WPS 1340

POLICY RESEARCH WORKING PAPER 1340

Opportunity Cost and Prudentiality

An Analysis of Futures Clearinghouse Behavior

Herbert L. Baer
Virginia G. France
James T. Moser

A futures clearinghouse sets margins to minimize its membership's collective costs of trading. These costs have two sources — the deadweight costs incurred when a member defaults, and the opportunity costs incurred when members are required to post margin to insure against default. This simple framework yields insights about the impact of netting, monitoring, expulsion, the opportunity cost of margin, and volatility on default risk and margin levels. Empirical analysis suggests that opportunity cost is an important factor in margin setting.

The World Bank
Policy Research Department
Finance and Private Sector Development Division
August 1994

Summary findings

Margin deposits, which serve as collateral to protect the clearinghouse, are typically the most important tool for risk management. Baer, France, and Moser develop a model that explains how creating a futures clearinghouse may allow traders simultaneously to reduce both the risk of default and the total amount of margin that members post. Optimal margin levels are determined by the need to balance the deadweight costs of default against the opportunity cost of holding additional margin. Both costs are a consequence of market participants' imperfect access to capital markets.

The simultaneous reduction in default risk and in the opportunity cost of margin deposits is possible because the creation of the clearinghouse facilitates multilateral netting. The authors characterize the conditions under which multilateral netting will dominate bilateral netting.

They also show that it is credible for the clearinghouse to expel members who default, further reducing the risk of default. Finally, they show that it may (but need not) be optimal for the clearinghouse to monitor the financial condition of its members. If monitoring occurs, it will reduce the amount of margin required, but need not affect the probability of default.

The empirical tests run by Baer, France, and Moser indicate that the opportunity cost of margin plays an important role in determining margin. The relationship between volatility and margins indicates that participants face an upward-sloping opportunity cost for margin, which appears to more than offset the effects that monitoring and expulsion would be expected to have on margin setting.

This paper — a product of the Finance and Private Sector Development Division, Policy Research Department — is part of a larger effort in the department to analyze the role of financial institutions in market economies. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Paulina Sintim-Aboagye, room N9-057, extension 38526 (45 pages). August 1994.

Produced by the Policy Research Dissemination Center

Opportunity Cost and Prudentiality:

An Analysis of Futures Clearinghouse Behavior

by

Herbert L. Baer

Virginia G. France

and

James T. Moser

The authors are Financial Economist at the World Bank Policy Research Department; Assistant Professor at the University of Illinois at Urbana-Champaign; and Senior Economist at the Federal Reserve Bank of Chicago, respectively. Much of this paper was completed while France was visiting at the Chicago Mercantile Exchange and the University of Chicago. Susanne Malek and Jan Napoli provided valuable research assistance. The authors thank John Conley, Ramon DeGennaro, Todd Petzel, Jerry Roberts, an anonymous referee, and seminar participants at the University of Illinois at Urbana-Champaign, the Federal Reserve Bank of Chicago, and the Chicago Risk Management Workshop. Opinions expressed are entirely those of the authors and do not reflect concurrence by the Federal Reserve, the Chicago Mercantile Exchange, or the World Bank. Comments may be addressed to the third author at 312-322-5769; or the middle author at V-FRANCE@UIUC.EDU.

Opportunity Cost and Prudentiality:

An Analysis of Futures Clearinghouse Behavior

INTRODUCTION

A futures clearinghouse reduces the risk of default by netting all a trader's trades with other clearinghouse members, in turn allowing its members to economize on margin. In this paper, we show that clearinghouse netting systems are *Pareto superior* to bilateral margin setting, and characterize the cost savings involved. Margin deposits are typically the most important tool in the clearinghouse's risk management efforts. Margin deposits serve as collateral[1] to protect the clearinghouse. The opportunity cost of margin deposits constrains the level of protection which the members will regard as optimal. Margins are optimal when the marginal opportunity cost of margin is equal to the incremental protection obtained from additional margin.

However, the creation of a clearinghouse will have additional risk reducing effects. Since membership is valuable, it is credible and effective for the clearinghouse to threaten defaulting members with expulsion. At a minimum, this further reduces default risk by causing potential defaulters to perform when the amount owed exceeds the margin on deposit. It may also enable members to further economize on margin. The clearinghouse may also find it optimal to undertake monitoring that would not otherwise occur.

Four alternative models are provided: one in which the marginal opportunity cost of margin requirements is constant, one in which the marginal opportunity cost of margin increases as margin requirements increase, one in which the threat of expulsion acts as a partial substitute for margin, and one in which senior claims on the firm's pool of unencumbered assets act as a substitute for margin.

If the marginal cost of margin is constant, our model predicts that the level of margin protection chosen by the clearinghouse is determined by opportunity costs but is independent of volatility. With increasing costs of margin, the elasticity of margin with respect to changes in volatility is less than one. If the clearinghouse can credibly threaten expulsion or can monitor the member's financial condition, our model predicts that the elasticity of margin with respect to changes in volatility will be greater than one.

We focus on margin levels as the main policy tool because it is margin which clearinghouses use as their main active risk management tool. Margins alone typically eliminate more than 98% of the overnight credit risk (Kofman, 1992). They are the first line of defense in a default, since the margin funds are the most readily accessible assets which can be seized: they are restricted in form to very liquid assets, and are usually kept either at the clearinghouse itself or in an account to which the clearinghouse has immediate access. However, exchanges and clearinghouses have other policy tools at their disposal: clearing fees, required deposits in a clearinghouse guarantee fund, daily price change limits, speculative position limits, tick size, minimum capital requirements, settlement interval, and the required minimum number of seats for clearing members, for example. Most of these are changed infrequently if at all. The second most important tool for active risk management is monitoring of clearing firm capital. Clearinghouses typically require formal reports on firm capital only at quarterly or monthly intervals, but clearinghouse staff monitors certain firms less formally on a day-to-day basis. We investigate the monitoring function of the clearinghouse in a later section.

Our empirical work tests these hypotheses at three levels. Our sample consists of a time series for eighteen futures contracts having associated futures options. We construct coverage ratios by dividing required margin by the futures price volatility (in dollar terms). A coverage ratio of three, for instance, implies that margin deposits are exhausted when the magnitude of a price change exceeds three standard deviations. Estimates of volatility are extracted from option prices, and thus reflect a market-consensus forecast of volatility. The coverage ratio expresses the level of loss protection provided by a given level of margin in a form which is comparable over time and across contracts.

We first examine the hypothesis that margin levels are positively associated with the level of expected volatility using cross-section regressions at each date in the sample. This re-examines previous tests of prudentiality by Gay, Hunter and Kolb (1986). Our evidence confirms their finding that margin levels increase with volatility, as is consistent with prudentiality. Our next test examines the time series of daily coverage ratios for four contracts to determine how coverage ratios are adjusted in response to shocks. The evidence of this section confirms a Gay, Hunter and Kolb finding that coverages are increased when coverage ratios are lower than their unconditional means. These tests also demonstrate that clearinghouses lower coverage when margin coverage is excessive. This result is not predicted by the previous literature, but is predicted by our model. We also find evidence that clearinghouses respond less quickly to excessive margin than to inadequate margin.

We present empirical evidence that margin levels are strongly influenced by the opportunity cost of margin deposits as well as by prudential concerns. Our third series of tests examines the cross section of contracts pooled over the sample period. Our results are consistent with the clearinghouse adjusting margin levels to allow for changes in the opportunity cost of margin. Our regressions indicate that margin coverage is negatively related to economy-wide shifts in the opportunity cost of margin deposits and also negatively related to participant-specific shifts in participants' borrowing needs as proxied by the levels of implied standard deviation. The results are consistent with margin levels having increasing costs for market participants. Sensitivity tests are conducted for the possibility that margins are a fixed proportion of the futures price, or a fixed value. The results favor our model over these alternatives.

Though this paper deals with clearinghouses as they exist at organized futures exchanges, it has implications for the over-the-counter (OTC) derivatives markets. It suggests that the default risk in these markets could be decreased, and cost savings attained, by the development of an over-the-counter clearinghouse. Multinet, the foreign exchange clearinghouse, is currently allowing only bilateral netting, but proposes to extend itself to multilateral netting as soon as regulatory and legal obstacles are resolved. Our model establishes the benefits which motivate this innovation.

I. LITERATURE REVIEW

The literature on margin has two strands: the usefulness of margin levels as a public policy tool to control excess volatility; and the private interest in setting margin levels to provide adequate protection against default. This paper has implications for the second strand, usually referred to as prudential margin setting. A number of earlier researchers have analyzed prudential margin setting, most notably Telser (1981); Figlewski (1984); Hunter (1986); and Gay, Hunter, and Kolb (1986). Recent work by Craine(1992), and Fenn and Kupiec (1993) is discussed in the body of the paper. Our model advances the theory of margins by explicitly incorporating the cost of margin deposits into the margin-setting decision, demonstrating the tradeoff between these costs and prudential concerns, and showing how margin setting is affected by other clearinghouse activities.

Our model of expulsion from the clearinghouse and of the effect of value of clearing is related to concurrent work being done by Bhasin and Brown (1994). They model the value of exchange seats by analyzing the benefits stemming from trading. Their model analyzes the incentive to default intraday. Since positions may in some cases be held during the day without the posting of margin, intraday default is primarily secured by the value of the exchange seat itself. Their model is complementary to ours, in explaining the dynamics of default during the trading period. Another complementary literature deals with the role of price limits in risk management. Brennan (1986) shows how they can act as a partial substitute for margin during intraday trading.

