Econometric Analysis of Tick Data

SS 2014

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Course Description

The course covers diverse topics lying at the intersection of high-frequency financial econometrics and empirical market microstructure. While, nowadays, high-frequency financial econometrics is commonly understood as the statistical analysis of intra-day financial time series, empirical market microstructure looks at markets, rules, and traders generating these time series at the highest possible sampling frequency (tick or transactions data), and analyzes policy implications.

PART I first sketches out the trading process which varies with the institutional arrangements of the market under consideration. These organizational structures and the motives and behaviors of market participants lead to different degrees of data availability and quality. Consequently, there are different proxies for market variables of interest to traders and regulators. Since stochastic properties of market variables turned out to be qualitatively similar (in a statistical sense) over all asset classes, they became to be known as "stylized facts of financial markets" (Cont, 2001). Stylized facts are important as they guide the way to realistic econometric models. Yet, stylized facts of tick data (like errors, price discreteness, irregularly spaced observations, seasonality, etc.) are markedly different from those of daily or lower frequency data and, thus, call for a much more elaborate scrutiny of data as well as data-preprocessing before standard econometric techniques can be applied.

PART II presents simple economic models which help to explain some of the above stylized facts. A special role in this part is played by bid and ask prices as they convey information on the efficient price, liquidity, and uncertainty.

PART III applies time series techniques to tackle some of the issues raised in PART I. Specifically, GARCH-type models and vector autoregressions will be used to model randomly clustering observations and to analyze the process of price discovery in financial markets. The resulting insights and implications are relevant for policy makers and regulators of exchanges.

PART IV shows that tick data might also have an edge over lower frequency modeling when it comes to volatility. Tick data allows for the nonparametric estimation of latent volatility, which is known as realized volatility.

Learning Outcomes

By the successful completion of this course, students will have a solid understanding of trading processes on financial markets and the data they are generating, based on a mix of practical and theoretical insights. Likewise, they will be able to implement and check appropriate empirical models, and to discuss their

results in a balanced way.

Course Requirement/Graded Activities

Upon successful completion of this course, students will earn six ECTS points. To this end, students will have to write an empirical research paper on an extension of one of the topics covered in this course. The paper should comprise (no more than) fifteen text pages and must be submitted (along with code) within six weeks after final class.

Tutorial

The lecture is accompanied by a tutorial which will take place in the institute's Student PC Lab. This is due to the fact that, after a short recap of fundamental concepts of financial and time series econometrics, students are required to gain a substantial amount of hands-on experience concerning data handling and model implementation. These are time-consuming issues when starting from scratch but inevitable for accomplishing the final empirical research paper. Thus, it is strongly recommended to participate in the computer tutorial on a regular basis in order to reduce the research paper's workload.
The tutorial will present implementations in MathWorks' Matlab which is one of the standard software package in the financial industry. For students unfamiliar with Matlab, the tutorial will provide an introduction suitable for mastering all upcoming computational challenges. Recently, MathWorks also started to offer a Trading Toolbox which would be a natural followup on this course.

Course Readings and Material

- Dacorogna, M. M. and Gençay, R. and Müller, U. A. and Olsen, R. B. and Pictet, O. V. (2001): *An Introduction to High-Frequency Finance*. Academic Press.
- Harris, L. (2003): *Trading & Exchanges: Market Microstructure for Practitioners*. Oxford University Press.
- Hasbrouck, J. (2007): *Empirical Market Microstructure: The Institutions, Economics, and Econometrics of Securities Trading*. Oxford University Press.
- Hautsch, N. (2012): *Econometrics of Financial High-Frequency Data*. Springer.
- Lo, A. W. and MacKinlay, A. C. (2002): *A Non-Random Walk Down Wall Street*. Princeton University Press.
- O'Hara, M. (1995): *Market Microstructure Theory*. Blackwell Publishing.
- Tsay, R. S. (2005): *Analysis of Financial Time Series*. 2nd ed., Wiley.
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Course Outline

I. A Glimpse on Financial Markets and Data

1. **Anatomy of Financial Markets: Assets, Agents & Markets**
   Required readings: Dacorogna et al. (2001, Ch. 2), Harris (2003, Parts I & VII), Hautsch (2012, Ch. 2)
   Recommended readings: Hasbrouck (2007, Ch. 2 & 12), Madhavan (2000), Madhavan (2002), Shiryaev (1999, Ch. I)

