



University of Essex

Economics Department

Centre for Computational Finance and Economic Agents

IMF Workshop *Operationalizing Systemic Risk Monitoring*: May 26-28 2010

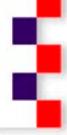
Too Interconnected To Fail:

**Financial Contagion and Systemic Risk in Network
Model of CDS and Other Credit Enhancement
Obligations of US Banks**

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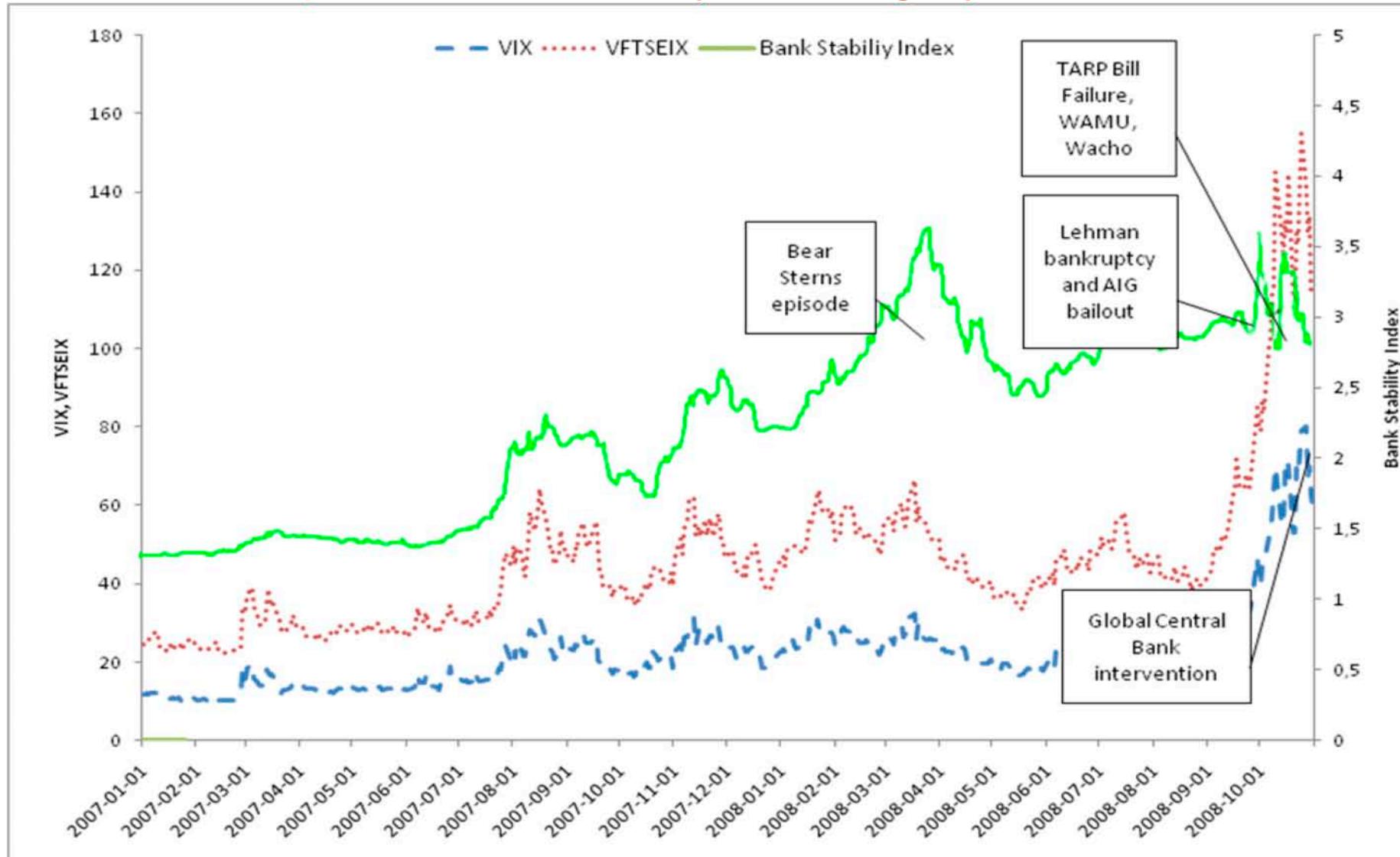
with Simone Giansante, Mateusz Gatkowski and Ali Rais Shaghaghi



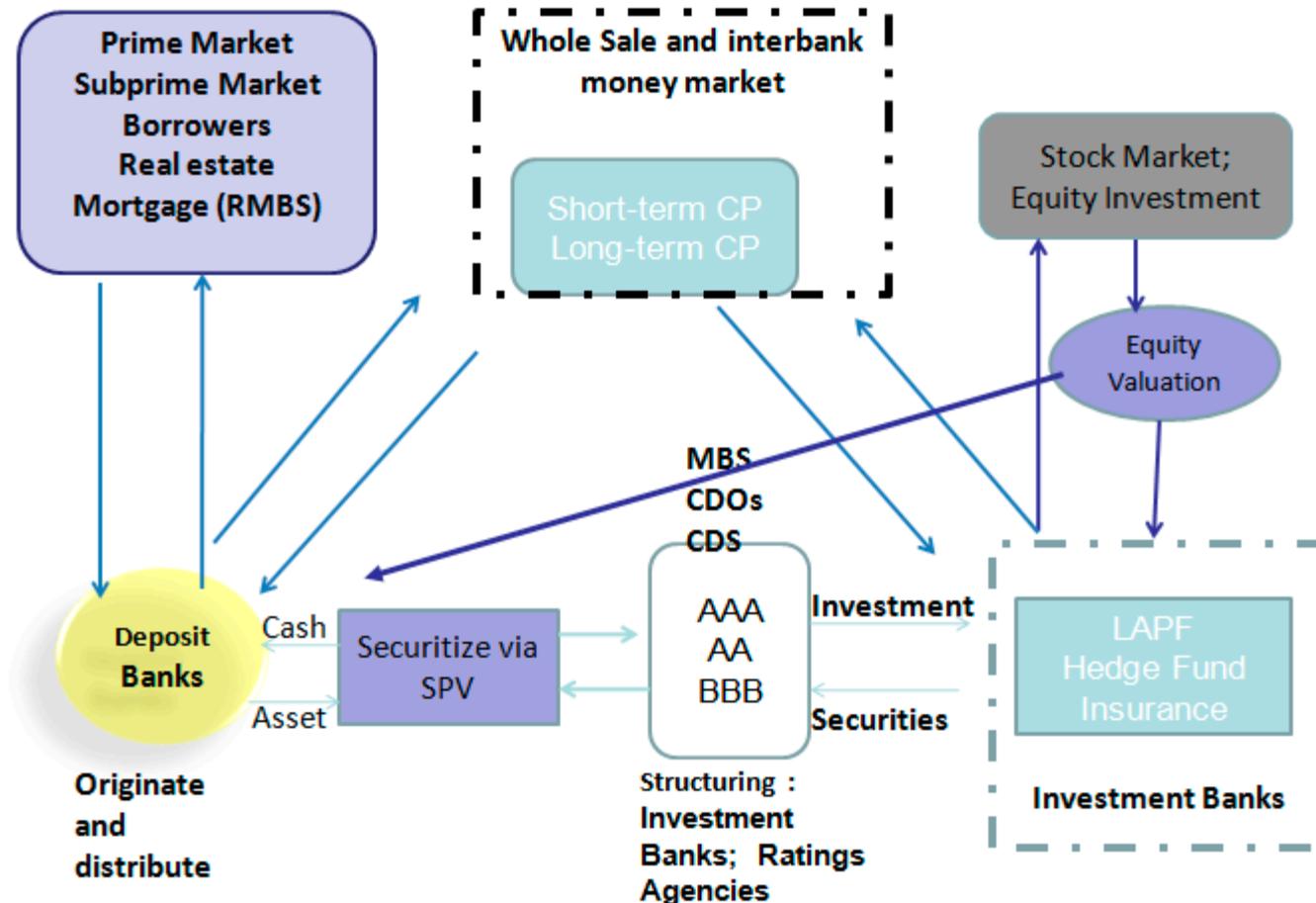
Roadmap: *Opus Reticulatum (Networks)*

- **Overview**
 - Financial Crisis 07-08 and Credit Derivatives
 - Financial Contagion and Systemic Risk
 - Synthetic Securitization and Basel II – Regulatory and Market Failure
 - Post Crisis Intercontinental Exchange (ICE) CDS Central Clearing : New Player in CDS Network (Taken approx. 30% of US CDS Market Share since March 2009)
- **Model of Structural Contagion v Statistical Models of Contagion**
 - Fine Grained Data-base driven Multi Agent Based Models of Financial Sector : Model Verite
*New **Office of Financial Research** in the US Treasury to put an end to regulators flying blind*
 - Network Approach
 - Stress Test
 - **Results (Simulator on acefinmod.com website)**
- **Conclusions**

Banking Stability Index (Segoviano, Goodhart 09/04) v Market VIX and V-FTSE Indexes : *Sadly market data based indices spike contemporaneously with crisis ; devoid of requisite info for Early Warning System*

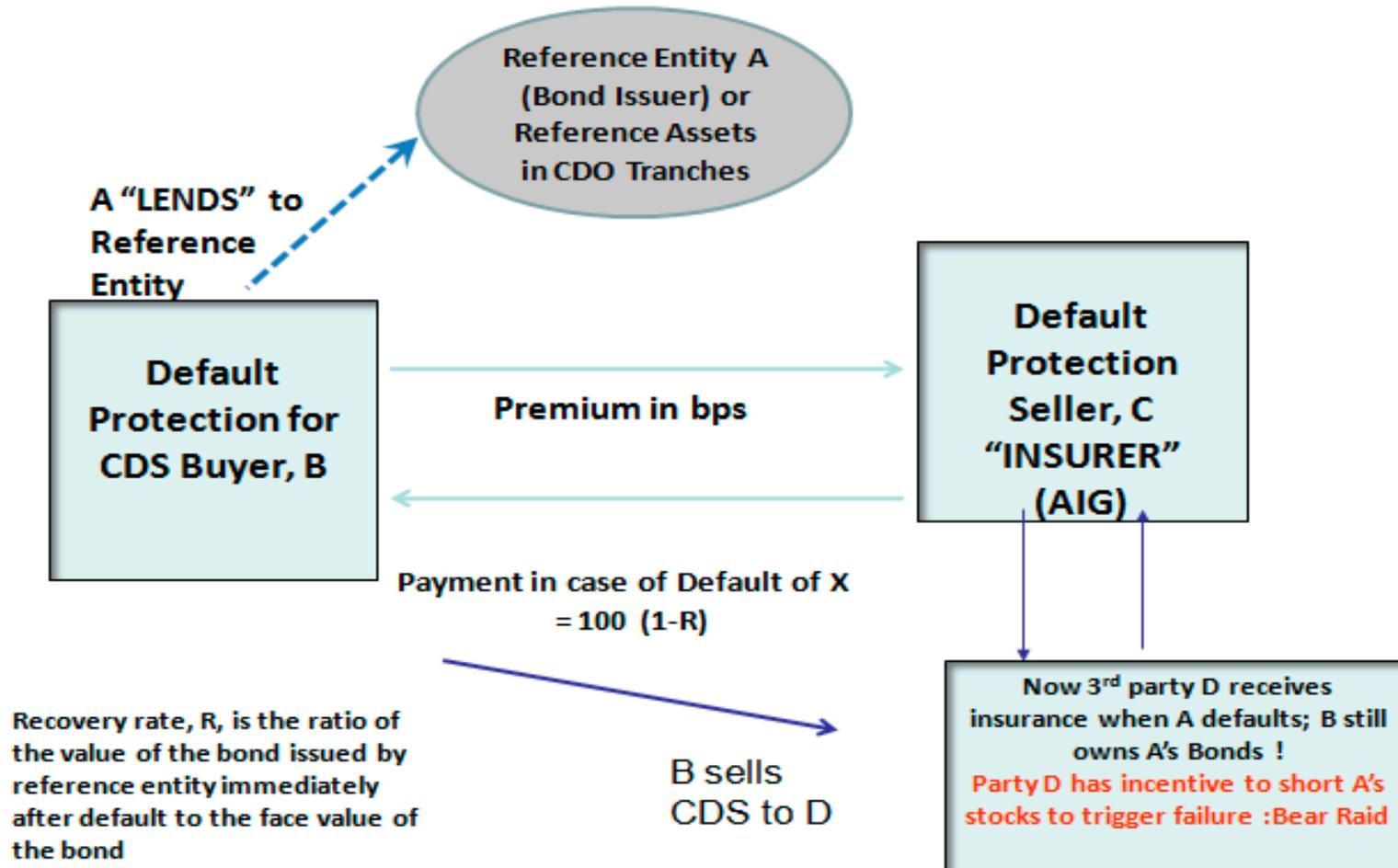


Financial Contagion and Systemic Risk: Multi Agent Model of US Financial Sector (For *TWO* decades regulators, central bankers and academics had no incentive to study and build large scale integrative financial sector models (Gary Gorton) Why ?)



Credit Default Swap (CDS) CHAINS and Bear Raids:

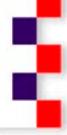
CDS had *a unique, endemic and pernicious role in current crisis* in context of Basel II and Fed Reserve Board Reg 99.32 Credit Risk Transfer (CRT) Scheme



Overview 1

- Few/No empirical studies of financial network interconnections among banks and between banks and non-banks as CDS protection buyers and protection sellers (Cont *et. al.* 2009 calibrate CDS network using network statistics and exposures of Austrian and Brazilian interbank market; **concentration risk** for banks much higher in CDS market than interbank one).
- Technical insolvency of US banks not just from legacy/toxic RMBS assets but also due to credit risk exposures from the SPV vehicles and the CDS markets
- Dominance of few big players in chains of insurance and reinsurance for credit default risk :idea of “too interconnected to fail” (Eg AIG) Tax payer bailout to maintain fiction of non-failure to avert credit event that can bring down the CDS pyramid and financial system.
- Methodological issues: Complex system Agent-based Computational Economics (ACE) for financial network modeling for systemic risk proposed: ‘Wind Tunneling Tests’

Our crusade is for full digital network mapping of many key financial sectors with live data feeds ; Combine with institutional micro-structure and behavioural rules for agents to create computational agent based test beds



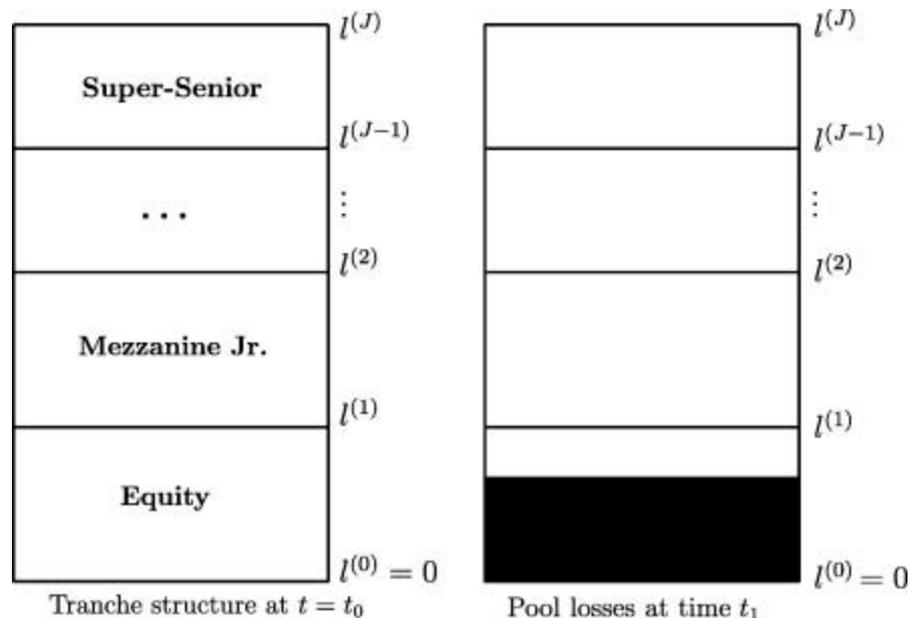
Overview 2

- Empirical reconstruction of the US CDS network (**FDIC 08 Q 4 data; also DTCC Data**) for stress tests to investigate implications of fact that top 5 US banks account for 98% of \$16 tn of the \$37 tn gross notional value of CDS reported by the BIS and DTCC for the end of 2008
- **ARE WE OUT OF THE CDS WOODS ?** Empirically based CDS network for 26 US banks (2008 Q 4) data fundamentally unstable by May-Wigner criteria; does not have enough bank capital to prevent system collapse due to failure of a large CDS seller
- Above better than an equivalent random graph which leads to worse consequences
- Implications of ICE CDS Central Clearing : **Network Stability updates after March 2009**
- New concepts such as '**super-spreader**' fund based on centrality in terms of connectivity of a financial entity in financial system
- **Systemic Risk Ratio**: measures the liquidity loss impact in terms of aggregate bank core capital loss due to failure of a major bank or non-bank player from its activities in CDS and credit enhancement
- Super-spreader funds: **financial entities have to contribute proportional to their systemic risk impact.** Over turns current practice where 'big' banks have lenient collateral requirements
- Eigenvalue Centrality statistics for superspreaders. Can this proxy for systemic risk losses of core capital for the CDS participants ?