Our model of capital monitoring by the clearinghouse is also related to general work on risk management and financial guarantees by Merton and Bodie (1992) and Hsieh (1993). Our models of clearinghouse behavior extend this earlier work by showing that expulsion from the clearinghouse, monitoring of the financial condition of the membership by the clearinghouse, and a recognition that members face an upward sloping supply of external funds have very different effects on optimal margin setting and the probability of default. Our model also has interesting parallels with models of the bank clearinghouse process, as discussed in Gorton (1985), particularly in the role of expulsion and the mutualization of risk.

II. A MODEL OF PRUDENTIAL MARGINS

A futures clearinghouse allows its members to exploit a variety of economies of scale accessible only by acting as a group. Our emphasis is on the ability of a central clearinghouse to take margin on the net position of a member, rather than on each open contract. However, a centralized clearinghouse also simplifies recordkeeping, since members need only keep track of their net positions with the clearinghouse. Credit monitoring and control is simplified, since a member's financial standing need only be assessed once by the clearinghouse, rather than separately by each trading partner. There are economies of scope between record keeping and credit control, since knowledge of a member's net position is necessary to assess exposure. In addition, because exchange members precommit to binding arbitration, disputes are no longer a matter for bilateral bargaining.

We first present a model of a clearinghouse acting solely as a netting facility. We demonstrate the benefits of clearinghouse arrangements when the clearinghouse is treated as a club of its members, not a separate, for-profit agency. We ignore any *ex ante* conflicts of interest among members. We assume that all members are clearing members. We also ignore the presence of customers served by members in their broker capacity; the clearinghouse exists to provide local public goods to the exchange membership, not to enforce a brokerage cartel.[2]

A. The basic model of the clearinghouse

We demonstrate that margin setting and the formation of clearinghouses are both motivated by the need of market participants to balance deadweight losses due to counterparty defaults against the opportunity cost of margin deposits. Despite the fact that interest-bearing assets may be posted, we assume margin requirements have a positive opportunity cost because a firm's marginal borrowing cost exceeds the return on its marginable assets.[3] In the simplest case, the marginal opportunity cost of a margin deposit is assumed to be a constant differential rate denoted as i. We later generalize this to the case where the opportunity cost is an increasing function of the amount of margin demanded.

Bilateral Margin Setting:

We first model the setting of margin in a bilateral marketplace. There are two parties j and h. Assume that in the event of default, participants are only able to attach collateral that has previously been posted.[4] There are two periods. In the opening period, the two parties trade with each other, each entering into a contract with the other. The motivation for trading is exogenous to our model; however, our model does imply that a clearinghouse system reduces the cost of obtaining whatever benefits trading may provide. Let N(j,h) denote the number of contracts outstanding between j and h. If N(j,h) is positive, j holds a long position in the contract. If N(j,h) is negative, then j's position in the contract is short. Contra-positions are held by h, so that N(h,j) = -N(j,h).

In the second period, the contract is settled based on a random final price for the underlying good.[5] The final price is assumed to be distributed with a finite variance such that the change in the contract price, x, is a random variable with mean zero and standard deviation s.

Margin posted by j with h is denoted M(j,h), and the margin posted by h with j is denoted M(h,j). Since our model applies to clearing members, we assume that initial and maintenance margins are identical; this is standard practice on most clearinghouses. Margin payments are made in cash and placed into interest-bearing accounts. Interest on these deposits is paid to the party posting the margin.[6] At the end of period 2, the contract is settled. If x is positive and less than M(h,j), x is transferred from the short's account to the long's account. Thus the short now has M(h,j)–x; the long now has M(j,h) + x. If x is negative and |x| is less than M(j,h) then x is transferred from the long to the short.

After contracts are settled, traders are assumed to immediately bring their margin-account balances back to M(j,h) and M(h,j) by making new cash deposits when they are on the losing side and by withdrawing any excess balances when gains are realized. Recoveries in the event of a default are limited to the margin account balance.[7] Because participants do not carry excess balances, we preclude the possibility that traders who have previously realized gains are better able to weather adverse price movements. This means that a simple two-period futures contract resembles an n-period contract which is marked to market at the close of each period.

By entering into a contract, the counterparties implicitly give each other an option to default (Figlewski, 1984). In the simplest case, contract default occurs whenever losses exceed margin-account balances. Thus, if x is positive and greater than M(h,j), the short rationally defaults on the contract and the long takes possession of the margin assets M(h,j). Similarly, if x is negative and |x| is greater than M(j,h), the long rationally defaults and the short takes possession of the margin assets M(j,h). We assume that default imposes a deadweight loss on the counterparty that is a constant proportion, denoted α, of the amount of the difference between the promised payment and the actual payment. These deadweight losses include the cost of recontracting, higher borrowing costs which arise from liquidity problems, and costs arising from financial distress. The expected deadweight loss from default born by agent j is:

$$D(j,h) = \alpha N \int_{M(h,j)}^{\infty} (x - M(h,j)) f(x,s)\, dx \tag{1}$$

where N is the net number of contracts j has open with h; i.e, the absolute value of N(j,h).

We assume that the parties have a wide choice of partners at the inception of each trade. This situation approximates perfect competition and ensures the absence of bargaining power so that parties to the contract will seek to jointly minimize the costs of contracting. The bargaining problems which may arise between the two parties after the trade are regarded as included in the deadweight losses subsumed in α. Contracting entails three costs: the opportunity cost of margin deposits I(j); the credit risk, that is, the expected difference between the promised and the actual payment when h defaults on j, L(j,h); and the expected deadweight losses incurred when h defaults on j, D(j,h). Offsetting these costs, each party also receives an option to default O(j,h). The two parties seek to jointly minimize:

$$\begin{array}{ll} I(j) + I(h) & \textit{Opportunity Costs} \\ + D(j,h) + D(h,j) & \textit{Deadweight Losses} \\ + L(j,h) + L(h,j) & \textit{Credit Risk} \\ - O(j,h) - O(h,j) & \textit{Default Options} \end{array} \tag{2}$$

Because one party's default option is another party's credit risk, that is, L(j,h) = O(h,j), the expression for joint contracting costs reduces to

$$I(j) + I(h) + D(j,h) + D(h,j) \tag{3}$$

which is the sum of the interest costs and deadweight losses for h and j. Thus, substituting into (3) from (1), the total cost to be minimized is

$$N(i(M(j,h)+M(h,j)) + \alpha[\int_{M(h,j)}^{\infty}(x-M(h,j))f(x,s)dx + \int_{-\infty}^{-M(j,h)}(-M(j,h)-x)f(x,s)dx]) \tag{4}$$

The first order conditions for minimization of (3) with respect to M(j,h) and M(h,j) are as follows:

$$1 - F(M^*(j,h),s) = \frac{i}{\alpha} \qquad F(-M^*(h,j),s) = \frac{i}{\alpha} \tag{5}$$

For a normal distribution, this can be expressed as:

$$\frac{M^*}{s} = F^{-1}(\frac{i}{\alpha}) \tag{6}$$

Thus margin amounts are optimal when the probability of default is equated to the ratio of opportunity cost of an additional dollar of margin to the deadweight loss rate. The higher this ratio, the lower the optimal level of margin. Positive margin requirements are optimal when $i/\alpha < 1$. If i/α exceeds unity firms set margin at zero, the losing trader always defaults, and the contract is unenforceable.

Note that the objective function is linear in the number of contracts. Hence, in the case of constant marginal opportunity cost, the level of margin per unit of exposure is independent of the aggregate level of exposure, and margin can be set on a per-contract basis. Further, if the distribution of price changes is symmetric, margins will be equal on long and short positions. Finally, note that when prices are normally distributed, margin increases proportionately with s. We define the coverage ratio as:

$$CR = \frac{M}{s} \tag{7}$$

The above first-order conditions imply that when the distribution is normal and the opportunity cost of margin assets is constant, the coverage ratio should not vary with volatility. Fenn and Kupiec (1993) and Craine (1992) derive a similar result.

Craine (1992) models the clearinghouse as a profit-maximizing entity and describes the option to default. He contends that, since the clearinghouse does not explicitly charge a default premium to either long or short, it must keep the value of this premium at or close to zero. Our model, by contrast, implies that the value of the default premium equals the credit risk for these agents. Fenn and Kupiec (1993) also implicitly assume that the clearinghouse is an independent entity, minimizing its costs. In contrast, we model the clearinghouse as a club of members which minimizes their joint costs. In our formulation, the clearinghouse does not have to make a profit: our clearinghouse need not actually recover the deadweight losses incurred by the membership, because members would be willing to subsidize the clearinghouse to avoid the greater cost of a bilateral arrangement. In neither Craine's nor Fenn and Kupiec's model is there an explicit economic rationale for the existence of the clearinghouse.

The main contribution of Fenn and Kupiec is to examine the role of frequency of settlement in setting margin size. They model cases where the clearinghouse sets the frequency of regular settlements, and when it will call for special settlement. Their clearinghouse minimizes total costs, where costs involve margin costs, settlement costs, and the cost of allowing a deficit to arise in a clearinghouse's account. The clearinghouse sets the probability of a deficit equal to the ratio of opportunity costs per settlement period to the marginal cost of an account deficit. As volatility increases, more frequent settlement may be cost-minimizing, and the margin-to-volatility ratio may decline. In practice, changes in settlement frequency are not very common. Most clearinghouses settle once a day; some have instituted twice-daily settlements between clearing members. Only in extremely rare circumstances do clearinghouses call for special settlement; when they do, it is always in addition to regular settlement. With the exception of the model in this paper, only Fenn and Kupiec take explicit account of the opportunity cost of margin, though it is implicit in some of the earlier work.

