High-Performance Computing (HPC) Solutions for Financial Engineering and Risk Management

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Joint project

- The Financial Engineering and Risk Management Lab (FERM Lab) of the Higher School of Economics, Microsoft and HP announced the commencement of a joint project on May 14th , 2008
- For press release in Russian please refer to http://www.microsoft.com/rus/news/issues/2008/05/ferm_lab_hp_and_microsoft_start_joint_project.mspx

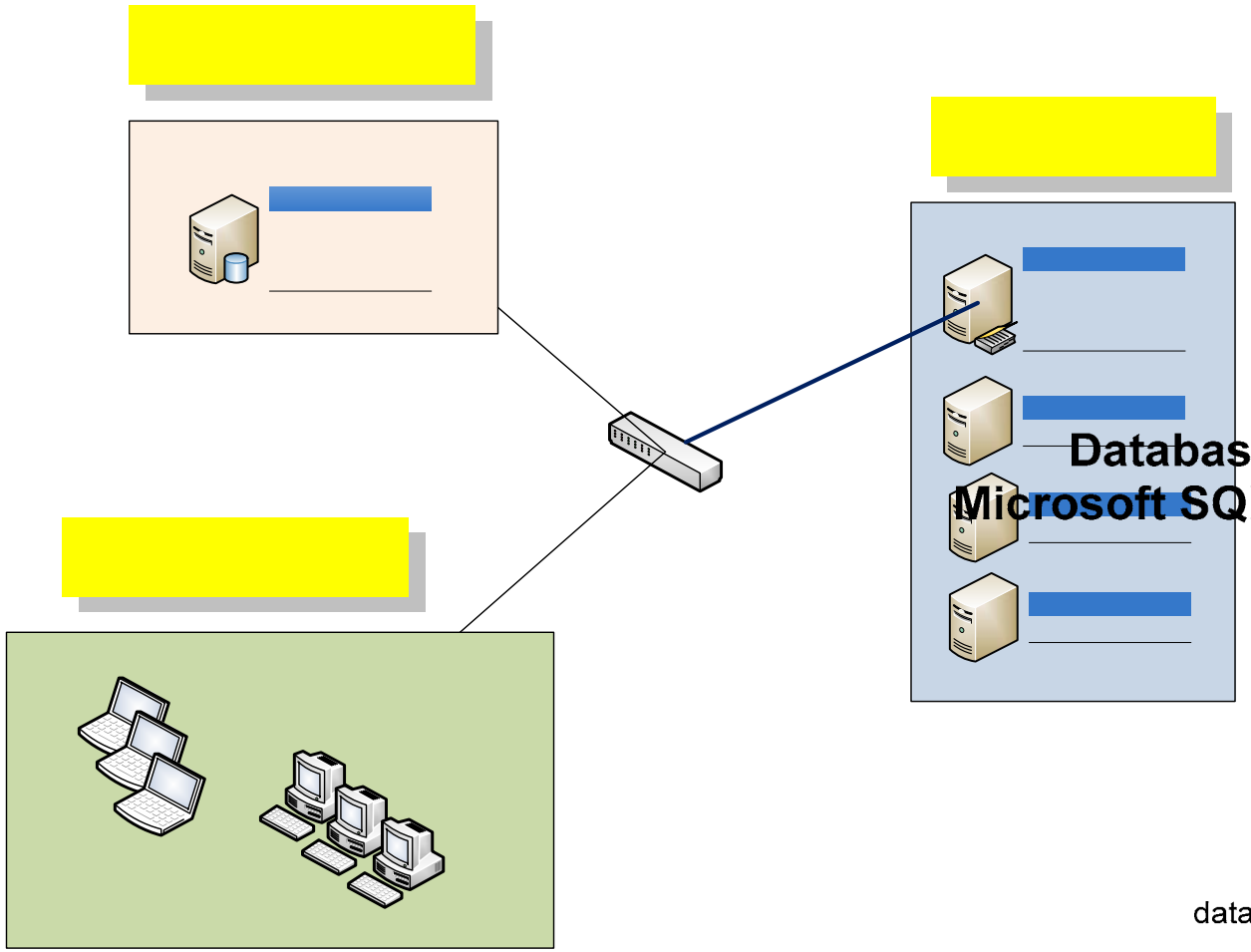
Partnership

- In this project the Lab will develop solutions for financial engineering and risk management problems arising in practice.
- Research in this field will be carried out based on the cutting-edge high performance technology provided by Microsoft and HP with the help of high performance computing (HPC) systems.

