Wall Street Computation 2014

Equity COLO
to
Interest Rate Swap NOLO
Jonathan Sandberg
Outline

• Background
• Computation on Wall Street
• Front Office to Back Office Computation
• Industrial automation of Markets and Trading
• Current Wall Street Computation Trends
  – ALGO/SOR COLO Infrastructure
  – Post Credit Crisis Regulation
  – NOLO Trading (speculative)
Background

• Algorithms, Complexity, Numerical Analysis
• Princeton: Non-Coherent Shared Memory Comm.
• Industrial vs. Wall Street vs. CS Theory R&D
• Morgan Stanley: Rates and Credit R&D
  – floating point inner loop optimization on the Street
• Lehman Brothers: Credit R&D
• Citi: Counterparty Valuation Adjustment Risk
• Goldman/UBS (clients): High Frequency Equity R&D
FinQuant Programming

Finance
Capital Markets
CS
The Trading Floor
Computing on Wall Street

• Massive multi-decade automation process
• Singularity in chess, driving, and rock/paper/scissors why not trading?
• Frequently modeling/computation is the rate limiting step: see *The Quant Delusion*
  – Black Scholes: Equity and FX options
  – Raneri: Securitization
  – OIS Interest Rate Swaps
  – Masters: Credit Default Swaps (Codere)
Black Scholes

Equity Option Contracts

http://www.theocc.com/webapps/historical-volume-query

\[ C(S, t) = N(d_1)S - N(d_2)Ke^{-r(T-t)} \]

\[
\begin{align*}
    d_1 &= \frac{1}{\sigma\sqrt{T-t}} \left[ \ln \left( \frac{S}{K} \right) + \left( r + \frac{\sigma^2}{2} \right) (T-t) \right] \\
    d_2 &= \frac{1}{\sigma\sqrt{T-t}} \left[ \ln \left( \frac{S}{K} \right) + \left( r - \frac{\sigma^2}{2} \right) (T-t) \right] \\
        &= d_1 - \sigma\sqrt{T-t}
\end{align*}
\]
Securitization

Steps to pricing a MBS product:
- Value the expectation by Monte Carlo Simulation
- Specify an interest rate model
- Generate interest rate paths
- Generate cash flows for each interest rate path using the prepayment model
- Calculate the total present values for cash flows for each interest rate path
- Take average for all possible present values to get the price

Interest Rate Swaps

Shows the price of two 1MM USD notional swaps as a function of a delta perturbation to the 2Y par swap rate. The first swap position is long with the fixed rate struck 0.1 basis points above the 2Y par rate. The second position is short with the fixed rate 0.1 bp less than the 2Y par rate.
Credit Default Swaps

Credit Default Swap

Protection Buyer

Periodic Payments (spread)

Default Payment

Physical Delivery (if required)

Protection Seller

Reference Entity or Basket

Figure 4. The equivalent of a binomial tree in the modeling of default in which the tree terminates and makes a payment K at default.
CDS Standard Analytics
Front to Back Computation

• New Trade Evaluation
  – 100s to millions of trades per day

• Position marking, management, and hedging
  – Equity Prices, Libor, Treasury, FX, CDS spreads

• Trading Desk P&L, Risk, and Explanatories
  – 100 K to 1 MM positions w daily MTM
  – Overnight position risk

• Division/Regional P&L, Margin, Risk, and Explanatories
  – 1 MM to 10 MM positions w daily MTM

• Firm Books & Records P&L, Regulatory Capital, and Risk
  – CVA, DVA, FVA
Automation of Multi Asset Trading
Automating Markets and Trading

• 2006 regulatory changes Reg NMS, MIFID 2
• 2010 Flash Crash 15c3-5 risk checks
  – Naked versus sponsored exchange access
• Dodd Frank
• Volcker
Internalization to Exhaust
UST Market Automation

**UST Inventory Outstanding**

Shows the outstanding positions held globally in each type of U.S. Treasury security (SIFMA).

**Daily Average Trading Volume**

Shows the average aggregate secondary trading volume in US Treasury Securities and recent Treasury/IR Futures (SIFMA).

**US Treasury Securities & IR Futures:**

1. UST Market size and composition: $8+T inventory; $500B traded daily; UST 85% ECN traded since 2006 ICAP/Brokertec, BGC/eSpeed, Tradeweb, and CME (Tbond futures); 25K UST trades/day (Fleming & Mizrach 2006). 20 MM USD is average UST trade size.
2. CME holds dominant market share in US Treasury Futures 95% in 2010. NYSE ELX is gaining market share (2.7% 2009) and recently won legal decision against CME on fungability of contracts. IR Futures predominantly ECN traded.
3. ECNs dominate Secondary UST trading since 2001 (Mizrach & Neely)
4. Note 2X growth in trading volume post ECN 2001 rollout, similar to Equity ECN trade volume growth post Reg NMS.
5. BGC and ICAP are the dominant ECN platforms for UST secondary trading of OTR and off the run UST securities (Mizrach & Neely)
6. Liquid Maturities: OTR 2Y, 5Y, 10Y, 30Y most liquid terms in secondary trading. 2Y and 5Y most liquid (Fleming & Mizrach)

**Daily Avg. Trade Volume by Maturity**

Shows the US Treasury secondary intradealer trading volume broken down by maturity through 2006 from Fleming and Mizrach.
US Equity Market Automation

Stock Mkt Vol (Daily Avg., MM Shrs.) SIFMA

Value traded (Daily Avg., $ Bils.) SIFMA
Bid Ask Spreads

Bid Ask Spread Pre/Post ECN by Term (1999 vs. 2005)

Shows the bid ask spreads in the UST market pre ECN (GovPX) and post UST moving to predominantly ECN secondary trading with eSpeed (from Mizrah).