The Clearinghouse:

Clearinghouses offer market participants the possibility of reducing both deadweight default costs and the opportunity costs associated with holding assets in margin accounts, even in the absence of other externalities such as failure of the payments system or reputation. In this model, the clearinghouse acts as a club, that is, a voluntary organization which furthers the joint interests of its members by internalizing some of the externalities which would otherwise exist between members. Thus, members of the clearinghouse seek to minimize their joint contracting costs. They do this by netting positions multilaterally to limit cherrypicking and by allocating any losses among themselves according to a pre-agreed rule. Our model is consistent with the normal practice of paying for losses out of a clearinghouse guarantee fund, in effect sharing losses among clearing members. The exact distribution of losses is not derived since we assume the clearinghouse seeks only to minimize its joint contracting costs: many loss sharing rules would be consistent with this objective function.

Let party j's open interest $\sum_{h=1}^{n} N(j,h)$ be denoted by N(j). If we assume that f(•) is symmetric then the clearinghouse will choose M(j,h) to minimize joint contracting costs of:

$$\sum_{j=1}^{n} \{|N(j)|[i\,M(j) + \alpha \int_{M(j)}^{\infty} (x-M(j))f(x,s)dx]\} \tag{8}$$

When i and α are the same for all members of the clearinghouse, the solution to this problem is the same as that given by equation (5). Thus, per contract, margin will be the same whether contracts are cleared and settled bilaterally by pairs of counterparties or multilaterally through a clearinghouse. Because a clearinghouse will set the same margin rate that these agents willingly negotiate between themselves, it becomes relatively straightforward to analyze the benefits derived from forming a clearinghouse. In our model, the key benefit of the clearinghouse is that it permits its members to economize on margin while at the same time reducing their expected deadweight losses. Clearinghouses economize on margins and deadweight loss because, for the same set of contracts, each participant's net exposure is smaller. As a result, the total amount of margin posted with the clearinghouse is smaller than the total amount posted in a world of bilateral transactions and the expected deadweight loss to each party is also smaller.

Under a clearinghouse system, j posts margin only against the net of his position with the rest of the market which is $M|N(j)|$. In effect, the clearinghouse gives participants a vehicle for securing a potential defaulter's long losing positions with one counterparty with the potential defaulter's winning positions from another counterparty. For each individual, posted margin will be the same or lower under a clearinghouse system.

Similarly, no counterparty's expected deadweight loss is greater under a clearinghouse system and for some it will be smaller.[8] In a bilateral system, j's expected loss from counterparty default is proportional to the number of his open contracts; that is, $\sum_{h=1}^{n} |N(j,h)|$. In a multilateral clearinghouse, if no loss sharing occurs, j's expected loss from defaults is proportional to the net number of his open contracts; that is, $|N(j)|$. Thus, it pays for each individual to join the clearinghouse.

The creation of a clearinghouse leaves no participant worse off and, if there are offsetting positions, lowers margin requirements and deadweight default costs for some participants. Thus, the creation of a clearinghouse is *Pareto* improving. In our model, these improvements are achieved because the clearinghouse is able to make the proceeds from a party's winning positions available to offset losing positions. This makes it difficult for members to cherrypick each other by honoring advantageous contracts while at the same time defaulting on disadvantageous contracts.

B. Increasing opportunity cost of funds

The cost of funds function may be increasing in the amount of margin required. Thus, an increase in margins would drive up the marginal cost of funds. If marginal costs of margin are increasing in M:

$$\rho = \rho(M); \quad \rho'(M) > 0 \tag{9}$$

the clearinghouse sets margin to meet the condition:

$$\frac{\rho'(M)}{\alpha} = 1 - F(M, s) \tag{10}$$

An increase in s now causes the clearinghouse to increase margin less than proportionately with s. As the standard deviation increases, the clearinghouse would increase the margin level to keep the probability of default constant. However, doing so drives up the marginal financing costs of its members. The members of the clearinghouse therefore choose to bear greater deadweight losses in order to economize on their financing costs. Thus, coverage ratios should decrease with volatility.

Note that, even if their cost functions are identical, individuals who hold different numbers of contracts may have different marginal costs of funds. In addition, unlike the agents of the previous section, the slope and level of the cost functions may differ across individuals. This will result in disagreement among members as to appropriate margin levels, though each will have only one preferred margin level. To represent diverse interests, we rely on a result from the club literature: Majority rule reflects median voter preferences provided individuals have single-peaked preferences.[9] Thus, assuming this preference structure, the relevant marginal cost is that of the median voting member. Note that disagreement about the appropriate level of margin gives clearinghouse members an incentive to split off into a rival clearinghouse if disagreement becomes too severe. It is also possible that some traders may choose not to join the clearinghouse.

If the participants in some markets tend to have higher financing costs than others, clientele effects might be observed. If coverage ratios are systematically higher for financial than for agricultural futures, this might reflect lower financing costs for financial firms. In addition, cost of funds schedules are likely to be steeper for smaller firms, again implying clientele effects. If marginal interest costs increase with borrowing levels, then coverage ratios will decrease less as volatility increases for contracts that are a smaller part of the total portfolio.

Other Clearinghouse Risk Control Mechanisms

The preceding section describes a clearinghouse whose actions have been fairly limited in scope — registering trades, netting trades, and controlling margin deposits. The twin goals of these activities are to reduce opportunistic default and economize on margin by making a party's winning positions available to offset its losing positions. This simple clearinghouse does not monitor the financial condition of its participants, link margin deposits to the riskiness of its participants, expel nonperforming members or otherwise seek to control risk. The question is whether the behaviors we have modelled are indeed the *raison d'etre* of modern derivatives clearinghouses. To gain a better understanding of this issue we begin by examining clearinghouse policy toward members that default on their contracts. We show that because membership is valuable it will be credible to threaten expulsion and that such a threat will cause members to perform when the change in the value of their position exceeds their margin deposit. We then examine one model in which the clearinghouse monitors the value of membership and another in which it monitors the financial condition of the membership.

A. The Threat of Expulsion

Because clearinghouses both reduce the deadweight welfare losses associated with opportunistic default while at the same time allowing participants to economize on margin, each member of the clearinghouse finds membership valuable. We will show that when traders expect to trade in more than one period, the threat of expulsion from the clearinghouse allows traders to achieve additional reductions in opportunistic default.[10] If the value of membership is verifiable by the clearinghouse it may also be possible to further reduce the amount of margin posted. These gains are possible because the threat of expulsion will cause potential defaulters to honor their contracts even when the price change x exceeds the posted margin m. This section lays out conditions under which it is credible to expel a defaulting member. The next section examines the impact of credible expulsion on margin requirements and the probability of default.

Let C denote the present value of the total gains, present and future, derived if the potential defaulting party d remains a member in good standing of the clearinghouse. These gains have two sources, the reduced deadweight losses associated with default and the reduced margin requirements. Some of these gains accrue to d and are denoted by C(d,d). The remainder of the gains from d's membership accrue to the clearinghouse and are denoted by C(d,CH).

It would be rational for the potential defaulter d to respond to an expulsion threat by performing if the cost of performing on the contract is less than the value of remaining a member:

$$\left|\sum_{j=1}^{n} N(d,j)\right| |x-M| < C(d,d) \qquad (11)$$

It is rational for the rest of the clearinghouse to decide to vote to expel a defaulting party if the total costs of the default, including both the contractual shortfall and the deadweight loss, exceed the future costs incurred by expelling the defaulting firm.

$$(1+\alpha)\left|\sum_{j=1}^{n} N(d,j)\right||x-M| > C(d,CH) \qquad (12)$$

It will be credible for the clearinghouse to threaten expulsion *and* for the potential defaulter to respond by performing on the contract when

$$\frac{C(d,CH)}{(1+\alpha)} < \left|\sum_{j=1}^{n} N(d,j)\right||x-M| < C(d,d) \qquad (13)$$

If the potential defaulter d is small relative to the membership of the clearinghouse so that members suffer virtually no loss from refusing to trade with d, then the entire cost of the expulsion are born by d and C(d,CH) = 0. We will assume that C(d,CH) = 0 and C(d,d) = C. When C(d,CH) is zero, the membership needs no information to implement this policy: it simply expels any defaulters. Moreover, it is *Pareto improving* for all members of the clearinghouse to precommit to expel a defaulter. Agreeing to a policy of expulsion allows members to precommit to behavior that further reduces opportunistic default without raising margin levels. In the next section we discuss the interactions between margin setting rules and expulsion.

B. Expulsion and margin

A clearinghouse should also take expulsion into account when setting margin. The decrease in opportunistic default caused by the threat of expulsion implies that the clearinghouse is no longer at the optimum margin level. The introduction of expulsion does not greatly alter the clearinghouse's basic maximizing problem. The only difference is that $|x|>M$ is the optimal default rule only when the value of future clearing privileges is zero. The general default rule is given by equation (11). This has three implications. First, firms perform in more states of the world. Second, the value of clearing membership C is a perfect substitute for margin deposits M in preventing default. Third, the value of membership is an imperfect substitute for margin deposits when default occurs. This occurs because each dollar increase in required margin increases the amount received in default states while increases in the value of membership generate no return because the value of membership to the defaulting firm is not transferable. This presumes that the value of an exchange seat reflects trading rather than clearing privileges. A related paper by Bhasin and Brown (1994) attributes the value of exchange seats to the value of trading on the exchange.