Structural vs Statistical Contagion

- **DEFINITION:** Economic and financial contagion refers to the *spreading of a negative shock* on the solvency conditions of an economic or financial entity in a physical supply chain or in terms of generic credit/debt and liquidity obligations governing interbank, payment and settlement systems and/or claims on other financial markets
- Structural model based on default causality of chain reactions governed by the network connections of the financial entities
- In contrast, models made popular by Kaminsky and Reinhart (2000) view financial contagion as the **downward co-movement** of asset prices across different markets and for different asset classes. This is based on statistical or econometric methods which measure (amongst other ways) the increased correlations of asset prices
- Above models complimentary to the causal default models that use financial network simulations, especially in the use of contagion models based on CDS price co-movements (*Jorge Chan-Lau et al., 2009*)

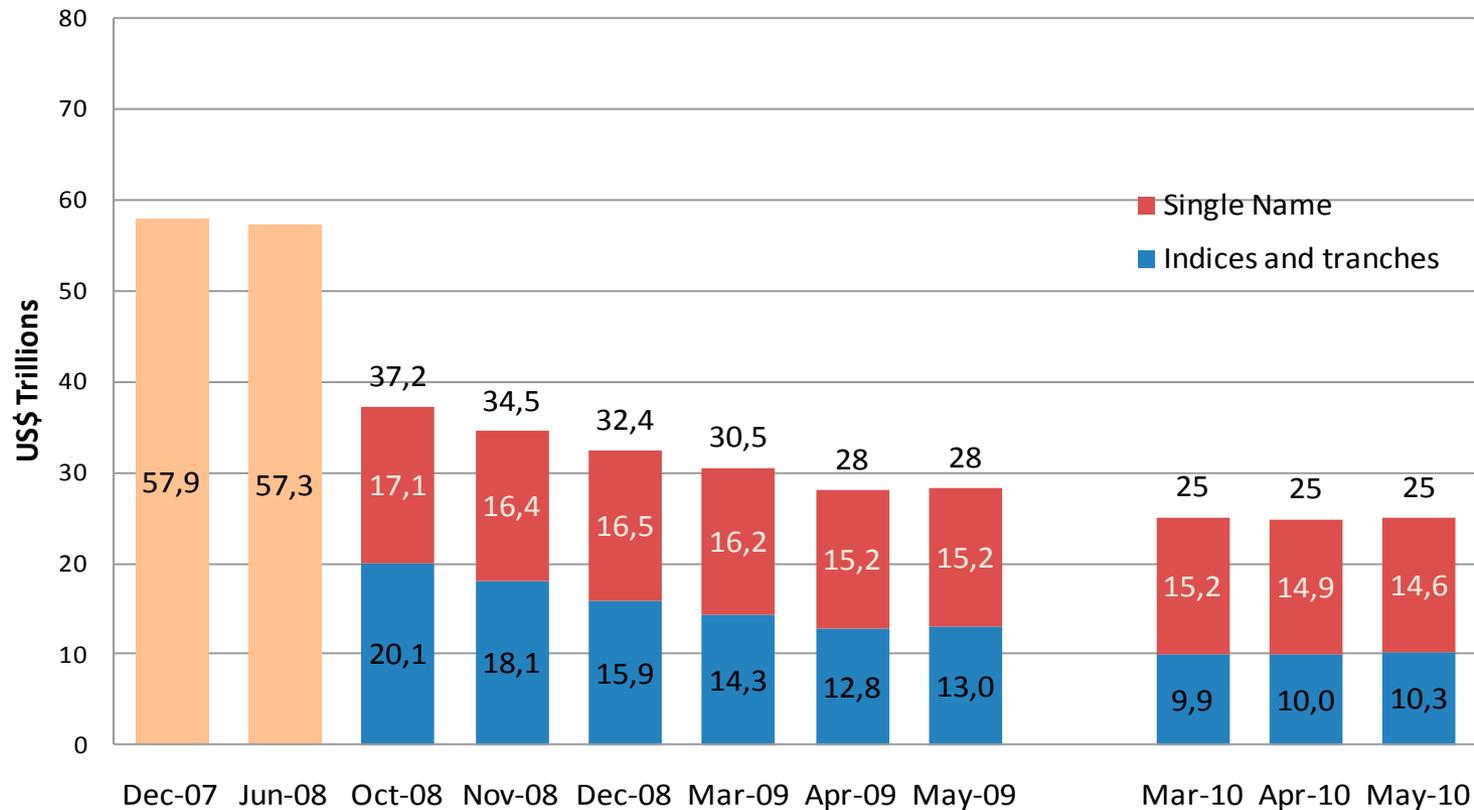
Collateralized Debt Obligation, CDO (\$155bn at peak 2007) Synthetic CDO combines CDO Tranches with CDS



Tranche structure at time t_0 ; at time t_1 , pool's losses (shaded in black) absorbed by Equity tranche; Mezzanine Jr., Mezzanine, Senior and Super-Senior tranches are not yet affected by pool losses.

Drastic Compression post Lehman especially in tranche CDS

Credit Default Swaps Outstanding – Gross Notional



Source: BIS Dec 07, Jun 08 ; DTCC other dates



Remote Securitization of Bank Loans vs. Synthetic Securitization & CDS

- **Basel I required 8% of equity capital against bank assets**
 - **Consider \$1 bn Mortgage Loans**
 - **Equity Capital needed \$80 million**
 - **If \$.5 bn securitized and moved off balance sheet ie.50% of securitization Bank now needs only \$40 million of Equity Capital**
 - **Further \$40 million can be lent out ; securitize again and again**
.....**First MONEY PUMP**
- **Synthetic securitization BASEL II and 2002 US Reg99.32 : an originating bank uses credit derivatives or guarantees to transfer the credit risk, in whole or in part**
- **CDS or insurance from AAA rated entities yield low risk weighting for ABS retained on balance sheet (from 8% - 1.6%)**
Huge bank behaviour changing incentive aggravated by negative CDS carry trade (triple whammy for banks : seemingly risk reduction, capital reduction plus huge leverage opportunities)
- ***Second Money Pump: Peak of CDS Dec 07 \$57 Tn ; Dec 08 \$32 Tn of this \$15.64 Tn involved top 5 US banks***
- ***Credit Risk transmuted to counterparty risk of bank and non-bank CDS protection sellers and now with tax payer bailout of these institutions post Lehman demise we have increased sovereign risk and the worst case of moral hazard***

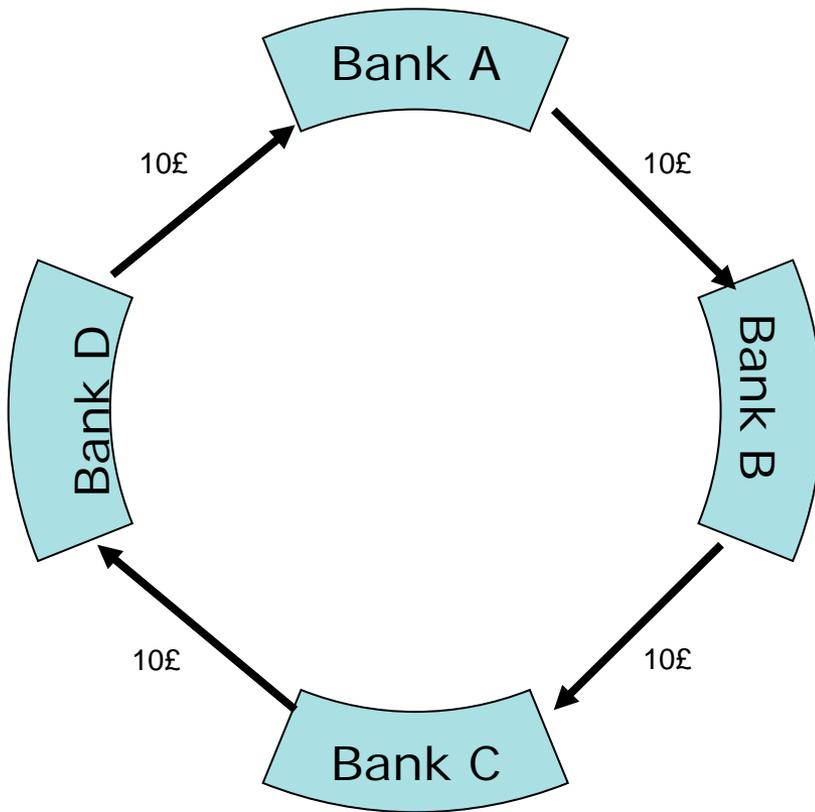


CDS Network Structures Private Incentives and Concentration Risk: Gross v Net

- ***Synthetic Securitization Regulation yields greatest capital relief with CDS cover from AAA rated entities like AIG and top banks- these are few in number***
- ***Offsetting by Broker dealers; bilateral offsets to minimize liquidity and rich club structures***
- **B buys a CDS from C with a certain annual "premium", say 3% (See Figure on CDS Chain)**
- **Condition of reference entity worsens, CDS premium rises, so B sells CDS to company D with a premium of say, 6%, and benefits from 3% difference. Note, in case of no insolvency of counterparty C, B has zero economic obligations due to offset. Otherwise, B has to settle gross.**
- **Closed /Circular CDS Chains are ex ante efficient in liquidity but with counterparty insolvency truncated chains require more than net notional to settle**
- **Closed CDS chains evolve which minimize settlement obligations through offset and maximize returns from CDS premia (lengthening chains) calling to question whether the CDS market can provide sufficient hedge for the reference assets**

Multilateral Settlement (MS) and Circular Networks Ex Ante Efficient but Potentially Unstable vs. Fully Funded Gross Settlement Stable but Costly in terms of Liquidity

Private Sector Arrangements aim to minimize liquidity : ICE CDS
Clearer could increase concentration risk

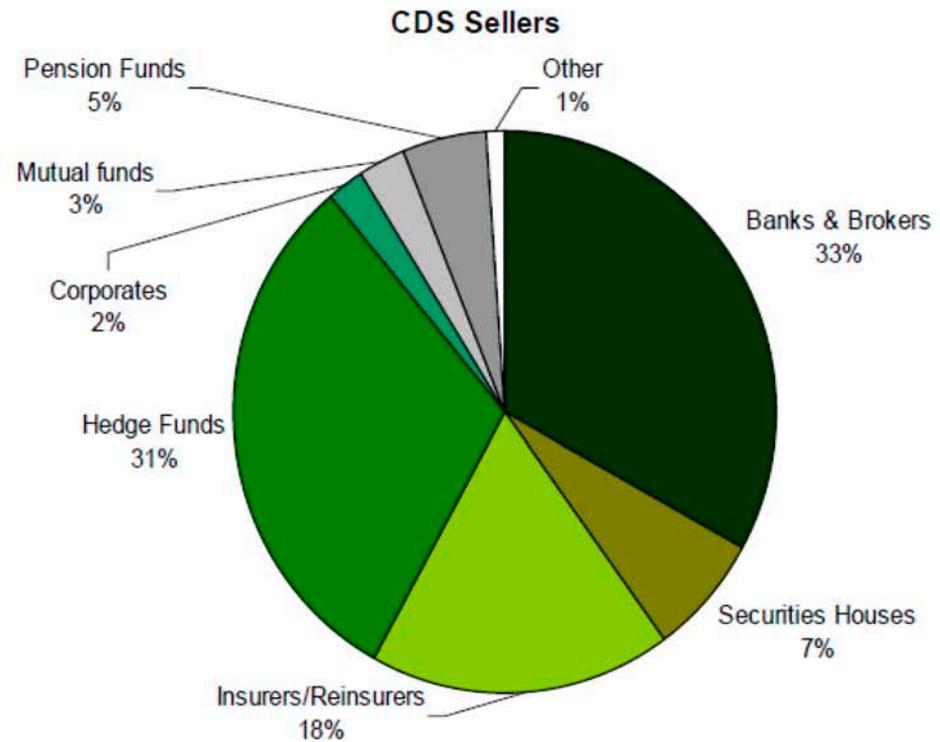
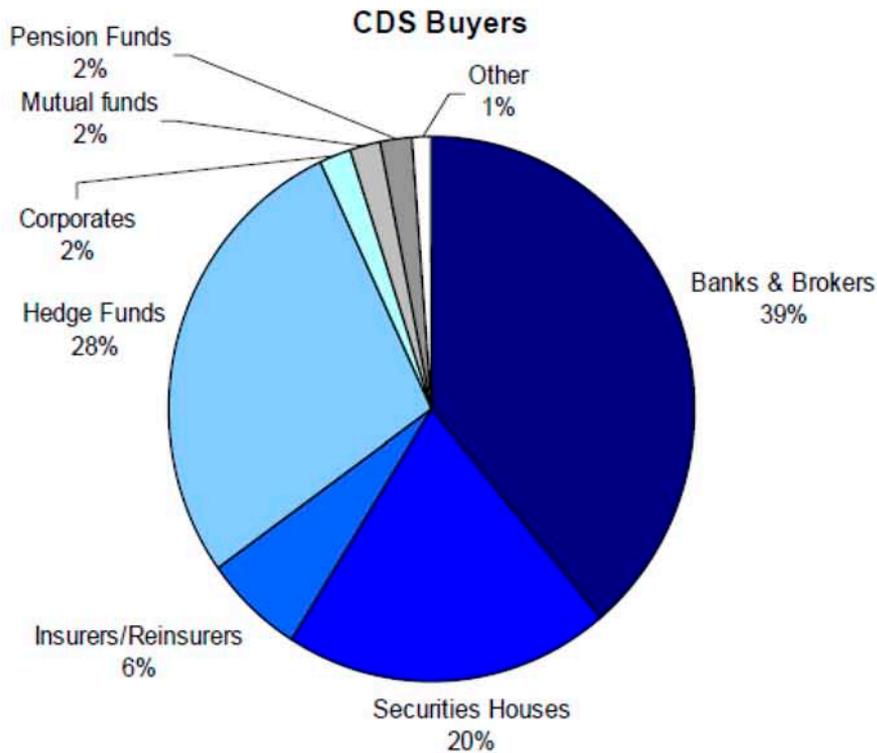


| | Liquidity |
|-------------------------------|-----------|
| MS & Net Notional | 0 £ |
| Fully Funded Gross Settlement | 40 £ |

Actual liquidity needed is between net notional and gross notional as counterparties default and concentration risk increases

Q4 2006 : Counterparties for CDS: Buying CDS Insurance from a passenger on Titanic

