行政院國家科學委員會專題研究計畫 成果報告

財務市場分析
研究成果報告(精簡版)

計 畫 主 持 人 ：山本竜市

計畫參與人員 ： 碩士班研究生-兼任助理：邱莉婷、郭佩婷

報 告 附 件 ： 出席國際會議研究心得報告及發表論文

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Ryuichi Yamamoto

National Chengchi University

(NSC 95-2415-H-004-024)

My research project was about simulation analyses to present theoretical explanations on well-known empirical properties in the stock market. I assume that investors in the models trade shares according to their trading rules, and those rules are subject to evolution. Investors repeatedly evaluate their past performances and update their strategies to demonstrate higher performances in the market in the future. I examine how I can explain empirical properties in the stock market with the evolution on the trading strategies. I eventually show why and where these features are coming from. It is relatively new in a field of financial economics to show the ultimate causes of the empirical features in stock markets like volatility clustering, long-memory of trading volume, and so on. The general conclusion is that imitative behavior of investors is critical to understanding most of the properties. The following are brief summaries of my findings in each of my three research papers.

In the first project, titled "What Causes Volatility Clustering and Asymmetric Volatility? One Possible Explanation", the two empirical puzzles on the stock return volatility, i.e., volatility clustering and asymmetric volatility are closely investigated. I consider two popular learning mechanisms in an agent-based stock market literature, i.e., imitative and experiential learning. I conclude that volatility clustering can be explained with imitative behavior of investors while asymmetric volatility can be generated with heterogeneous predictions across investors, which were created through experiential learning. At the end of the paper, I reproduce two volatility phenomena simultaneously with a simple extension of an imitative learning economy which allows heterogeneous predictions. During each learning and adaptation period, small numbers of investors are randomly chosen and update their trading rules by imitation, while others don't change their strategies for the next trading rounds. This economy can keep both imitation and heterogeneous predictions to simultaneously replicate volatility clustering and asymmetric volatility. This paper was presented at the following conferences:

- Midwest Finance Association Annual Meeting (2006), held in Chicago, USA on March 23-25.
- Financial Management Association Doctoral Student Seminar (2005) Chicago, USA.
- 4th International Conference on Computational Intelligence in Economics and Finance in

conjunction with 8th Joint Conference on Information Sciences (2005) in Salt Lake City in Utah on July 21-25, USA (a shorter version was presented)

- 10h Annual Workshop on Economic Heterogeneous Interacting Agents (WEHIA 2005) the University of Essex, United Kingdom on June 13-15, 2005 (a shorter version was presented).

This paper was selected to *2006 Midwest Finance Association Proceedings*. The shorter version has been published to *New Mathematics and Natural Computation*: Vol. 2 No 3 Nov. pp.261-270.

The second paper, titled "Long-Memory in an Order-Driven Market", is a joint research project with Professor Blake LeBaron at Brandeis University. We investigate long-memory processes on volatility, volume, and signs of market orders in an order-driven market. Agents submit limit or market orders according to their own trading rules. The paper considers imitative learning to update their trading rules, and shows that imitative behavior of agents is key to explaining the long-memory properties in an order-driven market. Such imitative learning is also important to produce a contemporaneous positive correlation between volatility and volume, and a relation between persistence in volume and long-memory on volatility. This paper was presented at the following conferences:

- Econophysics Colloquium (2006), International Christian University, Tokyo November 23-25.

The second paper, "Long-Memory in an Order-Driven Market", was published to *Physica A (Science Citation Index)* in 2007. We are currently working on more formal analyses (with more sophisticated mathematics and computer algorithms) on the idea of that paper and plan to publish it to some economics journal. The more formal paper has been presented at:

1. The 13th Annual Conference on Computing in Economics and Finance (CEF 2007), which was taken place in Montréal, Canada from June 14 through 16, 2007.
2. International Conference on Economic Science with Heterogeneous Interacting Agents (formerly the Workshop on Economies of Heterogeneous Interacting Agents),

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National Chengchi University
(NSC 95-2415-H-004-024)

which was taken place in Fairfax, Virginia, USA from June 17-20.
I attended these two conferences with the financial support by National Science Council (NSC 95-2415-H-004-024).