Goals of the project

- The efficient tool for the Lab to carry out sophisticated processing of high volumes of financial data is provided by Microsoft's and HP's high performance solutions. The choice of these technologies is natural as they are the most user-friendly and simple in installation, support and maintenance.
- The project should demonstrate the advantages of HPC as a powerful practical tool both for financial institutions and real sector enterprises. Joint effort of the Lab, HP and Microsoft is targeted to deliver financial engineers and risk managers cost-efficient solutions for computer intensive problems, including financial data collection, processing and analysis.

Network Architecture



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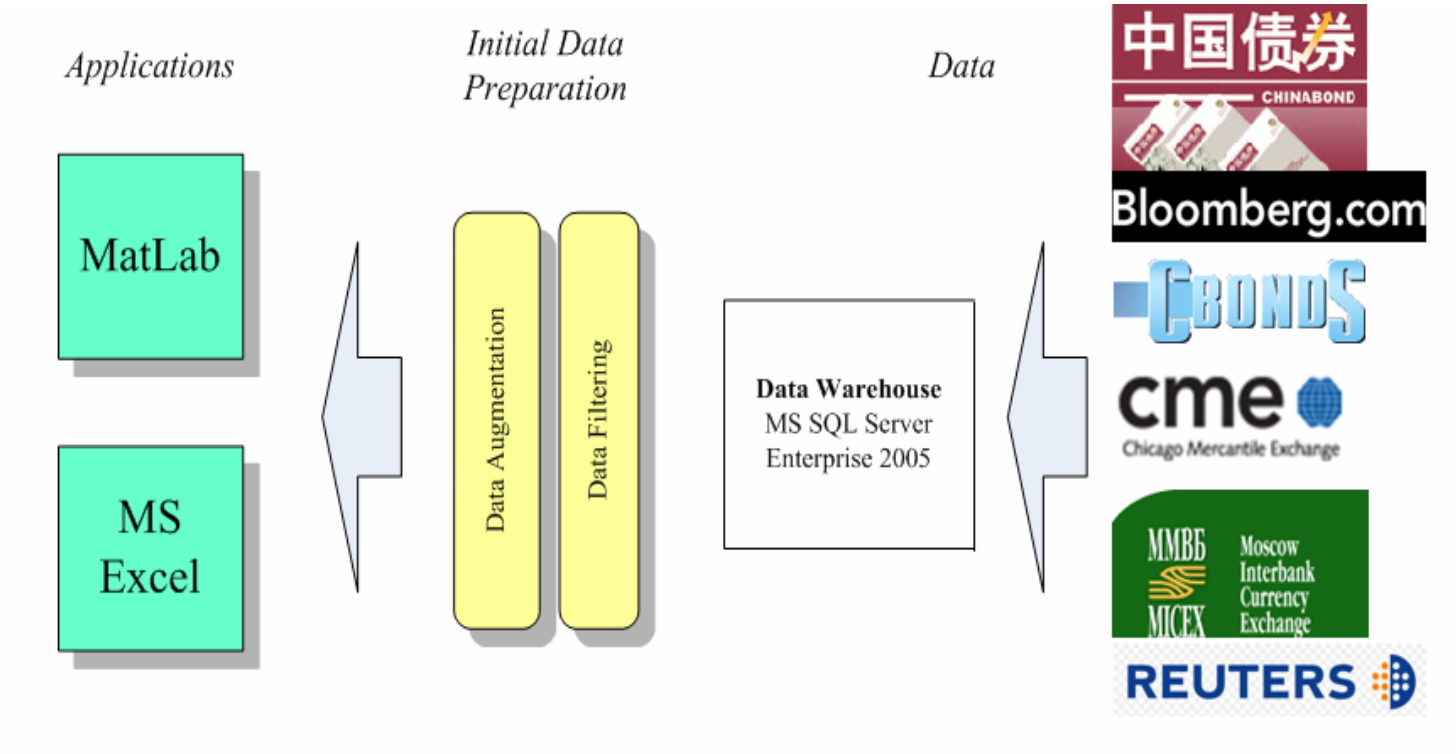
Data handling



Databases and Data Sources.

