while eschewing mutualization for non-standard instruments.[21] The foregoing argument implies that such separate treatment of standardized and non-standardized trades would be cheaper if dealers were to specialize in one type of product or the other.

The continued dominance of dealers who trade both standardized and non-standardized products therefore argues for the existence of economies of scope from having the same dealers bear the default risks for both standardized and non-standardized deals. Absent scope economies, in equilibrium one would expect to see "boutique" dealers specializing in standard instruments that are then cleared and others who specialize in trading non-standard–and

[21]Indeed, futures markets where brokerage firms trade standardized products are an example of such separation/specialization. Broker-members of exchange clearinghouses typically have portfolios of standardized instruments, all of which are traded on transparent markets. The risk characteristics of these portfolios can be quantified using fairly straightforward applications of portfolio theory. Indeed, the Standardized Portfolio Analysis of Risk System (SPAN) that most clearinghouses in the US use to evaluate default risk and (and to set margins) is such an application.

non-cleared–products.

OTC dealers' superior knowledge about their counterparties is a likely source of scope economies. Recall that the distribution of $\tilde{Z}_i$ (the dealer's equity net of his derivative exposure) depends on the distribution of the $\tilde{V}_j$, the equity values (gross of derivatives exposure) of his counterparties. The dealer is also likely to possess important information if he has entered into non-standard derivative contracts with a particular counterparty. The combination of the dealer's special information about the counterparty and his special information about the value of the non-standard derivative allows him to evaluate the default risks of a standard derivative transaction with this same counterparty more accurately than could other dealers or a third-party clearer. In this case, informational considerations create a scope economy. It is cheaper for a dealer to offer standardized products to a counterparty with whom he has had extensive dealings, especially if this counterparty has also entered into non-standard derivatives transactions with the dealer. Similarly, a bank can utilize information gained from a lending or deposit relationship to reduce the cost of evaluating the credit risk of a derivatives counterparty. Thus, there are economies of scope across different forms of intermediation.

Moreover, the possibility for netting induces a scope economy when there are deadweight costs associated with bankruptcy. To see this, assume that a creditor recovers only fraction $\alpha < 1$ of a debtor's net assets in bankruptcy.

Consider a firm j that has entered into a standardized transaction and a non-standardized one. The value of the standardized deal is $\tilde{v}_j^S$ and that of the non-standardized trade is $\tilde{v}_j^N$. (Recall that the value of the deal is viewed from the perspective of j's dealer-counterparty, and hence is positive if j loses money on the trade.) Assume that $\tilde{v}_j^N > 0$ and $\tilde{v}_j^S < 0$. (A similar analysis holds when the inequalities are reversed.) If j trades with a single dealer, and there is netting across the standard and non-standard deals, default occurs if $\tilde{v}_j^N + \tilde{v}_j^S > \tilde{V}_j$, where as before V_j is the value of j's equity gross of the value of the standardized and non-standardized trades. In this event, the dealer recovers $\alpha\tilde{V}_j$, leading to a net loss from default of $\tilde{v}_j^N + \tilde{v}_j^S - \alpha\tilde{V}_j$.

Now consider the net loss from default when j trades the non-standardized product through one dealer and the standardized product through another. Here, j's equity plus the gain on the winning trade is $\tilde{V}_j - \tilde{v}_j^S$. j defaults if $\tilde{v}_j^N > \tilde{V}_j - \tilde{v}_j^S$. In this event, the counterparty to the non-standardized trade recovers $\alpha(\tilde{V}_j - \tilde{v}_j^S)$ through bankruptcy proceedings, leading to total loss from default of:

$$v_j^N - \alpha(\tilde{V}_j - \tilde{v}_j^S) = v_j^N + \alpha\tilde{v}_j^S - \alpha\tilde{V}_j < \tilde{v}_j^N + \tilde{v}_j^S - \alpha\tilde{V}_j.$$

Thus, all else equal, the total amount of dealer capital required to avoid dealer defaults is greater when j's standardized and non-standardized trades are executed by different dealers than through the same dealer. Total dealer capital must be larger to offset the higher deadweight costs associated with bankruptcy when j splits its business across dealers. Put differently, netting economizes on deadweight costs from bankruptcy, and concentrating positions at a single dealer maximizes the netting possibilities. Note further that the benefits of concentrating business with a single dealer are greater, the more expansive netting concept. Thus, multi-product netting creates more scope economies than single-product netting.[22] This suggests that

[22] Of course, there are reasons a firm j might wish to deal with multiple dealers. One

widespread adoption of multi-product netting will lead to increasing dealer concentration and impede the growth of clearing of standardized OTC trades.