Annex 5: Quotes vs. Screens

<table>
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<tr>
<th>Firm</th>
<th>Currency</th>
<th>Asset (M)</th>
<th>Maturity (Y)</th>
<th>Pay/Rec</th>
<th>Best Quote</th>
<th>Avg Quote</th>
<th>H-L Spread</th>
<th>ISIN/Best Quote</th>
<th>ISIN/Avg Quote</th>
<th>ISIN/Best Quote Comp</th>
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Spreads:

1. UST bid ask spreads contract 75% between voice trade GovPX data from 1999 and the eSpeed ECN data in 2005 (Mizrach).
3. ISDA reports on USD Swap bid ask spread survey in 2011 showing .38 bps on average and 1.3 bps worst case.
5. [www2.isda.org/agachment/MTY2NQ==/ISDATestReport.pdf](www2.isda.org/agachment/MTY2NQ==/ISDATestReport.pdf)

Summarizes the ISDA survey of swap market bid ask spreads differences between RFQs and broker screen levels.
Current Trends

• Market Microstructure
• ALGO/SOR COLO Infrastructure
  – ALGO Algorithmic Trading
  – SOR Smart Order Routing
  – COLO Colocation w. Exchange Matching Engines
• Post Credit Crisis Regulation
  – Extend REG NMS ideas to OTC Derivatives
• Multiple Asset NOLO Trading
  – Optimal trading location varies w. time
Efficient Market Hypothesis
Market Microstructure
ALGO/SOR/Exchange Infrastructure

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<th>COLO A</th>
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<td>Carteret</td>
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ALGO/SOR/Exchange Infrastructure

Nasdaq SIP

Global Trading Systems
Hudson
Quantlab
Tower Research

Native Exch Mkt Data

Algo  SOR  Gw  Norm  Gw

BATS/DE
NYSE
NASDAQ

Message Bus

Exchange COLO

Agg COLO

PB Audit/OATS

(80, 0.5) mic

(210, 37.5) mic

(500, 200) ms
COLO Infrastructure: THOR Patent

http://www.google.it/patents/US8489747
Post Credit Crisis Regulation

• The Volker Rule (mid 2015)
• Substituted Compliance (US EU jurisdiction)
• Manipulated ISDAFix Broken
• Swap Execution Facilities Arrive
• Swap Data Repositories Go Live
• Swap Futures Spread

COLO to NOLO Trading
NOLO Trading: \( f(t) = c \)

"Optimal intermediate trading node locations (small circles) for all pairs of 52 major securities exchanges (large circles)....from 2008 data reported by the World Federation of Exchanges."

A. D. Wissner-Gross and C.E. Freer Relativistic statistical arbitrage
Physical Review E 82, 056104 (2010)
NOLO Trading: \( f(t) \) not constant

<table>
<thead>
<tr>
<th>Micro sec</th>
<th>Loc</th>
<th>Msg</th>
<th>Amt</th>
<th>Price</th>
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<td>VWAP</td>
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<tr>
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Assumptions:
1. Maximize exclusive arbitrage window at \( f(t) \)
2. \( f(t) \) moves in the direction of the greatest expected profit
3. \( f(t) \) moves in the direction of the best expected market data.
Summary

• Efficient Market Hypothesis vs. Market Microstructure

http://www.celent.com/reports/execu-on-quality-nyse-market-7
Quantitative Changes

Goldman and the OIS gold rush
How fortunes were made from a discounting change

Matt Cameron, Risk Magazine, Goldman and the OIS gold rush
Massive Floating Point Supply
Industrial Scale MultiAsset Automation

Algos in Futures Markets

January 29, 2014 – 5 pm → The Westin New York Grand Central

Join us for a panel discussion on the evolution of algorithmic trading in the futures market, moderated by TABB Group.

Matt Simon, Senior Analyst, TABB Group.

Our panel of experts will discuss:

- Factors driving the use of automated trading strategies in derivatives markets
- The rationale behind existing futures algorithms offered by FCMs and independents
- Regulation, including opinions around the CFTC Concept Release on Automated Trading
- The latest requirements from buy-side futures traders to minimize execution costs
- “Algos of the future” – spanning across geographies and asset classes

Speakers

- Andrew Keane, Global Head, Algo Trading, Listed Derivatives, CitiBank
- James Deighton, Head of Futures Electronic Trading, Wells Fargo Securities
- Greg Wood, Director, Algorithmic Execution, Listed Derivatives & Foreign Exchange, Deutsche Bank Securities

Fidessa

Fixed Income 2014:

01.16.14
The TimesCenter
NYC

Breaking Rates

Equity Trading 2014:
Efficiency & Disorder
5.20.14 • Grand Hyatt, NY
Summary

• Low Latency gateways for sponsored exchange access
• Market Data Feeds & Parsers
• Algo Servers for pretrade inventory/market analysis
• AVX2/AVX3.2 SIMD Algo analytics code.
• Exchange-side gateways & matching engines
• Broker Regulatory Reporting OATS/CATS
  – http://www.sifma.org/cat-resources/

and
Multi Asset NOLO Traders