Math Methods – Financial Price Analysis

Spring 2023, Mathematics, GR5360

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The dates of seminars

1. 1/21/2023;
2. 1/28/2023;
3. 2/4/2023;
4. 2/11/2023 (HW1 given out);
5. 2/18/2023;
6. 2/25/2023;
7. 3/4/2023;
8. 3/11/2023 (HW2 given out);
9. 3/25/2023;
10. 4/1/2023;
11. 4/8/2023 (Practical Project given out);
12. 4/15/2023;
13. 4/22/2023 (Practical Project presentations).

SEMINAR TIME: Saturdays, 7:00 PM – 9:20 PM

SEMINAR ROOM: 312 Mathematics Building

GRADE = ATTENDANCE (20%) + HWs (40%) + PROJECT (40%)

Tentative subjects to be covered

1. Can casino be beaten? Ed Thorp. Blackjack. Basic strategy. Card counting. Position sizing. Fixed-fraction betting. Kelly optimal betting. The combined strategy. St. Petersburg Paradox. Can markets be beaten? James Simons, Ed Thorp, J. Doyne Farmer, J.-P. Bouchaud. Sample CTA/hedge funds equity curves and performance characteristics.
   References for "gambling, blackjack": Book8, Book14, Book16, Book23, Book24, Book25, Book26, Book27, Book28, Article116, Article117, Article118, Article119, DVD1, DVD2, DVD3.
   References for "hedge funds, general": Book15, Book18, Book29, Article3, Article102, Article103, Article104, Article114, Article116, Article121.

2. Working with financial data. Futures markets: exchanges, expirations (maturities). Conventions. Back-adjustment techniques. Equities. Exchanges. Data Sources. Fundamental Equities Data. Data Sources.
   References for financial data are the data providers: Bloomberg, CQG, CME, TickData.com, CRSP, etc.

3. Is there order in Pi? Counting frequencies of chains of same digits in Pi and comparing with the fully random case. Elementary notions of statistics, or particularly, of "statistical fluid mechanics" or of "statistical turbulence" theory. Probability Density Function. Mean. Stationary process. Fourier transform of a random process. Correlation function. Structure function. Gaussian variables and other distribution functions, their properties. Measurements of functions of price differences over time in real markets. Notions of scale invariance, self-similarity. Power laws.
   References for "statistics": Book1, Book2, Book3, Book4, Book6, Book7.

4. Elementary notion from Statistical Physics: Brownian motion or Random Walk. Its discrete definition and exact solution. Langevin equation. Continuous random walk. Log-Brownian motion. Mean-reversion model (Ornstein-Uhlenbeck process). Computer simulations of both for various values of parameters.
   References for "random walk": Book30.

5. Counting the lengths of chains of price change signs "+" and "-" in the S&P 500 futures: first deviation from Random Walk: Long memory Effects. Second deviation from Random Walk: Counting "c"ontinuations and "r"eversals: evidence of mean-reversion. Physical meaning of auto-correlation. Memory in stochastic processes: short-range memory vs. long-range memory. Relationship to the "energy" spectrum: 1/f^0=const, 1/f^2, 1/f^1- noises. Variance as a function of time-shift in relationship to Random Walk and Mean-Reverting Process. More deviations from Random Walk: non-Gaussian effects (fat tails), long memory of volatility and absolute value of price changes. Variance Ratio test. Andrew Lo's expansion for the Variance Ratio test. Trend-

following and mean-reversion properties through the Variance Ratio test. Examples from the detailed measurements in the S&P 500 E-mini futures. Intra-day seasonality effects.
References for "deviations from Random Walk": Book1, Book3, Book4, Book5, Article67, Article68, Article111.

6. Response functions. Push-response functions (or push-response diagrams) and other response functions. Mean-reversion and trend-following through the response functions.
References for "push-response diagrams": Article43, Article44, Article45, Article46, Article113.

7. More complex Probability Density Functions (PDFs): Levy distribution. Definitions of Symmetric and Asymmetric Levy distribution functions. Analytical formulas relevant for Levy distribution function: Asymptotical series expansion for the pdf for small fluctuations and for large fluctuations limits; asymptotical behavior of structure functions (multi-scaling behavior or intermittency). Direct measurements of Levy exponent in high-frequency price differences of S&P 500 E-Mini futures market. Multi-scaling (Bi-scaling) behavior in the S&P 500 E-Mini futures. Inference of the Levy exponent from the scaling laws of structure functions of high-frequency price differences for the S&P 500 E-Mini futures. Consistency of direct PDF measurements and structure functions scaling law measurements for the S&P 500 E-Mini futures. Option pricing using Levy distributions.
References for "Levy or power-law distributions": Book1 (specifically), Book2, Book3, Book4 (specifically), Book21, Book22, Article11, Article21, Article31, Article37, Article41, Article50, Article55, Article63, Article64, Article65, Article66, Article78, Article88, Article89, Article101, Article111, Article 124.