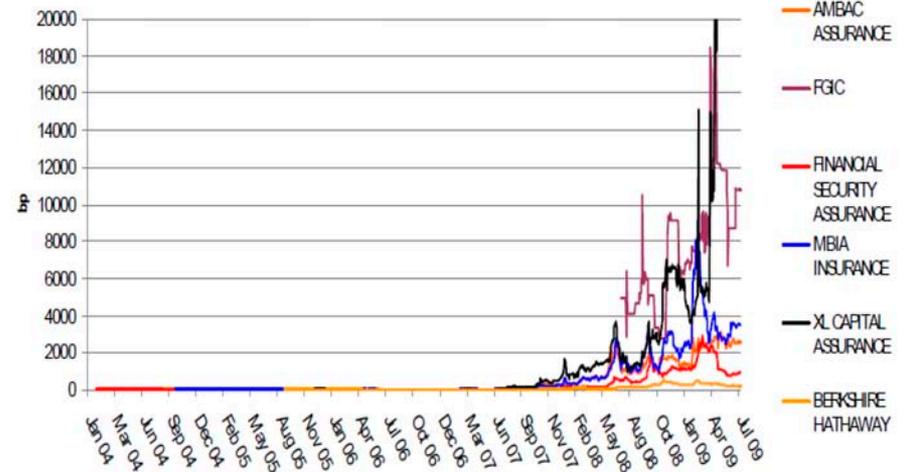
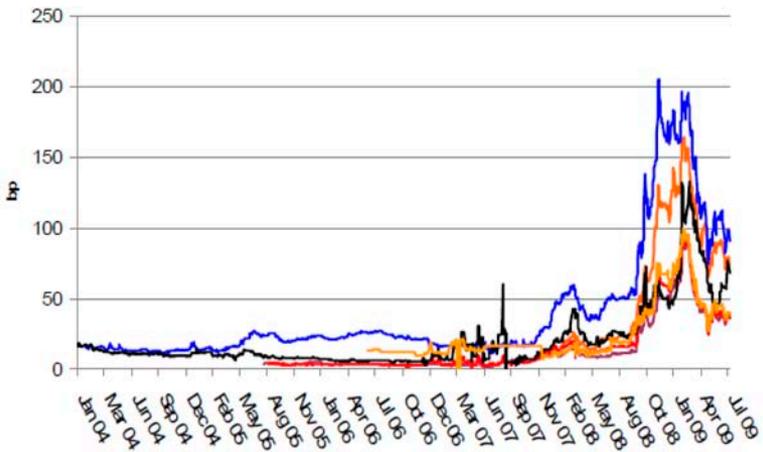
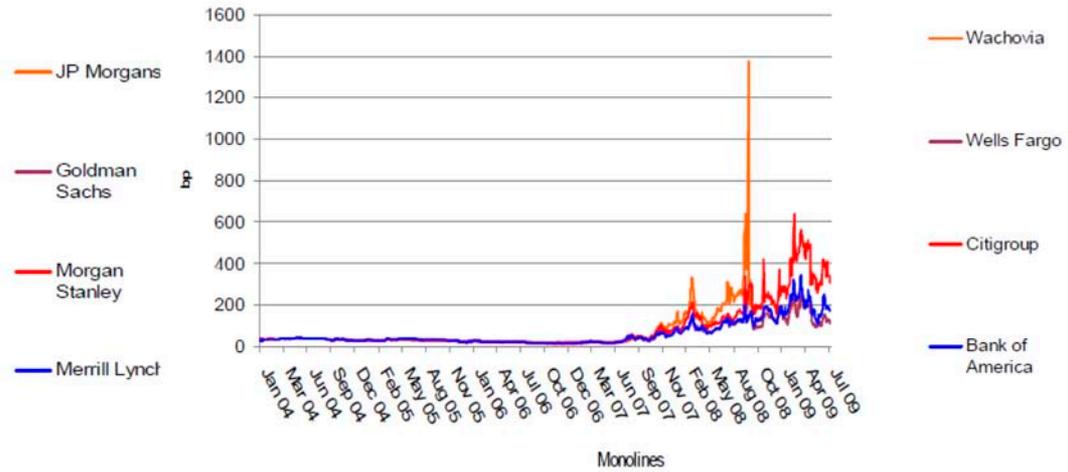
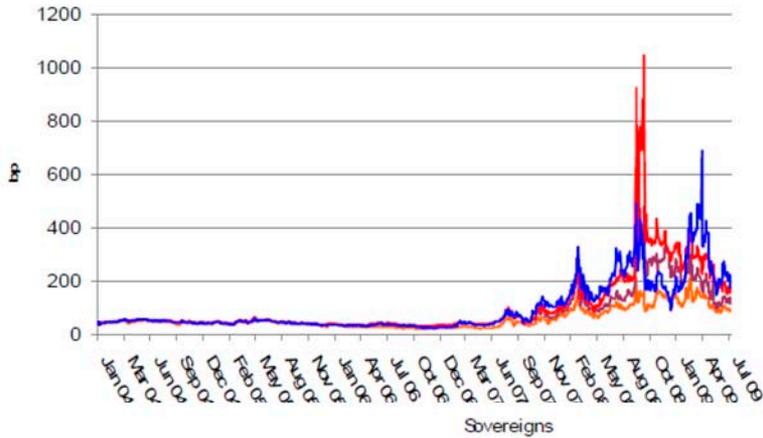
The Role of the Monolines and Non-Regulated Bank Sector Credit Risk Converted to Counterparty Risk and now to Sovereign Risk



Source: British Bankers Association

NB: Threat to the system came from CDS Sellers 49% Hedge Funds and Monolines with inadequate capital base

CDS Spreads: Default Risk Transmuted to Counterparty Risk and the Sovereign Risk (Source *Datastream*)



Three major methodological issues: Why no dogs barked ?

1. Why was the need for macroprudential framework eschewed?
Mainstream Neoclassical 'Representative Agent' Models;
Unfortunate Irrelevance of Most State of the Art Monetary Economics (Buiter 09)
2. Why were there no system wide quantitative models developed for stress tests of how the financial network would function under these micro regulatory rules of individual bank behaviour?
Failure of macro-econometric models for policy analysis (Lucas Critique); we have yet to replace this with multi-agent fine grained data base driven financial network models
3. Urgent need for modelling tools to monitor liquidity gridlocks, direction of an ongoing financial contagion, systemic risk: Subject matter of this workshop

Answer: Lack of **Complex Adaptive System** framework- Red Queen type competitive co-evolution esp between regulator and regulatee requires constant vigilance and production of countervailing measures (Markose 2004, 2005)

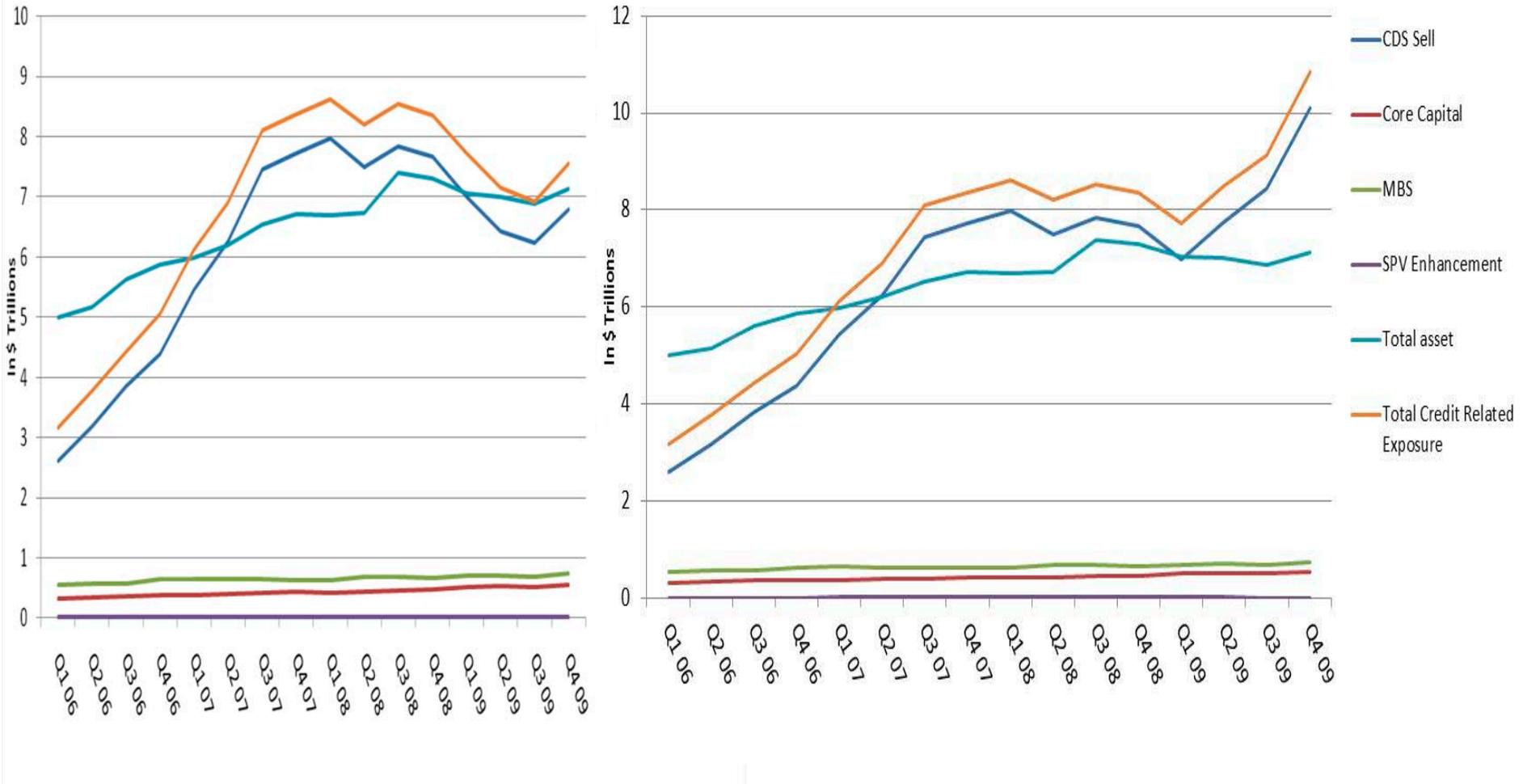
US Banks With CDS Positions(\$bns):2008 Q4 FDIC Data

| Namefull | CDS Buy | CDS Sell | Core Capital | Mortgage Backed Securities | SPV Enhancement |
|--------------------------------------|----------|----------|--------------|----------------------------|-----------------|
| JPMorgan Chase Bank | 4,166.76 | 4,199.10 | 100.61 | 130.33 | 3.53 |
| Citibank | 1,397.55 | 1,290.31 | 70.98 | 54.47 | 0.11 |
| Bank of America | 1,028.65 | 1,004.74 | 88.50 | 212.68 | 0.16 |
| Goldman Sachs Bank USA | 651.35 | 614.40 | 13.19 | 0.00 | 0.00 |
| HSBC Bank USA | 457.09 | 473.63 | 10.81 | 20.92 | 0.01 |
| Wachovia Bank | 150.75 | 141.96 | 32.71 | 32.83 | 2.44 |
| Morgan Stanley Bank | 22.06 | 0.00 | 5.80 | 0.00 | 0.00 |
| Merrill Lynch Bank USA | 8.90 | 0.00 | 4.09 | 3.00 | 0.00 |
| Keybank | 3.88 | 3.31 | 8.00 | 8.09 | 0.00 |
| PNC Bank | 2.00 | 1.05 | 8.34 | 24.98 | 0.00 |
| National City Bank | 1.29 | 0.94 | 12.05 | 11.95 | 0.71 |
| The Bank of New York Mellon | 1.18 | 0.00 | 11.15 | 29.29 | 0.00 |
| Wells Fargo Bank | 1.04 | 0.49 | 33.07 | 60.15 | 0.59 |
| SunTrust Bank | 0.59 | 0.20 | 12.56 | 14.85 | 0.00 |
| The Northern Trust Company | 0.24 | 0.00 | 4.39 | 1.37 | 0.00 |
| State Street Bank and Trust Company | 0.15 | 0.00 | 13.42 | 23.03 | 0.00 |
| Deutsche Bank Trust Company Americas | 0.10 | 0.00 | 7.87 | 0.00 | 0.00 |
| Regions Bank | 0.08 | 0.41 | 9.64 | 14.30 | 0.21 |
| U.S. Bank | 0.06 | 0.00 | 14.56 | 29.34 | 0.42 |
| RBS Citizens | 0.00 | 0.06 | 8.47 | 19.75 | 0.01 |

Note: FDIC Data; All figures in \$bn

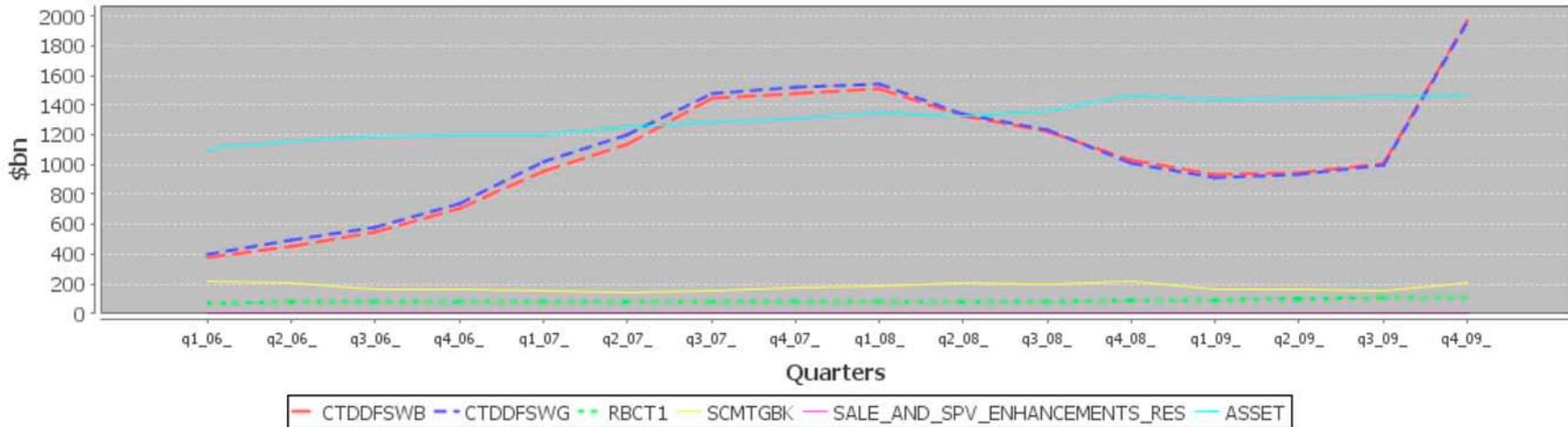
US FDIC Banks in CDS Market Tier 1 Capital and Credit Exposure

(LHS): 2006 marks technical insolvency of US Banks as CDS (Sell) plus SPV Enhancement obligations of US banks in CDS exceeds assets; Marked improvement in 08 Q4 (LHS); However RHS 08Q4 With ICE

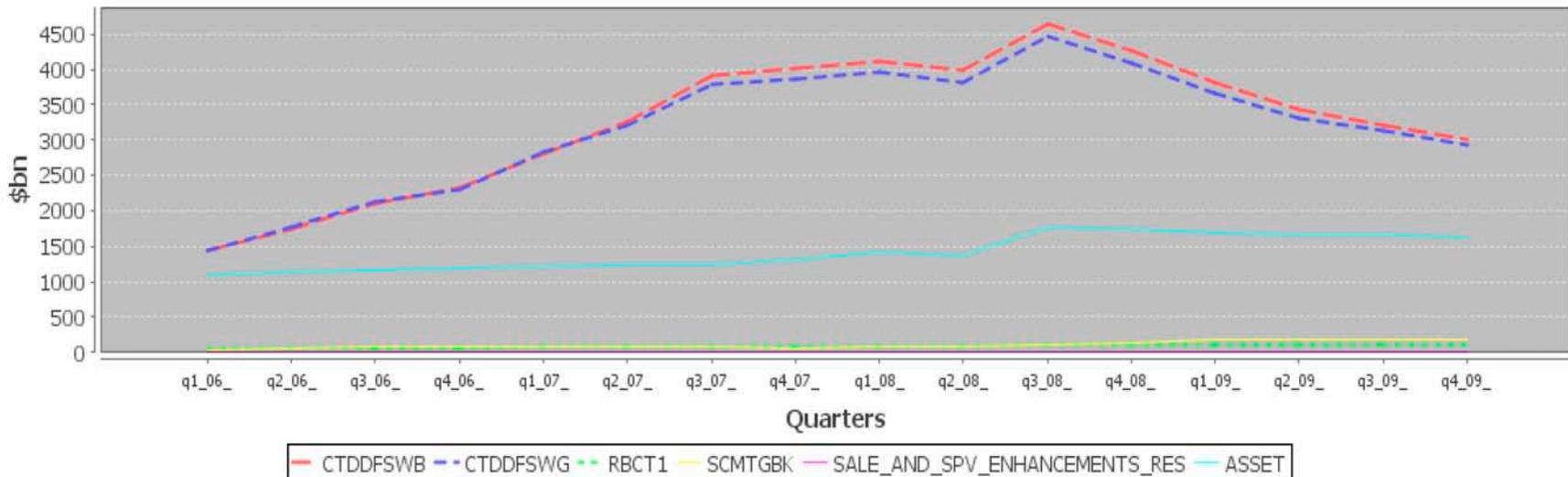


Trends in CDS Market for Some US Banks (Source FDIC) NB Bank of America has increased market share while others like JP Morgan have reduced drastically by Q409

