Market Microstructure
Ph.D. Mini-Course

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Monday, September 23, through Thursday, September 26, 2019
9:00–12:00 and 13:30–15:00, HHS, Stockholm

Content. Market microstructure combines theoretical modelling, institutional understanding, and empirical analysis to understand how prices result from the interactions of traders in financial markets. This will be an idiosyncratic course which emphasizes my own, mostly-theoretical contribution.

Course credit. Students are required to:

- Complete required homework problems.
- Write a 5-page discussion of a small set of papers assigned at the end of the course in lieu of an exam.

Both requirements are to be completed after the lectures have finished.

Format. 18 hours of lectures over four days.

Course Outline

Day 1

History of trading. Industrial organization of markets. History of market microstructure ideas. Dealers as market makers. Organized exchanges. Tick size.

- Joel Hasbrouck. Securities trading: Principles and procedures. Technical report, NYU. Available at `http://pages.stern.nyu.edu/~jhasbrou/TeachingMaterials/STPPms12a.pdf`, 2016.
- Holbrook Working. Futures trading and hedging. *American Economic Review*, 43(3):314–343, 1953.

Normal backwardation. Inventory models. The efficient markets hypothesis.

- Hans R Stoll. The supply of dealer services in securities markets. *The Journal of Finance*, 33(4):1133–1151, 1978*a*.
- Hans R Stoll. The pricing of security dealer services: An empirical study of nasdaq stocks. *The Journal of Finance*, 33(4):1153–1172, 1978*b*.
- Sanford J. Grossman and Merton H. Miller. Liquidity and market structure. *The Journal of Finance*, 43(3):617–633, 1988.
- Stephen F. LeRoy. Efficient capital markets and martingales. *Journal of Economic Literature*, 27(4):1583–1621, 1989.

Rational expectations. Liquidity traders and noise traders. Symmetric versus asymmetric models. Perfect competition and risk aversion. Value of information.

- John F. Muth. Rational expectations and the theory of price movements. *Econometrica*, 29(3):315–335, 1961. ISSN 00129682. URL `http://www.jstor.org/stable/1909635`.
- Sanford J. Grossman and Joseph E. Stiglitz. On the impossibility of informationally efficient markets. *American Economic Review*, 70(3):393–408, 1980.
- Douglas W Diamond and Robert E Verrecchia. Information aggregation in a noisy rational expectations economy. *Journal of Financial Economics*, 9(3):221–235, 1981.
- Jean Tirole. On the possibility of speculation under rational expectations. *Econometrica*, 50(5):1163–1181, 1982. URL `DOI:0012-9682(198209)50:5<1163:OTPOSU>2.0.CO;2-7`.
- Paul Milgrom and Nancy Stokey. Information, trade and common knowledge. *Journal of Economic Theory*, 26(1):17–27, 1982.
- Martin F. Hellwig. On the aggregation of information in competitive markets. *Journal of Economic Theory*, 22(3):393–408, 1980.
- Jiang Wang. A model of intertemporal asset prices under asymmetric information. *The Review of Economic Studies*, 60(2):249–282, 1993.
- Jiang Wang. A model of competitive stock trading volume. *Journal of Political Economy*, 102(1):127–167, 1994.
- Fischer Black. Noise. *Journal of Finance*, 41(3):529–543, 1986.
- Anat R. Admati and Paul Pfleiderer. Selling and trading on information in financial markets. *American Economic Review*, 78(2):96–103, 1988.
- Bradyn Breon-Drish. On existence and uniqueness of equilibrium in a class of noisy rational expectations models. *The Review of Economic Studies*, 82(3):868–921, 2015.

Overconfidence. Higher order beliefs.

- Franklin Allen, Stephen Morris, and Hyun Song Shin. Beauty contests and iterated expectations in asset markets. *Review of Financial Studies*, 19(3):719–752, 2006.
- Snehal Banerjee, Ron Kaniel, and Ilan Kremer. Price drift as an outcome of differences in higher-order beliefs. *Review of Financial Studies*, 22(9):3707–3734, 2009.
- Jungsuk Han and Albert S. Kyle. Speculative Equilibrium with Differences in Higher Order Beliefs. *Management Science*, 64(9):4317–4332, 2018.