8. Analogies between the high-frequency finance and the physics of fluid turbulence. Universal scaling laws, fat tails, intermittency. Multi-scaling behavior: universal scaling laws in low-order moments and divergence of high-order moments. Random-force-driven Burgers equation and its similarity to the S&P 500 index.
References for "Analogies with Turbulence": Book1, Book4, Book6, Book7, Article127, Article125, Article17, Article18, Article19, Article48, Article126, Article128.

9. Limit order book (LOB). Data available for: S&P 500 E-mini, Russell 2000 E-mini. More non-Brownian behavior: long memory of market order signs. Long memory of the absolute value of price differences. LOB controversy: a strong predictability of market order signs, absolute value of price changes and near absence of price predictability. Interplay between the supply and demand. Universal scaling laws, power laws. Intra-day seasonality in the limit order books. Introduction of "mu"-variable – a market order that takes a large fraction of immediately available supply. Predictability of mu-variable. Detailed example: S&P 500 E-mini LOB statistics.
References for "Limit Order Book Statistics": Article12, Article22, Article51, Article52, Article53, Article56, Article57, Article72, Article74, Article75, Article76, Article77, Article78, Article79, Article80, Article81, Article87, Article93, Article94, Article95, Article97, Article98, Article99, Article100, Article101.

10. Stock prices measurements. Sector-by-sector analysis of stock push-response diagrams and variance ratio tests.
    References for "Stock Prices Measurements": Book1, Book5, Article32, Article34, Article35, Article42, Article43, Article44, Article45, Article46, Article47, Article67, Article68.

11. Buying Winners and Selling Losers: Investigation of Momentum by Jegadeesh & Titman (JT93). Present Day Direct Momentum Measurements: Does it Exist? Does It Survive the Transaction Costs? Fundamental stock data analysis and Accounting variables. The Notion of Value. EPS forecasting via stochastic regressions. Some inefficiencies (non-Brownian) behavior in stock prices conditional on certain fundamental variables.
    References for "Fundamental Stock Data Analysis": Article2, Article6, Article14, Article15, Article20, Article25, Article26, Article27, Article28, Article30.

12. Elements of trading system design. Performance measures: equity curve based and trade-by-trade table based. Basic Indicator Ideas. Trend-following: "Channel Rule", and "Moving Average Crossover". Mean-reversion: "Bollinger Bands". Example of a workable yet simple mean-reverting trading system (MR System with Stops). Some in-sample testing results. Out-of-sample reality. Example of a workable yet simple trend-following trading system (Channel with Stops). Some in-sample testing results. Out-of-sample reality. Parameter in-sample optimization: full walk-though and genetic search. "Heat maps".
    The main technical reference for "Trading Systems" is Book19 (a required reading). Recommended reading material: Book9, Book10, Book18, Article58, Article90, Article91, Article103.

13. The notion of drawdown: various definitions of a drawdown. Basic properties of drawdowns: probability distribution function of drawdowns for random walk (Exponential or Poisson distribution), distributions functions of drawdowns in real liquid markets and alternative investment portfolios. "Fat tails" (as compared to exponential) of drawdown distributions in real, human-driven markets. The exact solution of a drawdown-control problem by Grossman & Zhou (1993). Portfolio optimization. Standard mean-variance or Markowitz portfolio optimization. Its deficiencies. More advanced optimization techniques: drawdown-related risk measure portfolio optimization. Comparison of statistical properties of standard deviation and average drawdown. Some examples of real-life portfolio optimizers.
    References for "Portfolio Optimization": Book13, Book20, Article16, Article17.