2. **Data Errors & Cleaning**
   Required readings: Barndorff-Nielsen et al. (2009), Brownless and Gallo (2006)
   Recommended readings: Hautsch (2012, Ch. 3)

3. **Stylized Facts of Tick Data**
   Required readings: Dacorogna et al. (2001, Ch. 5), Hautsch (2012, Ch. 3), Tsay (2005, Ch. 5)
   Recommended readings: Goodhart and O'Hara (1997)

II. Economic Models for Tick Data Peculiarities

1. **Asynchronous Trading**
   Required readings: Lo and MacKinlay (2002, Ch. 4)
   Recommended readings: Lo and MacKinlay (1990), Tsay (2005, Ch. 5)

2. **Bid-Ask Bounce**
   Required readings: Hasbrouck (2007, Ch. 3), Tsay (2005, Ch. 5)
   Recommended readings: Roll (1984)

3. **Asymmetric-Information Perspectives on Bid-Ask Spreads**
   Required readings: O'Hara (1995, Ch. 3–6)
   Recommended readings: Admati and Pfleiderer (1988), Easley and O'Hara (1992), Glosten and Milgrom (1985), Kyle (1985)

III. Econometric Models

1. **The Autoregressive Conditional Duration Model**
   Required readings: Tsay (2005, Ch. 5)
   Recommended readings: Engle and Russell (1998), Pacurar (2008), Zhang et al. (2001)

2. **Price Formation & Informational Efficiency**
   Required readings: Hasbrouck (2007, Ch. 8–10)
   Recommended readings: Dufour and Engle (2000), Hasbrouck (1991a,b)

IV. Realized Volatility

1. **Realized Volatility & Market Microstructure Noise**
   Required readings: McAleer and Medeiros (2008)
   Recommended readings: Andersen and Bollerslev (1998), Andersen et al. (2001a,b), Zhang et al. (2005)

2. **A Heterogeneous Autoregressive Model of Realized Volatility**
   Required readings: Corsi (2009)
   Recommended readings: Aït-Sahalia and Mancini (2008), Müller et al. (1997)

3. **Market Expectations on Realized Volatility**
   Required readings: Giot and Laurent (2007)
   Recommended readings: Busch et al. (2011), Christensen and Prabhala (1998), Shiryaev (1999, Ch. VIII)

References

Admati, A. R. and Pfleiderer, P. (1988). A theory of intraday patterns: Volume and price variability. *The Review of Financial Studies*, **1** 3–40.

Aït-Sahalia, Y. and Mancini, L. (2008). Out of sample forecasts of quadratic variation. *Journal of Econometrics*, **147** 17–33.

Andersen, T. G. and Bollerslev, T. (1998). Answering the skeptics: Yes, standard volatility models do provide accurate forecasts. *International Economic Review*, **39** 885–905.

Andersen, T. G., Bollerslev, T., Diebold, F. X. and Ebens, H. (2001a). The distribution of realized stock return volatility. *Journal of Financial Economics*, **61** 43–76.

Andersen, T. G., Bollerslev, T., Diebold, F. X. and Labys, P. (2001b). The distribution of realized exchange rate volatility. *Journal of the American Statistical Association*, **96** 42–55.

Barndorff-Nielsen, O. E., Hansen, P. R., Lunde, A. and Shephard, N. (2009). Realized kernels in practice: Trades and quotes. *The Econometrics Journal*, **12** C1–C32.

Brownless, C. T. and Gallo, G. M. (2006). Financial econometric analysis at ultra-high frequency: Data handling concerns. *Computational Statistics & Data Analysis*, **51** 2232–2245.

Busch, T., Christenesen, B. J. and Nielsen, M. Ø. (2011). The role of implied volatility in forecasting future realized volatility and jumps in foreign exchange, stock, and bond markets. *Journal of Econometrics*, **160** 48–57.

Christensen, B. J. and Prabhala, N. R. (1998). The relation between implied and realized volatility. *Journal of Financial Economics*, **50** 125–150.