Day 2

Strategic trading. Adverse selection and bid-ask spreads. Dimensional analysis, leverage neutrality, and market microstructure invariance. Market impact. Informativeness of prices.

- Jack Treynor. The only game in town. *Financial Analysts Journal*, 51(1):81–83, 1995. Reprint of Walter Bagehot (pseud.), 1971, "The Only Game in Town." *Financial Analysts Journal*, 22(2): 12–14, 22.
- Albert S. Kyle. Continuous auctions and insider trading. *Econometrica*, 53(6):1315–1335, 1985. ISSN 00129682. URL `http://www.jstor.org/stable/1913210`.
- Lawrence R. Glosten and Paul R. Milgrom. Bid, ask and transaction prices in a specialist market with heterogeneously informed traders. *Journal of Financial Economics*, 14(1): 71–100, 1985.
- Kerry Back. Insider trading in continuous time. *Review of Economic Studies*, 5(3):387–409, 1992.
- Kerry Back and Shmuel Baruch. Information in securities markets: Kyle meets glosten and milgrom. *Econometrica*, 72:433–465, 2004.
- Kerry Back and Shmuel Baruch. Working orders in limit order markets and floor exchanges. *The Journal of Finance*, 62(4):1589–1621, 2007.
- Kerry Back, Henry C. Cao, and Gregory A. Willard. Imperfect competition among informed traders. *Journal of Finance*, 55(5):2117–2155, 2000.
- Douglas F. Foster and S. Viswanathan. Strategic trading when agents forecast the forecasts of others. *Journal of Finance*, 51(4):1437–1478, 1996.
- Craig W. Holden and Avanidhar Subrahmanyam. Long-lived private information and imperfect competition. *Journal of Finance*, 47(1):247–270, 1992.
- Minh Chau and Dimitri Vayanos. Strong-form efficiency with monopolistic insiders. *Review of Financial Studies*, 21(5):2275–2306, 2008.

Market microstructure invariance.

- Albert S. Kyle and Anna A. Obizhaeva. Market Microstructure Invariance: Empirical Hypotheses. *Econometrica*, 84(4):1345–1404, July 2016b.

- Albert S. Kyle and Anna A. Obizhaeva. Market microstructure invariance: A dynamic equilibrium model. Technical report, Working Paper. Available at Available at SSRN: `https://ssrn.com/abstract=2749531` or `http://dx.doi.org/10.2139/ssrn.2749531`, 2017a.

- Albert S. Kyle and Anna A. Obizhaeva. Dimensional Analysis, Leverage Neutrality, and Market Microstructure Invariants. Technical report, Working Paper. Available at `http://dx.doi.org/10.2139/ssrn.2785559`, 2017b.

- Albert S. Kyle and Anna A. Obizhaeva. Adverse selection and liquidity: From theory to practice. Technical report, Available at SSRN: `https://ssrn.com/abstract=3236030` or `http://dx.doi.org/10.2139/ssrn.3236030`, 2018b

Nasdaq tick collusion. Reg NMS and MiFiD. TRACE data. Pre-trade and post-trade transparency.

- Charles Lee and Mark Ready. Inferring trade direction from intraday data. *The Journal of Finance*, 46:733–746, 1991.

- William G. Christie and Paul H. Schultz. Why do nasdaq market makers avoid odd-eighth quotes? *Journal of Finance*, 49(5):1813–1840, 1994.

- William G. Christie, Jeffrey H. Harris, and Paul H. Schultz. Why did nasdaq market makers stop avoiding odd-eighth quotes? *Journal of Finance*, 49(5):1841–1860, 1994.

- Joel Hasbrouck. Measuring the information content of stock trades. *Journal of Finance*, 46(1):179–207, 1991.

Day 3

Single-price auctions. Electronic limit order books.

- Albert S. Kyle. Informed speculation with imperfect competition. *Review of Economic Studies*, 56(3):317–355, 1989.