BANK OF AMERICA



JPMORGAN

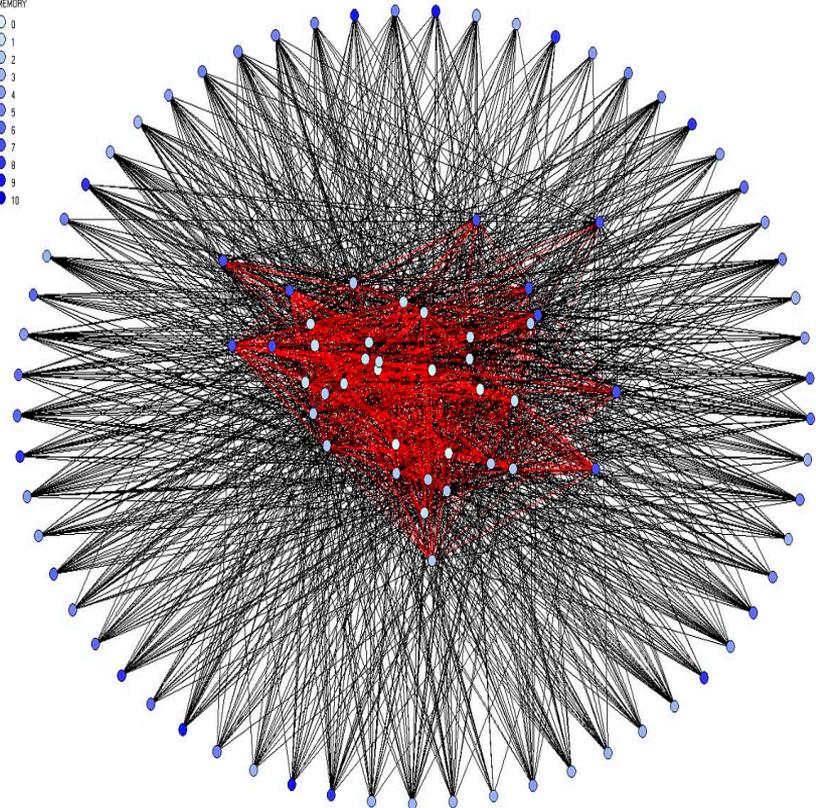
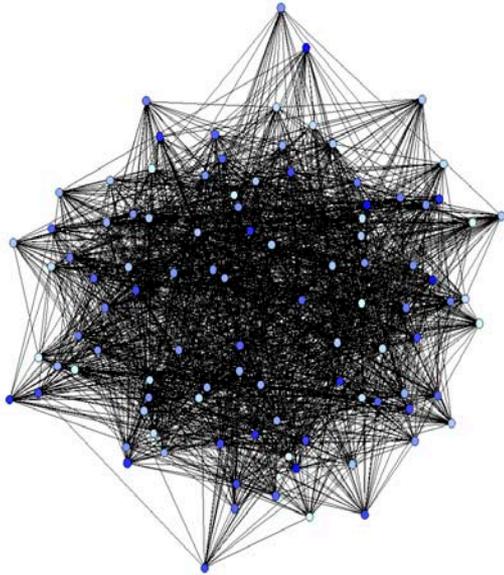


Inclusion of ICE CDS Clearer 09Q4 : US CDS Market Shares and Eigenvalue Centrality 08 Q4 v 09 Q4

(Source FDIC ; B: CDS BUY. G: CDS Guarantees; RECT 1 Core capital **NB ICE Capital only \$45m, 0.0013% of Tot Exposure**)

| BANK | CTDDFSWB | | | | CTDDFSWG | | | | RBCT1 | | | | Eigen Value | |
|-----------------------|------------|---------|------------|---------|------------|---------|------------|---------|-----------|---------|-----------|---------|-------------|--------|
| | q4_08 | | q4_09 | | q4_08 | | q4_09 | | q4_08 | | q4_09 | | Centrality | |
| | \$1,000 | | \$1,000 | % | \$1,000 | % | \$1,000 | % | \$1,000 | % | \$1,000 | % | q4_08 | q4_09 |
| ICETRUST | | 0.000% | 3301673718 | 32.039% | | 0.000% | 3301673718 | 32.702% | | 0.000% | 45624 | 0.008% | 0 | 0.5308 |
| JPMORGAN CHASE | 4262320000 | 52.910% | 3007303000 | 29.183% | 4103539000 | 53.564% | 2939911000 | 29.118% | 100597000 | 20.798% | 96372000 | 17.650% | 0.6605 | 0.4874 |
| CITIBANK | 1397546000 | 17.348% | 1160557000 | 11.262% | 1290310000 | 16.843% | 1089611000 | 10.792% | 70977000 | 14.674% | 96833000 | 17.734% | 0.2474 | 0.2071 |
| BANK OF AMERICA | 1028649827 | 12.769% | 1972633388 | 19.142% | 1004736144 | 13.115% | 1964463832 | 19.457% | 88979017 | 18.396% | 111915735 | 20.496% | 0.1929 | 0.3477 |
| GOLDMAN SACHS USA | 718013000 | 8.913% | 374417000 | 3.633% | 640462000 | 8.360% | 339144000 | 3.359% | 13212000 | 2.731% | 17152000 | 3.141% | 0.1274 | 0.0724 |
| HSBC USA | 457089844 | 5.674% | 366613338 | 3.558% | 473629328 | 6.182% | 372604526 | 3.690% | 10821919 | 2.237% | 13353708 | 2.446% | 0.1027 | 0.0795 |
| WACHOVIA | 150748000 | 1.871% | 90859000 | 0.882% | 141959000 | 1.853% | 85699000 | 0.849% | 32772000 | 6.775% | 39786000 | 7.286% | 0.0337 | 0.0186 |
| MORGAN STANLEY | 22058000 | 0.274% | 24606000 | 0.239% | 0 | 0.000% | 0 | 0.000% | 5776000 | 1.194% | 7360000 | 1.348% | 0 | 0 |
| MERRILL LYNCH USA | 8897423 | 0.110% | 0 | 0.000% | 0 | 0.000% | 0 | 0.000% | 4321213 | 0.893% | 0 | 0.000% | 0 | 0 |
| KEYBANK | 3876800 | 0.048% | 2496491 | 0.024% | 3309302 | 0.043% | 1916952 | 0.019% | 8012102 | 1.656% | 8089597 | 1.482% | 0.0009 | 0.0004 |
| PNC BANK | 2000500 | 0.025% | 1046000 | 0.010% | 1054500 | 0.014% | 542000 | 0.005% | 8337592 | 1.724% | 24490673 | 4.485% | 0.0003 | 0.0001 |
| NATIONAL CITY | 1285226 | 0.016% | 0 | 0.000% | 943218 | 0.012% | 0 | 0.000% | 12757364 | 2.637% | 0 | 0.000% | 0.0002 | 0 |
| NEW YORK MELLON | 1175000 | 0.015% | 804000 | 0.008% | 2000 | 0.000% | 2000 | 0.000% | 11148000 | 2.305% | 10149000 | 1.859% | 0 | 0 |
| WELLS FARGO | 1036000 | 0.013% | 865000 | 0.008% | 488000 | 0.006% | 340000 | 0.003% | 33129000 | 6.849% | 43765000 | 8.015% | 0.0001 | 0.0001 |
| SUNTRUST | 585219 | 0.007% | 525226 | 0.005% | 195819 | 0.003% | 144476 | 0.001% | 12564741 | 2.598% | 11973001 | 2.193% | 0.0001 | 0 |
| NORTHERN | 235500 | 0.003% | 127000 | 0.001% | 0 | 0.000% | 0 | 0.000% | 4385245 | 0.907% | 4755543 | 0.871% | 0 | 0 |
| STATE STREET | 145000 | 0.002% | 170000 | 0.002% | 0 | 0.000% | 0 | 0.000% | 13422034 | 2.775% | 11378194 | 2.084% | 0 | 0 |
| DEUTSCHE BANK | 100000 | 0.001% | 68000 | 0.001% | 0 | 0.000% | 68000 | 0.001% | 7872000 | 1.627% | 8289000 | 1.518% | 0 | 0 |
| U.S. BANK | 63500 | 0.001% | 116000 | 0.001% | 0 | 0.000% | 0 | 0.000% | 14558168 | 3.010% | 16249713 | 2.976% | 0 | 0 |
| COMMERCE | 17385 | 0.000% | 0 | 0.000% | 30365 | 0.000% | 0 | 0.000% | 1368254 | 0.283% | 0 | 0.000% | 0 | 0 |
| MERCANTIL | 10500 | 0.000% | 0 | 0.000% | 0 | 0.000% | 0 | 0.000% | 538101 | 0.111% | 0 | 0.000% | 0 | 0 |
| ASSOCIATED BANK | 7500 | 0.000% | 7500 | 0.000% | 120645 | 0.002% | 109781 | 0.001% | 1576864 | 0.326% | 1779593 | 0.326% | 0 | 0 |
| COMERICA | 5273 | 0.000% | 3608 | 0.000% | 45558 | 0.001% | 26560 | 0.000% | 5706736 | 1.180% | 5763297 | 1.055% | 0 | 0 |
| SIGNATURE | 3000 | 0.000% | 8000 | 0.000% | 0 | 0.000% | 0 | 0.000% | 760308 | 0.157% | 840057 | 0.154% | 0 | 0 |
| BANK OF PENNSYLVANIA | 1 | 0.000% | 0 | 0.000% | 9295 | 0.000% | 0 | 0.000% | 2479166 | 0.513% | 0 | 0.000% | 0 | 0 |
| LEUMI USA | 0 | 0.000% | 0 | 0.000% | 10000 | 0.000% | 5000 | 0.000% | 441536 | 0.091% | 445902 | 0.082% | 0 | 0 |
| TD | 0 | 0.000% | 114733 | 0.001% | 52273 | 0.001% | 93996 | 0.001% | 6157532 | 1.273% | 9271987 | 1.698% | 0 | 0 |
| HORICON | 0 | 0.000% | 0 | 0.000% | 6000 | 0.000% | 5600 | 0.000% | 42265 | 0.009% | 49437 | 0.009% | 0 | 0 |
| AMEGY | 0 | 0.000% | 0 | 0.000% | 175 | 0.000% | 301 | 0.000% | 939442 | 0.194% | 1271949 | 0.233% | 0 | 0 |
| CALIFORNIA | 0 | 0.000% | 0 | 0.000% | 371 | 0.000% | 0 | 0.000% | 872714 | 0.180% | 0 | 0.000% | 0 | 0 |
| MITSUBISHI UFJ | 0 | 0.000% | 0 | 0.000% | 50000 | 0.001% | 0 | 0.000% | 695894 | 0.144% | 0 | 0.000% | 0 | 0 |
| RBS CITIZENS | 0 | 0.000% | 0 | 0.000% | 55477 | 0.001% | 0 | 0.000% | 8471557 | 1.751% | 0 | 0.000% | 0 | 0 |
| AMERICAN CHARTERED | 0 | 0.000% | 0 | 0.000% | 0 | 0.000% | 4100 | 0.000% | 0 | 0.000% | 194418 | 0.036% | 0 | 0 |
| SOUTHWEST | 0 | 0.000% | 954 | 0.000% | 0 | 0.000% | 625 | 0.000% | 0 | 0.000% | 477944 | 0.088% | 0 | 0 |
| M&I MARSHALL & ILSLEY | 0 | 0.000% | 3423 | 0.000% | 0 | 0.000% | 9274 | 0.000% | 0 | 0.000% | 3949430 | 0.723% | 0 | 0 |
| STATE BANK FINANCIAL | 0 | 0.000% | 0 | 0.000% | 0 | 0.000% | 16059 | 0.000% | 0 | 0.000% | 27713 | 0.005% | 0 | 0 |
| TOTAL | 8055868498 | | 7003344661 | | 7661008470 | | 6794718082 | | 483692764 | | 545983891 | | | |

Some Network Concepts: A graphical representation of random graph (left) and small world graph with hubs, Markose et. al. 2004



Properties of Networks

Diagonal Elements Characterize Small World Networks

Watts and Strogatz (1998), Watts (2002) See Markose et. al. (2004)

| Properties | Clustering Coefficient | Average Path Length | Degree Distribution |
|-----------------------------|-------------------------------|----------------------------|--|
| Networks | | | |
| Regular | <i>High</i> | High | Equal and fixed In-degrees to each node |
| Random | Low | <i>Low</i> | Exponential/ Poisson |
| Scale Free/Power Law | Low | Variable | <i>Fat Tail Distribution</i> |

Financial Networks for the US CDS Obligations: High Clustering from broker dealer behaviour and Barabasi et. al. Preferential attachment model

- Our algorithm assigns in and out degrees for a bank in terms of its respective market shares ($s_i^{B/G}$) for CDS purchases (B) and sales (G), resp.

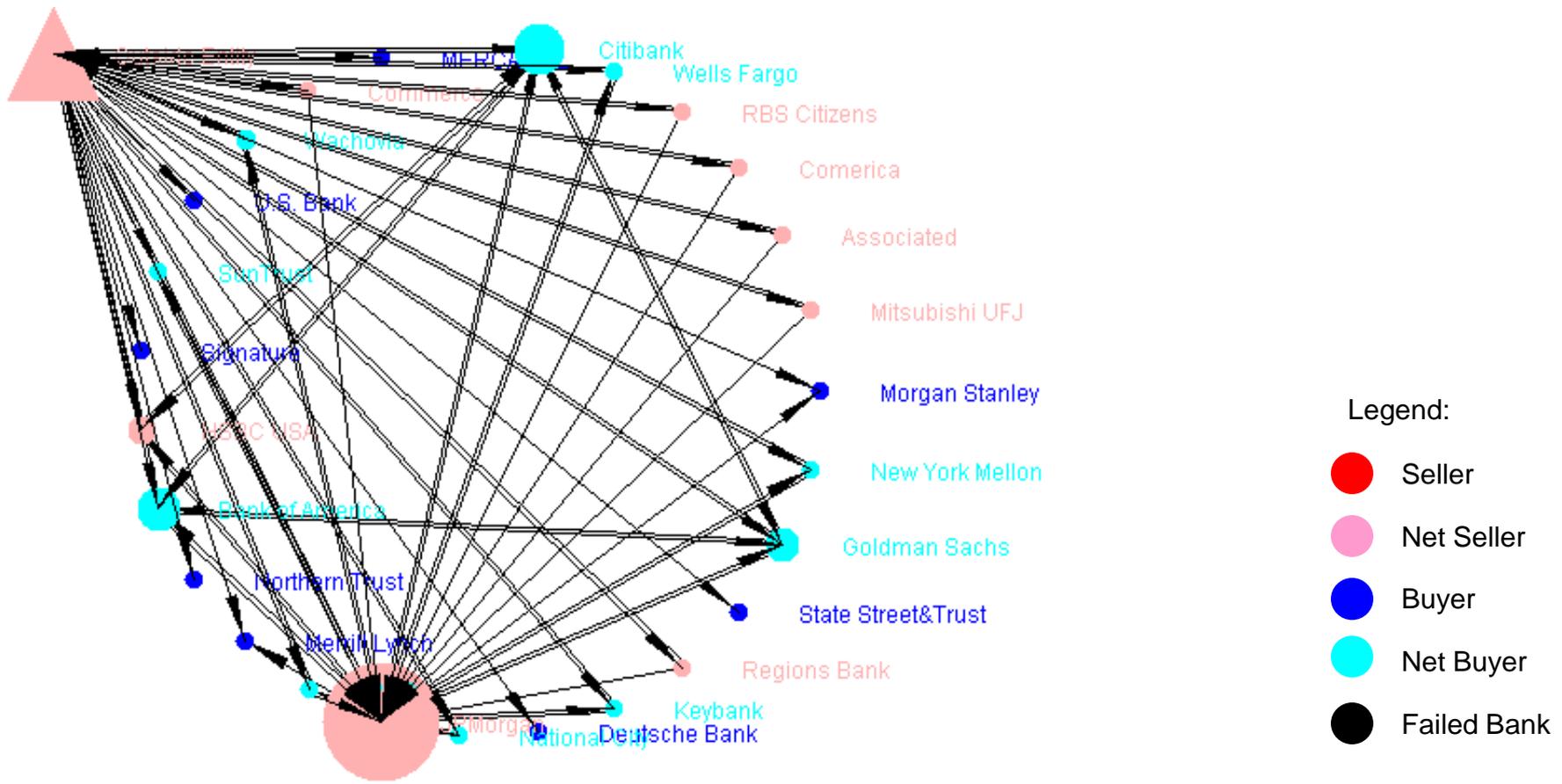
$$\mathbf{X} = \begin{bmatrix} 0 & x_{12} & x_{13} & \dots x_{ij} \cdot & \dots & x_{1N+1} \\ x_{21} & 0 & x_{23} & \dots & \dots & x_{2N+1} \\ \cdot & \cdot & 0 & \dots & \dots & \cdot \\ x_{i1} & \cdot & & 0 & & x_{iN+1} \\ \cdot & \cdot & & & 0 & \\ x_{N+11} & & & x_{N+1j} & & 0 \end{bmatrix} \left| \begin{array}{l} \Gamma = \sum G_i \\ G_1^i \\ G_2 \\ \cdot \\ G_i \\ \cdot \\ G_{N+1} \end{array} \right.$$

$$\Theta = \sum_j B_j \quad B_1 \quad \cdot \quad \cdot \quad B_j \quad \dots \quad B_{N+1}$$

