Economics 531: Financial Economics II
(Continuous-Time Models)

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Contact Details

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Class Time and Location

Lecture: Tuesday 13:10 - 16:10, NJ Hall 105.

Course Overview

The main purpose is to introduce students to the recent development of continuous-time modeling techniques:

(i) Various applications of **stochastic control** in economics (macroeconomics and contract theory), finance (asset pricing and theoretical corporate finance);

(ii) **high frequency econometrics**.

Students will learn how to employ the mathematical tools of stochastic control to solve various economic problems, and get to know the frontiers in high frequency econometrics.

Evaluation: homework and term project/paper.

Course Outline

Mathematical Preliminary

- **Lecture 1: Stochastic process and stochastic calculus**
  - Brownian motion and Itô process
  - Martingales and martingale representation theorem
  - Quadratic (co-)variation and Itô's formula

Part I. Stochastic Control with Applications to Financial Economics

- **Lecture 2: Deterministic control**
  - Pontryagin's maximum principle (MP): Hamiltonian systems (first-order)
  - Bellman's dynamic programming (DP): HJB equations (first-order)
  - Mathematical relationship and economic interpretation (shadow price)
- **Lecture 3: Stochastic control**

  - Pontryagin's maximum principle (MP): Hamiltonian systems (first-order and second-order)
  - Bellman's dynamic programming (DP): HJB equations (first-order and second-order)
  - Mathematical relationship and economic interpretation (shadow price and relative risk aversion)

  Reference for Lecture 1∼3: Yong, J. and X. Zhou (1999). *Stochastic Controls: Hamiltonian Systems and HJB Equations*. Springer.

- **Lecture 4: Continuous-time macroeconomics (with a financial sector)**
  Brunnermeier, M. K. and Y. Sannikov (2016). Macro, money and finance: A continuous-time approach. *Handbook of Macroeconomics 2*.

  Other references:

  - Achdou, Y., J. Han, J.-M. Lasry, P.-L. Lions, and B. Moll (2014). Heterogeneous agent models in continuous time. *Preprint*.
  - Brunnermeier, M. K. and Y. Sannikov (2016). Macro, money and finance: A continuous-time approach. *Handbook of Macroeconomics 2*.
  - Brunnermeier, M. K. and Y. Sannikov (2014). A macroeconomic model with a financial sector. *The American Economic Review 104*(2), 379–421.
  - Merton, R. C. (1975). An asymptotic theory of growth under uncertainty. *The Review of Economic Studies 42*(3), 375–393.
  - Gabaix, X., J.-M. Lasry, P.-L. Lions, and B. Moll (2016). The dynamics of inequality. *Econometrica 84*(6), 2071–2111.

- **Lecture 5: Contract-theory in continuous-time (with application to theoretical corporate finance)**
  Cvitanic, J. and J. Zhang (2013). *Contract Theory in Continuous-Time Models*. Springer.

  - First best (risk-sharing)
  - Second best (moral hazard)
  - Third best (adverse selection)

  Other references:

  - DeMarzo, P. M. and Y. Sannikov (2006). Optimal security design and dynamic capital structure in a continuous-time agency model. *The Journal of Finance 61*(6), 2681–2724.
  - Sannikov, Y. (2008). A continuous-time version of the principal-agent problem. *The Review of Economic Studies 75*(3), 957–984.

- **Lecture 6: Continuous-time finance (portfolio choice and risk-neutral pricing)**
  - Portfolio choice: Aït-Sahalia, Y., J. Cacho-Diaz, and T. R. Hurd (2009). Portfolio choice with jumps: A closed-form solution. *The Annals of Applied Probability 19*(2), 556–584.
  - Risk-neutral pricing: Schreve, S. E. (2004). *Stochastic Calculus for Finance II*. Springer.

Other references (estimating risk premia):

- Bollerslev, T. and V. Todorov (2011). Tails, fears, and risk premia. *The Journal of Finance 66(6)*, 21652211.
- Andersen, T. G., N. Fusari, and V. Todorov (2015). The risk premia embedded in index options. *Journal of Financial Economics 117*, 558–584.
- Andersen, T. G., N. Fusari, and V. Todorov (2016). The pricing of tail risk and the equity premium: Evidence from international option markets. Working paper.

Part II. High Frequency Econometrics

Recommended textbooks:

Jacod, J. and P. Protter (2011). *Discretization of Processes*. Springer.

Aït-Sahalia, Y. and J. Jacod (2014). *High Frequency Financial Econometrics*. Princeton University Press.