Another potentially important impediment to clearing of standardized trades is strategic behavior by the large dealers. In essence, each megadealer operates a closed network and exploits network economies by growing large. Mutualization of OTC credit risk for standardized derivatives effectively opens the megadealer networks if entry to the OTC clearinghouse is unrestricted, thereby allowing any other firms that join the clearinghouse to enjoy the network economies. Although formation of a larger network allows large dealers to realize additional scale economies, it provides an even larger benefit to dealers with small existing networks. These smaller dealers experience a larger cost reduction from opening the network than the large dealers. This increases competition for the megadealers in the provision of market making services. They are therefore unlikely to favor clearing even their standardized products. This impairs the ability of an open clearinghouse to achieve scale economies. Indeed, there is some anecdotal evidence that major market dealers have been the major opponents of central clearing of standardized derivative products. Although small dealers can attempt to

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dealer may offer a better price on a good deal and a worse price on another. Also, j may split up its trading to conceal its trading activity. This may be valuable if j has an information advantage and wants to exploit that advantage by concealment. Similarly, j may want to avoid being held up by a single dealer. Or dealers may provide information to their counterparties (in the form of research and market intelligence). In this case, j might want to deal with multiple firms to collect information from multiple sources. The analysis demonstrates, however, that netting in the presence of bankruptcy costs that increase with the magnitude of the shortfall generates a scope economy that is lost if standardized and non-standardized trades are systematically executed with different counterparties. This is a cost of degementing derivatives intermediaries into those who specialize in standardized deals and others who specialize in exotic ones.

mutualize risk amongst themselves, if the megadealers are sufficiently large, a coalition of small dealers may still fail to overcome the large dealers' scale advantage.[23]

The rapid growth in clearing in energy derivatives is also instructive in this regard. Prior to 2003, although OTC energy clearing had been mooted, it gained little traction, and energy derivatives intermediation was dominated by a relatively small number of firms. In 2002-2003, however, a rapid decline in energy trading volumes and the stock prices of energy trading firms caused the exit of many firms, including many major energy derivatives dealers, from the trading business. In the aftermath of this meltdown, there was no dominant, well capitalized dealer firm in the marketplace, and the ability of many firms to trade was severely constrained by their weak financial condition. In 2004-2006, the volume of cleared energy derivatives transactions grew dramatically. The contrast between the experiences in the energy markets on the one hand and interest, currency, and equity markets on the other is consistent with the view that the existence of well-capitalized, dominant dealers impedes the development of centrlaized clearing.

[23] Jackson and Manning (2005) identify another difficulty that can arise if clearinghouse membership is heterogeneous. Specifically, it raises the costs of determining prices at which default risk is transferred to the clearinghouse. Although it would be desirable to vary margins and clearing fees to reflect the creditworthiness of each firm, this faces severe practical challenges. Uniform pricing/margining underprices some risk and overprices others, resulting in deadweight losses that reduce the benefits of clearing. Pirrong (1998) first mooted the possibility that strategic considerations may induce large dealers to eschew clearing. Bliss and Papathanossiou (2005) also argue that these strategic considerations may be important.

