

**SLOAN SCHOOL OF MANAGEMENT  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY**

Andrew W. Lo

15.481

Spring 2014

## **Financial Market Dynamics and Human Behavior**

This course develops a new perspective on the dynamics of financial markets and the roles that human behavior and the business environment play in determining the evolution of behavior and institutions. Although neoclassical economic theories such as expected utility maximization, rational expectations, general equilibrium, and efficient markets have dominated the literature on economic behavior and market structure, recent advances in the cognitive neurosciences, artificial intelligence, computational social science, and evolutionary biology provide a number of new insights into market dynamics. We will draw on these diverse disciplines to develop a more complete understanding of human behavior in the specific context of markets and other economic institutions. Academic research will be the main focus of the course, but topics will be motivated and illustrated by practical applications from financial markets, the hedge fund industry, private equity, government regulation, and political economy. Using the ideas from this new perspective, we will formulate several new hypotheses regarding recent challenges to traditional finance thinking, including: how financial crises are formed and whether or not they can ever be eliminated; why certain investment strategies seem to wax and wane; where business cycles come from; what role ethics play in financial intermediation; whether capitalism is more sustainable than other political systems; and why financial engineering may be the solution to some of society's biggest challenges.

### **Class Schedule**

The class meets once per week: T 4:00–7:00pm, E51-345.

### **Recitations**

The TA, Dimitrios Bisiias (dbisias@mit.edu), will hold recitations where class material will be reviewed, and additional applications and exercises presented. Recitation sessions will take place on Fridays from 2:00 to 3:00pm in E51-335

### **Course Website**

The course website is on Stellar and all class announcements, TA office hours, project data, and additional teaching materials will be posted on this site.

### **Office Hours**

The course instructor and TA will also hold regular office hours. The times and locations will be announced on the course website.

### **Administrative Assistant**

Patricia Thompson, E62-611, 617 715-4817, pthomps@mit.edu

## Course Requirements and Grading

Course requirements include regular attendance and participation in class, which requires having read the assigned articles prior to coming to class and being prepared to discuss them (10%), three group-based projects (10% each, totaling 30%), and one 5,000-word research paper (60%) due before the end of the semester. There is no final examination for the class. The projects are:

1. Efficient Markets Revisited
2. The Power of Selection
3. AQR Delta Strategy Case Study

The research paper involves identifying and analyzing a specific business context in which human behavior departs from traditional economic logic. The analysis should include a brief literature review, a proposed explanation for the anomaly (i.e., how it arose and why it persists), and how your knowledge of this anomaly might change the way you approach business decisions in this context. Several well-executed research papers from last year will be posted on the course website to illustrate the possibilities for this project.

## Course Materials

- **Class Notes and Recitation Notes.** Notes will be available on the course website.
- **Research Articles.** Research articles will be made available on the course website.
- **Gazzaniga, M.,** 2008, *Human: The Science Behind What Makes Us Unique*. New York: HarperCollins.

## Additional Readings (not required)

B. Malkiel, *A Random Walk Down Wall Street*, W. W. Norton & Company, 2007.

- This best-selling introduction to investing is now in its 9<sup>th</sup> edition and is as popular as ever because of its entertaining style and sage advice. This is a great way to ease into financial markets, particularly for those who are not financially inclined.

P. Bernstein, *Capital Ideas*, Free Press, 1993.

- Bernstein was one of the most well-respected and influential practitioners in the financial industry, and the founding editor of the *Journal of Portfolio Management*. This is a lively and beautifully written account of the most important ideas in academic finance, many of which were developed at MIT in the 1960's and 1970's.

## Sloan Values

You are responsible for upholding Sloan's code of conduct, which mandates zero tolerance for cheating and plagiarism. For more details on Sloan's academic policies, please read the document "Classroom Values in Practice" which is available on the course website.