Cont, R. (2001). Empirical properties of asset returns: Stylized facts and statistical issues. *Quantitative Finance*, **1** 223–236.

Corsi, F. (2009). A simple approximate long-memory model of realized volatility. *Journal of Financial Econometrics*, **7** 174–196.

Dacorogna, M. M., Gençay, R., Müller, U. A., Olsen, R. B. and Pictet, O. V. (2001). *An Introduction to High-Frequency Finance*. Academic Press.

Dufour, A. and Engle, R. F. (2000). Time and the price impact of a trade. *The Journal of Finance*, **55** 2467–2498.

Easley, D. and O'Hara, M. (1992). Time and the process of security price adjustment. *The Journal of Finance*, **47** 577–605.

Engle, R. F. and Russell, J. R. (1998). Autoregressive conditional duration: A new model for irregularly spaced transaction data. *Econometrica*, **66** 1127–1162.

Giot, P. and Laurent, S. (2007). The information content of implied volatility in light of the jump/continuous decomposition of realized volatility. *The Journal of Future Markets*, **27** 337–359.

Glosten, L. R. and Milgrom, P. R. (1985). Bid, ask and transaction prices in a specialist market with heterogeneously informed traders. *Journal of Financial Economics*, **14** 71–100.

Goodhart, C. A. E. and O'Hara, M. (1997). High frequency data in financial markets: Issues and applications. *Journal of Empirical Finance*, **4** 73–114.

Harris, L. (2003). *Trading & Exchanges: Market Microstructure for Practitioners*. Oxford University Press.

Hasbrouck, J. (1991a). Measuring the information content of stock trades. *The Journal of Finance*, **46** 179–207.

Hasbrouck, J. (1991b). The summary informativeness of stock trades: An econometric analysis. *The Review of Financial Studies*, **4** 571–595.

Hasbrouck, J. (2007). *Empirical Market Microstructure: The Institutions, Economics, and Econometrics of Securities Trading*. Oxford University Press.

Hautsch, N. (2012). *Econometrics of Financial High-Frequency Data*. Springer.

Kyle, A. S. (1985). Continuous auctions and insider trading. *Econometrica*, **53** 1315–1335.

Lo, A. W. and MacKinlay, A. C. (1990). An econometric analysis of nonsynchoronous trading. *Journal of Econometrics*, **45** 181–212.

Lo, A. W. and MacKinlay, A. C. (2002). *A Non-Random Walk Down Wall Street*. Princeton University Press.

Madhavan, A. (2000). Market microstructure: A survey. *Journal of Financial Markets*, **3** 205–258.

Madhavan, A. (2002). Market microstructure: A practitioner's guide. *Financial Analysts Journal*, **58** 28–42.

McAleer, M. and Medeiros, M. C. (2008). Realized volatility: A review. *Econometric Reviews*, **27** 10–45.

Müller, U. A., Dacorogna, M. M., Davé, R. D., Olsen, R. B., Pictet, O. V. and von Weizsäcker, J. E. (1997). Volatilities of different time resolutions — Analyzing the dynamics of market components. *Journal of Empirical Finance*, **4** 213–239.

O'Hara, M. (1995). *Market Microstructure Theory*. Blackwell Publishing.

Pacurar, M. (2008). Autoregressive conditional duration models in finance: A survey of the theoretical and empirical literature. *Journal of Economic Surveys*, **22** 711–751.

Roll, R. (1984). A simple implicit measure of the effective bid-ask spread in an efficient market. *Journal of Finance*, **39** 1127–1139.

Shiryaev, A. N. (1999). *Essentials of Stochastic Finance: Facts, Models, Theory*. World Scientific Publishing Company.

Tsay, R. S. (2005). *Analysis of Financial Time Series*. 2nd ed. Wiley.

Zhang, L., Mykland, P. A. and Aït-Sahalia, Y. (2005). A tale of two time scales: Determining integrated volatility with noisy high-frequency data. *Journal of the American Statistical Association*, **100** 1394–1411.

Zhang, M. Y., Russell, J. R. and Tsay, R. S. (2001). A nonlinear autoregressive conditional duration model with applications to financial transaction data. *Journal of Econometrics*, **104** 179–207.