The third paper, which is titled "Evolution with Individual and Social Learning in an Agent-Based Stock Market", examines an economy with evolution which allows agents to update their trading rules through imitation and their own experience. The economy with agents who have more ideas to update their rules provides the following results. First, the time series generated from such an economy with intelligent agents cannot achieve a homogeneous rational expectation equilibrium. The second result says that imitation learning becomes much more popular in the economy. Agents will be better off in an ex ante welfare sense by imitating others. This result implies that income levels are never equalized across agents. I conclude that such income differences are critical to understanding the mechanism of herd behavior in financial markets. This paper was presented at the following conferences:

- 11th International Conference on Computing in Economics and Finance (2005) at George Washington University Washington DC, USA on June 23-25, 2005.
- 10h Annual Workshop on Economic Heterogeneous Interacting Agents (WEHIA 2005) the University of Essex, United Kingdom on June 13-15, 2005.

This paper is available at *Computing in Economics and Finance 2005*, 228, Society for Computational Economics.

References

Andersen, Torben G. "Return Volatility and Trading Volume: An Information Flow Interpretation of Stochastic Volatility." *The Journal of Finance* 51 (1996):169-204.

Arthur, W.B., Holland, J., Lebaron, B., Palmer, R., and Tayler, P. "Asset Pricing under Endogenous Expectations in an Artificial Stock Market." In W. B. Arthur, S. Durlauf, and D. Lane, eds, *The Economy as an Evolving Complex System II,* Addison-Wesley, Reading, MA,

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National Chengchi University
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(1996): 15-44.

Baillie, R.T., T. Bollerslev, and H.-O. Mikkelsen. "Fractionally integrated generalized
    Autoregressive conditional heteroskedasticity." *Journal of Econometrics* 74 (1996): 3-30.

Bollerslev, T. "Generalized autoregressive conditional heteroskedasticity", *Journal of
    Econometrics* 31 (1986):307-327.

Bollerslev, T. and H.-O. Mikkelsen. "Modeling and pricing long-memory in stock market
    volatility." *Journal of Econometrics* 73 (1996): 151-184.

Chen, Shu-Heng, and Yeh, Chia-Hsuan. "Evolving Traders and the Business School with Genetic
    Programming: A New Architecture of the Agent-Based Artificial Stock Market." *Journal of
    Economic Dynamics and Control* 25 (2001): 363-393.

Ding, Zhuanxin and Clive Granger W. J. "Modeling Volatility Persistence of Speculative Returns:
    A New Approach." *Journal of Econometrics* 73 (1996): 185-215.

Engle, Robert F. "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance
    of United Kingdom Inflation." *Econometrica* 50 (1982): 987-1008.

Engle, Robert F and Victor K. Ng. "Measuring and Testing the Impact of News on Volatility."
    The Journal of Finance 48 (1993): 1749-1778.

Graham, John R. "Herding among Investment Newsletters: Theory and Evidence." *The Journal
    of Finance* 54 (1999): 237-268.

Graham, John and Campbell Harvey. "Market Timing Ability and Volatility Implied in
    Investment Newsletters' Asset Allocation Recommendations." *Journal of Financial
    Economics* 42 (1996): 397-421.

LeBaron, Blake. "Evolution and Time Horizons in an Agent-Based Stock Market."
    Macroeconomic Dynamics 5 (2001): 225-254.

LeBaron, B. "Calibrating an Agent-Based Financial Market." Technical report, Brandeis
    University, Waltham, MA, (2002a).

LeBaron, Blake. "Building the Santa Fe Artificial Stock Market." Technical Report, Brandeis
    University (2002b).

Lillo, F., and J. D. Farmer. "The Long Memory of the Efficient Market." *Studies in Nonlinear
    Dynamics & Econometrics* 8 (3) article 1 (2004).

Lillo, F., S. Mike, and J. D. Farmer. "Theory for Long Memory in Supply and Demand." *Phys.
    Rev. E* 7106 (2005): 287-297.

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Lobato, I. and Velasco, C. "Long memory in stock-market trading volume", *Journal of Business and Economic Statistics* 18 (2000): 410–426.

Mantegna, Rosario N., and Stanley, Eugene H. "Scaling Behavior in the Dynamics of an Economic Index." *Nature* 376 (1995): 46-49.

Mantegna, Rosario N., and Stanley, Eugene H. "Stock Market Dynamics and Turbulence: Parallel Analysis of Fluctuation Phenomena." *Physica A* 239 (1997): 255-266.

Nelson, Daniel B. "Conditional Heteroskedasticity in Asset Returns: A New Approach." *Econometrica*, 59 (1991): 347-370.

Pagan, Adrian. "The Econometrics of Financial Markets." *Journal of Empirical Finance* 3 (1996): 15-102.

Tauchen, G. E. and Pitts, M. "The price variability-volume relationship on speculative markets." *Econometrica*, 51(2) (1983): 485-505.