Assuming for the moment that C is constant across individuals, the threat of expulsion alters the problem by changing the lower limit of integration in equation (4) from M to $M+C/|N(j)|$. The problem of the clearinghouse now becomes minimizing

$$\sum_{j=1}^{n}[\,|N(j)|\,[i\,M(j)\;+\alpha\int_{M(j)+\frac{C}{|N(j)|}}^{\infty}(x-M(j))f(x,s)dx]] \qquad (14)$$

The first order condition for minimization of (14) with respect to M(j,h) and M(h,j) is:

$$1-F(M^{**}+\frac{C}{|N(j)|},s)\;+\;\frac{C}{|N(j)|}\;f(M^{**}+\frac{C}{|N(j)|},s)\;=\;\frac{i}{\alpha} \qquad (15)$$

Whenever membership in the clearinghouse is valuable ($C > 0$) the final term on the left hand side is strictly positive. This means that a policy of expelling a defaulting member reduces the probability of default $F(\bullet)$ to less than i/α, the level that would prevail if expulsion did not occur. Differentiating equation (15) with respect to M^{**} and $C/|N(j)|$, it is straightforward to show that $dM^{**}/d(C/|N(j)|) \leq 0$. Thus the greater the value of the membership to the potential defaulting party, the greater the reduction in the required margin deposits. If the value of clearing C is not positively correlated with volatility, the optimal margin coverage ratio M^{**}/s increases as volatility increases. Thus margin must increase more rapidly than volatility in order to supply the same overall level of protection. This result contrasts sharply with our basic model which predicts that the coverage ratio is constant. It also is at odds with the increasing opportunity cost model which predicts that coverage ratios should fall as volatility rises.

These results suggest that the benefits of creating a clearinghouse extend beyond economizing on margin and deadweight default costs by eliminating cherrypicking. In addition, the creation of a clearinghouse also makes it possible to compel firms to perform even when price movements exceed the margin on deposit. This benefit can be achieved without the clearinghouse expending resources to monitor the financial condition of members.

E. The clearinghouse as monitor

We now relax the assumption that only collateral can be attached in the event of default and allow counterparties to grant senior claims on a general pool of unencumbered assets k(j).[11] Each party knows its own k(j), however we assume that a counterparty can only determine k(j) by incurring an examination cost which is denoted e. A trader will choose to be monitored if the savings from being able to grant a senior claim against its pool of unencumbered assets k(j) exceeds the cost of examination. The most the firm can save by being examined is ik(j). If the quantity ik(j) is less than the cost of inspecting e, then inspection clearly does not pay. However, failure of this condition is not sufficient for inspection to occur. If the optimal margin $M^*|N(j)|$ in the absence of inspection is less than k(j), the opportunity cost savings from granting a senior claim to a part of k(j) would be $iM^*|N(j)|$.

If a firm is inspected one of two conditions will hold. If the firm's unencumbered assets k(j) exceed $M^*|N(j)|$, then no margin is posted. If $M^*|N(j)|$ exceeds the firms's unencumbered assets, then the clearinghouse's problem is of the same form as equation (4) with $M+k(j)/|N(j)|$ substituted for M. In this case the optimal margin rule is

$$M^{***}+\frac{k(j)}{|N(j)|} = F^{-1}(\frac{i}{\alpha},s) \tag{16}$$

Because k(j) is less than $M^*|N(j)|$, parties must still post some margin. Thus, if the opportunity cost of margin is assumed constant, the optimal52 default probability is identical to the case where no examination occurs. Firms merely substitute claims against unencumbered assets k(j) for more costly margin.[12] This contrasts sharply with our model of margin setting with expulsion. In that model, increases in the value of membership always decrease the probability of default. Equation (14) tells us that when the clearinghouse monitors firms, the coverage ratio M/s increases as volatility increases, as the firm's unencumbered assets k(j) decrease, and as the firm's open interest increases.

The prediction that the coverage ratio will decline as a firm's supply of unencumbered assets increases contrasts sharply with predictions of the basic netting model laid out in equation (5) and the increasing opportunity cost model of equation (10). It also seems at odds with the observed uniformity of margin requirements across clearing members of organized clearinghouses. This uniformity arises for several reasons. First, delays in payment could be the principal reason default generates a deadweight loss for members of the clearinghouse. When time is of the essence, the existence of unencumbered assets which cannot be immediately liquidated would be relatively unimportant. Second, it is possible that the clearinghouse cannot verify the existence of k in a timely fashion. Third, netting may reduce each party's net exposure to such low levels that intensive monitoring is not cost effective. In any event, the uniformity of margins across clearinghouse members suggests that if clearinghouses do engage in extensive monitoring, it must be for a purpose other than the control of risk between members of the clearinghouse.

The prediction of a positive correlation between volatility and the coverage ratio also contrasts sharply with the independence of the coverage ratio and volatility predicted by the simple netting model of equation (5) and the negative correlation generated by the increasing opportunity cost of funds model of equation (10). The goal of the empirical work presented in this paper will be to use data on coverage ratios and volatility to draw inferences about the relevance of these alternative models of clearinghouse behavior.

III. Tests of the model

A. Data

Margin data were obtained from the clearing organizations for eighteen contracts trading on the following futures exchanges: the Chicago Board of Trade, the Chicago Mercantile Exchange, the Coffee, Sugar and Cocoa Exchange, the Commodity Exchange, and the New York Mercantile Exchange. The eighteen contracts selected are the most heavily traded contracts having options on the underlying futures contract.

With the exception of the New York Mercantile Exchange, margin requirements are differentially assessed based on affiliation with the exchange. The speculative positions of non-clearing members are assessed the highest levels of margin.[13] The initial margin requirement for clearing members is usually the same as the initial margin amount for the hedge positions of non-clearing members. Finally, the maintenance margin requirements of clearing members are the same as their initial requirements. Thus, our assumption that accounts are brought back to M after each settlement period gives a lower bound for the amount of margin in a clearing member's account: they must always have at least the amount of the current initial margin, and may choose to allow excess balances to remain in the account.

Table I provides summary information on these contracts. Listed under each exchange are the contracts trading on that exchange which were used in the analysis. The start date is the first date used in the sample; generally, this date is determined by the beginning of options trading on the respective futures contracts. In each case, the sample extends through June 1991. Sample dates are the last Thursday of every contract month. The number of available observations ranges from 29 for the Treasury Bond and Deutschemark contracts to 15 for the Heating Oil contract. Mean margin levels reported are for initial positions classified as nonmember speculative and for clearing members (or nonmember hedgers) on the above-indicated sample dates.

For each of the sample dates, data were collected to impute volatilities for the respective contracts. These data are: prices for call options expiring in the next delivery month at each strike price traded on that date, futures settlement prices for corresponding delivery months, and Treasury bill rates with maturities most closely matching the time until expiration of the option contracts. These data were obtained from the *Wall Street Journal*. The Barone-Adesi and Whaley (1987) model was used to impute volatilities for each of the option contracts. A time series of representative implied standard deviations (ISDs) for each contract was calculated on each sample date using a Taylor-series approximation based on iterated regressions as described by Whaley (1982). The method employs a nonlinear regression to obtain a representative ISD incorporating the information available from each of the options traded. Mean ISDs are reported. These range from a low of .01 for the Eurodollar contract to .53 for the Sugar contract.[14]

Margin coverage ratios divide the respective margin amounts by dollar-price volatility. To obtain dollar-price volatility, ISDs are multiplied by the dollar value of the contract—futures prices times number of deliverable units—and divided by the square root of 365. This gives a market-based estimate of dollar volatility for one day. Initial speculative and member margin requirements are divided by the dollar volatilities previously described. Means of these coverage ratios are reported in Table I. Margin coverage ratios appear to be grouped according to their classification as member or nonmember. Nonmember speculative margin coverage ratios seem to be roughly distributed around five. Comparison of nonmember speculative and member margin requirements indicates that clearing member margins are about 80% of the level required for speculative positions. The exception is the New York Mercantile Exchange where they are equal.

Notably, the coverage ratio for the S&P 500 contract is well above the typical level obtained for nonmember speculative positions, averaging 10.17 during the sample period. Member margin coverage ratios are generally around four; the S&P 500 member margin does not fall outside the range obtained for other contracts.

The discrepancy between these coverage ratios suggests that determination of nonmember speculative margins for the S&P contract may have reflected additional requirements during the sample period. The political firestorms accompanying the market breaks in 1987 and 1989, and the resulting debate over whether the federal government should assume responsibility for the regulation of margin requirements, may have resulted in margins which were higher than the clearinghouse would have set for purely prudential reasons. It should be noted that a great deal of empirical work on margins and volatility has been devoted to the study of the S&P 500, which our data suggests is atypical.

This contrast becomes even more extreme when allowance is made for the length of the settlement period. During part of this period, the S&P 500 contract settled twice per day. Other contracts settled only once per day throughout the period. Since the daily standard deviation is used in calculating the coverage ratio, one would expect the coverage ratio to be smaller, not larger, for the S&P 500, other things equal (Fenn and Kupiec's analysis suggests it should be approximately half as large: see Fenn and Kupiec, 1993).

Assuming price changes are normally distributed, the coverage ratios for clearing members imply that the probability of a price change exceeding required margin from one settlement period to the next is much less than 1%. Thus, clearinghouses seem to set margin such that the probability of losses exceeding margin levels is extremely small. A subsequent subsection examines the relationship between coverage ratios and our proxies for the opportunity cost of placing margin deposits.