- Xavier Vives. Aggregation of information in large cournot markets. *Econometrica*, pages 851–876, 1988.

- Marzena Rostek and Marek Weretka. Price inference in small markets. *Econometrica*, 80 (2):687–711, 2012.

- Ronald L. Goettler, Christine A. Parlour, and Uday Rajan. Equilibrium in a dynamic limit order market. *The Journal of Finance*, 60(5):2149–2192, 2005.

- Ioanid Roşu. A dynamic model of the limit order book. *The Review of Financial Studies*, 22(11):4601–4641, 2009

- Fischer Black. Equilibrium exchanges. *Financial Analysts Journal*, 51:23–29, 1995

- Alexander Kovalenkov and Xavier Vives. Competitive rational expectations equilibria without apology. *Journal of Economic Theory*, 149:211–235, 2014. ISSN 0022-0531. doi: http://dx.doi.org/10.1016/j.jet.2013.05.002. URL `http://www.sciencedirect.com/science/article/pii/S0022053113001026`. Financial Economics.

- Jeongmin Lee and Albert S. Kyle. When are financial markets perfectly competitive? Technical report, Working Paper. Available at SSRN., 2019.

- Albert S. Kyle and Jeongmin Lee. Information aggregation with symmetry. Technical report, Working Paper, available at `http://financetheory.org/wp-content/uploads/2016/11/RM15.Lee_.pdf`, 2016.

High frequency trading. Market fragmentation. Index arbitrage. Indexing. ETFs. Trading halts, price limits, speed bumps. Short-sale restrictions. Repo. Futures markets, tailored derivatives, CCPs.

- Matthew Baron, Jonathan Brogaard, and Andrei Kirilenko. The trading profits of high frequency traders. Technical report, Unpublished working paper., 2012.

- Joel Hasbrouck and Gideon Saar. Low-latency trading. *Journal of Financial Markets*, 16 (4):646–679, 2013.

- Ana Babus and Péter Kondor. Trading and information diffusion in over-the-counter markets. *Econometrica*, 86(5):1727–1769, 2018.

- Semyon Malamud and Marzena Rostek. Decentralized exchange. Technical report, Working Paper, Swiss Finance Institute, available at `http://sfi.epfl.ch/files/content/sites/sfi/files/users/192820/public/DE.pdf`, 2016.

- Darrell Duffie and Haoxiang Zhu. Does a central clearing counterparty reduce counterparty risk? *Review of Asset Pricing Studies*, 1(1):74–95, 2011.

Stock market volatility. Realized variance. VIX.

- Xavier Gabaix, Parameswaran Gopikrishnan, Vasiliki Plerou, and Eugene H. Stanley. Institutional investors and stock market volatility. *The Quarterly Journal of Economics*, 121: 461–504, 2006

- John Y. Campbell and Albert S. Kyle. Smart money, noise trading, and stock price behavior. *The Review of Economic Studies*, 60:1–34, 1993

Asset Pricing and Liquidity.

- Robert F. Stambough and Lubos Pastor. Liquidity risk and expected stock returns. *Journal of Political Economy*, 111:642–685, 2003.

- Michael J Brennan and Avanidhar Subrahmanyam. Market microstructure and asset pricing: On the compensation for illiquidity in stock returns. *Journal of Financial Economics*, 41(3):441–464, 1996.

- David Easley, Soeren Hvidkjaer, and Maureen O'hara. Is information risk a determinant of asset returns? *Journal of Finance*, 57(5):2185–2221, 2002.

Margins and capital requirements. Bubbles, contagion, wealth effects, short-sale constraints.

- Albert S. Kyle and Wei Xiong. Contagion as a wealth effect. *Journal of Finance*, 56(4): 1401–1440, August 2001. doi: 10.1111/0022-1082.00373. URL `https://onlinelibrary.wiley.com/doi/abs/10.1111/0022-1082.00373`.
- José A. Scheinkman and Wei Xiong. Overconfidence and speculative bubbles. *Journal of Political Economy*, 111:1183–1219, 2003.