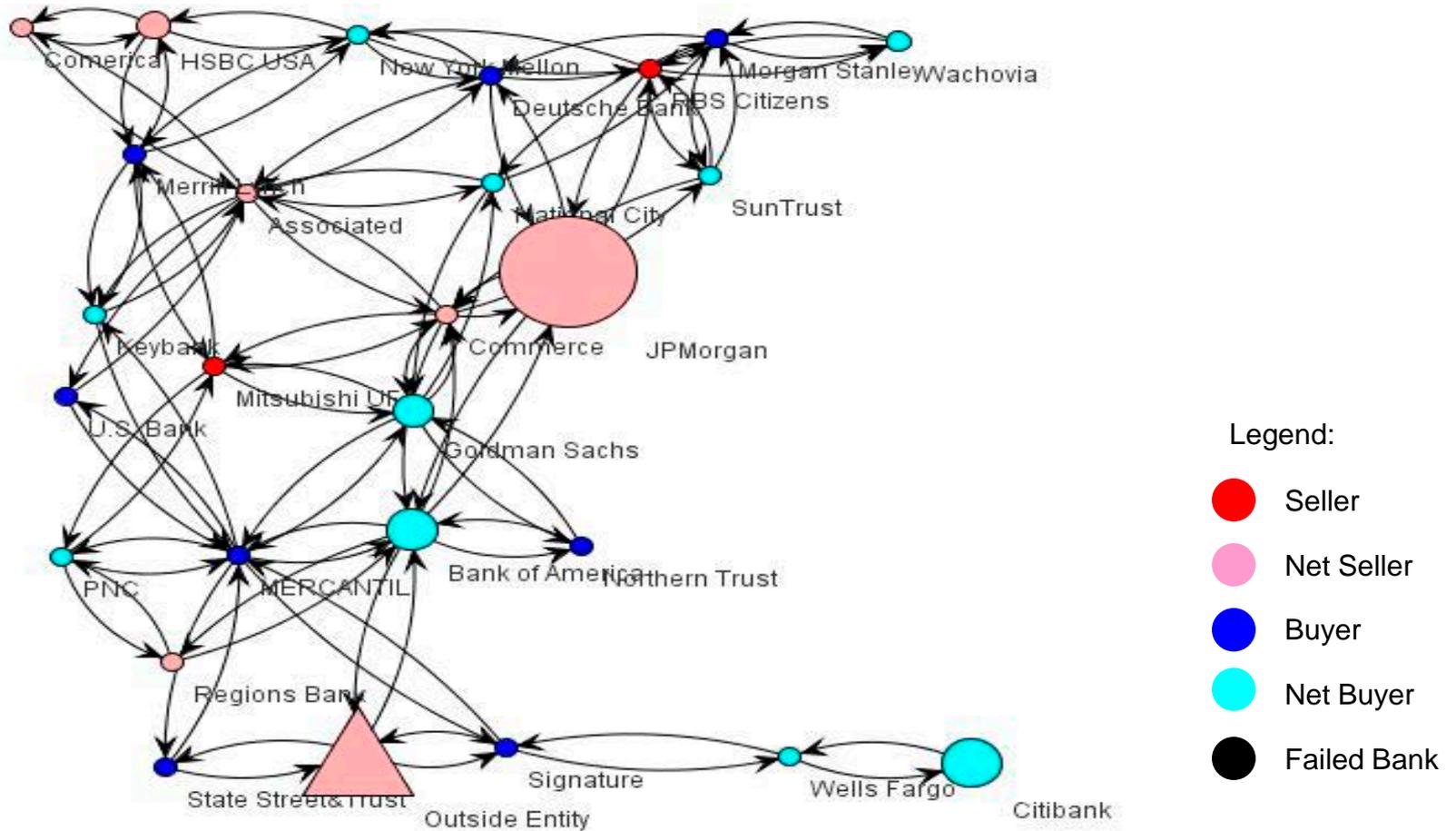
$$x_{ij} = \begin{cases} G^i s_j^B & \text{for the largest } (1 + N s_i^G)' \text{'s counterparties} \\ 0 & \text{otherwise} \end{cases}$$

Initial CDS Financial Network for 26 US Banks (2008 Q4):

Note Majority of Interconnections are among top 4 banks and Monolines & Hedge Funds(30%Triangle)



Random Graph with Same Connectivity and Gross CDS Buy/Sell



May-Wigner Stability Criteria for Networks

$$\sqrt{NC} \sigma < 1.$$

- Sinha (2005) and Sinha and Sinha (2006) found that the transition point between stability and instability with respect to the given parameters (N:No. of Nodes, C:Connectivity and sigma) does not differ between random and small world networks.
- However, they found that the speed and manner in which these different network systems transited into instability differed.
- An unstable clustered network system will disintegrate in a less pervasive way than an unstable random network system.

Network Statistics for Degree Distribution for CDS Network: Small World Network Properties Compared with Random Graph with Same Connectivity

Q409 Network Statistics with ICE CDS Clearing House (NB
less clustered , but remains May-Wigner Unstable)

| Initial Network Statistics (In Degrees) CDS Buyers | Mean | Standard Deviation σ | Skewness | Kurtosis | Connectivity | Clustering Coefficient | May-Wigner Stability |
|--|------|--------------------------------|----------|----------|--------------|---------------------------|-------------------------|
| In Degrees CDS Buyers | 3.04 | 4.44 | 3.13 | 9.12 | 0.12 | 0.92 | 7.814 |
| Out Degrees CDS Sellers | 3.04 | 5.34 | 3.60 | 14.12 | 0.12 | 0.92 | 9.432 |
| Random Graph | 3.48 | 1.50 | 0.70 | 0.04 | 0.12 | 0.09 | 2.64 |

MARKET SHARE NETWORK - Q4 2009

| | mean | std | skewness | kurtosis | connectivity | cluster coeff |
|-------------|----------|----------|----------|----------|--------------|---------------|
| in degrees | 3.366667 | 5.880906 | 3.135305 | 9.562411 | 0.116091954 | 0.911334428 |
| out degrees | | 4.671877 | 3.383789 | 13.35499 | 0.116091954 | |

Too Interconnected To Fail : Stress Test

- **Objective: Build CDS Network and Conduct Stress Tests**
There is very high correlation between the dominance of market share in CDS and CDS network connectivity
- Stress Tests: Follow Furfine (2003) Algorithm
- We use 20% reduction of core capital to signal bank failure
- **Experiment 1:** (A) The loss of CDS cover due to the failed bank as counterparty suspending its guarantees will have a contagion like first and multiple order effects. Full bilateral tear up assumed; No possibility for Novation

NET EXPOSURE > 20% Core Capital

- **Experiment 2:** Armageddon Scenario
- Experiment 1 + (B) **Concentration Risk** ($Div_i = (\text{Gross notional} - \text{Net Notional}) \times \text{failed counterparties}$) and **Liquidity Risk** (DTCC Data based relative CDS activity on i as reference entity) and Loss from SPV Credit Enhancements

$$[s_G^j + \%Gross_j] [Net_i^R + Div_i^R (\sum_{i \in D^1} s_G^i)] + \beta MBS_j (SPV^j / \sum_e SPV^e).$$

Contagion table – exp 1

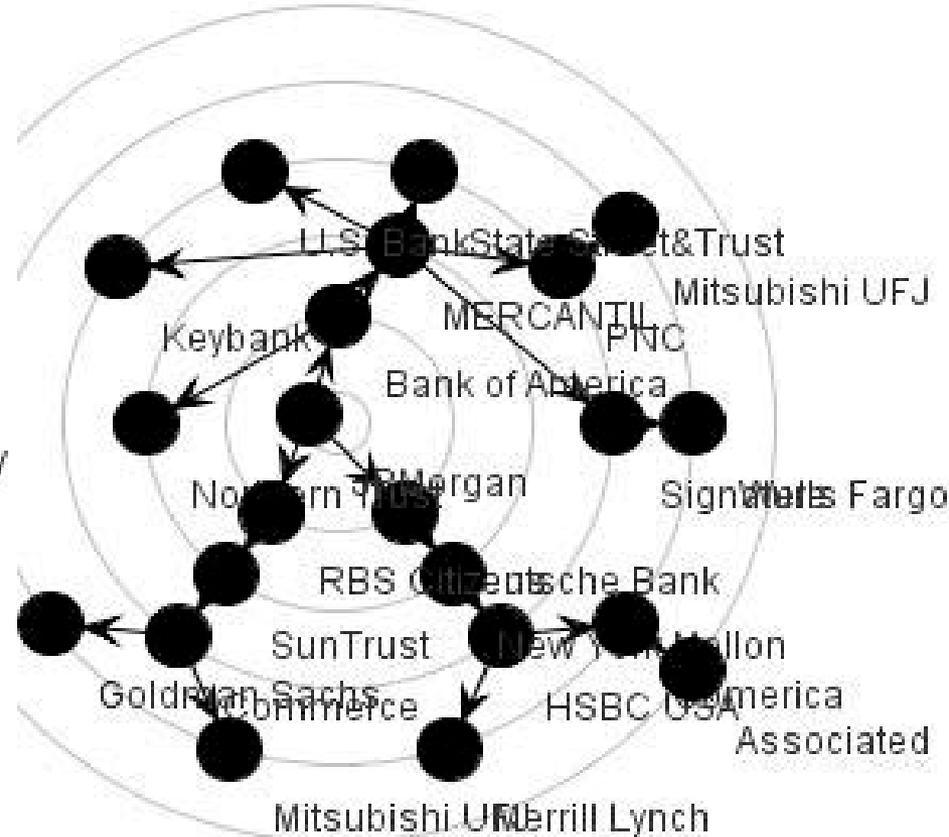
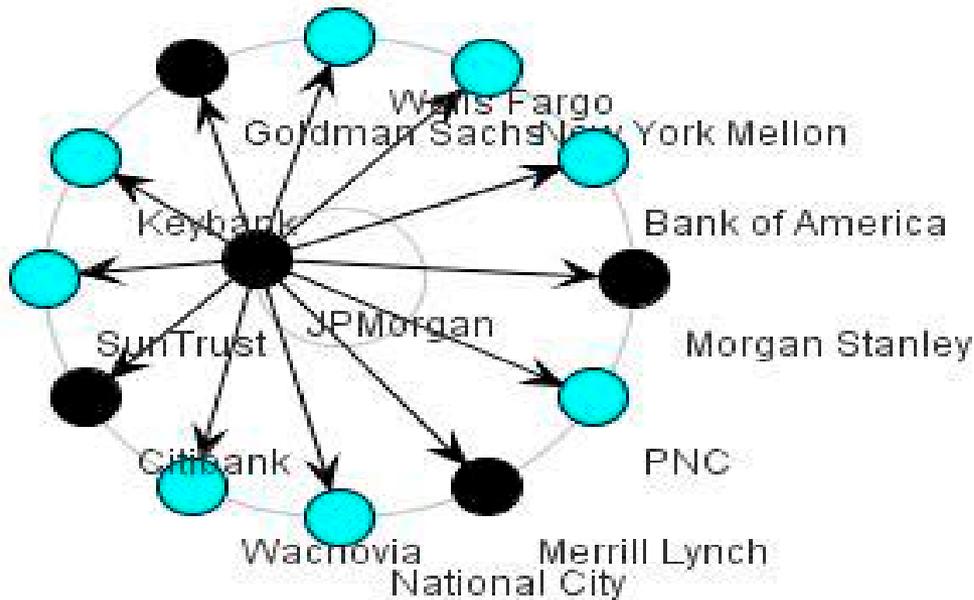
| | Net Core Capital (loss CDS Cover only) | | | | | | | | | | | | | | | | | | | |
|----------------------|--|-------|----------|----------|----------|----------|-----------------|----------|--------|----------|----------------|----------|---------------|----------|-------------|----------|----------|----------|------------|----------|
| | Original | | JFMorgan | | Citibank | | Bank of America | | HSBC | | Morgan Stanley | | National City | | Wells Fargo | | Comerica | | 30% off OE | |
| JFMorgan | 100.61 | 0.00% | 0.00 | -100.00% | 100.61 | 0.00% | 100.61 | 0.00% | 93.75 | -8.82% | 100.6 | 0.00% | 100.61 | 0.00% | 100.61 | 0.00% | 100.58 | -0.02% | 74.81 | -25.84% |
| Citibank | 70.98 | 0.00% | 8.64 | -87.82% | 0.00 | -100.00% | 58.93 | -16.97% | 61.84 | -12.87% | 70.98 | 0.00% | 70.98 | 0.00% | 70.98 | 0.00% | 70.98 | 0.00% | -11.45 | -116.13% |
| Bank of America | 88.50 | 0.00% | 71.67 | -19.03% | 88.50 | 0.00% | 0.00 | -100.00% | 88.50 | 0.00% | 88.5 | 0.00% | 88.50 | 0.00% | 88.50 | 0.00% | 88.50 | 0.00% | 68.14 | -23.01% |
| Goldman Sachs | 13.19 | 0.00% | -8.98 | -168.09% | 13.19 | 0.00% | 10.35 | -21.54% | 13.19 | 0.00% | 13.19 | 0.00% | 13.19 | 0.00% | 13.19 | 0.00% | 13.19 | 0.00% | 9.16 | -30.57% |
| HSBC | 10.81 | 0.00% | 10.81 | 0.00% | 10.81 | 0.00% | 10.81 | 0.00% | 0.00 | -100.00% | 10.81 | 0.00% | 10.81 | 0.00% | 10.81 | 0.00% | 10.81 | 0.00% | 7.98 | -26.18% |
| Wachovia | 32.71 | 0.00% | 27.45 | -16.07% | 32.71 | 0.00% | 32.71 | 0.00% | 32.71 | 0.00% | 32.71 | 0.00% | 32.71 | 0.00% | 32.71 | 0.00% | 32.71 | 0.00% | 26.52 | -18.63% |
| Morgan Stanley | 5.80 | 0.00% | -5.69 | -202.31% | 5.80 | 0.00% | 5.80 | 0.00% | 5.80 | 0.00% | 0 | -100.00% | 5.80 | 0.00% | 5.80 | 0.00% | 5.80 | 0.00% | -6.07 | -204.68% |
| Merrill Lynch | 4.09 | 0.00% | -0.64 | -115.67% | 4.09 | 0.00% | 4.09 | 0.00% | 4.09 | 0.00% | 4.092 | 0.00% | 4.09 | 0.00% | 4.09 | 0.00% | 4.09 | 0.00% | -0.70 | -117.01% |
| Keybank | 8.00 | 0.00% | 7.69 | -3.94% | 8.00 | 0.00% | 8.00 | 0.00% | 8.00 | 0.00% | 8.005 | 0.00% | 8.00 | 0.00% | 8.00 | 0.00% | 8.00 | 0.00% | 7.67 | -4.24% |
| PNC Bank | 8.34 | 0.00% | 7.83 | -6.09% | 8.34 | 0.00% | 8.34 | 0.00% | 8.34 | 0.00% | 8.338 | 0.00% | 8.34 | 0.00% | 8.34 | 0.00% | 8.34 | 0.00% | 7.82 | -6.24% |
| National City | 12.05 | 0.00% | 11.86 | -1.54% | 12.05 | 0.00% | 12.05 | 0.00% | 12.05 | 0.00% | 12.05 | 0.00% | 0.00 | -100.00% | 12.05 | 0.00% | 12.05 | 0.00% | 11.85 | -1.61% |
| New York Mellon | 11.15 | 0.00% | 10.52 | -5.60% | 11.15 | 0.00% | 11.15 | 0.00% | 11.15 | 0.00% | 11.15 | 0.00% | 11.15 | 0.00% | 11.15 | 0.00% | 11.15 | 0.00% | 10.52 | -5.60% |
| Wells Fargo | 33.07 | 0.00% | 32.78 | -0.89% | 33.07 | 0.00% | 33.07 | 0.00% | 33.07 | 0.00% | 33.07 | 0.00% | 33.07 | 0.00% | 0.00 | -100.00% | 33.07 | 0.00% | 32.77 | -0.91% |
| SunTrust | 12.58 | 0.00% | 12.36 | -1.65% | 12.58 | 0.00% | 12.58 | 0.00% | 12.58 | 0.00% | 12.58 | 0.00% | 12.58 | 0.00% | 12.58 | 0.00% | 12.58 | 0.00% | 12.35 | -1.68% |
| Northern Trust | 4.39 | 0.00% | 4.39 | 0.00% | 4.39 | 0.00% | 4.39 | 0.00% | 4.39 | 0.00% | 4.385 | 0.00% | 4.39 | 0.00% | 4.39 | 0.00% | 4.39 | 0.00% | 4.38 | -0.03% |
| State Street & Trust | 13.42 | 0.00% | 13.42 | 0.00% | 13.42 | 0.00% | 13.42 | 0.00% | 13.42 | 0.00% | 13.42 | 0.00% | 13.42 | 0.00% | 13.42 | 0.00% | 13.42 | 0.00% | 13.42 | -0.01% |
| Deutsche Bank | 7.87 | 0.00% | 7.87 | 0.00% | 7.87 | 0.00% | 7.87 | 0.00% | 7.87 | 0.00% | 7.872 | 0.00% | 7.87 | 0.00% | 7.87 | 0.00% | 7.87 | 0.00% | 7.87 | -0.01% |
| Regions | 9.64 | 0.00% | 9.64 | 0.00% | 9.64 | 0.00% | 9.64 | 0.00% | 9.64 | 0.00% | 9.64 | 0.00% | 9.64 | 0.00% | 9.64 | 0.00% | 9.64 | 0.00% | 9.64 | 0.00% |
| U.S. Bank | 14.58 | 0.00% | 14.58 | 0.00% | 14.58 | 0.00% | 14.58 | 0.00% | 14.58 | 0.00% | 14.58 | 0.00% | 14.58 | 0.00% | 14.58 | 0.00% | 14.58 | 0.00% | 14.58 | 0.00% |
| Commerce | 1.37 | 0.00% | 1.37 | 0.00% | 1.37 | 0.00% | 1.37 | 0.00% | 1.37 | 0.00% | 1.388 | 0.00% | 1.37 | 0.00% | 1.37 | 0.00% | 1.37 | 0.00% | 1.37 | -0.01% |
| MERCANTIL | 0.54 | 0.00% | 0.54 | 0.00% | 0.54 | 0.00% | 0.54 | 0.00% | 0.54 | 0.00% | 0.538 | 0.00% | 0.54 | 0.00% | 0.54 | 0.00% | 0.54 | 0.00% | 0.54 | -0.01% |
| Associated | 1.58 | 0.00% | 1.58 | 0.00% | 1.58 | 0.00% | 1.58 | 0.00% | 1.58 | 0.00% | 1.577 | 0.00% | 1.58 | 0.00% | 1.58 | 0.00% | 1.58 | 0.00% | 1.58 | 0.00% |
| Comerica | 5.68 | 0.00% | 5.68 | 0.00% | 5.68 | 0.00% | 5.68 | 0.00% | 5.68 | 0.00% | 5.681 | 0.00% | 5.68 | 0.00% | 5.68 | 0.00% | 0.00 | -100.00% | 5.68 | 0.00% |
| Signature | 0.78 | 0.00% | 0.78 | 0.00% | 0.78 | 0.00% | 0.78 | 0.00% | 0.78 | 0.00% | 0.78 | 0.00% | 0.78 | 0.00% | 0.78 | 0.00% | 0.78 | 0.00% | 0.78 | 0.00% |
| RBS Citizens | 8.47 | 0.00% | 8.47 | 0.00% | 8.47 | 0.00% | 8.47 | 0.00% | 8.47 | 0.00% | 8.468 | 0.00% | 8.47 | 0.00% | 8.47 | 0.00% | 8.47 | 0.00% | 8.47 | 0.00% |
| Mitsubishi UFJ | 0.70 | 0.00% | 0.70 | 0.00% | 0.70 | 0.00% | 0.70 | 0.00% | 0.70 | 0.00% | 0.698 | 0.00% | 0.70 | 0.00% | 0.70 | 0.00% | 0.70 | 0.00% | 0.70 | 0.00% |
| Aggregate CC | 480.80 | 0.00% | 255.00 | -46.98% | 409.82 | -14.78% | 377.41 | -21.50% | 454.00 | -5.57% | 475.00 | -1.21% | 488.76 | -2.51% | 447.73 | -8.88% | 475.12 | -1.18% | 320.31 | -33.38% |