B. Examination of individual cross-sections

The arguments of Figlewski (1984) and others state that margin levels should rise as volatility in the underlying contract rises. To examine this hypothesis, regressions were run for contract cross sections at each of the thirty sample dates. Dependent variables in these regressions were the initial margin levels for the open futures positions of members and nonmembers. These were regressed on the dollar volatilities imputed from the corresponding futures options. The specification is:

$$MARGIN_i = \alpha_0 + \alpha_1 DOLVOL_i + \varepsilon_i \tag{17}$$

for each contract i. Results for member margin levels are reported in Table II. Not surprisingly, these results are in the main consistent with the hypothesis that price volatility is an important determinant of clearinghouse margin policy. Coefficients are all positive as predicted and generally differ reliably from zero. The one exception is apparent in Table II: for the sample date of 6/84, where the number of observations is smallest—3—the coefficient is positive but not significant. The R^2 figures obtained from these regressions add support for the conclusion that margins are set in accord with price volatility—considerable portions of the cross-sectional variations are explained by price volatility.

C. Time-series Evidence

To obtain further insight into the margin-setting process, daily data were obtained for four of the eighteen contracts. These contracts are: Deutschemark, S&P 500, Soybean and Treasury Bond. Implied volatilities were computed using the procedures previously described. These were matched with required margin levels on these dates and margin coverage ratios were computed. The time series of these quantities were examined.

The first test considers whether the coverage ratio for a contract tends to revert to its long-run, unconditional mean. Denoting coverage ratios CR_t, our model implies that shocks to these ratios result in pressures to bring them back to acceptable levels. Such a test does depend on the time path of volatility. Substantial research finds evidence that the volatility of returns on financial assets is nonstationary.[15] Thus, adjustments to coverage ratios are appropriately ascribed to changes in margin as opposed to mean reversion in volatility: prudential concerns that coverage ratios have become too small lead to increased margin coverage and the cost concerns inherent in excessively large ratios lead to reduced margin coverage. Our model implies that in the absence of either of these pressures, coverage ratios would not be adjusted to equilibrium levels, resulting in a non-stationary time series of coverage ratios (the alternative hypothesis). Thus, evidence of stationarity is consistent with our model.

The augmented Dickey-Fuller (ADF) procedure is employed to consider this hypothesis. Changes in coverage ratios are regressed on the first lag of their levels and lags of changes in the coverage ratio. The specification is:

$$\Delta CR_{i,t} = \alpha_{i,0} + \alpha_{i,1} CR_{i,t-1} + \sum_{j=1}^{K} \alpha_{i,1+j} \Delta CR_{i,t-j} + u_{i,t} \qquad (18)$$

The number of lags—K—is determined by comparing Akaike's Information Criterion (AIC) at various lag lengths, choosing the lag length which obtains maximum AIC values.

The test examines the coefficient on the lag level. This test employs the critical values provided by Fuller (1976): −1.95 at the 5% level and −2.58 at the

1% level. Results of the test are reported in Table III. Coefficient t statistics below these critical values are indicative of mean reversion in the series. In each case, evidence of mean reversion is found at the 1% level or better regardless of the margin category.

This test is then extended to determine if reversion to the mean is more rapid when coverage ratios are above or below their long-run averages. The prudential hypothesis of previous authors such as Gay, Hunter, and Kolb predicts that clearinghouses will respond to low coverage ratios by raising margin requirements, but prudentiality does not predict how clearinghouses will respond to shocks which result in high coverage ratios. In contrast, the model of this paper predicts that the cost of margin coverage will induce clearinghouses to lower margin coverage provided their prudentiality objectives are met. The ADF test is modified to test for differential slopes on the lagged level of the coverage ratio. Quartiles are determined for the sample of coverage ratios and dummy variables, denoted Q^1, computed to classify observations according to these quartiles. Lagged coverage ratios are multiplied by these dummy variables to obtain a specification which can capture differential responses by the clearinghouses based on levels of lagged coverage ratios. This specification is:

$$\Delta CR_t = \alpha_0 + \sum_{l=1}^{4} \alpha_1^l Q^l CR_{t-1} + \sum_{i=1}^{K} \alpha_i \Delta CR_{t-i} + u_t \qquad (19)$$

Results are reported in Table III. Coefficients generally differ reliably from zero. The exception is the speculative margin requirement of the Soybean contract where response to low coverage ratios has the correct sign, but is not significant. However, in every case coefficients on the highest quartile classification differ reliably from zero. This is consistent with a clearinghouse policy to lower margin requirements when margin coverage ratios exceed their long-run averages. This result implies an internalization of the costs of high margins born by the exchange membership. The internalization of these costs, although generally implicit in the literature, is explicitly predicted only by Fenn and Kupiec (1993) and the model in this paper.

Further evidence of the tradeoff between prudentiality and margin costs can be obtained from a comparison of the coefficients on the low and high coverage quartiles. Coefficients which are larger (in absolute value) imply quicker responses to shocks to the coverage ratio. In every case, the coefficients on the low-coverage quartiles are larger in absolute value than those on the high-coverage quartiles. This implies that these clearinghouses respond more quickly to surety lost when coverage ratios decline than to the increase in costs borne by clearinghouse members when coverage ratios rise.[16]

D. Pooled cross-section time series analysis

Our theoretical analysis suggests that margin setting by clearinghouses is influenced by the opportunity costs incurred by posting margin assets. When the opportunity cost of margin increases with the total margin requirement, the higher the volatility, the lower the coverage ratio. Models where the clearinghouse monitors either the financial condition of its members or the value its members attach to membership predict the opposite relationship.

The opportunity cost of margin is the difference between the cost of financing an additional dollar of margin assets and the return on those assets. If participants were required to post margin in the form of non-interest-bearing cash, movements in firms' short-term borrowing costs would provide a good proxy for the impact of money-market conditions on changes in the opportunity cost of margin. However, most margin deposits are in the form of securities or standby letters of credit rather than cash.

In the case of securities, the appropriate measure of opportunity cost is the difference between the yield on the margin assets and an additional dollar of credit with a comparable duration. During the period covered in this paper, the five clearinghouses included in our sample accepted government and agency-debt securities as margin; Treasury bills being the most widely posted form of margin.[17]

Ideally, we would like to have a time series on the spread between the risk-adjusted borrowing costs of market participants and rates on Treasury bills. However, such a series is unavailable. This forces us to proxy for the cost of borrowing. The borrowing costs of market participants could vary over time because of economy-wide shifts in the cost of borrowing. However, if individual borrowers face upward-sloping supply curves for credit, borrowing costs for market participants could also vary over time because of changes in the credit demands of market participants.

Commercial banks are a significant source of credit to futures market participants. As a result, the prime rate is a useful indicator of economy-wide shifts in the cost of credit obtained through the banking system. Indeed, the majority of floating-rate loans made to commercial borrowers are tied to the prime rate.[18] When the prime rate rises, firms with prime-based loan agreements experience a change in borrowing costs irrespective of changes in open market rates. Differences between the prime rate and the Treasury bill rate provide one indicator of changes in the opportunity cost of margin.[19]

Proxies for shifts in the market participant's borrowing costs

If the borrower does not face a perfectly elastic supply of external financing, borrowing costs also vary over time and across borrowers as the quantity borrowed increases. The assumption that borrowers do not face a perfectly elastic supply of external financing is supported by a growing body of literature which indicates that firms—both financial and nonfinancial—find it costly to raise additional debt or equity from external sources.

If clearinghouse members do not face a perfectly elastic supply of external finance, we would expect to observe a negative correlation between coverage ratios and volatility levels. Holding the coverage ratio, open interest, and the clearing member's other assets constant, an increase in volatility implies higher margin deposits and greater external financing. With an upward-sloping supply of external funds, this higher margin requirement will result in higher borrowing costs and a higher opportunity cost for deposited margin. An optimizing clearinghouse will respond to this higher opportunity cost by reducing its coverage ratios. Thus, we would expect that, holding constant economy-wide borrowing costs, volatility and borrowing cost will be positively correlated while volatility and the coverage ratio would be negatively correlated.

The specification

The foregoing discussion suggests the following specification:

$$CR_{it} = \alpha_{i0} + \alpha_1 R_t + \alpha_{i2} ISD_{it} + \mu_{it} \tag{20}$$

where i denotes the ith contract, R_t is a proxy variable designed to capture intertemporal variation in the opportunity cost of borrowing that are the result of economy-wide changes in the cost of borrowing from the banking system, and

ISD_{it} is the implied standard deviation for the particular contract. These implied standard deviations are included to capture intertemporal and cross-sectional differences in market participants' opportunity cost that are the result of differences in the demand for credit to finance margin positions. The increasing opportunity cost model offers the following restrictions:

$$\alpha_1 \leq 0, \ \alpha_{i2} \leq 0$$

We estimate equation (20) by pooling data on 18 contracts for the time periods reported in Table I. Table IV presents the pooled estimation results for equation (20) using both the prime rate (RPR) and the spread between the prime rate and the Treasury bill rate (SPREAD) as the measures of changes in the opportunity cost of margin. Columns (1) and (2) of Table IV present the results for a pooled regression where the coefficients on ISD are constrained to be the same across contracts.[20] In both cases the coefficient on ISD is negative and reliably different from zero. The coefficient on RPR is negative but insignificant while the coefficient on SPREAD is negative and significant at the 5% level. Columns (3) and (4) of Table IV present estimates of equation (20) where we constrain the coefficients α_{i0} and α_{i2} to be constant across time periods but permit them to vary across commodities. We find that the coefficients on RPR and SPREAD are significantly less than zero at the 5 percent level. In both specifications, we also find that the coefficients on implied volatility are negative for all contracts and significantly less than zero in 12 of 18 contracts. In addition, an F test rejects the joint hypothesis that all coefficients on ISD equal zero; that is, consistent with our model we reject $\alpha_{1,2} = \ldots = \alpha_{1,2} = \ldots = \alpha_{18,2} = 0$ at the .0001 level.