- MICEX equity market (MICEX).
- MICEX bonds market (MICEX, cbonds, Bloomberg).
- Russian EuroBonds (cbonds, Bloomberg)
- Shanghai SE bonds market (ChinaBond, Bloomberg).
- Derivatives market, FTSE100 Index family (Bloomberg).
- Derivatives market, DAX Index family (Bloomberg).
- Derivatives market, S&P500 Index family (CME, Bloomberg).

What is Financial Engineering

- Financial engineering is the application of mathematical methods to the solution of problems in finance.
- Investment banks, commercial banks, hedge funds, insurance companies, corporate treasuries, and regulatory agencies employ financial engineers for new product development, valuation of derivative financial instruments, portfolio structuring, risk management, etc.
- Quantitative analysis has brought innovation, efficiency and rigor to financial markets and to the investment process. As the pace of financial innovation accelerates, the need for highly qualified people with specific training in financial engineering continues to grow in all market environments.

From IAFE website

What is Financial Engineering

Financial engineering involves the development and creative application of financial theory and financial instruments to structure solutions to complex financial problems and to exploit financial opportunities. Financial engineering is not a tool. It is a profession that uses tools, of which derivatives are one. Importantly, financial engineering differs from financial analysis. The term “analysis” means to “decompose in order to understand.” The term “engineering” means to “build.”

Jack Marshall, Ph.D. Co-Founder of the International Association of Financial Engineers (IAFE) and its Executive Director from 1992 to 1998

Lab main research activities

- Data filtering and augmentation.
- Applied market microstructure research
- Yield curve fitting and modelling
- Pricing for derivatives and structured financial products
- Measuring portfolio credit risk

Data filtering and augmentation

- Given the ongoing turmoil in the traditional financial markets, more and more investors turn their attention to emerging markets. However, financial institutions working in these markets are challenged with low liquidity of their asset holdings.
- The distinctive feature of this kind of markets is the low reliability of market prices and quotes and missing data problem.
- The Lab develop filters for inadequate market quotes, on one hand, and MCMC procedures for filling the gaps in high frequency data on illiquid instruments in order to construct adequate estimate for probability distribution of portfolio value and derive correct risk measures from this distribution.

Market microstructure research

- Conventional risk management models widely used by the practitioners do not account for the actual cost of asset holding liquidation. However, liquidation value of a portfolio can differ significantly from its market-to-market value in case they have to assess and manage market liquidity risk.
- Understanding this sort of risk requires knowledge of market microstructure, including market clearing mechanisms and optimal trade execution, in order to the design of strategies to optimize transaction costs and market risk.
- Liquidity fluctuations are studied because of their particular importance for extreme price movement. The market resilience is modelled using real data with complete order book market information

Yield curve fitting and modelling

- To calculate Present Value of future cash flows, the corner stone of investment analysis, it is necessary to know term structure of interest rates. This can be estimated from the market prices of debt instruments by fitting a zero coupon yield curve.
- The Lab has developed robust method for zero coupon yield curve construction taking into account low liquidity of the market, in particular using data filtering and augmentation.
- To describe yield curve evolution (in particular for pricing interest rate derivatives) a stochastic dynamic is studied in a way consistent with fitting procedures.

Pricing for derivatives and structured financial products

- The Lab recently started development of models that will allow for more adequate pricing of derivatives, portfolio management, risk assessment, liquidation strategies, etc. taking into consideration market imperfections, such as transactions costs, market liquidity. Calibration of the models is performed using high frequency real data.
- Such type of models typically have no close-form solution and solved numerically, using Monte-Carlo simulations, thus computationally intensive and suitable for parallel computing.

