行政院國家科學委員會專題研究計畫 成果報告

Agent-based models 以及股票市場的實證現象
研究成果報告(精簡版)

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Final Report:

Ryuichi Yamamoto

Department of International Business, National Chengchi University

Project title: Agent-based models and empirical features in stock markets

Project number: 99-2410-H-004-056

First of all, I would like to emphasize that I am grateful to NSC for having provided me funds to attend an international conference, hire research assistants, buy research-related stuffs. I believe that all opportunities that NSC provided to me have helped me greatly improve my papers. In my NSC research project of academic year 99, I proposed three research ideas which are titled as follows:

1. Order aggressiveness, order book conditions, and long-memory in an order-driven market

2. The impact of herding on asymmetry of volatility through volatility feedback effect

3. Information and volatility clustering in stock markets

Due to the big support from NSC, the first one has been completed and accepted to *Journal of Economic Dynamics and Control (forthcoming), (SSCI: Impact factor 1.117)* titled: "Order aggressiveness, pre-trade transparency, and long-memory in an order driven market." The third one has been completed and published to: *Journal of Economic Interaction and Coordination 6, 41-59 (SSCI: Impact factor 0.759),* titled: "Volatility clustering and herding agents: Does it matter what they observe?" Since I have spent most of the time for writing and publishing the first and third papers to the journals, the second paper is still in progress. The contents of the first and third papers are pretty much the same as I proposed in the 99 NSC project. In these research papers, I have mainly been doing simulation analyses to explain well-known empirical properties in the stock market, e.g., volatility clustering, and long-memories in volume, volatility, and order signs (and yet, the market is informationally efficient in a sense that there is no persistence in returns). Recent empirical studies found these empirical properties but it still lacks of research on explaining theoretically why and where these features are coming from. I have been trying to achieve this goal in agent-based models. More details (research purposes, literature review, methodologies, results, contributions, and references) on the first and third papers are explained in the following.

The first project, titled: "Order aggressiveness, pre-trade transparency, and long-memory in an order driven market," is summarized as follows. Long-memory processes of trading volume, volatility, and order signs are important features in the high-frequency time series of stock markets, and yet the market is informationally efficient in that returns are

uncorrelated over time.[1] Recent empirical research has demonstrated these results, but theoretical attempts to explain these observations have foundered on the challenge of simultaneously explaining all phenomena. This paper achieves this goal in an agent-based model.

We conduct simulations on a continuous double auction market, where agents place their orders to an electronic order book. The price is determined once the submitted order is matched and executed with the limit orders in the book. Consistent with the behavior of stock investors in reality, the trading strategy of our agents is influenced by the state of the order book. Our agents tend to submit more aggressive orders as the depth on the same side of the order book becomes thicker, and less aggressive orders as it becomes thinner.[2] This suggests that our agents' trading decisions involve a trade-off between advantageous price and non-execution risk. When an agent places a limit order rather than a market order, the agent can obtain a favorable execution price, but at a higher risk of non-execution, as the order may be left unfilled, and the agent failing to receive any profits. Such risk of non-execution increases as the depth on the same side of his order becomes thicker. If an agent observes the order book and recognizes that the book is thick, then the agent places more aggressive orders. An agent who places a market order can soon execute it, ensuring certain positive profits, but he will then lose the opportunity to execute his order at a more favorable price. If the book is thin, the agent reverses his strategy, placing less aggressive orders because his order is likely to be executed. We model the order placement strategy in terms of a trade-off between advantageous price and non-execution risk, and conjecture that such a strategy is related to long memories of volume, volatility, and order signs. We demonstrate that this strategic behavior is critical for simultaneously generating all long memories.

We examine our conjecture within two types of artificial stock markets: a *transparent market*, in which agents observe all limit orders on both sides of the book and order volumes at those prices prior to trading; and a *less transparent market*, in which agents observe only the best five bid and ask quotes with the depth available at these limit prices before trading. In terms of the level of pre-trade transparency, the first market structure resembles certain stock exchanges in reality, such as the Australian Stock Exchange, NYSE OpenBook, the London Stock Exchange, and the NASDAQ, while the second market structure is consistent with stock exchanges such as Euronext Paris, the Toronto Stock Exchange, the Tokyo Stock Exchange, and Hong Kong Exchanges and Clearing.[3] We demonstrate that both markets can simultaneously generate the above-mentioned long memories, implying that an order placement strategy involving a trade-off between advantageous price and immediacy of execution is a possible source of the long memories in many actual stock exchanges.