- **Lecture 7∼9: Stochastic volatility**
  - Barndorff-Nielsen, O. E. and N. Shephard (2002). Econometric analysis of realized volatility and its use in estimating stochastic volatility models. *Journal of the Royal Statistical Society: Series B 64*, 253–280.
  - Andersen, T. G., T. Bollerslev, F. X. Diebold, and P. Labys (2003). Modeling and forecasting realized volatility. *Econometrica 71*(2), 579–625.
  - Barndorff-Nielsen, O. E. and N. Shephard (2004b). Power and bipower variation with stochastic volatility and jumps. *Journal of Financial Econometrics 2*, 1–48.
  - Barndorff-Nielsen, O. E. and N. Shephard (2004a). Econometric analysis of realised covariation: High frequency covariance, regression and correlation in financial economics. *Econometrica 72*(3), 885–925.
  - Jacod, J. (2009). Statistics and high frequency data. Lecture notes.
  - Jacod, J. and M. Rosenbaum (2013). Quarticity and other functionals of volatility: Efficient estimation. *The Annals of Statistics 41*(3), 1462–1484.
  - Li, J., V. Todorov, and G. Tauchen (2016b). Inference theory for volatility functional dependencies. *Journal of Econometrics 193*, 17–34.
  - Li, J. and D. Xiu (2017). Generalized method of integrated moments for high-frequency data. *Econometrica 84*(4), 1613–1633.
- **Lecture 10: Factor model in continuous-time**
  - Aït-Sahalia, Y. and D. Xiu (2017). Principal component analysis of high frequency data. *forthcoming, Journal of the American Statistical Association*. Chicago Booth Working Paper No. 15-39.
  - Aït-Sahalia, Y. and D. Xiu (2016). Using principal component analysis to estimate a high dimensional factor model with high-frequency data. *Journal of Econometrics, forthcoming*.
- **Lecture 11∼13: Jump-related problems**

  Testing the presence of jumps

- Barndorff-Nielsen, O. E. and N. Shephard (2006). Econometrics of testing for jumps in financial economics using bipower variation. *Journal of Financial Econometrics 4*(1), 1–30.
- Aït-Sahalia, Y. and J. Jacod (2009b). Testing for jumps in a discretely observed process. *The Annals of Statistics 37*, 184–222.
- Aït-Sahalia, Y., J. Jacod, and J. Li (2012). Testing for jumps in noisy high frequency data. *Journal of Econometrics 168*(2), 207–222.
- Aït-Sahalia, Y. and J. Jacod (2012). Analyzing the spectrum of asset returns: Jump and volatility components in high frequency data. *Journal of Economic Literature 50(4)*, 1007–1050.

Co-jumps

- Jacod, J. and V. Todorov (2009). Testing for common arrivals of jumps for discretely observed multidimensional processes. *The Annals of Statistics 37*, 1792–1838.
- Jacod, J. and V. Todorov (2010). Do price and volatility jump together? *Annals of Applied Probability 20*(4), 1425–1469.

Jump activity index

- Aït-Sahalia, Y. and J. Jacod (2009a). Estimating the degree of activity of jumps in high frequency data. *The Annals of Statistics 37*, 2202–2244.
- Aït-Sahalia, Y. and J. Jacod (2011). Testing whether jumps have finite or infinite activity. *The Annals of Statistics 39*, 1689–1719.

Jump contagion

- Aït-Sahalia, Y., J. Cacho-Diaz, and R. J. Laeven (2015). Modeling financial contagion using mutually exciting jump processes. *Journal of Financial Economics 117*, 585–606.
- Boswijk, P. H., R. J. Laeven, and X. Yang (2017). Testing for self-excitation in jumps. working paper.
- Mardi Dungey, Deniz Erdemlioglub, M. M. X. Y. (2017). Testing for mutually exciting jumps and financial flights in high frequency data. *forthcoming in Journal of Econometrics*.

- **Lecture 14: Continuous-time regression**
  - Li, J., V. Todorov, and G. Tauchen (2017). Jump regressions. *Econometrica 85*(1), 173–195.
  - Li, J., V. Todorov, and G. Tauchen (2016a). Adaptive estimation of continuous-time regression models using high-frequency data. *forthcoming in Journal of Econometrics*.
  - Li, J., V. Todorov, and G. Tauchen (2016c). Robust jump regression. *Journal of the American Statistical Association, forthcoming*.
  - Li, J., V. Todorov, G. Tauchen, and R. Chen (2016). Mixed-scale jump regressions with bootstrap inference. *Journal of Econometrics, forthcoming*.