Measuring portfolio credit risk: estimating PD

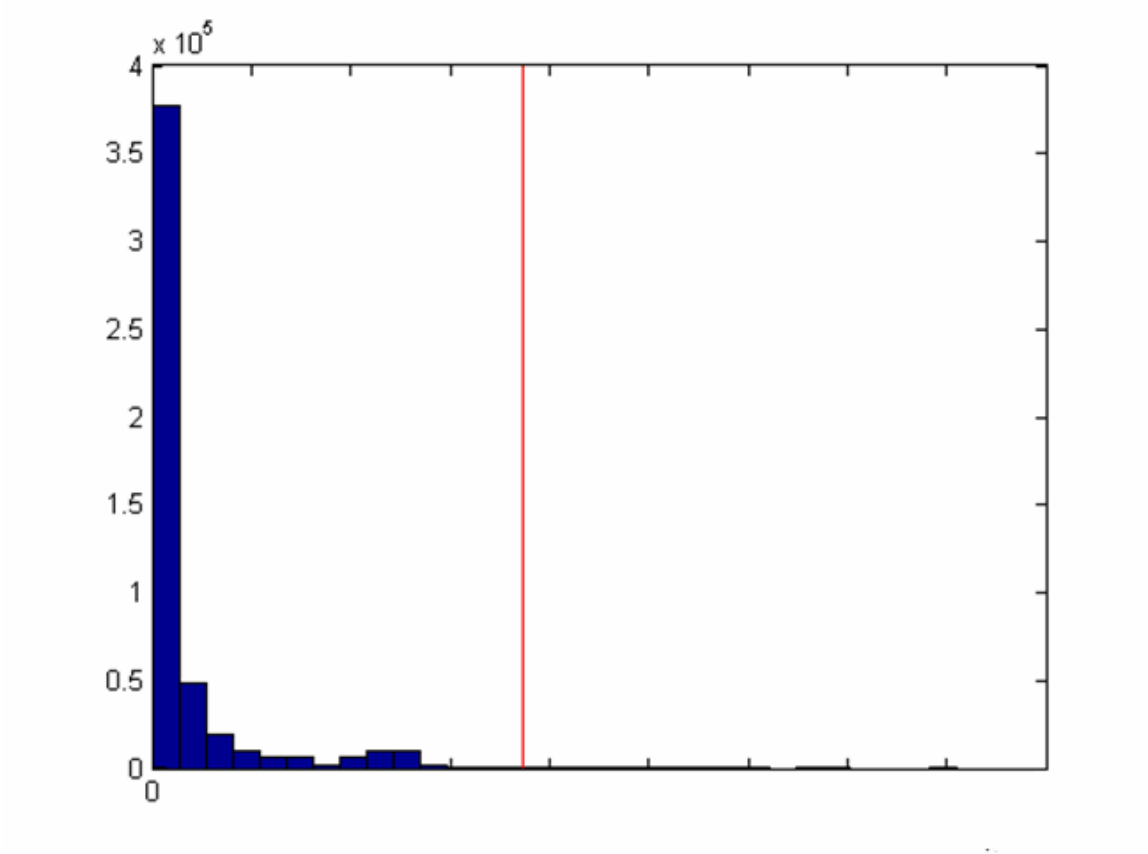
Lab use different approaches to estimate PD for real cases:

- Econometric estimation of probabilities of default, based on available relevant default history, financial reporting data, industry and macroeconomic data are used to calibrate a model
- Market-based evaluation of probability of default reflect the market's sentiment of the borrower's soundness accommodate to changes in his solvency faster than credit ratings.
  - *Structural models* assume that default occurs when the value of a firm's assets is lower than that of its liabilities.
  - *Reduced-form models* estimate default intensities treating default as unpredictable event, the parameters are derived from the credit spreads
  - *Hybrid models* attempt to reconcile several different approaches to probability of default estimation