Day 4

Smooth trading. Liqudity and time.

- Fischer Black. Toward a fully automated exchange, part i. *Financial Analysts Journal*, 27: 29–34, 1971.
- Dimitri Vayanos. Strategic trading and welfare in a dynamic market. *Review of Economic Studies*, 66(2):219–254, 1999.
- Albert S. Kyle, Anna A. Obizhaeva, and Yajun Wang. Smooth Trading with Overconfidence and Market Power. *Review of Economic Studies*, 85:611–662, March 2018. URL `\url{https://doi.org/10.1093/restud/rdx017}`.
- Songzi Du and Haoxiang Zhu. What is the optimal trading frequency in financial markets? *The Review of Economic Studies*, 84(4):1606–1651, 2017.
- Darrell Duffie. Presidential address: Asset price dynamics with slow-moving capital. *Journal of Finance*, 65(4):1237–1267, 2010.
- Francis Longstaff. Optimal portfolio choice and the valuation of illiquid securities. *Review of Financial Studies*, 14:407–431, 2001.

Funding and trading liquidity. Square root model.

- Myron S. Scholes. The market for securities: Substitution versus price pressure and the effects of information on share prices. *The Journal of Business*, 45(2):179–211, April 1972.
- Thomas Loeb. Trading cost: The critical link between investment information and results. *Financial Analysts Journal*, 39:39–44, 1983.
- André F. Perold. The implementation shortfall: Paper versus reality. *Journal of Portfolio Management*, 14(3):4–9, Spring 1988
- Barra. *Market Impact Model Handbook*. Berkley, CA: Barra, 1997

- Yakov Amihud. Illiquidity and stock returns: Cross-section and time-series effects. *The Journal of Financial Markets*, 5:31–56, 2002.
- James J. Angel, Lawrence E. Harris, and Chester S. Spatt. Equity trading in the 21st century: An update. *Quarterly Journal of Finance*, 5(01):1550002, 2015. doi: DOI:10.1142/S2010139215500020.
- Robert Almgren and Neil Chriss. Optimal execution of portfolio transactions. *Journal of Risk*, 3:5–39, 2000.
- Joel Hasbrouck. Trading costs and returns for us equities: Estimating effective costs from daily data. *The Journal of Finance*, 64(3):1445–1477, 2009.
- Albert S. Kyle and Anna A. Obizhaeva. The Market Impact Puzzle. Technical report, Working Paper. Available at `https://papers.ssrn.com/sol3/papers.cfm?abstract\_id=3124502`, 2018a.
- Jean-Philippe Bouchaud, Doyne J. Farmer, and Fabrizio Lillo. How markets slowly digest changes in supply and demand. In *Handbook of Financial Markets: Dynamics and Evolution*, pages 47–160. North Holland, 2009.
- Alfonso Dufour and Robert F. Engle. Time and the price impact of a trade. *Journal of Finance*, 55(6):2467–2598, 2000.
- Shrihari Santosh. The speed of price discovery: Trade time vs. clock time. Technical report, Available at SSRN: `https://ssrn.com/abstract=2567486`, 2016.

Market crashes. Trading costs. Flash crash. Stock market crashes. 1987 crash.

- Andrei Kirilenko, Albert S Kyle, Mehrdad Samadi, and Tugkan Tuzun. The flash crash: High-frequency trading in an electronic market. *The Journal of Finance*, 72(3):967–998, 2017.
- Michael J. Brennan and Eduardo S. Schwartz. Portfolio insurance and financial market equilibrium. *Journal of Busines*, 62:455–472, 1989.
- Albert J. Menkveld and Bart Z. Yueshen. Anatomy of the Flash Crash. Technical report, Working Paper, 2013.
- Albert S. Kyle and Anna Obizhaeva. Large Bets and Stock Market Crashes. Technical report, Working Paper. Available at SSRN: `https://ssrn.com/abstract=2023776orhttp://dx.doi.org/10.2139/ssrn.2023776`, 2016a.

Market design. High frequecy trading. Flow trading.

