Default Risk on Derivatives Exchanges:

Evidence from Clearing House Data

Robert A. Jones (Simon Fraser University)

Christophe Pérignon (HEC Paris)

HEC Paris

Goal of the Paper

- Study empirically default risk on derivatives exchanges
  - Quantify the risk of default by a clearing member
  - Develop an insurance contract allowing the clearing house to hedge this risk

Who Cares about the Default Risk of a Clearing Member

- Clearing house
- Non-defaulting clearing members
- Non-defaulting investors
- Parent company of the clearing members
- Federal Reserve, as the "insurer of last resort" (Bernanke, 1990)

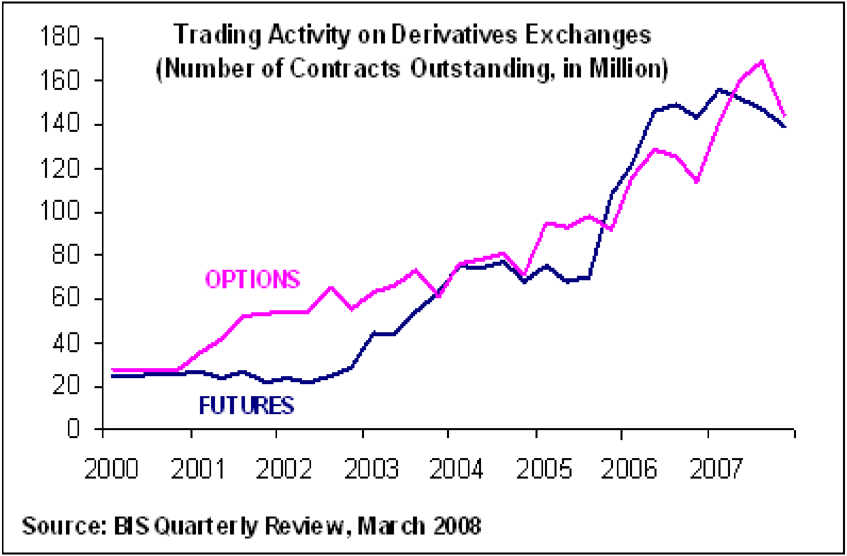
Recent Concerns about Default Risk in the Clearing Process

- Derivatives markets continue to experience a sharp increase in activity
  - OTC
  - Derivatives Exchanges
- Derivatives exchanges are consolidating at rapid pace
  - CME+CBOT(+NYMEX?), EURONEXT+LIFFE+NYSE
- New derivatives products (complex, illiquid)
- Cross-border clearing

$\Longrightarrow$ **Substantial Systemic Risk Concerns**

- Several clearing houses purchased default insurances
  - e.g. NYMEX, Sydney Futures Exchange, Norwegian Futures Exchange

Trading Activity on Derivatives Exchanges



Literature on Default Risk on Derivatives Exchanges

- **Individual Margins**
  - Prob($\text{Loss}_t > \text{Margin}_t$) Figlewski, 1984
  - E($\text{Margin}_t - \text{Loss}_t \mid \text{Loss}_t > \text{Margin}_t$) Bates and Craine, 1999
  - Optimal margin such that prob(Default) $= x$ Booth et al., 1997
  - Optimal margins + price limits + capital requirement Shanker and Balakrishnan, 2005
- **Portfolio Margins**
  - Prob($\text{Loss}_t >$ SPAN Margin_t) Kupiec, 1994, Kupiec and White, 1996
- **Default Insurance Premium**
  - Hypothetical insurance on a single futures contract on S&P 500 Bates and Craine, 1999
  - Stylized clearing house assumed to clear three futures contracts, "highly subjective" default probabilities Gemmil, 1994