5.3 Summary

In sum, differences in the characteristics of OTC and exchange traded derivatives create varying degrees of information asymmetry. Valuation of the default risk inherent in portfolios of OTC transactions that contain substantial positions in non-standard instruments requires specialized valuation expertise. Dealers who trade non-standardized OTC derivatives have a comparative advantage in developing this expertise because it helps them price their products more accurately and to manage their price risks more effectively as well as to evaluate default risk more precisely; specialized valuation expertise would benefit a third party clearer only to the extent that it would permit more precise estimation of default risk. As a result, dealers in non-standard OTC derivatives are likely to have better information than third parties about the default risks inherent in their positions. This asymmetry impedes the sharing of default risk through a central clearing mechanism. In contrast, information asymmetries are not so severe for exchange traded products and the brokerage firms that trade them. This lower level of information asymmetry facilitates the sharing of default risk through a clearinghouse. Thus, differences in the degree of information asymmetry can explain the different default loss sharing mechanisms in OTC and exchange markets. Moreover, scope economies arising from information effects, and netting and deadweight bankruptcy costs, can make it economical not to mutualize default risk for some standardized OTC derivative transactions.

6 The Dark Side of Default Risk Allocation in OTC Markets

The foregoing argues that informational considerations affect the cost of default risk sharing through mutualization. It must be noted, however, that the private information that gives dealers a comparative advantage in evaluating the creditworthiness of counterparties to complex derivatives deals entails a cost as well. Specifically, dealer firms may be subject to catastrophic failure due to insolvency or the mere threat of insolvency. This risk is exacerbated by the fact that, unlike exchange clearinghouses, OTC dealer firms are not constrained to have zero market risk exposure.

The private information on the value of customer positions makes it difficult for outsiders to evaluate and monitor a dealer's value. In the notation of section 3, the dealer has much better information on $\tilde{Z}_i$ than outsiders. Moreover, if the dealer is a bank (as is usually the case), due to the informational intensity of its intermediation activities, its balance sheet is somewhat opaque giving it an information advantage over $\tilde{E}_i$.

This problem is especially acute because the dealer (unlike an exchange clearinghouse) is not constrained to have a zero net position. Indeed, the dealer faces strong incentives to take mismatched positions that expose the firm to market risk.

First, a large dealer obtains valuable information on supply and demand imbalances due to its ability to observe a considerable portion of the market deal flow. The dealer can utilize this information to speculate profitably. This exposes the dealer to some market risk.

Second, by offsetting perceived temporary order imbalances, the dealer can earn market making profits by selling into temporary buy imbalances and buying into temporary sell imbalances. Relatedly, dealers may engineer specialized transactions to meet the needs of a particular customer and lay some of this risk off through dynamic hedging transactions using other instruments. For instance, a dealer offering a customer a structured natural gas transaction that embeds various options may hedge this risk by trading natural gas futures contracts. However, as noted earlier, these dynamic hedges are never perfect, leaving the dealer to bear the residual hedging risk.

Third, the pricing expertise that a dealer develops permits it to identify mis-priced transactions and profitably speculate by taking advantage of the mispricing. This ability to enter into speculative positions (i.e., positions subject to market risk as well as default risk) increase the likelihood that the dealer will become insolvent.

Those trading with and extending credit to the dealer recognize these problems, and attempt to mitigate them by conditioning their transactions with dealer i on its equity capital, $\tilde{E}_i$. However, this is a noisy measure of V_i, and due to the opacity of the dealer's derivative operations and the rest of its balance sheet if it is a bank, (1) the dealer still has substantial private information about $\tilde{Z}_i$, and (2) the dealer may be insolvent even if $\tilde{E}_i$ is large.

These conditions, when combined with contracting practices common in derivatives markets, make derivatives dealers subject to "runs" that can destroy the intermediary. For instance, an adverse shock to the dealer's equity capital $\tilde{E}_i$ may lead to a "run." Terms in many derivatives trades and master agreements, and in some instances the terms of the financing of dealers, effectively create a sequential service constraint such as that inherent in a bank's demand deposits. Failure of a party to an OTC transaction to meet certain financial conditions (e.g., maintaining an investment grade credit rating) can put that party into default. This permits those dealing with the defaulting firm to demand that it post collateral or to close the deals and pay their mark-to-market value immediately. Similarly, the dealer's borrowings may include terms that permit creditors to force the acceleration of principal payments on its debt when the dealer fails to meet certain financial conditions. In essence, just as owners of demand deposits can demand more cash than a bank can pay (even if the bank is solvent), under certain circumstances derivatives counterparties and the dealer's creditors can demand more cash than a dealer can raise. Moreover, the counterparties of the dealer may face a collective action problem similar to that faced by demand depositors; since derivatives deals are not subject to the automatic stay provisions of bankruptcy, there is an advantage to being the first counterparty to demand closeout when the dealer's financial situation fails to meet the conditions set in the Master Agreement. This default effectively puts the dealer out of business and deprives it of any rents that it could otherwise earn.