Useful references (books) with # of citations[1] a/o 1/5/2021

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2. Michel M. Dacorogna, Ramazan Gencay, Ulrich Muller, Richard B. Olsen, Olivier V. Pictet, "An Introduction to High-Frequency Finance." Academic Press, 2001. (**citations: 1,382**)
3. Jean-Philippe Bouchaud and Marc Potters, "Theory of Financial Risks. From Statistical Physics to Rick Management." Cambridge University Press, 2001. (**citations: 1,470**)
4. Jean-Philippe Bouchaud and Marc Potters. "Theory of Financial Risk and Derivative Pricing. From Statistical Physics to Risk Management." Cambridge University Press, 2005. (**citations: 1,238**)
5. John Y. Campbell, Andrew W. Lo, A. Craig MacKinlay, "The Econometrics of Financial Markets." Princeton University Press, 1997. (**citations: 11,604**)
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8. Thomas A. Bass, "The Predictors. How a Band of Maverick Physicists Used Chaos Theory to Trade Their Way to a Fortune on Wall Street." Henry Holt and Co., 1999. (**citations: 66**)
9. Laurence A. Connors, Linda Bradford Raschke, "Street Smarts. High Probability Short Term Trading Strategies." M. Gordon Publishing Group, 1995. (**citations: 31**)
10. Larry Connors, "Short Term Trading Strategies That Work. A Quantified Guide to Trading Stocks and ETFs." TradingMarkets Publishing Group, 2008. (**citations: 25**)
11. William J. O'Neil, "How to Make Money in Stocks. A Winning System in Good Times or Bad." McGraw-Hill, 2002. (**citations: 185**)
12. Charles P. Kindleberger, "Manias, Panics, and Crashes. A History of Financial Crises." Basic Books, Inc., 1978. (**citations: 9,138**)
13. Richard C. Grinold, Ronald N. Kahn, "Active Portfolio Management. Quantitative Theory and Applications." McGraw-Hill, 1995. (**citations: 289**)
14. William Poundstone, "Fortune's Formula. The Untold Story of the Scientific Betting System That Beat the Casinos and Wall Street." Hill and Wang, 2005. (**citations: 248**)
15. Jack D. Schwager, "Market Wizards. Interviews With Top Traders." HarperBusiness, 1989. (**citations: 269**)
16. Ralph Vince, "The New Money Management. A Framework for Asset Allocation." John Wiley & Sons, Inc., 1995. (**citations: 60**)
17. Bradley Efron, Robert J. Tibshirani, "An Introduction to the Bootstrap." Chapman & Hall, 1998. (**citations: 45,282**)
18. Ernest L. Jaffarian, Efficient Capital Management, "A Survey of the Managed Futures Industry." 2007. (**citations: 2**)

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19. Robert Pardo, “The Evaluation and Optimization of Trading Strategies.” John Wiley & Sons, Inc., 2008. (**citations: 144**)
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24. Joshua Hornik, “Mensa Guide to Blackjack”, Sterling Publishing Co., Inc., 2005. (**citations: 2**)
25. Ben Mezrich, “Bringing Down The House. The Inside Story of Six MIT Students Who Took Vegas for Millions.”, Free Press, 2003. (**citations: 69**)
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27. Don Schlesinger, “BlackJack Attack. Playing the Pros Way.” RGE Publishing, 1997. (**citations: 19**)
28. Peter A. Griffin, “The Theory of Blackjack. The Complete Card Counter’s Guide to the Casino Game of 21.”, Huntington Press, 1999. (**citations: 131**)
29. Michael Covel, “Trend Following: How Great Traders Make Millions in Up or Down Markets”, FT/Prentice Hall, 2004. (**citations: 120**)
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31. Damien Challet, Matteo Marsili, and Yi-Cheng Zhang, “Minority Games. Interacting Agents in Financial Markets”, Oxford University Press, 2005. (**citations: 578**)

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2. Clifford S. Asness, "The Interaction of Value and Momentum Strategies", Financial Analysis Journal, vol. 53, no. 2 (March/April 1997). (**citations: 392**)
3. Clifford S. Asness, "The Future Role of Hedge Funds", CFA Institute, cfapubs.org, June 2006. (**citations: 4**)
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6. Clifford S. Asness, Tobias J. Moskowitz, and Lasse H. Pedersen, "Value and Momentum Everywhere", AQR Capital Management, LLC, June 2008. (**citations: 2,197**)
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9. G. Bonanno, G. Caldarelli, F. Lillo, S. Micciche, N. Vandewalle, and R. N. Mantegna, "Networks of Equities in Financial Markets", arXiv:cond-math, January 2004. (**citations: 424**)
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14. Warren Buffett, "The Superinvestors of Graham-and-Doddsville", Hermes, The Columbia Business School Magazine, May 1984. (**citations: 169**)
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16. Alexei Chekhlov, Stanislav Uryasev, Michael Zabarankin, "Portfolio Optimization With DrawDown Constraints", University of Florida Preprint, January 2003. Also in: Supply Chain and Finance, Series on Computers and Operations Research, Vol. 2, Eds.: Panos M. Pardalos, Athanasios Midgalas, George Baourakis, Chapter 13, World Scientific, 2004. (**citations: 146**)

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22. Zoltan Eisler, Janos Kertesz, and Fabrizio Lillo, “The Limit Order Book on Different Time Scales”, arXiv:physics.data-an, May 2007. (**citations: 23**)
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27. Narasimhan Jegadeesh and Sheridan Titman, “Profitability of Momentum Strategies: An Evaluation of Alternative Explanations”, The Journal of Finance, Vol. LVI, No. 2, April 2001. (**citations: 3,147**)
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