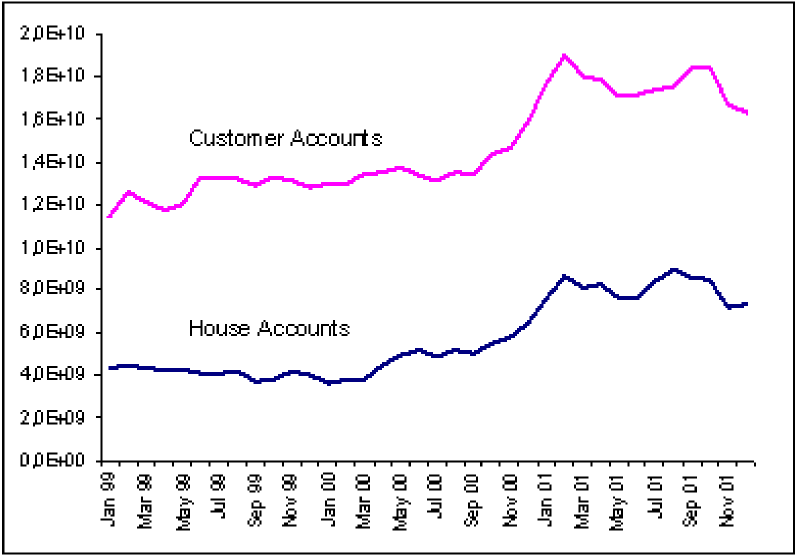
Our Contributions

- Analyze default risk of a clearing member using **actual** daily margins and daily profit and loss
- Design a **default insurance contract** covering the loss from default by one or several clearing members
- Price the insurance contract using actual data on clearing member's **proprietary** trading portfolios
- Put a dollar amount on the service provided by the **Federal Reserve**

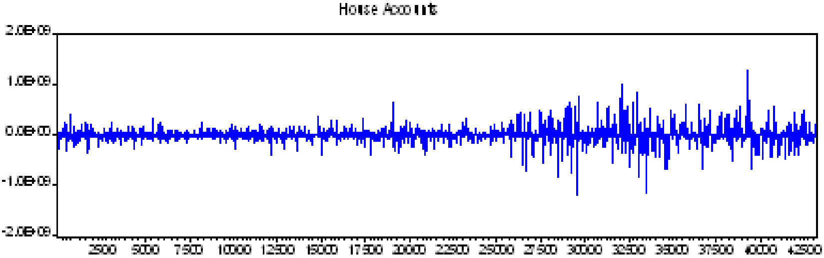
Data

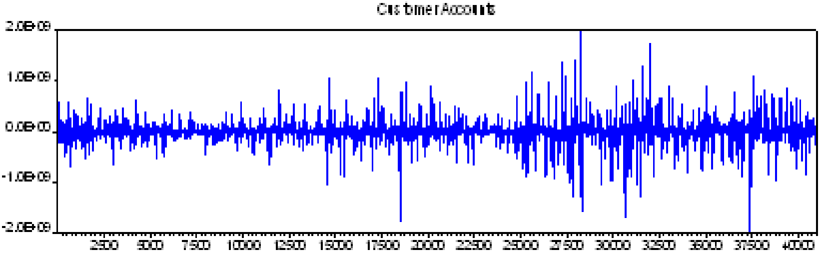
- Daily margins called "performance bonds", B, and daily profit and loss called "variation margins", V
- All clearing members of the **Chicago Mercantile Exchange**'s clearing house
- Performance bonds computed at the end of each trading day by the SPAN margining system
- Futures and options on interest rates, equity, foreign exchange rates, and commodities
- Sample period: January 4th, 1999 - December 31st, 2001
- For each clearing member, segregation between house accounts (under net margining), B_H and V_H, and customer accounts (under gross margining), B_C and V_C
- 71 clearing members (60 with both house and customer accounts, 9 with house account only, 2 with customer account only)