Even if the dealer is truly solvent, and knows that this is the case due to its superior information about $\tilde{V}_i$, it may not survive the run because the very information advantage that is its reason to exist makes it difficult to raise capital by selling debt or equity. Potential suppliers of outside capital fear buying a lemon, and hence are only willing to fund the dealer at prices that are often highly disadvantageous to the dealer. Moreover, addressing this asymmetric information problem through disclosure is costly; allowing outsiders to monitor the dealer by examining its books permits the outsiders to "frontrun" the dealer (thereby free riding on some of the dealer's information). Indeed, once they know the structure of the dealer's positions, its competitors may trade opportunistically thereby imposing costs on the dealer.[24] These factors make disclosure costly to the dealer.

The implosion of Enron illustrates these problems. Enron was a pioneer in the energy OTC markets. The firm first established its niche as a dealer that structured energy (primarily natural gas) transactions to meet the customized needs of energy producers and consumers. The firm managed the risk due to mismatches through a variety of means, including hedging using exchange traded instruments and the creation of partnerships ("special purpose entities") that allowed partners to share in some of the risks. In the late-1990s, Enron pioneered Internet commodity trading, making markets in numerous commodities through its EnronOnline operation. By 2000, the firm was the dominant dealer in OTC energy products, and was the seventh largest U.S. corporation (measured by revenue).

In October, 2001, Enron's CEO's brief reference to a writedown in equity made at an analysts' call initiated a precipitous collapse in the company's stock price that culminated in a bankruptcy filing less than two months later. Once Enron's viability came under question, counterparties began to desert the firm and it could not obtain additional financing. Moreover, restatement of the firm's financial statements resulted in a downgrading of its debt, thereby triggering a default on its derivative positions (which required

[24]It is widely reported that some investment banks front ran LTCM after reviewing the hedge fund's portfolio in response to its request for financing (Dunbar, 1999).

the firm to maintain an investment grade rating) and the acceleration of repayment on much of its debt. The firm's cash was quickly exhausted and it was forced into bankruptcy.

Although events such as the Enron debacle are frequently used as examples of inefficiency, the fragility of a dealer's financial structure (i.e., its susceptibility to a "run" of the type Enron experienced) may enhance efficiency. As Diamond and Rajan (2001a, 2001b) demonstrate, fragility can serve as a valuable commitment device when an intermediary has superior information. Absent the vulnerability to runs, the intermediary (the dealer in this instance) can exploit his information advantage by holding up creditors and counterparties. In equilibrium, the potential for holdups can reduce the amount of intermediation the dealer supplies. In this context, financial fragility can enhance efficiency by allowing the dealer to supply more liquidity to the market for derivatives. Thus, the very informational asymmetries that preclude sharing of default risk of non-standardized derivatives trades may make fragile financial structures that pose the risk of runs efficient.

Thus, the terms in OTC derivative transactions and in the debt that OTC dealers use to finance their activities are consistent with efficiency even though they may lead to a dealer's failure. As costly as a run may be, the alternative (less intermediation) may be costlier still.

7 Summary and Conclusions

Organized derivative exchanges and OTC derivative markets have very different mechanisms for allocating default risks. On exchanges, default risks are partially shared through the institution of the clearinghouse. Default risks and price risks are partially unbundled in these markets. In contrast, default risks are not shared in OTC derivative markets. Instead, market price risks and default risks are bundled.