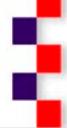
Net Core Capital = Core Capital – Losses.

Contagion table – exp 2

| | Net Core Capital (loss CDS Cover & CDS SPV impact) | | | | | | | | | | | | | | | | | | | |
|---------------------|--|----------|---------|----------|---------|-----------------|---------|----------|---------|----------------|---------|---------------|---------|-------------|---------|----------|---------|---------------------|---------|----------|
| | Original | JPMorgan | | Citibank | | Bank of America | | HSBC | | Morgan Stanley | | National City | | Wells Fargo | | Comerica | | Insurance Companies | | |
| JPMorgan | 100.61 | 0.00% | 0.000 | -100.00% | 35.777 | -64.44% | 10.371 | -89.68% | 92.347 | -8.21% | 98.625 | -1.97% | 100.476 | -0.13% | 98.988 | -1.63% | 100.582 | -0.02% | 68.666 | -33.74% |
| Citibank | 70.98 | 0.00% | 3.384 | -95.23% | 0.000 | -100.00% | 53.838 | -24.15% | 61.280 | -13.68% | 70.158 | -1.15% | 70.923 | -0.08% | 70.299 | -0.95% | 70.977 | 0.00% | -56.077 | -179.01% |
| Bank of America | 88.50 | 0.00% | 66.721 | -24.61% | 64.080 | -27.80% | 0.000 | -100.00% | 88.052 | -0.51% | 87.866 | -0.72% | 88.262 | -0.24% | 87.835 | -0.78% | 88.504 | 0.00% | 32.528 | -63.25% |
| Goldman Sachs | 13.19 | 0.00% | -13.014 | -198.66% | 8.963 | -32.12% | 9.103 | -30.99% | 12.722 | -3.55% | 12.528 | -5.02% | 13.190 | 0.00% | 12.679 | -3.88% | 13.190 | 0.00% | 6.435 | -51.21% |
| HSBC | 10.81 | 0.00% | -24.058 | -322.60% | -1.940 | -117.85% | -2.998 | -127.74% | 0.000 | -100.00% | 10.505 | -2.80% | 10.787 | -0.19% | 10.557 | -2.33% | 10.808 | 0.00% | 6.732 | -37.71% |
| Wachovia | 32.71 | 0.00% | 25.713 | -21.39% | 23.312 | -29.73% | 19.993 | -38.88% | 32.528 | -0.56% | 32.450 | -0.79% | 32.678 | -0.10% | 32.482 | -0.69% | 32.709 | 0.00% | 12.348 | -62.25% |
| Morgan Stanley | 5.80 | 0.00% | -8.415 | -145.09% | 3.193 | -44.94% | 3.274 | -43.65% | 5.512 | -4.96% | 0.000 | -100.00% | 5.800 | 0.00% | 5.4854 | -5.42% | 5.800 | 0.00% | 3.988 | -31.24% |
| Merrill Lynch | 4.09 | 0.00% | -3.184 | -177.82% | 2.991 | -26.91% | 1.518 | -62.91% | 3.799 | -7.17% | 3.677 | -10.14% | 4.089 | -0.07% | 3.7689 | -7.89% | 4.082 | 0.00% | 2.330 | -43.08% |
| Keybank | 8.00 | 0.00% | 7.415 | -7.37% | 7.488 | -6.49% | 7.481 | -6.54% | 8.004 | -0.01% | 8.004 | -0.02% | 7.997 | -0.10% | 7.9972 | -0.10% | 8.005 | 0.00% | 7.445 | -6.99% |
| FNCBank | 8.34 | 0.00% | 7.522 | -9.78% | 7.545 | -9.51% | 7.543 | -9.53% | 8.337 | -0.01% | 8.337 | -0.01% | 8.313 | -0.30% | 8.3166 | -0.25% | 8.338 | 0.00% | 7.532 | -9.68% |
| National City | 12.05 | 0.00% | 11.688 | -2.97% | 11.708 | -2.81% | 11.707 | -2.82% | 12.045 | 0.00% | 12.045 | 0.00% | 0.000 | -100.00% | 12.038 | -0.08% | 12.046 | 0.00% | 11.666 | -2.90% |
| New York Mellon | 11.15 | 0.00% | 10.235 | -8.19% | 10.235 | -8.19% | 10.235 | -8.19% | 11.148 | 0.00% | 11.148 | 0.00% | 11.119 | -0.26% | 11.124 | -0.22% | 11.148 | 0.00% | 10.235 | -8.19% |
| Wells Fargo | 33.07 | 0.00% | 9.160 | -72.33% | 26.452 | -20.01% | 23.854 | -27.87% | 32.927 | -0.43% | 32.868 | -0.61% | 33.010 | -0.18% | 0 | -100.00% | 33.070 | 0.00% | 21.538 | -34.87% |
| SunTrust | 12.56 | 0.00% | 12.200 | -2.90% | 12.204 | -2.87% | 12.204 | -2.87% | 12.565 | 0.00% | 12.565 | 0.00% | 12.560 | -0.12% | 12.562 | -0.10% | 12.565 | 0.00% | 12.202 | -2.86% |
| Northern Trust | 4.39 | 0.00% | 4.371 | -0.33% | 4.371 | -0.33% | 4.371 | -0.33% | 4.385 | 0.00% | 4.385 | 0.00% | 4.384 | -0.03% | 4.3841 | -0.03% | 4.385 | 0.00% | 4.371 | -0.33% |
| State Street&Trust | 13.42 | 0.00% | 13.199 | -1.66% | 13.199 | -1.66% | 13.199 | -1.66% | 13.422 | 0.00% | 13.422 | 0.00% | 13.399 | -0.17% | 13.403 | -0.14% | 13.422 | 0.00% | 13.199 | -1.66% |
| Deutsche Bank | 7.87 | 0.00% | 8.050 | 23.14% | 5.568 | -24.31% | 6.017 | 23.58% | 7.681 | -2.69% | 7.573 | -3.80% | 7.872 | 0.00% | 7.641 | -2.93% | 7.872 | 0.00% | -8.325 | -206.78% |
| Regions | 9.64 | 0.00% | 9.498 | -1.47% | 9.499 | -1.46% | 9.499 | -1.46% | 9.640 | 0.00% | 9.640 | 0.00% | 9.628 | -0.15% | 9.6281 | -0.12% | 9.640 | 0.00% | 9.499 | -1.47% |
| U.S. Bank | 14.56 | 0.00% | 14.275 | -1.94% | 14.275 | -1.94% | 14.275 | -1.94% | 14.568 | 0.00% | 14.568 | 0.00% | 14.529 | -0.20% | 14.534 | -0.17% | 14.568 | 0.00% | 14.275 | -1.94% |
| Commerce | 1.37 | 0.00% | 1.345 | -1.72% | 1.345 | -1.69% | 1.345 | -1.69% | 1.368 | 0.00% | 1.368 | 0.00% | 1.368 | -0.17% | 1.3683 | -0.14% | 1.368 | 0.00% | 1.345 | -1.70% |
| MERCANTIL | 0.54 | 0.00% | 0.524 | -2.57% | 0.524 | -2.57% | 0.524 | -2.57% | 0.538 | 0.00% | 0.538 | 0.00% | 0.537 | -0.28% | 0.5368 | -0.22% | 0.538 | 0.00% | 0.524 | -2.57% |
| Associated | 1.58 | 0.00% | 1.537 | -2.52% | 1.537 | -2.51% | 1.537 | -2.51% | 1.577 | 0.00% | 1.577 | 0.00% | 1.573 | -0.28% | 1.5735 | -0.21% | 1.577 | 0.00% | 1.537 | -2.51% |
| Comerica | 5.66 | 0.00% | 5.585 | -1.34% | 5.585 | -1.34% | 5.585 | -1.34% | 5.660 | 0.00% | 5.661 | 0.00% | 5.653 | -0.14% | 5.654 | -0.12% | 0.000 | -100.00% | 5.585 | -1.34% |
| Signature | 0.76 | 0.00% | 0.733 | -3.53% | 0.733 | -3.53% | 0.733 | -3.53% | 0.760 | 0.00% | 0.760 | 0.00% | 0.758 | -0.37% | 0.758 | -0.30% | 0.760 | 0.00% | 0.733 | -3.53% |
| FBS Citizens | 8.47 | 0.00% | 8.277 | -2.25% | 8.277 | -2.25% | 8.277 | -2.25% | 8.467 | 0.00% | 8.468 | 0.00% | 8.448 | -0.23% | 8.4512 | -0.19% | 8.468 | 0.00% | 8.277 | -2.25% |
| Mitsubishi UFJ | 0.70 | 0.00% | 0.695 | -0.07% | 0.695 | -0.07% | 0.695 | -0.07% | 0.698 | 0.00% | 0.698 | 0.00% | 0.698 | -0.01% | 0.6959 | -0.01% | 0.698 | 0.00% | 0.695 | -0.07% |
| Insurance Companies | 21.00 | 0.00% | 15.908 | -24.73% | 15.545 | -25.97% | 16.714 | -25.17% | 20.397 | -2.87% | 20.148 | -4.08% | 21.000 | 0.00% | 20.342 | -3.13% | 21.000 | 0.00% | 0.000 | -100.00% |
| Aggregate OC | 480.80 | 0.00% | 171.445 | -64.34% | 277.998 | -42.18% | 234.181 | -51.29% | 449.975 | -6.41% | 469.423 | -2.37% | 488.060 | -2.65% | 442.725 | -7.92% | 475.117 | -1.18% | 197.312 | -58.96% |

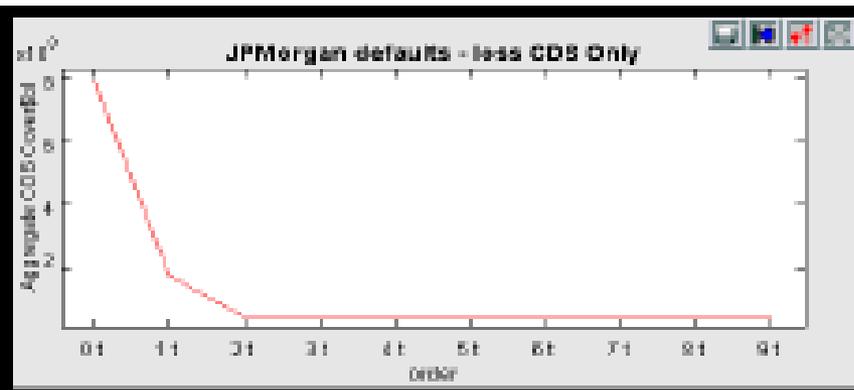
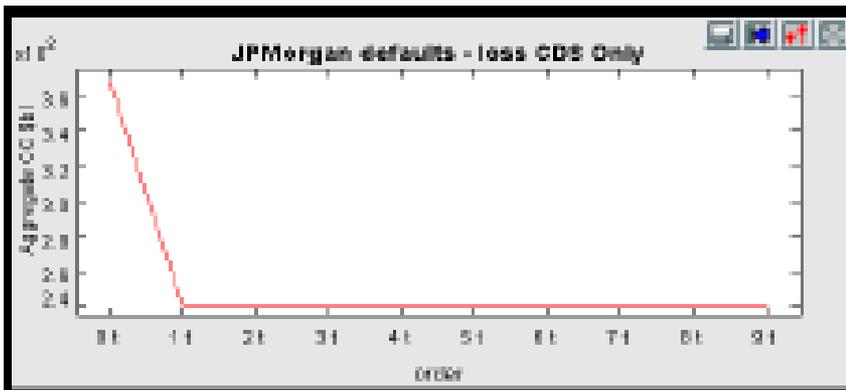
Contagion when JP Morgan Demises in Clustered CDS Network (Left
 4 banks fail in first step and crisis contained) v
 In Random Graph (Right 22 banks fail !! Over many steps)
 Innoculate some key players v Innoculate all (Data Q4 08)



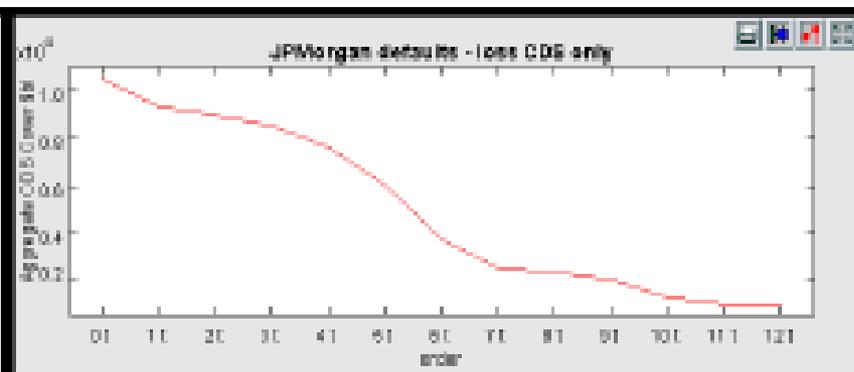
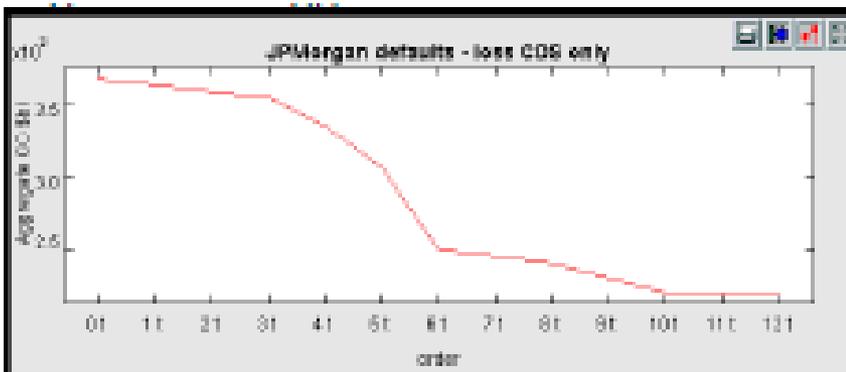