Cumulative Performance Bond



Daily Variation Margins

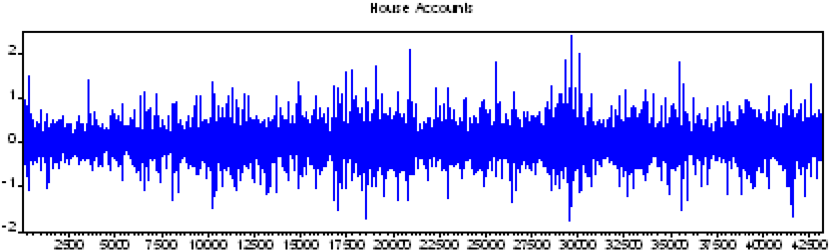


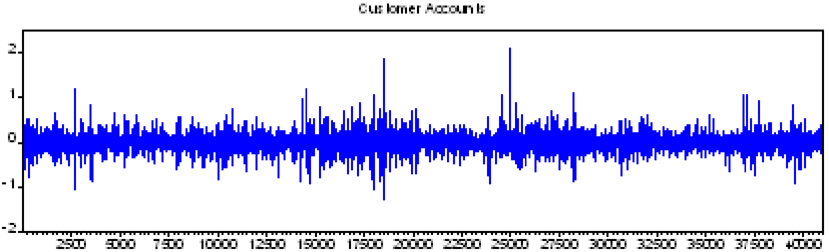


Risk Analysis

	B^H	V^H	$\frac{V^H}{B^H}$	$\frac{\lvert V^H \rvert}{B^H}$
Mean	98.78	0.47	0.003	0.150
Median	13.96	0.00	0.000	0.105
Std-Dev	226.79	43.92	0.217	0.156
Skewness	4.84	0.74	0.137	2.662
Kurtosis	35.54	116.71	8.774	15.949
Corr(B^i,•)	1.000	0.042	0.003	-0.040
	B^C	V^C	$\frac{V^C}{B^C}$	$\frac{\lvert V^C \rvert}{B^C}$
Mean	267.78	-0.53	-0.002	0.074
Median	40.48	0.00	0.000	0.045
Std-Dev	546.68	71.93	0.117	0.090
Skewness	3.41	-0.89	0.205	3.494
Kurtosis	17.16	138.70	16.133	28.966
Corr(B^i,•)	1.000	-0.021	0.000	-0.010

Ratio of the Variation Margins and Performance Bonds





Risk Analysis

- Potential default if $V_H / B_H < -1$
- 68 occurrences when $V_H / B_H < -1$
- 1/3 of the clearing members experienced at least one margin-exceeding loss
- Most severe loss: 173% of posted margin
- On the other hand, only 4 occurrences when $V_C / B_C < -1$

Tail Behavior

- Model the far end of the left tail using **Extreme Value Theory**
- Only use observation exceeding a given pre-specified threshold θ
- Distribution of the excess $z = X - \theta$ converges to the generalized Pareto distribution G
- Two parameters: a **scale parameter** σ and a **tail shape parameter** k, which both can be estimated by maximum likelihood
- Probability density function:

$$g(z;\sigma,k) = \frac{1}{\sigma}(1 - kz/\sigma)^{-1+1/k}$$

- Choice of the threshold θ: range from -0.7 to -0.9

EVT-based Tail Analysis

θ	n	k	s.e.(k)	σ	s.e.(σ)
Panel A: House Accounts					
-0.7	233	0.0107	0.0648	0.2243	0.0207
-0.8	142	0.1379	0.0723	0.2695	0.0297
-0.9	90	0.2492	0.0791	0.3059	0.0395
Panel B: Customer Accounts					
-0.7	32	0.1321	0.1534	0.1672	0.0389
-0.8	15	0.2658	0.1896	0.1946	0.0609
-0.9	8	0.1850	0.2882	0.1562	0.0705

Default Insurance: Contract Specifications

- Insurance contract that protects the clearing house against the default of one or several clearing members
- Fixed term of T years
- Policy deductible D
- Overall payout limit L
- Premium paid in advance for each payment interval, which have length t_p years, at an annual rate of p per dollar of policy limit
- Deductible reset to zero at the end of each reset interval of length t_r

Default Insurance: Valuation Strategy

- Two assumptions:
  - Default can only be due to a deficiency in the house account
  - V_H/B_H is independent of B_H
- Value changes of policy-relevant magnitude are in the left tail of V_H/B_H and exceed θ
- Trigger events arrive as a Poisson process with constant arrival intensity λ
- Upon arrival of a trigger event, V_H/B_H for a given firm exceeds θ with a fixed probability π

Default Insurance: Valuation Strategy (2)

- Size of exceedance z for a given firm is a random draw from a generalized Pareto distribution with scale parameter σ and tail shape parameter k. Size of exceedances may be correlated across firms (ρ_z)
- Firms with value loss exceeding performance bond, $z + \theta < -1$, are candidates for default.
- Default occurs with probability π_1 for $-2 \leq z + \theta < -1$ and with probability π_2 for $z + \theta < -2$
- If default by firm i occurs, the default cost is set by drawing a performance bond level from the empirical distribution of B^H

Default Insurance: Actuarial Pricing

- Fair actuarial pricing for the contract is the p satisfying:

$$p \cdot A(T, t_p, r) \cdot L = E(\text{NPV of Policy Payouts})$$

  where $A(T, t_p, r)$ is the present value of a \$1/year annuity for T years, paid in advance at intervals t_p, in a constant interest rate r environment. L is the policy limit on which the premium is paid and p is the annual premium rate.
- E(NPV of Policy Payouts) is the average net present value of policy payouts over Monte Carlo simulations of the default process
- Value is the present value of the insurance premiums in thousands of dollars