Sharing of default risks can improve welfare by reducing default risk and reducing the amount of expensive equity capital required to facilitate trade in derivatives; as Barzel (1997) notes, equity capital is a contract bonding mechanism, and in the absence of information-related frictions, less of it is required to bond derivatives contracts when default risks are shared. Due to the option-like nature of default exposure, there is an economy of scale to bearing default risk.

As with any risk sharing arrangement, default risk mutualization faces problems associated with moral hazard and asymmetric information. The problems with asymmetric information about default risk are more acute in OTC markets due to the nature of many OTC derivatives. These products are frequently complex and can only be valued and hedged using sophisticated mathematical models; such tools are not required to value and hedge the standardized products traded on exchanges. Dealers that intermediate OTC transactions can develop these models at lower cost than a third party clearinghouse. As a result, dealers have substantially better information about their vulernability to default than the third party clearer. This information asymmetry makes it costlier to share default risks through a clearinghouse in OTC markets than exchange markets, which explains the different default risk allocation mechanisms in the two markets. Dealers in OTC markets exploit scale economies by growing large, rather than through mutualization of default risks. Moreover, since (a) dealers have better information about customers that trade both standardized and non-standardized products, and (b) gains and losses on a defaulter's standardized and non-standardized derivatives positions can be netted (thereby economizing on equity capital) when the firm trades with a single dealer, there are economies of scope to trading standardized and non-standardized OTC instruments with the same dealer. This makes it costly to mutualize default risks even for standardized OTC products.

Although asymmetric information favors the formation of large OTC dealers who do not mutualize default risks, this information asymmetry can also make these dealers vulnerable to "runs" that trigger failure. Recent theoretical developments in the banking literature suggest that the potential for failure can be an efficient commitment device. Indeed, the fact that the terms of OTC derivatives transactions and the financing of derivatives dealers can lead to run-like behavior suggests that the threat of failure serves to discipline opportunistic behavior by dealers.

The theory outlined herein offers a different perspective on the "migration from intermediaries to markets" identified by Finnerty (1992) and Merton (1993) as a characteristic of the evolution of the trade in financial products. As conventionally explained, dealer-intermediaries create new financial instruments to address particular risk management needs of their clients. During the early phase of development the market for the financial innovation is thin. Intermediaries acting as principals offer new contracts to end users, and either bear the risk inherent in these positions or hedge the risk dynamically using earlier-generation financial products. As the potential audience for the innovation expands, the need for intermediation declines and end users can transact directly with one another through markets, including organized exchanges that introduce centralized trading of the product.

This conventional explanation emphasizes the role of intermediaries in reducing the cost of searching for trading partners. As the number of potential traders increases, the potential market becomes large enough to justify incurring the fixed cost of establishing a centralized exchange. The introduction of an exchange reduces the need for dealer intermediation.

Default risk allocation rules do not play a central role in the conventional analysis of the division of trading in financial products between exchanges and dealer-intermediaries. In particular, the received analysis does not explain why default risk sharing is not observed in most dealer-intermediated transactions. There is no conceptual obstacle to default risk sharing in dealer-intermediated transactions, and such default risk sharing would improve welfare unless it is too costly to implement. In contrast, this article shows that there is in fact an intimate link between the the innovative nature of products traded via dealer-intermediaries and the absence of default risk sharing. The dealers that create and trade innovative products have private information about the value and risks of these products and the financial condition of their customers. Thus, a particular dealer has better information about his risk of default than others have. This information asymmetry impedes sharing of default risk. In contrast, the value and risks of the standard products traded on exchanges are much more widely understood, so asymmetric information problems are not as acute there. As a result, one can (and does) observe sharing of default risks on exchanges but no such sharing on OTC markets.