[1] Lobato and Velasco (2000) find the long memory of volume. Ding, Granger, and Engle (1993) demonstrate this for volatility. Bouchaud, Gefen, Potters, and Wyart (2004) and Lillo and Farmer (2004) show an informationally efficient market in the presence of strong dependence in order signs.

[2] This has been found in many empirical studies in the finance literature. See, for example, Biais, Hillion, and Spatt (1995); Duong, Kalev, and Krishnamurti (2009); Griffiths, Smith, Turnbull, and White (2000); Hall and Hautsch (2006); Handa, Schwartz, and Tiwari (2003); and Ranaldo (2004). In the literature, the most aggressive order is the market order, while limit orders within the spread are more aggressive than limit orders outside of the spread but are less aggressive than market orders.

[3] Other than those markets, the Jakarta Stock Exchange and the Singapore Exchange are examples of markets displaying a full limit order book to the public. The level of pre-trade transparency in Asia-Pacific exchanges is explained in Comerton-Forde and Rydge (2006).

Most significantly, this paper contains the following five contributions. First, our model reproduces all long memories simultaneously.[4] Several papers investigate possible sources of long memories, but each paper reproduces only one of them. For example, Alfarano, Lux, and Wagner (2008) and a series of spin-type models, such as those created by Bornholdt (2001); Chowdhury and Stauffer (1999); and Kaizoji, Bornholdt, and Fujiwara (2002), explain the long memory of volatility in their herding economies.[5] Several papers, such as that of Chiarella, Iori, and Perelló (2009), assert and demonstrate that the cause of long memory of volatility is the chartists' trend-following behavior. Lillo, Mike, and Farmer (2005) consider an order-splitting strategy widely used by investors in actual stock markets, whereby stock investors split their large orders into smaller pieces and execute them piece by piece so as to minimize the price impact.[6] Their model successfully generates the long memory of order signs.

Our second contribution is that we formulate our agents' trading strategies based on the order-book condition as well as the past price history. In most existing agent-based models, the trading strategies are based only on past price information.[7] However, stock investors in reality can also refer to order-book information, which can provide information about likely market dynamics. Agents in the previous papers do not observe the order-book condition, and hence, they do not consider the trade-off between advantageous price and immediacy of execution.

Third, we examine the impact of the varying degrees of transparency on the dynamic aspects of volatility, trading volume, and order signs. Some empirical studies in the finance literature also investigate the impact of changes in the pre-trade transparency regime but only on the static aspects of the economy. For example, Madhavan, Porter, and Weaver (2005) examine the impact on liquidity and volatility when the Toronto Stock Exchange disseminated information of the limit order book to the public.[8] They find that the increase in transparency decreases liquidity but increases execution costs and volatility. Boehmer, Saar, and Yu (2005) demonstrate that an increase in pre-trade transparency with the NYSE OpenBook service influences the liquidity and the price impact of trades.[9] For example, they demonstrate that investors submit smaller limit orders and cancel limit orders in the book more quickly and more frequently, whereas NYSE specialists trade less and add less depth to

[4] Other than this paper, the herding mechanisms due to agents' mutual imitation in LeBaron and Yamamoto (2007, 2008) and the order-splitting model of Yamamoto and LeBaron (2010) also replicate all long memories at once.

[5] Kirman (1993) and Lux (1995) are two of the classical papers on agent-based herding models.

[6] Vaglica, Lillo, Moro, and Mantegna (2008) provide empirical evidence on order-splitting in the Spanish stock exchange.

[7] Among several agent-based models of this type, see, for example, Brock and Hommes (1998); Chiarella, Iori, and Perelló (2009); Frankel and Froot (1990); Kirman (1991); and LeBaron, Arthur, and Palmer (1999).

[8] On April 12, 1990, the Toronto Stock Exchange instituted a computerized trading system that increased the level of pre-trade transparency. This system introduces public dissemination of the depth and quotes of the best five limit orders. See Madhavan, Porter, and Weaver (2005) for more details.

[9] NYSE's OpenBook was introduced in January 2002 and provides order-book information to traders off the exchange floor. In particular, it allows them to observe depth in the book in real time at each price level for all securities. See Boehmer, Saar, and Yu (2005) for more details.

the quote. They also present an increase in displayed liquidity in the book and a decline in the price impact of trades.