Contracts for which the implied standard deviation has no explanatory power are the British Pound, cattle, copper, gold, silver, and Treasury bonds. The heavy volume of the Treasury bond contract makes this exception especially interesting. Notably, margin requirements for the participants in this market are likely to be least onerous since their ordinary course of business makes available to them a ready supply of marginable assets. It is interesting to note that margin requirements for three of the remaining exceptions are determined by a single organization, COMEX.

Consideration of Alternative Specifications

There is the possibility that estimating equation (20) may yield a negative correlation between volatility and the coverage ratio even if our model were incorrect. Suppose that instead of being set on a cost-minimizing basis, clearinghouses set margin at fixed percentages of current prices for futures contracts, that is

$$M_{it} = \beta_{1i} P_{it} \qquad (21)$$

where $P_{i,t}$ is the price of the ith futures contract at time t. If we divide both sides of equation (21) by $DOLVOL_{i,t}$, then

$$CR_{it} = \frac{\beta_{1i} P_{it}}{DOLVOL_{it}} = \frac{\beta_{1i}}{ISD_{it}} \qquad (22)$$

In this case we would find that ISD and the coverage ratio would be negatively correlated even though (21) is the true model. However, this alternative model implies that coefficients on our proxies for the opportunity cost of margin, α_1 should be zero. Thus, our estimates of equation (20) reject this alternative in favor of our model.

Another possibility is that clearinghouses set margin at constant levels independent of either price or volatility, that is

$$M_{it} = \bar{\beta}_{0i} \tag{23}$$

In this instance, the coverage ratio becomes

$$CR_{it} = \frac{\bar{\beta}_{0i}}{DOLVOL_{it}} \tag{24}$$

The positive correlation of DOLVOL and ISD thereby implies a negative correlation between ISD and our coverage ratio even though, in this instance, equation (23) is the true model. This possibility is not strictly nested within the specification given in equation (20), requiring an alternative procedure. We estimate a specification based on (24), obtaining predicted values for coverage ratios. We augment equation (20) by including these predicted values and re-estimate. Under the alternative null the coefficients on our implied standard deviations and opportunity-cost proxies should be zero. The F statistic for these coefficients jointly equaling zero is 8.6. This result strongly favors our model over this alternative.

IV. Summary

Our models of clearinghouse behavior recognize that determination of margin requirements is driven by the cost of external funds and the deadweight losses associated with counterparty default. The opportunity cost of posting margins both creates the need for a clearinghouse and governs the setting of margins. As a voluntary association, the clearinghouse internalizes these costs into its margin decisions. Thus, clearinghouse pursuit of prudentiality through margin is constrained by the costs that members incur by carrying these balances. When margin is set without regard to additional information about the condition of the clearinghouse members, the coverage ratio is either uncorrelated or negatively correlated with volatility. Our models also emphasize that when a clearinghouse actively monitors its members for the purposes of managing risk between members of the clearinghouse, the coverage ratio will be positively correlated with volatility. Finally, the emphasis on the foundations of the clearinghouse, make clear that membership is valuable to all members. Because membership is valuable, it is credible and effective for the clearinghouse to expel defaulting members. This means that members will perform on their contracts even when price moves exceed the value of margin on deposit.

Our examination of the cross-section evidence confirms the results of previous research indicating that clearinghouse determination of margin incorporates prudential concerns. The time series of coverage ratios also supports this conclusion, but suggests that clearinghouses respond to high levels of margin by adjusting coverage ratios downward. This behavior cannot be explained by prudentiality alone.

Our pooled-regression results indicate that futures clearinghouses set margin in a cost-minimizing fashion, balancing the risk of loss against the greater opportunity costs associated with higher margins. Our results suggest that at least a portion of these opportunity costs arise because market participants have imperfect access to capital markets for their general financing. This is in contrast to the emphasis of Fenn and Kupiec (1993) on the transactions costs of frequent mark-to-market settlements. It also contrasts sharply with the view that the clearinghouse primarily acts as a delegated monitor by examining its members' financial condition.

If examination does not play an important role in controlling risk between members of the clearinghouse, what role does it play? We posit two alternative roles for examination. First, examination may be undertaken for the purpose of informing the customers of a clearing member about the clearing member's condition, not for controlling risk between clearing members. Second, examination may be undertaken to support the clearinghouse's expulsion policy rather than to economize on margin. The threat of expulsion can only be effective if the firm contemplating default has the financial capacity to honor its contracts and has a long time horizon. Insolvent firms violate both criteria and examination serves to identify them. For these firms, the threat of expulsion will not be effective.

References

Baer, Herbert L., and John McElravey, "Capital Adequacy and the Growth of U.S. Banks," in Charles Stone and Anne Zissu (eds.), *Risk Based Capital Regulations: Asset Management and Funding Strategies*, Homewood, IL: Dow-Jones-Irwin, forthcoming, 1993.

Baer, Herbert L., Virginia Grace France, and James T. Moser, "Opportunity Cost and Prudentiality: A Representative-Agent Model of Futures Clearinghouse Behavior," Faculty Working Paper #93-0142, University of Illinois, 1993.

Barone-Adesi, Giovanni and Robert E. Whaley. "Efficient Analytic Approximation of American Option Values." *Journal of Finance* 42 (1987), 301-320.

Bhasin, Vijay, and David P. Brown, "Competition, Valuable Exchange Seats and the Quality of Trade" working paper, Indiana University, January, 1994.

Bollerslev, Tim, Ray Y. Chou, Narayanan Jayaraman, and Kenneth F. Kroner. "ARCH Modelling in Finance: A Selective Review of the Theory and Empirical Evidence with Suggestions for Future Research," *Journal of Econometrics* 52 (1991), 5-59.

Brennan, Michael J., "A Theory of Price Limits in Futures Markets," *Journal of Financial Economics* 16 (1986), 49-56.

Calomiris, Charles W., and R. Glenn Hubbard, "Internal Finance and Investment: Evidence from the Undistributed Profits Tax of 1936-37," mimeo, University of Illinois, December, 1992.

Cornes, Richard and Todd Sandler. *The Theory of Externalities, Public Goods, and Club Goods*. Cambridge: Cambridge University Press, 1986.

Craine, Roger. "Are Futures Margins Adequate?" Working paper, Department of Economics, University of California at Berkeley, March, 1992.

Diamond, Douglas. "Financial Intermediation and Delegated Monitoring," *Review of Economic Studies* 51 (1984), 393-414.

Fazzari, Steven M., R. Glenn Hubbard, and Bruce C. Peterson, "Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activity*, (1988), 141-195.

Federal Reserve Board, "Terms of Lending at Commercial Banks Survey for November 2-6, 1992," *Federal Reserve Bulletin*, February, 1993.

Fenn, George, and Paul Kupiec. "Prudential Margin Policy in a Future-Style Settlement System." *Journal of Futures Markets* 13 (1993), 389-408.

Figlewski, Stephen. "Margins and Market Integrity: Margin Setting for Stock Index Futures and Options." *Journal of Futures Markets* 4 (Fall 1984), 385-416.

Fuller, Wayne A. *Introduction to Statistical Time Series*. New York: John Wiley and Sons, 1976.

Gay, Gerald D., Hunter, William C., and Kolb, Robert W. "A Comparative Analysis of Futures Contract Margins." *Journal of Futures Markets* 6 (Summer 1986), 307–324.

Gorton, Gary, "Clearinghouses and the Origin of Central Banking in the U.S.," *Journal of Economic History* 45 (June 1985), 277–283.

Hsieh, David A., "Implication of Non-Linear Dynamics for Financial Risk Management," *Journal of Financial and Quantitative Analysis* 28 (March 1993), 41–64.

Hubbard, R. Glenn, and Anil K. Kashyap, "Internal Net Worth and the Investment Process: An Application to U.S. Agriculture," *Journal of Political Economy* 100 (June 1992), 506–534.

Hunter, William C. "Rational Margins on Futures Contracts: Initial Margins." *Review of Research in Futures Markets* 5 (1986), 160–173.

Kofman, Paul, "Optimizing Futures Margins with Distribution Tails," *Advances in Futures and Options Research*, vol. 6, Winter, 1992, forthcoming.

Laffont, Jean–Jacques, *Fundamentals of Public Economics*, Cambridge, Mass.: MIT Press, 1988.

Merton, Robert C., and Zvi Bodie, "On the Management of Financial Guarantees" *Financial Management* 21 (Winter 1992), 87–109.

Sarkar, Asani, "The Regulation of Dual Trading: Winners, Losers, and Market Impact – Revised," Bureau of Economic and Business Research Faculty Working Paper #93–0125, University of Illinois, April 1993.

Telser, Lester G. "Margins and Futures Contracts." *Journal of Futures Markets* 1 (Summer 1981), 225–253.

Whaley, Robert E. "Valuation of American Call Options on Dividend–Paying Stocks: Empirical Tests." *Journal of Financial Economics* 10 (1982), 29–57.