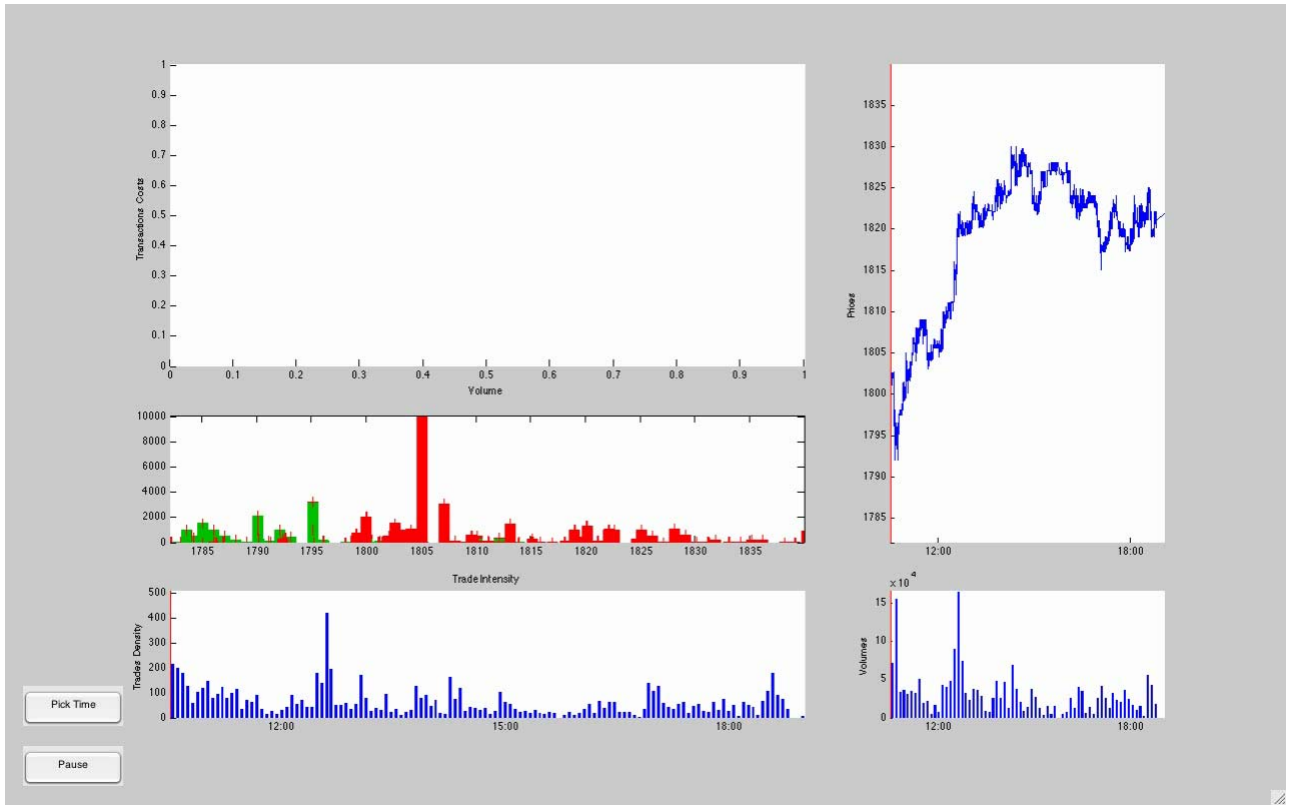
Portfolio credit risk: concentration study

- The industry sponsored metodology is the Vasicek portfolio credit loss model. In particular, it is the basis of the Basel II internal ratings based (IRB) approach..
- Under certain homogeneity conditions, the Vasicek one factor model leads to a simple analytic asymptotic approximation of loss distribution and the VaR. The approximation works well when the portfolio is of large size and there is no exposure concentration in presence, i.e., the portfolio is not dominated by a few loans.
- However, the Vasicek one factor model can not detect exposure concentration and inhomogeneity of sensitivities and PDs when it is inherent in the portfolio. It tends then to underestimate risk. One of possible way of analyzing portfolio in this case is to use Monte-Carlo simulations.