- Eric Budish, Peter Cramton, and John Shim. The High-Frequency Trading Arms Race: Frequent Batch Auctions as a Market Design Response. *Quarterly Journal of Economics*, 130(4):1547–1621, November 2015.

- Albert S. Kyle and Jeongmin Lee. Toward a fully continuous exchange. *Oxford Review of Economic Policy*, 33(4):650–675, November 2017. URL `https://doi.org/10.1093/oxrep/grx042`.

- Darrell Duffie and Haoxiang Zhu. Size discovery. *Review of Financial Studies*, 30(4):1095–1150, 2017.

Price manipulation. Cash Settlement. LIBOR. Corners and squeezes. Spoofing.

- Albert S. Kyle and S. Viswanathan. How to define illegal price manipulation. *The American Economic Review*, 98(2):274–279, 2008.

- Sergei Glebkin. Liquidity versus information efficiency. Technical report, Working Paper, INSEAD., 2019.

- Yuliy Sannikov and Andrzej Skrzypacz. Dynamic trading: Price inertia and front-running. Technical report, Working paper. Available at SSRN., 2016.

- Praveen Kumar and Duane J. Seppi. Futures manipulation with "cash settlement". *Journal of Finance*, 47(4):1485–1502, 1992. ISSN 00221082. URL `http://www.jstor.org/stable/2328948`.

- Jos Van Bommel. Rumors. *Journal of Finance*, 58(4):1499–1520, 2003.

- Markus K. Brunnermeier and Lasse H. Pedersen. Predatory trading. *Journal of Finance*, 60(4):1825–1863, 2005.

Books

- Larry Harris. *Trading and Exchanges: Market Microstructure for Practitioners*. Oxford University Press, USA, 2002. ISBN 0195144708. URL `http://www.amazon.com/Trading-Exchanges-Market-Microstructure-Practitioners/dp/0195144708`.

- Maureen O'Hara. *Market Microstructure Theory*. Blackwell Publishing Ltd, 1995. ISBN 1557864438

- Joel Hasbrouck. *Empirical Market Microstructure: The Institutions, Economics, and Econometrics of Securities Trading*. Oxford University Press, USA, 2007. ISBN 0195301641. URL `http://www.amazon.com/Empirical-Market-Microstructure-Institutions-Econometrics/dp/0195301641`.

- Richard C. Grinold and Ronald N. Kahn. *Active Portfolio Management*. Probus Publishing, 1995.

- Andrei Shleifer. *Inefficient Markets: An Introduction to Behavioral Finance*. Clarendon Lectures in Economics. Oxford University Press, USA, 2000. ISBN 0198292287. URL `http://www.amazon.com/Inefficient-Markets-Introduction-Behavioral-Clarendon/dp/0198292287`.

- George A. Akerlof and Robert J. Shiller. *Animal Spirits: How Human Psychology Drives the Economy, and Why It Matters for Global Capitalism.* Princeton University Press, 2009.
- Robert Shiller. *Market Volatility.* MIT Press, 1992.
- Daniel F. Spulber. *Market Microstructure: Intermediaries and the Theory of the Firm.* Cambridge University Press, 1999. ISBN 0521650259.
- Markus K. Brunnermeier. *Asset Pricing under Asymmetric Information: Bubbles, Crashes, Technical Analysis, and Herding.* Oxford University Press, USA, 2001. ISBN 0198296983. URL `http://www.amazon.com/Asset-Pricing-under-Asymmetric-Information/dp/0198296983`.
- Xavier Vives. *Information and Learning in Markets: The Impact of Market Microstructure.* Princeton University Press, 2008. ISBN 0691127433. URL `http://www.amazon.com/Information-Learning-Markets-Impact-Microstructure/dp/0691127433`.
- Thierry Foucault, Marco Pagano, and Ailsa Roell. *Market Liquidity: Theory, Evidence, and Policy.* Oxford University Press, 2013.
- Frank De Jong and Barbara Rindi. *The Microstructure of Financial Markets.* Cambridge University Press, 2009.