From this perspective, the distinction between "intermediation" and "markets" is misleading. Both exchanges and dealers are intermediaries, but the the form of intermediation differs in a crucial dimension. Exchange-based intermediation involves sharing of default risks; dealer-based intermediation does not. The innovative nature of OTC products plays a central role in this analysis just as it does in the "migration" theory, but the key consideration is not that the"thickness" of trading in standardized products creates scale economies in the sense that "the division of labor is limited by the extent of the market." Instead, the driving factor is the impact of novelty on the distribution of information about value and risk. Dealers have private information about the value and risks of novel products and the customers that use them. This private information makes it prohibitively costly to share default risks. In contrast, information asymmetries are less acute when trading volumes are large because transactions prices from heavily-traded products are accurate measures of value; this lowers the cost of default risk sharing.

References

[1] Baer, H, V. France, and J. Moser. 1995. "What Does a Clearinghouse Do?" 1 *Derivatives Quarterly* 39-46.

[2] Bergman, W., R. Bliss, C. Johnson, and G. Kaufmann. 2003. "Netting, Financial Contracts, and Banks." Working paper, Wake Forest University.

[3] Bliss, R, and C. Papathanassiou. 2005. "Derivaitves Clearing, Central Counterparties, and Novation: The Economic Implications." Working paper, Wake Forest University.

[4] Board of Trade Clearing Corporation. "Ensuring Financial Integrity at the Chicago Board of Trade and the Board of Trade Clearing Corporation." http://www.botcc.com/about/ensure.html.

[5] Chicago Board of Trade. "Rules and Regulations." http://www.cbot.com/cbot/www/page/0,1398,14+64,00.html

[6] Diamond, Douglas and Raghuram Rajan. 2001a. "Liquidity Risk, Liquidity Creation, and Financial Fragility: A Theory of Banking." 109 *Journal of Political Economy*: Forthcoming.

[7] Diamond, Douglas and Raghuram Rajan. 2001b. "A Theory of Bank Capital." 55 *Journal of Finance*: 2431-2465.

[8] Edwards, Franklin. 1983. "The Clearing Association in Futures Markets: Guarantor and Regulator." 3 *Journal of Futures Markets*: 369-392.

[9] Finnerty, J. D. 1992. "An Overview of Corporate Securities Innovation." 4 *Journal of Applied Corporate Finance*: 23-39.

[10] Gibson, R. and C. Murawski. 2006. "Default Risk Mitigation in Derivatives Markets and Its Effectiveness." Working paper, University of Zurich.

[11] Green, John. 1998. "NationsBank Scores a Four." 11 *Risk Magazine* : 8-9.

[12] Green, T. Clifton and Stephen Figlewski. 1999. "Market Risk and Model Risk for a Financial Institution Writing Options." 54 *Journal of Finance*

[13] Jackson, John P., and Mark J. Manning. 2005. "Comparing the Pre-Settlement Risk Implications of Alternative Clearing Arrangements." Working paper, Bank of England.

[14] Jordan, James and George Morgan. 1990. "Default Risk in Futures Markets: The Customer-Broker Relationship." 45 *Journal of Finance*: 909-933.

[15] Knott, R. and A. Mills. 2002. "Modelling Risk in Central Counterparty Clearinghouses: A Review." *Bank of England Stability Review.*

[16] Kroszner, R. 1999. "Can the Financial Markets Privately Regulate Risk? The Development of Derivatives Clearinghouses and Recent Over-the-Counter Innovations." 31 *Journal of Money, Credit, and Banking* 596-623.

[17] Moser, J. 1994. "What is Multilateral Clearing and Who Cares?" 87 *Chicago Fed Letter.*

[18] Merton, Robert. 1993. "Operation and Regulation in Financial Intermediation: A Functional Perspective," in P. Eglund (ed.), *Operation and Regulation of Financial Markets.* Stockholm: The Economic Council.

[19] Office of Technology Assessment. 1990. *Electronic Bulls and Bears.* Washington: Government Printing Office.

[20] Pirrong, Craig. 1998. "Derivatives Markets, Systemic Risk, and Monitoring." Working paper, Washington University.

[21] Presidential Task Force on Market Mechanisms. 1988. *Report of the Presidential Task Force on Market Mechanisms.* Washington: Government Printing Office.

[22] Telser, L. 1981. "Why There Are Organized Futures Markets." 24 *Journal of Law and Economics*: 1-22