## Course Outline

Class	Topic
1: 2/4	<b>Introduction and Economic Orthodoxy</b> <ul style="list-style-type: none"><li>▪ Origins of neoclassical economics and finance</li><li>▪ Expected utility theory, general equilibrium models, rational expectations, and market efficiency</li><li>▪ The rise of <i>Homo economicus</i></li></ul>
2: 2/11	<b>Rejecting the Random Walk and Efficient Markets</b> <ul style="list-style-type: none"><li>▪ Early evidence and the sociology of efficient markets</li><li>▪ Variance ratio tests, mean reversion, and contrarian trading strategies</li><li>▪ Other empirical anomalies and market inefficiencies</li></ul>
3: 2/24 <sup>†</sup>	<b>Psychology and Behavioral Biases (†Note: This class meets on <u>Monday 2/24</u>)</b> <ul style="list-style-type: none"><li>▪ Differences between psychology and economics</li><li>▪ Probability matching, loss aversion, overconfidence, and risk vs. uncertainty</li><li>▪ Bayesian learning models</li></ul>
4: 3/4	<b>Neuroscience and Decision-Making</b> <ul style="list-style-type: none"><li>▪ Basic neuroanatomy; fear, greed, pleasure, pain, and emotion</li><li>▪ Language, logic, theory of mind, abstraction, and executive function</li><li>▪ The psychology and psychophysiology of proprietary trading</li></ul>
5: 3/11	<b>Evolution and the Origin of Behavior</b> <ul style="list-style-type: none"><li>▪ Sociobiology, evolutionary psychology, and bounded rationality</li><li>▪ The binary choice model and evolutionary origins of risk aversion, loss aversion, probability matching, and mixed strategies</li><li>▪ Deriving bounded rationality, collective intelligence, and group selection</li></ul>
6: 4/1	<b>The Adaptive Markets Hypothesis</b> <ul style="list-style-type: none"><li>▪ Economic mechanisms as adaptive traits</li><li>▪ How markets adapt to stochastic environments</li><li>▪ The importance of systematic vs. idiosyncratic risk</li></ul>
7: 4/8	<b>Hedge Funds: The Galapagos Islands of Finance</b> <ul style="list-style-type: none"><li>▪ DE Shaw, Renaissance, and a brief history of the hedge-fund industry</li><li>▪ The dynamics of risk and return in hedge-fund strategies</li><li>▪ August 1998, August 2007, and May 2010</li></ul>

**8: 4/15      Applications of Adaptive Markets**

- Hedge-fund beta replication, strategy indexes, and structured products
- The evolution of quantitative trading strategies
- Dynamic asset allocation and risk-budgeting

**9: 4/29      The Financial Crisis**

- Establishing the phenomena and the importance of the scientific method
- The role of fear, greed, and complexity in economic bubbles and crashes
- Homeostasis, the NTSB, and adaptive regulation

**10: 5/6      Ethical Implications**

- Brief review of ethics and moral reasoning
- The neuroscience of ethics applied to financial transactions
- Ayn Rand, Karl Marx, and sustainable capitalism

**11: 5/13      The Finance of the Future and the Future of Finance**

- Why the Efficient Markets Hypothesis is still relevant for practice
- How career opportunities are created
- How financial engineering can cure cancer, stop global warming, and solve the energy crisis

## Readings\*

### 1: 2/4 Introduction and Economic Orthodoxy

1. \*Samuelson, P., 1998, “How Foundations Came to Be,” *Journal of Economic Literature* 36, 1375–1386.
2. \*Kantor, B., 1979, “Rational Expectations and Economic Thought,” *Journal of Economic Literature* 17, 1422–1441.
3. \*Lo, A., 2008 “Efficient Markets Hypothesis,” in S. Durlauf and L. Blume, eds., *The New Palgrave Dictionary of Economics*. New York: Palgrave Macmillan.
4. Samuelson, P., 1947, *Foundations of Economic Analysis*, Introduction, Chapters 1 and 3. Cambridge, MA: Harvard University Press.
5. Debreu, G., 1991, “The Mathematization of Economics,” *American Economic Review* 81, 1–7.

### 2: 2/11 Rejecting the Random Walk and Efficient Markets

1. \*Gazzaniga (2008), Chapters 1–2.
2. \*Lo, A. and C. MacKinlay, 1990, “When Are Contrarian Profits Due to Stock Market Overreaction?,” *Review of Financial Studies* 3, 175–206.
3. Lakonishok, J. and S. Smidt, 1988, “Are Seasonal Anomalies Real?: A Ninety-Year Perspective,” *Review of Financial Studies* 1, 403–425.
4. Lo, A. and C. MacKinlay, 1999, *A Non-Random Walk Down Wall Street*. Princeton, NJ: Princeton University Press.

### 3: 2/24 Psychology and Behavioral Biases

1. \*Gazzaniga (2008), Chapter 3.
2. \*Tversky, A. and D. Kahneman, 1981, “The Framing of Decisions and the Psychology of Choice,” *Science* 211, 453–458.
3. \*Lo, A., Repin, D. and Steenbarger, B., 2005, “Fear and Greed in Financial Markets: An Online Clinical Study,” *American Economic Review* 95, 352–359.
4. \*Kamstra, M., Kramer, L., Levi, M., 2003, “Winter Blues: A SAD Stock Market Cycle,” *American Economic Review* 93, 324–343.
5. Kelly, P. and Meschke, F., 2010, “Sentiment and Stock Returns: The SAD Anomaly Revisited,” *Journal of Banking & Finance* 34, 1308–1326.
6. Kamstra, M., Kramer, L., Levi, M., 2012, “A Careful Re-examination of Seasonality in International Stock Markets: Comment on Sentiment and Stock Returns,” *Journal of Banking & Finance* 36, 934–956.