Contagion Rounds

JPMORGAN DEFAULTS: Non calibrated Small World Empirical CDS Network



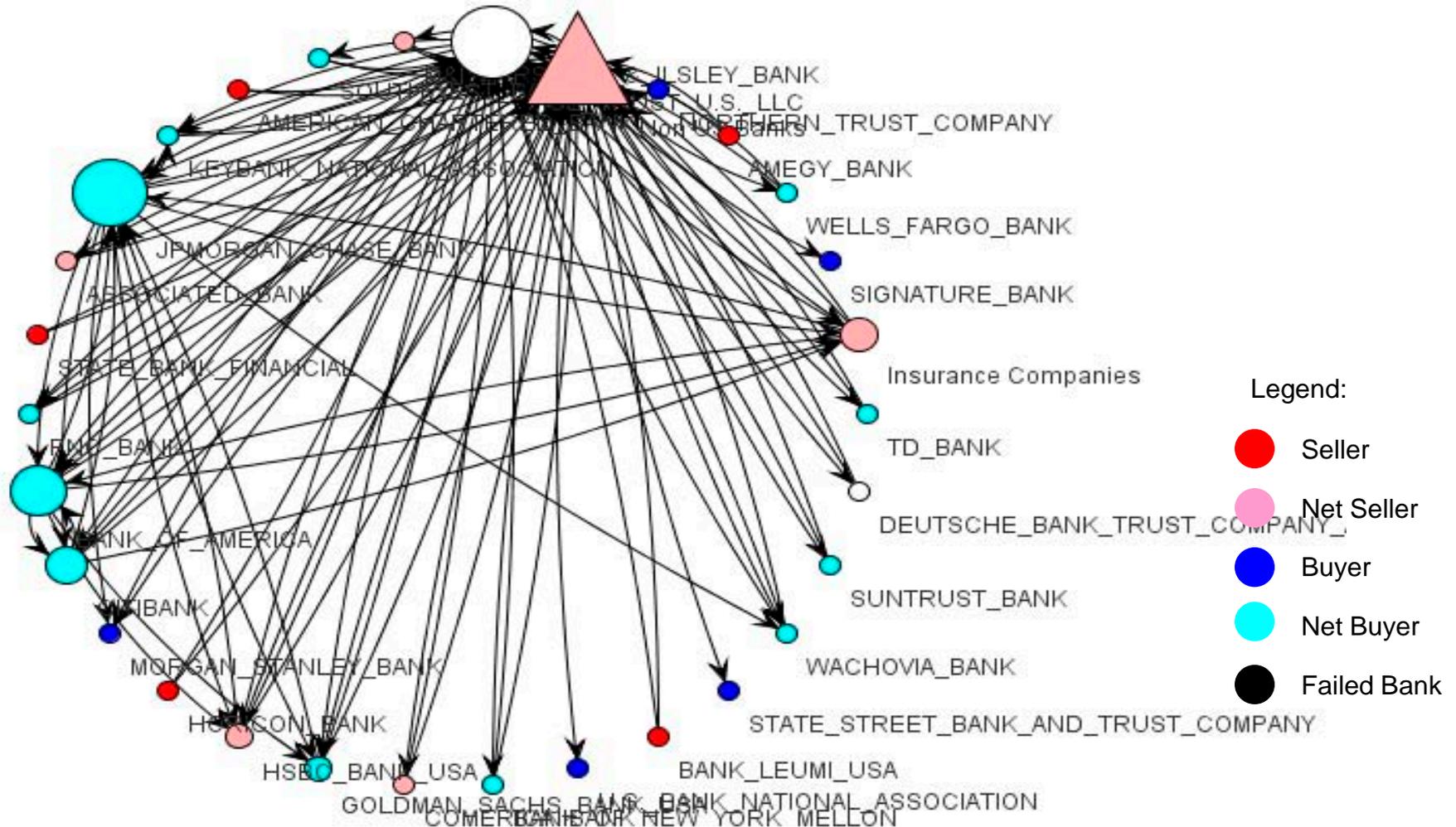
JPMORGAN DEFAULTS: Random Network



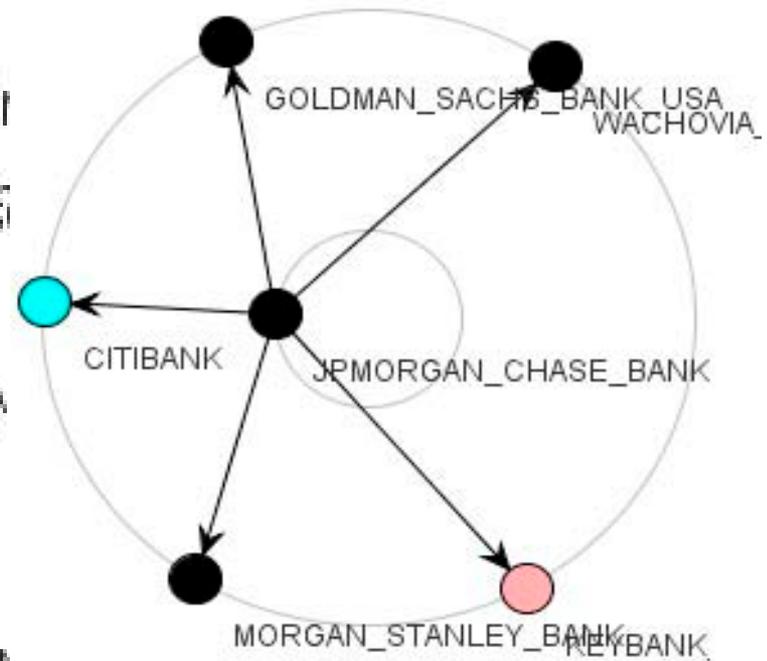
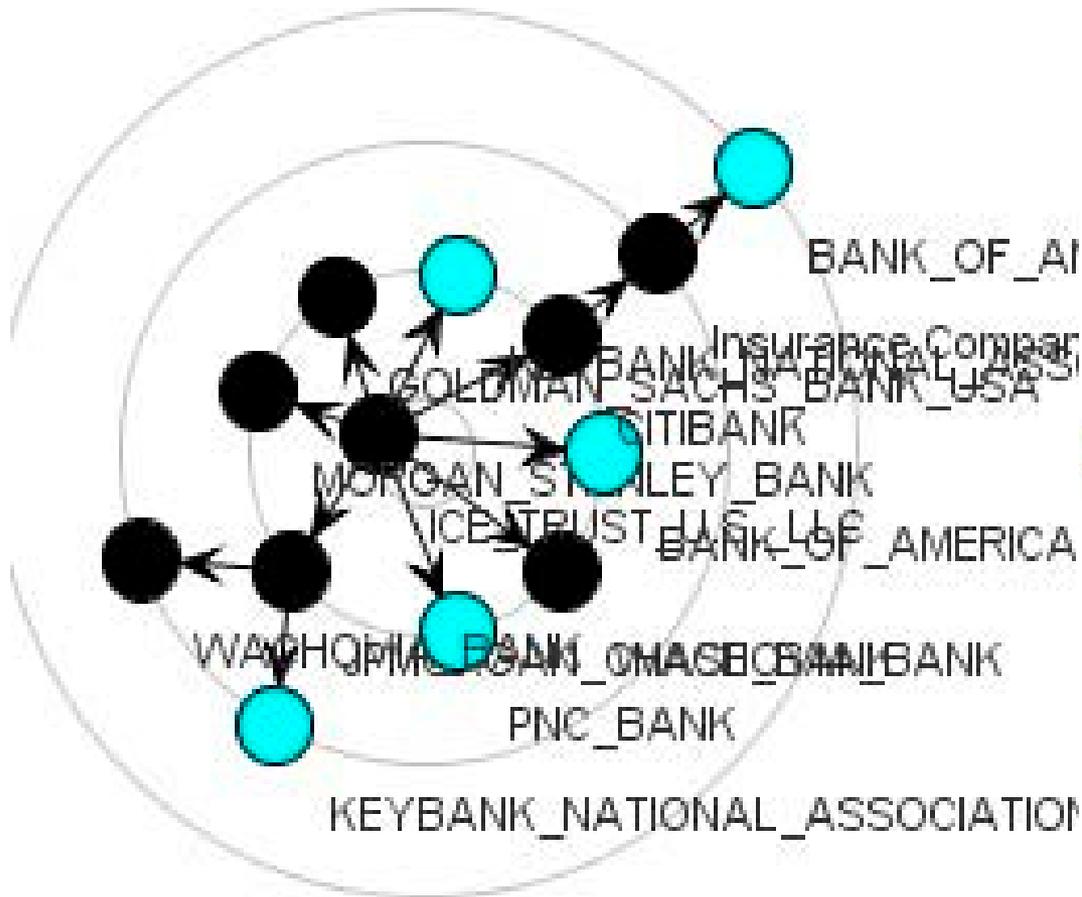
CDS Network with ICE 09Q4

ICE Trust clearing members are Bank of America, Barclays Capital, Citi, Credit Suisse, Deutsche Bank, Goldman Sachs, HSBC, JP Morgan Chase, Merrill Lynch,

Morgan Stanley, BNP Paribas, RBS and UBS (white circle ICE G=B)



09 Q4 Contagion from ICE as Trigger (LHS) and JP Morgan (RHS) (Note JP Morgan now a much less potent super-spreader)



Section on CDS Spreads
Correlation Calibration : To be
covered if time permitted

Financial Networks for US CDS Obligations

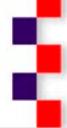
– Calibration with CDS Spread Correlations

- Our algorithm assigns in and out degrees for a bank in terms of its respective market shares for CDS purchases and sales

$$\mathbf{X} = \begin{bmatrix} 0 & x_{12} & x_{13} & \dots x_{ij} & \dots & x_{1N+1} \\ x_{21} & 0 & x_{23} & \dots & \dots & x_{2N+1} \\ \cdot & \cdot & 0 & \dots & \dots & \cdot \\ x_{i1} & \cdot & & 0 & & x_{iN+1} \\ \cdot & \cdot & & & 0 & \\ x_{N+11} & & & x_{N+1j} & & 0 \end{bmatrix} \left| \begin{array}{l} \Gamma = \sum G_i \\ G_1^i \\ G_2 \\ \cdot \\ G_i \\ \cdot \\ G_{N+1} \end{array} \right.$$

$$\Theta = \sum_j B_j \quad B_1 \quad \cdot \quad \cdot \quad B_j \quad \dots \quad B_{N+1}$$

$$x_{ij} = \begin{cases} G^i \hat{s}_j^B & \text{if } corr_{ij} \geq 0 \\ 0 & \text{otherwise} \end{cases} \quad \hat{s}_j^B = \frac{s_j^B (1 + deviation_{ij})}{\sum_{j=1}^N s_j^B (1 + deviation_{ij})}$$



Matrix of bilateral CDS Spreads Correlations Deviations

| | JP Morgan | Citi bank | Bank of America | Goldman | HSBC | Wachovia | Morgan Stanley | Merrill Lynch | Keybank | PNC | National City | Mellon | Wells Fargo | SunTrust | Northern Trust | State Street | Deutsche bank | Regions | U.S. Bank | Commerce | MERCANTIL | Associated | Comerica | Signature | RBS | Mitsubishi | Insurance Companies | | |
|---------------------|-----------|-----------|-----------------|----------|----------|----------|----------------|---------------|---------|-----|---------------|--------|-------------|----------|----------------|--------------|---------------|---------|-----------|----------|-----------|------------|----------|-----------|-----|------------|---------------------|----------|----------|
| JP Morgan | 0 | 0.195702 | 0.213203 | 0.05597 | -0.41879 | 0.289233 | 0.165155 | 0.174441 | 0 | 0 | 0 | 0 | 0.300984 | 0 | 0 | 0 | -0.43109 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.29769 | -0.24712 |
| Citi bank | 0.277298 | 0 | 0.078767 | 0.274468 | -0.31164 | 0.108442 | 0.324461 | 0.026995 | 0 | 0 | 0 | 0 | 0.119198 | 0 | 0 | 0 | -0.23238 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.3584 | -0.30721 |
| Bank of America | 0.244542 | 0.02851 | 0 | 0.021391 | -0.3027 | 0.302803 | 0.125423 | 0.078894 | 0 | 0 | 0 | 0 | 0.293388 | 0 | 0 | 0 | -0.34921 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.22218 | -0.22087 |
| Goldman | 0.115813 | 0.252714 | 0.049895 | 0 | -0.22097 | -0.02719 | 0.384968 | 0.08198 | 0 | 0 | 0 | 0 | -0.01836 | 0 | 0 | 0 | -0.14491 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.20911 | -0.26483 |
| HSBC | -0.08681 | -0.06125 | -0.00206 | 0.051171 | 0 | -0.11063 | 0.04495 | -0.23027 | 0 | 0 | 0 | 0 | -0.13054 | 0 | 0 | 0 | 0.353576 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.052142 | 0.119721 | |
| Wachovia | 0.344743 | 0.082356 | 0.326975 | -0.03153 | -0.3871 | 0 | 0.059234 | 0.146311 | 0 | 0 | 0 | 0 | 0.374169 | 0 | 0 | 0 | -0.40404 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.30465 | -0.20647 |
| Morgan Stanley | 0.164396 | 0.242105 | 0.093324 | 0.324366 | -0.28779 | 0.002965 | 0 | 0.085578 | 0 | 0 | 0 | 0 | 0.079495 | 0 | 0 | 0 | -0.19386 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.23336 | -0.27722 |
| Merrill Lynch | 0.291118 | 0.062076 | 0.164232 | 0.138814 | -0.44558 | 0.207477 | 0.203015 | 0 | 0 | 0 | 0 | 0 | 0.243663 | 0 | 0 | 0 | -0.48188 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.16496 | -0.21798 |
| Keybank | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PNC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| National City | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mellon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Wells Fargo | 0.33775 | 0.074367 | 0.298815 | -0.04143 | -0.42575 | 0.355424 | 0.117019 | 0.163751 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.39098 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.20675 | -0.28221 |
| SunTrust | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Northern Trust | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| State Street | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Deutsche Bank | -0.11468 | 0.002433 | -0.06413 | 0.111656 | 0.338009 | -0.14313 | 0.123314 | -0.28214 | 0 | 0 | 0 | 0 | -0.11133 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.12945 | 0.010554 |
| Regions | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| U.S. Bank | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Commerce | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MERCANTIL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Associated | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Comerica | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Signature | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RBS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mitsubishi | -0.01024 | -0.15254 | 0.033937 | 0.018499 | 0.007613 | -0.07271 | 0.054851 | 0.005818 | 0 | 0 | 0 | 0 | 0.043937 | 0 | 0 | 0 | 0.100488 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.02966 |
| Insurance Companies | 0.047437 | -0.09425 | 0.042349 | -0.03012 | 0.082295 | 0.032573 | 0.018097 | -0.0401 | 0 | 0 | 0 | 0 | -0.02442 | 0 | 0 | 0 | -0.0113 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.02255 | 0 |