Footnotes:

1. Margin is a deposit to ensure contract performance, just as collateral is a deposit to ensure loan performance. Like loan collateral, margin is seized in the event of default. However, in the case of margin on futures contracts, no loan is involved.

2. Violations of these assumptions can lead to economically important and interesting complications of our model. For instance, when some members act as brokers for non-member traders and some do not, members will disagree about regulations governing dual trading (see Sarkar, 1993).

3. Calomiris and Hubbard (1992), Fazzari, Hubbard, and Petersen (1987); and Hubbard and Kashyap (1992) all provide evidence that nonfinancial firms behave as if they find it relatively expensive to finance growth through external financing. Baer and McElravey (1993) report similar results for U.S. banking corporations.

4. In practice, clearinghouses may have additional collateral on clearing members: required deposits in an exchange guarantee fund, required purchases of minimum numbers of exchange memberships, etc. In addition, clearinghouses require that clearing firms maintain a certain minimum level of capital. We consider the existence of this additional capital in a later section.

5. A generalization to a multi-contract exchange results in a relation between the loss on a portfolio of contracts and the sum of margin deposits. The results resemble a standard Markowitz model with incomplete diversification, since most members will not be holding a large number of different futures contracts. Due primarily to notational complexity, this model has not been included, but is available in earlier working papers (Baer France Moser, 1993)

6. Most margin on US exchanges is actually deposited in interest-bearing forms, for instance in Treasury bills. In this case, the actual bill would be returned to the depositor when the account is closed, while any gains or losses (variation margin) would be handled by cash payments. By this arrangement, the depositor in effect gets interest on his deposit. The London Clearinghouse actually pays interest on cash deposits. Our formulation covers both cases. If cash is deposited, the opportunity cost is driven by the levels of market rates. Most clearinghouses allow standby letters of credit (SLOCs) as margin, but generally limit the SLOC portion of total margin posted. In the case of the Board of Trade Clearing Corporation, the SLOC share of margin deposits cannot exceed 25 percent of a member's adjusted net capital. In the case of the Chicago Mercantile Exchange Clearinghouse, for clearing members with margin requirements in excess of $5 million, standbys can be no more than 50 percent of margin requirements in excess of $5 million.

7. We are implicitly assuming that the courts are not effective in seizing collateral, or that the speed of payment is an issue. If payment delay is the principle reason that default imposes a deadweight loss on the membership, then only assets which are readily available and liquid are relevant in preventing default costs.

8. Certain loss sharing rules could potentially undo this result, by allocating a disproportionate share of losses to an individual member. Futures exchanges generally use a common fund to pay for defaults. By contrast, the prospectus for Multinet International, a over-the-counter foreign exchange clearinghouse, explicitly recognizing the moral hazard involved, states that "to the greatest extent possible, Multinet International will allocate any losses to those that traded with the failed participant." Both of these rules are consistent with a reduction in default losses for all individuals.

9. See Laffont, 1988, pp. 51-53, or Cornes and Sandler, 1986. Exchanges usually set margins, not on the basis of a direct vote, but by a committee designed to be representative of the membership.

10. In the 19th century, expulsion from the exchange was the principal mechanism for ensuring contract performance. Defaulters were barred from trading with any exchange member until they had settled with their creditors.

11. By relaxing this assumption we are implicitly assuming that courts are effective in seizing collateral and that the speed of payment is not an issue. If payment delay is the principal reason that default imposes a deadweight loss on the membership, then the existence of unencumbered assets may be irrelevant.

12. More generally, when the opportunity cost of margin is an increasing function of the total required margin, examination will lead to a decrease in the optimal default rate.

13. Margin amounts collected when these accounts are opened are referred to as initial margin. Should the amount of margin fall below a specified maintenance level, the margin balance must be restored to the current initial level. Maintenance margin requirements in U.S. stock markets differ. In stock markets, should a deficiency occur, margin must be restored to the maintenance level.

14. Implied standard deviations for short-term interest rate contracts are generally expressed in terms of yield variation. For consistency with our other contracts, they are here reported in terms of variation of rates of return.

15. For an extensive review of this literature see Bollerslev, Chou, Jayaraman, and Kroner (1992).

16. An F test indicates that the difference between t coefficients on the high and low quartiles of the S&P a Deutschemark contracts is significant at better than the 95% leve

17. Other clearinghouses, for instance the Options Cleari Corporation, have long accepted equity as margin. This practice increasingly being adopted by futures clearinghouses.

18. For example, see Federal Reserve Board (1993).

19. It is less obvious that the opportunity costs associated wi obtaining standby letters of credit (SLOC) should vary wi monetary policy since they create no funding obligation for t bank. However, as discussed above, clearinghouses generally lim the SLOC portion of total margin posted.

20. Note that our model does not require that the coefficients ISD be equal across contracts. Indeed, if different individua hold different numbers of contracts, the opportunity cost of a pe contract increase in margin would differ among members, a therefore might differ across contracts. All our model requires that this coefficient be negative.

Table I
Margins and implied volatilities

Contract	Sample Start Date	N	Mean ISD	Mean Initial Speculative Margin	Mean Speculative Coverage	Mean Initial Member Margin	Member Coverage
Chicago Board of Trade							
Corn	3/85	26	.21	520.58	5.10	353.85	3.38
Soybeans	12/84	26	.16	1396.38	5.61	1067.31	4.20
Treasury Bond	3/84	29	.11	2618.97	5.32	2120.69	4.27
Wheat	3/87	16	.21	725.31	4.38	543.75	3.24
Chicago Mercantile Exchange							
British Pound	3/85	26	.12	2197.23	5.44	1938.46	5.02
Deutschemark	3/84	29	.12	1864.17	5.45	1689.66	5.01
Eurodollar	3/85	17	.01	925.00	7.06	823.53	6.07
Japanese Yen	6/86	21	.10	2069.67	4.90	1788.10	4.24
Live Cattle	12/84	23	.14	756.78	4.02	619.57	3.29
Swiss Franc	3/85	26	.12	2111.38	4.81	1875.00	4.25
S&P 500	3/84	26	.17	11134.62	10.17	4865.38	4.56
Coffee, Sugar and Cocoa Exchange							
Coffee	12/87	15	.30	2733.33	5.25	1366.67	2.62
Sugar	3/85	26	.53	1209.62	5.46	604.81	2.73
Commodity Exchange							
Copper	6/86	20	.30	1734.50	4.81	1355.00	3.66
Gold	3/84	28	.16	1692.46	5.34	1253.57	3.95
Silver	12/84	27	.24	2004.52	5.55	1585.00	4.10
New York Mercantile Exchange							
Crude Oil	12/86	19	.36	2284.21	7.53	2284.21	7.53
Heating Oil	9/87	15	.37	2293.33	6.79	2293.33	6.79

Note: Start date is the first sample date. Mean margin is the average of initial speculative or initial member margin required on the sample dates. Mean ISD is the average implied standard deviation for options trading on the sample dates. The Barone-Adesi and Whaley (1987) model is used to impute volatilities. The Whaley (1982) method is used to combine volatilities at each sample date. Margin coverage is respective level of margin divided by the dollar volatility of the contract. Dollar volatilities are ISD multiplied by the dollar value of the contract and divided by the square root of 365.

Table II
Cross-section regressions of initial member-margin on dollar volatility

$$MARGIN_t = \alpha_0 + \alpha_1 DOLVOL_t + \varepsilon_t$$

Date	N	α_0	$t(\alpha_0)$	α_1	$t(\alpha_1)$	R^2
3/84	4	-93.4	-0.23	4.23*	4.61	.91
6/84	3	433.3	0.27	4.16	1.12	.56
9/84	4	-351.5*	-5.29	5.34*	36.28	.99
12/84	7	577.3	1.22	3.28*	2.35	.53
3/85	11	-318.1	-1.07	5.76*	7.30	.86
6/85	12	-177.9	-0.71	5.20*	6.95	.83
9/85	11	-340.7	-1.08	5.35*	6.01	.80
12/85	12	252.4	1.03	3.90*	5.35	.74
3/86	12	558.1	1.94	2.17*	3.96	.61
6/86	13	417.1*	2.29	2.68*	7.07	.82
9/86	13	293.2	1.53	2.82*	7.40	.83
12/86	14	573.4*	2.61	2.94*	5.26	.70
3/87	14	585.8*	3.13	2.86*	7.57	.83
6/87	13	498.0	1.49	3.30*	4.98	.69
9/87	17	468.9*	2.67	2.73*	8.14	.82
12/87	16	-156.3	-0.24	4.12*	4.51	.59
3/88	18	-854.6	-0.95	7.49*	3.55	.44
6/88	18	1038.6	1.53	2.31*	2.40	.26
9/88	18	733.3*	2.63	2.12*	3.72	.46
12/88	16	1205.0*	4.51	0.64*	2.00	.22
3/89	18	332.6	1.65	3.08*	6.87	.75
6/89	17	593.9*	3.32	1.89*	6.26	.73
9/89	18	486.8*	2.87	2.28*	7.09	.76
12/89	13	261.7	0.64	3.24*	2.69	.40
3/90	15	476.9	1.64	2.48*	3.17	.44
6/90	17	359.1	1.94	2.68*	10.29	.88
9/90	18	1044.9*	2.32	1.50*	4.07	.52
12/90	16	604.9	1.67	2.00*	4.58	.62
3/91	17	-861.8*	-2.35	6.10*	8.64	.83
6/91	15	281.9	1.28	2.53*	4.21	.58