Default Insurance: Valuation Results

- **Base case** for the insurance policy:
  - Three-year policy
  - $500 million deductible
  - $500 million payout limit
  - Deductible reset interval of 0.25 years
  - Premium payment interval of 0.25 years

θ	λ	p_{pay}	p_{max}	p_{def}	Value	DefMax
Panel A: Base Case						
−0.7	0.0052	0.0011	0.0004	0.0218	305.9	3,122
−0.8	0.0032	0.0010	0.0003	0.0192	262.2	1,859
−0.9	0.0020	0.0011	0.0003	0.0151	318.2	1,527
Panel B: No Policy Payout Limit						
−0.7	0.0052	0.0011	0.0000	0.0218	612.9	3,122
−0.8	0.0032	0.0010	0.0000	0.0192	403.7	1,859
−0.9	0.0020	0.0011	0.0000	0.0151	508.1	1,527
Panel C: No Deductible						
−0.7	0.0052	0.0218	0.0011	0.0218	1,547.2	3,122
−0.8	0.0032	0.0192	0.0010	0.0192	1,649.9	1,859
−0.9	0.0020	0.0151	0.0011	0.0151	1,446.5	1,527
Panel D: No Policy Payout Limit and No Deductible						
−0.7	0.0052	0.0218	0.0000	0.0218	2,160.0	3,122
−0.8	0.0032	0.0192	0.0000	0.0192	2,023.6	1,859
−0.9	0.0020	0.0151	0.0000	0.0151	1,968.9	1,527

Value of the Federal Reserve Guarantee

- Clear analogy between the premium of the default insurance and the fair cost of the guarantee provided by the Federal Reserve
- Fed may have to compensate the clearing house in the event of a default by one or several clearing member to prevent a breakdown of the financial system
- As Bernanke (1990) puts it "the Fed became the **insurer of last resort**" during past episodes of extreme volatility, such as October 1987
- Deductible corresponds to any guarantee fund held by the CCP ($821 million in total):
  - Market value of pledged shares and membership: $3 million
  - Surplus funds: $113 million
  - Security deposits of clearing firms: $705 million
- No policy payout limit

Value of the Federal Reserve Guarantee (2)

θ	λ	p_{pay}	p_{def}	Value	DefMax
-0.7	0.0052	0.0005	0.0218	382.5	3,122
-0.8	0.0032	0.0004	0.0192	202.9	1,859
-0.9	0.0020	0.0005	0.0151	265.2	1,527

- Theoretical values of the Fed guarantee is around $300,000, which is modest
- Value for the society is huge
- Notes: (1) Pre-merger data, (2) neglect 1987 crash, (3) do not account for defaults on customer accounts

Black Monday Effect

- We complement our original dataset with performance bonds and variation margins for all CME clearing members' house accounts on October 19th, 1987
- From a regulator's point of view, information about an actual crisis situation can be of great interest

θ	n	k	s.e.(k)	σ	s.e.(σ)
Panel A: Without Black Monday					
-0.7	233	0.0107	0.0648	0.2243	0.0207
-0.8	142	0.1379	0.0723	0.2695	0.0297
-0.9	90	0.2492	0.0791	0.3059	0.0395
Panel B: With Black Monday					
-0.7	238	-0.3153	0.0853	0.1873	0.0197
-0.8	147	-0.3201	0.1089	0.2147	0.0288
-0.9	95	-0.3403	0.1375	0.2395	0.0402

Black Monday Effect: Federal Reserve Guarantee

θ	λ	p_{pay}	p_{def}	Value	DefMax
Panel A: Without Black Monday					
-0.7	0.0052	0.0005	0.0218	382.5	3,122
-0.8	0.0032	0.0004	0.0192	202.9	1,859
-0.9	0.0020	0.0005	0.0151	265.2	1,527
Panel B: With Black Monday					
-0.7	0.0053	0.0021	0.0239	2,657.3	10,962
-0.8	0.0033	0.0020	0.0185	2,703.6	13,623
-0.9	0.0021	0.0019	0.0163	3,055.1	6,547

Conclusion

- We have investigated the exposure of the CME clearing house to default risk and have shown that the major source of default risk is proprietary trading
- We have also developed, and priced, a realistic insurance contract covering the loss to the clearing house from default by one or several clearing members
- The estimate of the insurance premium can be interpreted as the fair cost of the service provided by the Fed which is an implicit insurer of the CME clearing house