Fourth, in addition to long memories, we provide a condition that reproduces the conditional frequencies of order types on spread width and order-book depth, which are observed in some empirical research. Several empirical papers find that investors tend to place more (less) aggressive orders as the spread size becomes narrower (wider)[10] or the depth on the same side of the book is thicker (thinner). On the one hand, our simulation results explain that the conditional frequency on the spread is generated regardless of agents' strategic behavior, and is instead actually related to the order-book market structure itself. On the other hand, we replicate the conditional frequency on the depth when agents' order placement strategy involves the trade-off between advantageous price and immediacy of execution.

Fifth, this paper argues conditions for replicating absolute frequencies of order types, which are similar to the evidence presented in some empirical research. The absolute frequency of market orders amounts to approximately 28%-53% of orders submitted to the book, while that of limit orders within (outside of) the spread amounts to approximately 2%-19% (27%-65%), along with corresponding data from the Paris Bourse in Biais, Hillion, and Spatt (1995); Toronto Stock Exchanges in Griffiths, Smith, Turnbull, and White (2000); and Australian Stock Exchanges in Hall and Hautsch (2006) and Duong, Kalev, and Krishnamurti (2009).[11] Although the actual frequency varies across stock exchanges, we generate results that are closer to reality when agents are more willing to place aggressive orders than less aggressive orders. Our results imply that in reality, stock investors generally prefer the immediate execution of their orders over favorable prices.

The third research project, titled: "Volatility clustering and herding agents: Does it matter what they observe?" is summarized as follows.

Volatility clustering is an important empirical feature of stock markets.[12] Many agent-based models have successfully replicated the persistence of return volatility and provided theoretical explanations for it.[13] One popular theoretical explanation is that agents' herding behavior is related to this phenomenon, but agents in those agent-based herding models are assumed to herd on others by looking at detailed information on other agents that may not be observable in reality. For example, a series of spin-type models assume that agents can immediately observe whether the nearest neighbors bought or sold an asset and the exact information on the market-wide order flow.[14,15] However, in reality (for example, in Asia-

[10] Biais, Hillion, and Spatt (1995); Duong, Kalev, and Krishnamurti (2009); Griffiths, Smith, Turnbull, and White (2000); Hall and Hautsch (2006); and Ranaldo (2004) make this observation.
[11] We introduce more details for these numbers in Section 3.
[12] For example, clustered volatility is documented by Engle (1982) and Pagan (1996).
[13] For example, Lux (1998), Lux and Marchesi (1999), and Gaunersdorfer and Hommes (2005) explain volatility clustering as an endogenous phenomenon caused by the interaction between fundamentalists and technical analysts. Bornholdt (2001), Chowdhury and Stauffer (1999), and Kaizoji, Bornholdt, and Fujiwara (2002) also replicate clustered volatility in spin-type herding models, while LeBaron and Yamamoto (2007, 2008) generate it in their herding model. Yamamoto and LeBaron (2009) show that agents' order-splitting behavior causes persistence of volatility.
[14] Examples of the spin models include those by Bornholdt (2001), Chowdhury and Stauffer (1999), and Kaizoji, Bornholdt, and Fujiwara (2002).

Pacific stock exchanges), although the immediate reporting of trade details is generally required for both on- and off-market trades, delayed reporting is allowed for some off-market trades, e.g., in the Australian Stock Exchange, Hong Kong Exchanges and Clearing, and the Singapore Exchange.[16] Thus, the exact information on the net order flows or even on the nearest neighbors' actions is not often available immediately in those markets.

We conjecture that agents' ability to observe and imitate the strategy details of others is related to volatility clustering. We conduct three experiments independently with different levels of information sharing. In our first economy, agents can imitate the strategies of others but they make errors when copying the strategies of others. Our second economy describes a market where agents can imitate the strategies of only a fraction of the agents. In our third economy, agents can imitate the strategies of others, but update their parameters only by a proportion. In each experiment we change the probability of errors to copy the strategy of others, the fraction of agents to herd, or the proportion of the parameter that agents update, in order to examine the effect of the different degrees of information sharing on volatility clustering. We show that volatility clustering tends to disappear as agents have smaller information sets of others to imitate. Thus, we conclude that agents need to imitate the strategy details of others so as to generate clustered volatility. Since stock investors in reality cannot perfectly observe the actions of others, our result implies that other forms of social interactions, e.g., interactions via market sentiment indices (Lux 2009[17]), influences from the news media in setting the stage for market moves and in instigating the moves themselves (Shiller 2001), and/or some other behaviors of agents (like order-splitting behavior, e.g., Yamamoto and LeBaron (2009)), would also be related to generate clustered volatility.[18]