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\*Asterisks indicate required readings.

7. Tenenbaum, J., Kemp, C., Griffiths, T. L., and Goodman, N. D., 2011, “How to Grow a Mind: Statistics, Structure, and Abstraction,” *Science* 331, 1279–1285.

#### **4: 3/4 Neuroscience and Decision-Making**

1. \*Gazzaniga (2008), Chapter 5, 7, 8.
2. \*Breiter, H., Aharon, I., Kahneman, D., Anders, D., and Shizgal, P., 2001, “Functional Imaging of Neural Responses to Expectancy and Experience of Monetary Gains and Losses,” *Neuron* 30, 619–639.
3. \*Eisenberger, N., Lieberman, M., and Williams, K., 2003, “Does Rejection Hurt? An fMRI Study of Social Exclusion,” *Science* 302, 290–292.
4. \*Cohen, J., 2005, “The Vulcanization of the Human Brain: A Neural Perspective on Interactions Between Cognition and Emotion,” *Journal of Economic Perspectives* 19, 3–24.
5. \*Lo, A. and Repin, D., 2002, “The Psychophysiology of Real-Time Financial Risk Processing,” *Journal of Cognitive Neuroscience* 14, 323–339.
6. Rilling, J. and Sanfey, A., 2011, “The Neuroscience of Social Decision-Making,” *Annual Review of Psychology* 62, 23–48.
7. Lebestky, T., Chang, J., Dankert, H., Zelnik, L., Kim, Y., Han, K., Wolf, F., Perona, P., Anderson, D., “Two Different Forms of Arousal in Drosophila Are Oppositely Regulated by the Dopamine D1 Receptor Ortholog DopR via Distinct Neural Circuits,” *Neuron* 64, 522–536.
8. Bennett, C., Baird, A., Miller, M., and Wolford, G., 2010, “Neural Correlates of Interspecies Perspective Taking in the Post-Mortem Atlantic Salmon: An Argument for Proper Multiple Comparisons Correction,” *Journal of Serendipitous and Unexpected Results* 1, 1–5.
9. Brocas, I., 2012, “Information Processing and Decision-Making: Evidence from the Brain Sciences and Implications for Economics,” *Journal of Economic Behavior & Organization* 83, 292–310.

#### **5: 3/11 Evolution and the Origin of Behavior**

1. \*Gazzaniga (2008), Chapters 6, 9.
2. \*Herculano-Houzel, S., 2009, “The Human Brain in Numbers: A Linearly Scaled-Up Primate Brain,” *Frontiers in Human Neuroscience* 3. doi: 10.3389/neuro.09.031.2009.
3. \*Brennan, T. and A. Lo, 2011, “The Origin of Behavior,” *Quarterly Journal of Finance* 1, 55–108.
4. Brennan, T. and A. Lo, 2012, “An Evolutionary Model of Bounded Rationality and Intelligence,” *PLOS ONE* 7: e34569. doi:10.1371/journal.pone.0050310.
5. Schoenemann, T., 2006, “Evolution of the Size and Functional Areas of the Human Brain,” *Annual Review of Anthropology* 35, 379–406.
6. Hamilton, W. D., 1964, “The Genetical Evolution of Social Behavior I and II,” *Journal of Theoretical Biology* 7, 1–52.

7. Trivers, R. L., 1971, "The Evolution of Reciprocal Altruism," *Quarterly Review of Biology* 46, 35–57.

#### **6: 4/1 The Adaptive Markets Hypothesis**

1. \*Lo, A., 2004, "The Adaptive Markets Hypothesis: Market Efficiency from an Evolutionary Perspective," *Journal of Portfolio Management* 30, 15–29.
2. \*Lo, A., 2005, "Reconciling Efficient Markets with Behavioral Finance: The Adaptive Markets Hypothesis," *Journal of Investment Consulting* 7, 21–44.
3. \*Jensen, R., 2007, "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector," *Quarterly Journal of Economics* 122, 879–924.
4. Hirshleifer, J., 1977, "Economics from a Biological Viewpoint," *Journal of Law and Economics*, 20, 1–52.
5. Simon, H., 1956, "Rational Choice and the Structure of the Environment," *Psychological Review* 63, 129–138.