Tay, Nicholas S. P., and Linn, Scott C. "Fuzzy Inductive Reasoning, Expectation Formation and the Behavior of Security Prices." *Journal of Economic Dynamics and Control* 25 (2001): 321-361.

出席國際學術會議心得報告

計畫編號	95-2415-H-004-024-
計畫名稱	財務市場分析
出國人員姓名 服務機關及職稱	山本竜市 (Ryuichi Yamamoto), National Chengchi University, Department of International Business
會議時間地點	June 14-16 at Montreal, Canada and 17-20 at Fairfax, Virginia USA
會議名稱	13th Computing in Economics and Finance and ESHIA/WEHIA 2007
發表論文題目	Long-memory in an order-driven market

一、參加會議經過

I attended two conferences. The first one is The 13th Annual Conference on Computing in Economics and Finance (CEF 2007), which was taken place in Montréal, Canada from June 14 through 16, 2007. The program will cover all areas dealing with the computational aspects (broadly defined) of economics, finance, and decision making. These include (a) research that makes significant use of computers, (b) the development of computational techniques, and (c) the development of computational environments. The second one is International Conference on Economic Science with Heterogeneous Interacting Agents (formerly the Workshop on Economies of Heterogeneous Interacting Agents), which was taken place in Fairfax, Virginia, USA from June 17-20. The conference is interested in research dealing with computational and mathematical representations of economic and social processes in which the role of individual agents is explicit. Topics of interest include: Agent-based modeling, Artificial financial market models, Automata theoretic models of economic and social processes, Computational game theory, Econophysics, and so on.

These are great conferences to attend. Many well-known professors, like Professor Robert Axtell at George Mason University, attended the conferences and presented the latest results of a wide variety of research. The conferences brought together researchers and practitioners from diverse fields, such as computer science, economics, physics, and complex system theory for understanding emergent and collective phenomena in economic, organizational, and social systems, and to discuss on effectiveness and limitations of computational models and methods in social sciences.

Since I am doing research about the agent-based modeling for finance, these were really good conferences to attend and great opportunities for improving the quality of my paper. Moreover, I had many opportunities to talk with many professors in my field. Discussions with such professors further improved my research. I made oral presentations of my paper, Long-memory in an order-driven market, at these conferences.

二、與會心得

I had opportunities to present my paper to many audiences there and had many chances to talk with people with the same interests of mine and actually learned a lot from them. One of the editors at Eastern economic journal had interested in my presentation and she asked me to submit something on my idea to her journal. This is one of the achievements I had at these conferences. The followings are the details on what I learned from these two conferences.

My paper investigates why and where long-memory properties in an order-driven market come from, and shows that imitation of trading strategies by traders is key to understanding the long-memory properties. After my presentation, I got some good questions. Two of them are as follows.

Professor Barkley Rosser from James Madison Univ, a session chair of my talk at ESHIA 2007, asked; What is the critical rate that agents involve imitation in order to reproduce all long-memories? I answered: we didn't get the results when small percentage of agents (around 30-40%) involves imitation. But we suddenly got all long-memories when all agents involve it. But we didn't try to find the critical rate.

Professor Tony He from University of Technology at Sydney asked; Did we estimate decay rates of the autocorrelations by using our artificial data and compare it with those in the actual stock market?

I thought this would be interesting to compare. The decay rates from our artificial data would possibly change with different degrees of imitation, i.e., the autocorrelation should decay faster as we decrease the number of agents involving imitation.

Based on the discussion with them, after I came back to Taipei, I have done the simulations on long-memories with different degrees of imitation and calculated the critical rate to produce long-memories. As I expected, I found stronger results on long-memories as more agents involve imitation. In particular, we see all long-memories when around 60-70% of agents imitate. As my coauthor agreed, I plan to submit a paper focusing on this sensitivity analyses on long-memories with different degrees of imitation to Eastern economic journal.

I found an interesting talk at the Montreal meetings, which was given by Dr. Alec Schmidt at ICAP. He examined the high-frequency data of the ICAP. His paper talks a bit about long-memory of order signs and order-splitting in FX market, and it seems they are less frequent in FX brokered interdealer markets than in equity markets. The signed hit flows are uncorrelated. Quote flows are also uncorrelated since he says order-splitting is less common because of the minimum order size restricted to a sort of large size. In a discussion time during his presentation, someone said there would be order-splitting in FX customer markets. Some FX customers split their orders into small pieces by allocating their orders to different dealers. Since I am doing a research on FX markets as well as that on stock markets with my coauthor, his talk was so helpful to improve my idea on my current research topic.

Anyway, since I learned a lot there, I am grateful to NSC for funding me to have such great opportunities there. I believe the things I learned there have made my research ideas much better.