Initial matrix of bilateral CDS buys (B) sell (G) obligations of US Banks (\$bns) – Calibrated 08 Q4

| | JPMorgan | Citibank | Bank of America | Goldman | HSBC | Wachovia | Morgan Stanley | Merrill Lynch | Keybank | PNC | National City | Mellon | Wells Fargo | SunTrust | Northern Trust | State Street | Deutsche Bank | Regions | U.S. Bank | Commerce | MERCANTIL | Associated | Comerica | Signature | RBS | Mitsubishi | Insurance Companies | Non US Banks | Total G | |
|---------------------|-----------------|-----------------|------------------|----------------|------------------|----------------|----------------|-----------------|---------------|---------------|----------------|--------------|--------------|----------------|----------------|--------------|---------------|---------------|---------------|----------------|---------------|---------------|----------------|--------------|----------|------------|---------------------|------------------|--------------------|-------------|
| JPMorgan | 0 | 783.2338 | 561.7071 | 318.8864 | 183.146 | 88.94549 | 11.26937 | 5.040377 | 0 | 0 | 0 | 0 | 0.60809 | 0 | 0 | 0 | 0.038845 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 413.83554 | 1832.393 | 4199.104 |
| Citibank | 662.1212 | 0 | 140.6024 | 108.4377 | 57.02533 | 21.68394 | 3.641171 | 1.255846 | 0 | 0 | 0 | 0 | 0.14792 | 0 | 0 | 0 | 0.013322 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 108.39009 | 186.9911 | 1290.31 |
| Bank of America | 512.23811 | 152.7687 | 0 | 69.2944 | 46.22183 | 20.27005 | 2.443744 | 1.04965 | 0 | 0 | 0 | 0 | 0.13635 | 0 | 0 | 0 | 0.009483 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 95.108791 | 105.195 | 1004.736144 |
| Goldman | 286.58867 | 116.0124 | 68.43357 | 0 | 31.29571 | 3.5097 | 1.902759 | 0.601182 | 0 | 0 | 0 | 0 | 0.04207 | 0 | 0 | 0 | 0.007241 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 56.884783 | 49.12389 | 614.402 |
| HSBC | 186.10215 | 73.92698 | 55.11945 | 38.99294 | 0 | 0 | 0.623321 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.010282 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 74.891208 | 43.96299 | 473.629328 |
| Wachovia | 73.145511 | 21.09295 | 18.24755 | 8.627723 | 5.535293 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.001167 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12.660353 | 2.648447 | 141.959 |
| Morgan Stanley | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Merrill Lynch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Keybank | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PNC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| National City | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mellon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.943218 | 0.943218 |
| Wells Fargo | 0.2523412 | 0.07281 | 0.061932 | 0.029763 | 0.0185 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4.14E-06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.040893 | 0.011756 | 0.488 |
| SunTrust | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Northern Trust | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.195819 | 0.195819 |
| State Street | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Deutsche Bank | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Regions | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.407026 | 0.407026 |
| U.S. Bank | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Commerce | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.030365 | 0.030365 | |
| MERCANTIL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Associated | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.120645 | 0.120645 | |
| Comerica | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.045558 | 0.045558 | |
| Signature | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RBS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.055477 | 0.055477 | |
| Mitsubishi | 0.0220393 | 0.006753 | 0.006026 | 0.00388 | 0.003622 | 7.89E-04 | 1.27E-04 | 5.60E-05 | 0 | 0 | 0 | 0 | 6.19E-06 | 0 | 0 | 0 | 8.51E-07 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0066288 | 7.14E-05 | 0.05 |
| Insurance Companies | 428.46048 | 132.2366 | 109.4624 | 65.40128 | 69.90323 | 16.33803 | 2.177507 | 0.950313 | 0 | 0 | 0 | 0 | 0.10156 | 0 | 0 | 0 | 0.013802 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 124.2808 | 949.326 | |
| Non US Banks | 2017.8245 | 118.195 | 75.00936 | 41.67195 | 63.94029 | 0 | 0 | 0 | 3.8768 | 2.0005 | 1.2852 | 1.175 | 0 | 0.5852 | 0.2355 | 0.145 | 0.005853 | 0.077 | 0.0635 | 0.0174 | 0.0105 | 0.0075 | 0.0053 | 0.003 | 0 | 0 | 138.64672 | 0 | 2464.780611 | |
| Total B | 4166.755 | 1397.546 | 1028.6498 | 651.346 | 457.08984 | 150.748 | 22.058 | 8.897423 | 3.8768 | 2.0005 | 1.28523 | 1.175 | 1.036 | 0.58522 | 0.2355 | 0.145 | 0.1 | 0.0765 | 0.0635 | 0.01739 | 0.0105 | 0.0075 | 0.00527 | 0.003 | 0 | 0 | 900.465 | 2350.7709 | 11144.94899 | |

Contagion table – exp 1 (calibrated)

08 Q4

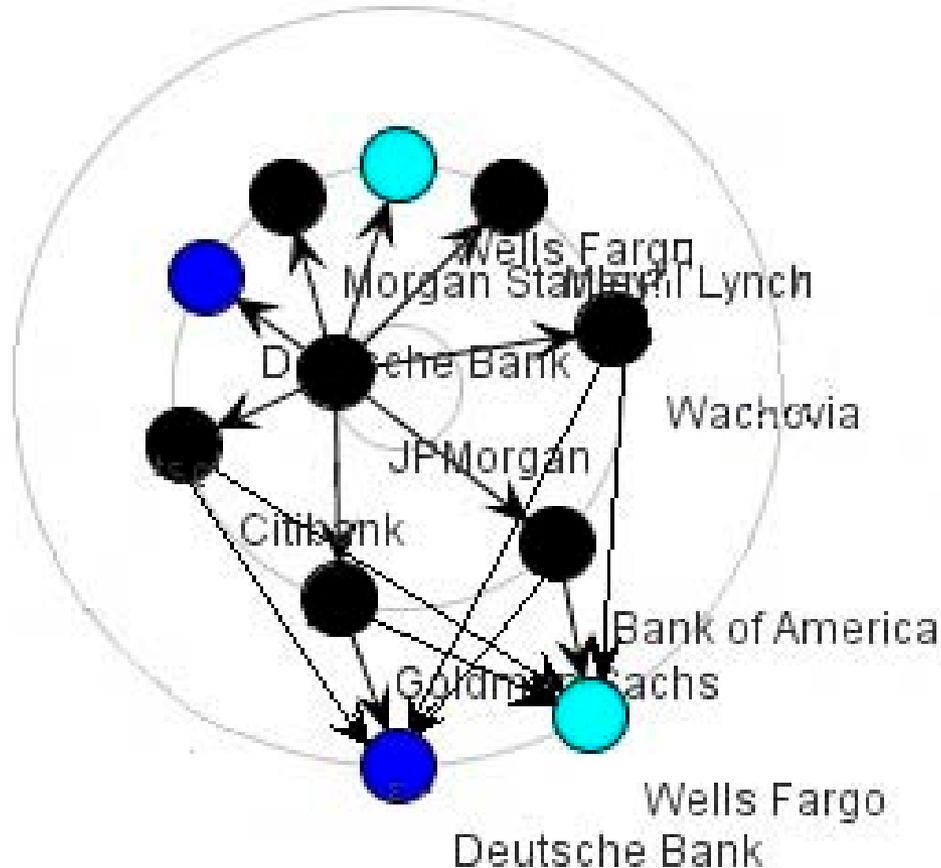
| | Net Core Capital (loss CDS Cover - EXP 1) | | | | | | | | | | | | | | | | | | | |
|---------------------|---|-------|----------|-------|----------|-------|-----------------|-------|---------|-------|----------------|-------|---------------|-------|-------------|-------|----------|-------|---------------------|-------|
| | Original | | JPMorgan | | Citibank | | Bank of America | | HSBC | | Morgan Stanley | | National City | | Wells Fargo | | Comerica | | Insurance Companies | |
| JPMorgan | 100.61 | 0.00% | 0.000 | -100% | 100.606 | 0% | 100.606 | 0% | 97.650 | -3% | 100.606 | 0% | 100.606 | 0% | 100.606 | 0% | 100.606 | 0% | 85.981 | -15% |
| Citibank | 70.98 | 0.00% | -50.136 | -171% | 0.000 | -100% | 58.811 | -17% | 54.075 | -24% | 70.977 | 0% | 70.977 | 0% | 70.977 | 0% | 70.977 | 0% | 47.131 | -34% |
| Bank of America | 88.50 | 0.00% | 39.035 | -56% | 88.504 | 0% | 0.000 | -100% | 78.280 | -12% | 88.504 | 0% | 88.504 | 0% | 88.504 | 0% | 88.504 | 0% | 74.150 | -16% |
| Goldman Sachs | 13.19 | 0.00% | -19.108 | -245% | 13.190 | 0% | 12.329 | -7% | 5.493 | -58% | 13.190 | 0% | 13.190 | 0% | 13.190 | 0% | 13.190 | 0% | 4.674 | -65% |
| HSBC | 10.81 | 0.00% | 10.808 | 0% | 10.808 | 0% | 10.808 | 0% | 0.000 | -100% | 10.808 | 0% | 10.808 | 0% | 10.790 | 0% | 10.808 | 0% | 10.808 | 0% |
| Wachovia | 32.71 | 0.00% | 16.909 | -48% | 32.118 | -2% | 30.687 | -6% | 32.709 | 0% | 32.709 | 0% | 32.709 | 0% | 32.709 | 0% | 32.709 | 0% | 29.031 | -11% |
| Morgan Stanley | 5.80 | 0.00% | -5.469 | -194% | 2.159 | -63% | 3.356 | -42% | -2.545 | -144% | 0.000 | -100% | 5.800 | 0% | 5.800 | 0% | 5.800 | 0% | 3.622 | -38% |
| Merrill Lynch | 4.09 | 0.00% | -0.948 | -123% | 2.836 | -31% | 3.042 | -26% | 1.285 | -69% | 4.092 | 0% | 4.092 | 0% | 4.092 | 0% | 4.092 | 0% | 3.142 | -23% |
| Keybank | 8.00 | 0.00% | 8.005 | 0% | 8.005 | 0% | 8.005 | 0% | 8.005 | 0% | 8.005 | 0% | 8.005 | 0% | 8.005 | 0% | 8.005 | 0% | 8.005 | 0% |
| PNC Bank | 8.34 | 0.00% | 8.338 | 0% | 8.338 | 0% | 8.338 | 0% | 8.338 | 0% | 8.338 | 0% | 8.338 | 0% | 8.338 | 0% | 8.338 | 0% | 8.338 | 0% |
| National City | 12.05 | 0.00% | 12.046 | 0% | 12.046 | 0% | 12.046 | 0% | 12.046 | 0% | 12.046 | 0% | 0.000 | -100% | 12.046 | 0% | 12.046 | 0% | 12.046 | 0% |
| New York Mellon | 11.15 | 0.00% | 11.148 | 0% | 11.148 | 0% | 11.148 | 0% | 11.148 | 0% | 11.148 | 0% | 11.148 | 0% | 11.148 | 0% | 11.148 | 0% | 11.148 | 0% |
| Wells Fargo | 33.07 | 0.00% | 32.552 | -2% | 32.995 | 0% | 32.996 | 0% | 32.922 | 0% | 33.070 | 0% | 33.070 | 0% | 0.000 | -100% | 33.070 | 0% | 32.922 | 0% |
| SunTrust | 12.56 | 0.00% | 12.565 | 0% | 12.565 | 0% | 12.565 | 0% | 12.565 | 0% | 12.565 | 0% | 12.565 | 0% | 12.565 | 0% | 12.565 | 0% | 12.565 | 0% |
| Northern Trust | 4.39 | 0.00% | 4.385 | 0% | 4.385 | 0% | 4.385 | 0% | 4.385 | 0% | 4.385 | 0% | 4.385 | 0% | 4.385 | 0% | 4.385 | 0% | 4.385 | 0% |
| State Street&Trust | 13.42 | 0.00% | 13.422 | 0% | 13.422 | 0% | 13.422 | 0% | 13.422 | 0% | 13.422 | 0% | 13.422 | 0% | 13.422 | 0% | 13.422 | 0% | 13.422 | 0% |
| Deutsche Bank | 7.87 | 0.00% | 7.802 | -1% | 7.859 | 0% | 7.863 | 0% | 7.827 | -1% | 7.872 | 0% | 7.872 | 0% | 7.872 | 0% | 7.872 | 0% | 7.838 | 0% |
| Regions | 9.64 | 0.00% | 9.640 | 0% | 9.640 | 0% | 9.640 | 0% | 9.640 | 0% | 9.640 | 0% | 9.640 | 0% | 9.640 | 0% | 9.640 | 0% | 9.640 | 0% |
| U.S. Bank | 14.56 | 0.00% | 14.558 | 0% | 14.558 | 0% | 14.558 | 0% | 14.558 | 0% | 14.558 | 0% | 14.558 | 0% | 14.558 | 0% | 14.558 | 0% | 14.558 | 0% |
| Commerce | 1.37 | 0.00% | 1.368 | 0% | 1.368 | 0% | 1.368 | 0% | 1.368 | 0% | 1.368 | 0% | 1.368 | 0% | 1.368 | 0% | 1.368 | 0% | 1.368 | 0% |
| MERCANTIL | 0.54 | 0.00% | 0.538 | 0% | 0.538 | 0% | 0.538 | 0% | 0.538 | 0% | 0.538 | 0% | 0.538 | 0% | 0.538 | 0% | 0.538 | 0% | 0.538 | 0% |
| Associated | 1.58 | 0.00% | 1.577 | 0% | 1.577 | 0% | 1.577 | 0% | 1.577 | 0% | 1.577 | 0% | 1.577 | 0% | 1.577 | 0% | 1.577 | 0% | 1.577 | 0% |
| Comerica | 5.66 | 0.00% | 5.661 | 0% | 5.661 | 0% | 5.661 | 0% | 5.661 | 0% | 5.661 | 0% | 5.661 | 0% | 5.661 | 0% | 0.000 | -100% | 5.661 | 0% |
| Signature | 0.76 | 0.00% | 0.760 | 0% | 0.760 | 0% | 0.760 | 0% | 0.760 | 0% | 0.760 | 0% | 0.760 | 0% | 0.760 | 0% | 0.760 | 0% | 0.760 | 0% |
| RBS Citizens | 8.47 | 0.00% | 8.468 | 0% | 8.468 | 0% | 8.468 | 0% | 8.468 | 0% | 8.468 | 0% | 8.468 | 0% | 8.468 | 0% | 8.468 | 0% | 8.468 | 0% |
| Mitsubishi UFJ | 0.70 | 0.00% | 0.696 | 0% | 0.696 | 0% | 0.696 | 0% | 0.696 | 0% | 0.696 | 0% | 0.696 | 0% | 0.696 | 0% | 0.696 | 0% | 0.696 | 0% |
| Insurance Companies | 21.00 | 0.00% | 21.000 | 0% | 21.000 | 0% | 21.000 | 0% | 16.012 | -24% | 21.000 | 0% | 21.000 | 0% | 21.000 | 0% | 21.000 | 0% | 0.000 | -100% |
| Aggregate CC | 480.80 | 0.00% | 144.619 | -70% | 404.249 | -16% | 373.671 | -22% | 420.870 | -12% | 475.002 | -1% | 468.756 | -3% | 447.713 | -7% | 475.141 | -1% | 412.473 | -14% |

Financial Contagion – CDS Spreads

Correlation calibrated

Contagion when JP Morgan Demises

(6 banks fail in first step and crisis spreads to the second step hitting Wells Fargo and Deutsche Bank)



Systemic Risk Ratio (SRR) : Non Correlation Calibrated Case

- JP Morgan has a SRR of 46.96% implying that in aggregate the 25 US banks will lose this percentage of core capital with Citibank, Goldman Sachs, Morgan Stanley and Merrill Lynch being brought down.
- The highly likely scenario of the demise of 30% of a non-bank CDS protection seller (such as a Monoline) has a SRR of 33.38% with up to 7 banks being brought down.
- Bank of America has an SSR of 21.5%, followed by Citibank at 14.76% and then Wells Fargo at 6.88%. The least connected banks in terms of the CDS network, National City and Comerica have SSRs of 2.51% and 1.18%.
- The premise behind too interconnected to fail can be addressed only if the systemic risk consequences of the activities of individual banks can be rectified with a price or tax reflecting the negative externalities of their systemic risk impact to mitigate the over supply of a given financial activity.



Ongoing tests and Concluding Remarks

- Behavioural change – test *carry trade* strategies and *capital structure* arbitrage
- *What if* questions in 2006 : if Basel II capital relief incentives were disallowed
- Worst case of regulatory failure : concerted effort via VaR and copious micro bank level stress testing led to undercapitalization of banks
- Basel II use of AAA CDS sellers increased leverage by a factor of 65
- Our work finds no evidence that CDS market can deliver AAA cover for bank assets; **immediate repeal of Basel II re unfunded CDS cover leading to capital relief**
- Super spreader tax and fund recommended over ad hoc breakup of banks
- Further stress tests for robustness of ICE to see if .0013% capital is sufficient
- Can eigenvalue centrality be a good systemic risk proxy for % loss of core capital for the CDS participants from trigger bank?

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Financial Contagion and Systemic Risk in Network
Model of CDS and Other Credit Enhancement
Obligations of US Banks ([pdf version](#)) [[Abstract](#)]*

Simulator link [**CDS Network Simulator**](#)

<http://www.acefinmod.com/CDS1.html>

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- Amadeo Alentorn and Serafin Martinez have a Phd from the Centre for Computational Finance and Economic Agents (CCFEA), University of Essex.