#### **7: 4/8 Hedge Funds: The Galapagos Islands of Finance**

1. \*Getmansky, M., Lee, P., and A. Lo, 2014, "Hedge Funds: A Dynamic Industry In Transition," to appear in *Annual Review of Financial Economics*.
2. \*Khandani, A. and A. Lo, 2007, "What Happened to the Quants in August 2007?," *Journal of Investment Management* 5(2007), 29–78.
3. \*Khandani, A. and A. Lo, 2011, "What Happened to the Quants in August 2007?: Evidence from Factors and Transactions Data," *Journal of Financial Markets* 14, 1–46.
4. \*Brennan, T. and A. Lo, 2014, "Dynamic Loss Probabilities and Implications for Financial Regulation," to appear in *Yale Journal on Regulation*.

#### **8: 4/15 Applications of Adaptive Markets**

1. \*Lorenz, J., Rauhut, H., Schweitzer, F., and Helbing, D., 2011, "How Social Influence Can Undermine the Wisdom of Crowd Effect," *PNAS* 108, 9020–9025.
2. \*Hasanhodzic, J. and A. Lo, 2007, "Can Hedge-Fund Returns Be Replicated?: The Linear Case," *Journal of Investment Management* 5, 5–45.
3. \*Merton, R., 1993, "Operation and Regulation in Financial Intermediation: A Functional Perspective," in P. Englund, ed., *Operation and Regulation of Financial Markets*. Stockholm: The Economic Council.
4. Hasanhodzic, J., and A. Lo, 2013, "Black's Leverage Effect Is Not Due To Leverage," unpublished working paper.

### **9: 4/29 The Financial Crisis**

1. \*Lo, A., 2012, “Reading about the Financial Crisis: A 21-Book Review,” *Journal of Economic Literature* 50, 151–178.
2. \*Lo, A., 2013, “Fear, Greed, and Financial Crises: A Cognitive Neurosciences Perspective,” in J.P. Fouque and J. Langsam, eds., *Handbook of Systemic Risk*. Cambridge, UK: Cambridge University Press.
3. \*Lo, A. and M. Mueller, 2010, “WARNING: Physics Envy May Be Hazardous To Your Wealth,” *Journal of Investment Management* 8, 13–63.
4. \*Fielding, E., Lo, A., and H. Yang, 2011, “The National Transportation Safety Board: A Model for Systemic Risk Management,” *Journal of Investment Management* 9, 18–50.

### **10: 5/6 Ethical Implications**

1. \*Gazzaniga (2008), Chapter 4.
2. \*Falk, A. and Szech, N., 2013, “Morals and Markets,” *Science* 340, 707.
3. \*Greene, J., 2009, “The Cognitive Neuroscience of Moral Judgment,” in M. Gazzaniga, ed., *The Cognitive Neurosciences*, 4th edition. Cambridge, MA: MIT Press.
4. \*Loewenstein, G., Cain, D. and Sah, S., 2011, “The Limits of Transparency: Pitfalls and Potential of Disclosing Conflicts of Interest,” *American Economic Review* 101, 423–428.
5. \*Proctor, D., Williamson, R., de Waal, F., and Brosnan, S., 2013, “Chimpanzees Play the Ultimatum Game,” *PNAS* 110, 2070–2075.
6. CFA Institute, 2010, *Code of Ethics and Standards of Professional Conduct*. Charlottesville, NC: CFA Institute.
7. Greene J., Morelli, S., Lowenberg, K., Nystrom, L., and Cohen, J., 2008, “Cognitive Load Selectively Interferes with Utilitarian Moral Judgment,” *Cognition* 107, 1144–1154.

### **11: 5/13 The Finance of the Future and the Future of Finance**

1. \*Lo, A., 2012, “Adaptive Markets and the New World Order,” *Financial Analysts Journal* 68, 18–29.
2. \*Kirilenko, A. and A. Lo, 2013, “Moore’s Law vs. Murphy’s Law: Algorithmic Trading and Its Discontents,” *Journal of Economic Perspectives* 27, 51–72.
3. \*Fernandez, J-M., Stein, R., and Lo, A., 2012, “Commercializing Biomedical Research Through Securitization Techniques,” *Nature Biotechnology* 30, 964–975.
4. Fagnan, D., Fernandez, J-M., Stein, R., and Lo, A., 2013, “Can Financial Engineering Cure Cancer?,” *American Economic Review* 103, 406–411.