Note: $Margin_t$ is the initial amount of margin required for member positions in the sample contracts. $DOLVOL_t$ is the volatility expressed in dollars implied by futures options trading on the sample date. Implied standard deviations are computed using the Barone-Adesi and Whaley pricing procedure. The Whaley (1982) method is used to combine volatilities obtained for the contracts at each sample date. Margin coverage is initial speculative margin divided by the dollar volatility of the contract. Dollar volatilities are ISD multiplied by the dollar value of the contract and divided by the square root of 365. Results for speculative margins were similar (Baer France Moser, 1993)

Table III
Margin coverage adjustments

$$\Delta CR_t = \alpha_0 + \alpha_1 CR_{t-1} + \sum_{i=1}^{K} \alpha_{1+i} \Delta CR_{t-i} + u_t$$

Initial Member Margin

Contract	α_1	$t(\alpha_1)$
Deutschemark	−.004579*	−3.52
S&P 500	−.004704*	−2.88
Soybean	−.012160*	−4.04
Treasury Bond	−.017178*	−6.84

$$\Delta CR_t = \alpha_0 + \sum_{i=1}^{4} \alpha_1^i Q^i CR_{t-1} + \sum_{i=1}^{K} \alpha_{4+i} \Delta CR_{t-i} + u_t$$

Level of margin coverags at time t−1

Contract	Lowest Quartile α_1	Lowest Quartile $t(\alpha_1)$	Second Quartile α_1	Second Quartile $t(\alpha_1)$	Third Quartile α_1	Third Quartile $t(\alpha_1)$	Highest Quartile α_1	Highest Quartile $t(\alpha_1)$
Deutschemark	−.0135*	(−3.18)	−.0084*	(−2.58)	−.0097*	(−3.43)	−.0090*	(−3.78)
S&P 500	−.0438*	(−4.47)	−.0417*	(−5.25)	−.0239*	(−4.44)	−.0233*	(−5.35)
Soybean	−.0277*	(−2.12)	−.0265*	(−2.88)	−.0200*	(−2.91)	−.0180*	(−3.49)
Treasury Bond	−.0408*	(−5.96)	−.0389*	(−6.48)	−.0356*	(−6.55)	−.0321*	(−6.83)

CR_t is the time−t ratio of initial member margin to the option-implied volatility stated in dollars. Q^i is the coverage quartile for margin coverage during the sample period. K, the number of lagged changes in coverage ratio included in the specification, is determined by AIC. Critical values are from Fuller (1976): −1.95 at the 5% level and −2.58 at the 1% level. Lower values of t are indicative of reversion to the mean; i.e., the null of no mean reversion is rejected.

Table IV
Pooled Time-Series Regressions

$$CR_{it} = \alpha_0 + \alpha_1 R_t + \alpha_2 ISD_{it} + \sum_{j=2}^{18} \beta_j D_j + \sum_{k=1}^{18} \delta_k D_k ISD_{kt} + \mu_{it}$$

	Proxy:	Coefficient Restriction: $\alpha_2=0$ RPR		SPREAD		Coefficient Restriction: $\delta_k=0$ RPR		SPREAD	
	Contract								
α_0		7.22*	(4.98)	6.84*	(4.99)	6.52*	(8.86)	6.60*	(10.32)
α_1		−0.13*	(2.05)	−0.45*	(2.22)	−0.12	(1.70)	−0.46*	(2.16)
α_2						−3.21*	(7.00)	−3.15*	(6.87)
δ_1	*British Pound*	−7.79	(.74)	−5.54	(.52)				
δ_2	*Cattle*	−11.43	(1.71)	−10.63	(1.60)				
δ_3	*Coffee*	−3.04	(1.79)	−3.57	(1.76)				
δ_4	*Copper*	−3.51	(1.62)	−3.36	(1.55)				
δ_5	*Corn*	−5.67*	(2.68)	−5.90*	(2.78)				
δ_6	*Crude Oil*	−3.47*	(4.02)	−3.27*	(3.77)				
δ_7	*Deutschemark*	−29.44*	(4.00)	−29.31*	(3.98)				
δ_8	*Eurodollar*	−1874*	(7.18)	−1911*	(7.32)				
δ_9	*Gold*	−4.92	(.62)	−4.98	(.63)				
δ_{10}	*Heating Oil*	−3.92*	(4.20)	−3.88*	(4.15)				
δ_{11}	*Japanese Yen*	−47.49*	(2.76)	−43.64*	(2.52)				
δ_{12}	*Swiss Franc*	−23.58*	(2.11)	−23.09*	(2.06)				
δ_{13}	*Sugar*	−1.53*	(2.37)	−1.54*	(2.38)				
δ_{14}	*Silver*	−1.36	(.21)	−0.20	(.03)				
δ_{15}	*Soy Bean*	−17.12*	(2.77)	−16.66*	(2.69)				
δ_{16}	*S&P 500*	−22.34*	(3.59)	−21.16*	(3.42)				
δ_{17}	*Treasury Bond*	−14.55	(1.40)	−12.75	(1.23)				
δ_{18}	*Wheat*	−6.56	(1.77)	−6.15	(1.66)				

Tests of coefficient restrictions:

	RPR	SPREAD	RPR	SPREAD
$\beta_2 = \ldots = \beta_j = \beta_{18} = 0$	17.33	17.07	12.22	12.26
$\delta_1 = \ldots = \delta_k = \delta_{18} = 0$	8.93	8.73	NA	NA

*Significant at the 5% level. (T statistics in parentheses.)

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS1319	The Financial System and Public Enterprise Reform: Concepts and Cases	Asli Demirgüç-Kunt Ross Levine	July 1994	B. Moore 35261
WPS1320	Capital Structures in Developing Countries: Evidence from Ten Countries	Asli Demirgüç-Kunt Vojislav Maksimovic	July 1994	B. Moore 35261
WPS1321	Institutions and the East Asian Miracle: Asymmetric Information, Rent-Seeking, and the Deliberation Council	Jose Edgardo Campos Donald Lien	July 1994	B. Moore 35261
WPS1322	Reducing Regulatory Barriers to Private-Sector Participation in Latin America's Water and Sanitation Services	Barbara Richard Thelma Triche	July 1994	M. Dhokai 33970
WPS1323	Energy Pricing and Air Pollution: Econometric Evidence from Manufacturing in Chile and Indonesia	Gunnar S. Eskeland Emmanuel Jimenez Lili Liu	July 1994	C. Jones 37699
WPS1324	Voucher Funds in Transitional Economies: The Czech and Slovak Experience	Robert E. Anderson	July 1994	F. Hatab 35835
WPS1325	The Economics of Research and Development: How Research and Development Capital Affects Production and Markets and Is Affected by Tax Incentives	Anwar Shah	July 1994	C. Jones 37699
WPS1326	Banks, Capital Markets, and Corporate Governance: Lessons from Russia for Eastern Europe	Gerhard Pohl Stijn Claessens	July 1994	L. Hovsepian 37297
WPS1327	Is the Debt Crisis History? Recent Private Capital Inflows to Developing Countries	Michael Dooley Eduardo Fernandez-Arias Kenneth Kletzer	July 1994	S. King-Watson 31047
WPS1328	The Use of New York Cotton Futures Contracts to Hedge Cotton Price Risk in Developing Countries	Panos Varangis Elton Thigpen Sudhakar Satyanarayan	July 1994	D. Gustafson 33714
WPS1329	The Regulation and Supervision of Domestic Financial Conglomerates	David H. Scott	August 1994	K. Waelti 37655
WPS1330	Revenue Uncertainty and the Choice of Tax Instrument during the Transition in Eastern Europe	Delfin S. Go	August 1994	C. Jones 37699

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS1331	The Myth of Monopoly: A New View of Industrial Structure in Russia	Annette N. Brown Barry W. Ickes Randi Ryterman	August 1994	M. Berg 36969
WPS1332	Poverty and Household Size	Peter Lanjouw Martin Ravallion	August 1994	P. Cook 33902
WPS1333	A Test of the International Convergence Hypothesis Using Panel Data	Norman V. Loayza	August 1994	R. Martin 39026
WPS1334	Taxation, Public Services, and the Informal Sector in a Model of Endogenous Growth	Juan Braun Norman V. Loayza	August 1994	R. Martin 39026
WPS1335	Labor Regulations and the Informal Economy	Norman V. Loayza	August 1994	R. Martin 39026
WPS1336	Modernizing Payment Systems in Emerging Economies	Robert Listfield Fernando Montes-Negret	August 1994	F. Montes-Negret 37832
WPS1337	The Countrywide Effects of Aid	Howard White Joke Luttik	August 1994	E. Khine 37471
WPS1338	Commodity Exports and the Adding-Up Problem in Developing Countries: Trade, Investment, and Lending Policy	Maurice Schiff	August 1994	A. Kim 33715
WPS1339	China's Emergence: PRospects, Opportunities, and Challenges	Andres Boltho Uri Dadush Dong He Shigeru Otsubo	August 1994	J. Queen 33740
WPS1340	Opportunity Cost and Prudentiality: An Analysis of Futures Clearinghouse Behavior	Herbert L. Baer Virginia G. France James T. Moser	August 1994	P. Sintim-Aboagye 38526
WPS1341	Explaining Pakistan's High Growth Performance Over the Past Two Decades: Can It Be Sustained?	Sadiq Ahmed	August 1994	A. Bhalla 84440
WPS1342	Winners and Losers in Transition: Returns to Education, Experience, and Gender in Slovenia	Peter F. Orazem Milan Vodopivec	August 1994	