Risk-based assessment of Deposit Insurance Fund adequacy : case of Russia, 2008

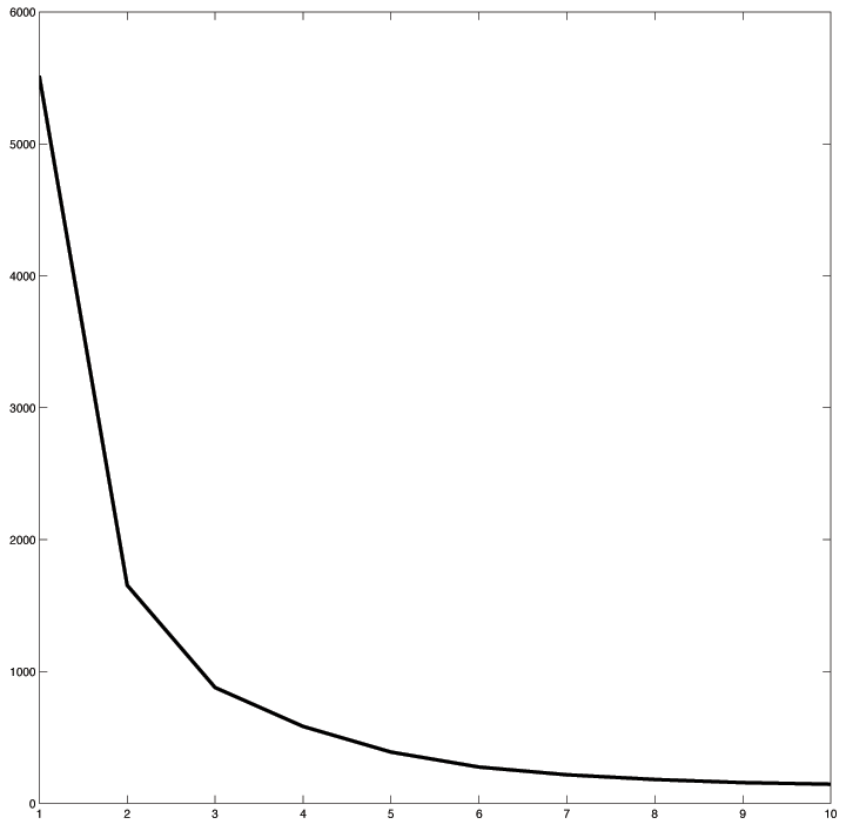


Market microstructure: case of MICEX, January 2006



Positions liquidation

(Lukoil shares)



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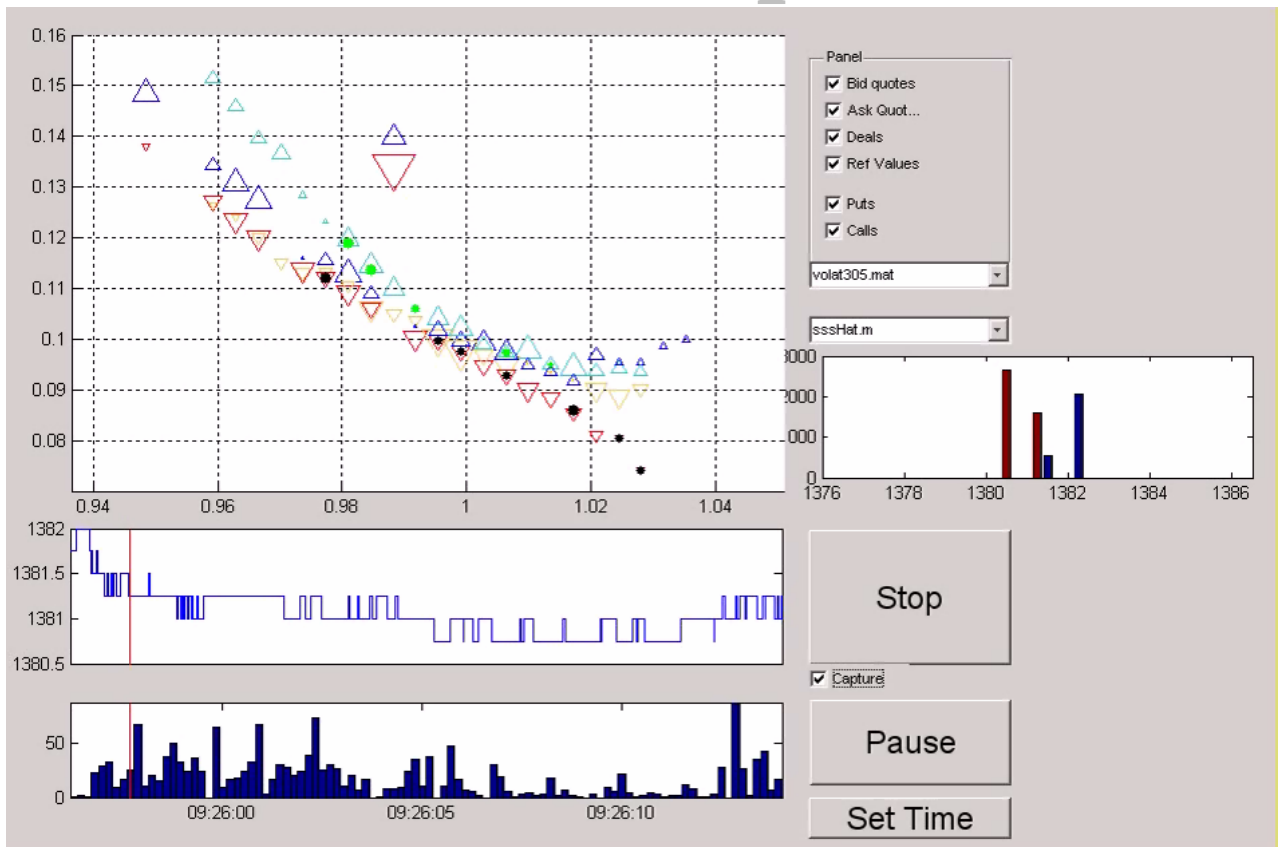
Market microstructure: case of CME E-mini® S&P 500® futures and options



Thank you for attention.

Questions?