Herding plays an important role in real-world decision making. Pingle and Day (1996) conduct an experimental study on imitative behavior. They show that when people make economic decisions they tend to economize on their decision costs, such as time, energy, or other valuable resources, by following the decisions of others. An experimental work by Offerman and Sonnemans (1998) shows that individuals learn from imitating successful others as well as from their own experience. Apesteguia, Huck, and Oechssler (2007) also give support to imitative behavior at the individual level, in terms of both choice and perception. They also show that individuals are more likely to imitate successful actions as the payoff differences among agents become larger. As Offerman and Sonnemans (1998) mention, such experimental evidence suggests that it is a promising way to model agents' behavior in an environment where they learn from successful others. Thus, we assume that our agents herd on successful others and analyze how crucial such herding behavior is in order to generate an empirical feature in stock markets, i.e., volatility clustering. Moreover, the previous experimental works imply that herding is prevalent when the environment becomes more complex or largely unknown. Financial markets should be an environment in which we examine the impact of herding, because they are quite complicated.

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[15] The market-wide order flow is the sum of the signed trading volume in the market. A buy (sell) order is counted as positive (negative). In the spin-type models, agents can trade one unit at a time. Thus, a buy (sell) order is counted as +1 (-1).

[16] See Comerton-Forde and Rydge (2006) for details of post-trade transparency in Asia-Pacific exchanges.

[17] Lux (2009) analyzes survey data on the business climate index for the German economy to show that respondents' assessments of the economic outlook tend to change through social interactions.

[18] Yamamoto and LeBaron (2009) generate volatility clustering when agents split their large orders into small pieces and execute them piece by piece.

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Report on using traveling fund from NSC

I have used the NSC traveling fund for having attended the Japanese Economic Association meeting at Kumamoto, Japan from May 21 to 22, 2011 and Brandeis University research seminar on March 1, 2011.

The Japanese Association meeting is a great and actually prestigious conference in the field of Economics in Japan. This conference normally invites great professors in relevant fields, and they are also editors for excellent international journals. This year Professor Kazuo Ueda at University of Tokyo was invited for the keynote speech. This conference is organized by many well-known professors in Japan. Usually, more than 100 people attend this conference. The conference brings together researchers and practitioners from diverse fields in Economics and Finance for understanding emergent and collective phenomena in economic, organizational, and social systems, and to discuss on effectiveness and limitations of economic models and methods in Economics. Since I am doing research about the agent-based modeling for Economics, it is a really good conference to attend and a great opportunity for improve the quality of my papers. Moreover, I will have many opportunities to talk with many professors in my field. Discussions with such professors will further improve my research. After attending this conference and the discussions with others, my paper has been improved a lot and actually been submitted to Pasific-Basin Finance Journal for a publication.

I have attended Eastern Economic Association annual meeting at NYC USA from Feburary 25 to 27, 2011. After that, I have presented my paper at Brandeis University research seminar. I have actually talked with many researchers at Brandeis including Professor Blake LeBaron, Professor Carol Osler and many others, and improved and refined the idea of my papers, including the paper presented this time and other papers co-authored with Professor Blake LeBaron. After the discussions with others, my paper has been improved a lot and now almost ready to be submitted to Journal of Economic Dynamics and Control for a publication.

I learned a lot by having attended these conferences. I really feel that I am grateful to the NSC for funding me to attend the conference and talk with many researchers in my fields. I believe the things I learned there have made my research ideas much better.

In the following, I attach the invitation email for the Japanese Economic Association conference and the research seminar program at Brandeis University. After that, I attach the

summary of the papers presented at those conferences.

Invitation email for the Japanese Economic Association conference:

From:hiruma@waseda.jp
To:ryuichi@nccu.edu.tw
Cc:h-hirata <h-hirata@hosei.ac.jp>
Date:Mon, 25 Apr 2011 10:29:55 +0900
Subject:Re: 日本経済学会、論文 acceptance email のお願い

To whom it may concerns;

This is to certify that Ryuichi Yamamoto and Hideaki Hirata's paper entitled "Belief changes and expectation heterogeneity in buy- and sell-side professionals in the Japanese stock market" is accepted by the Japanese Economic Association's spring conference. Their paper will be presented in the session of "Asset markets and demand behavior" that I will chair on 21 May, 2011.

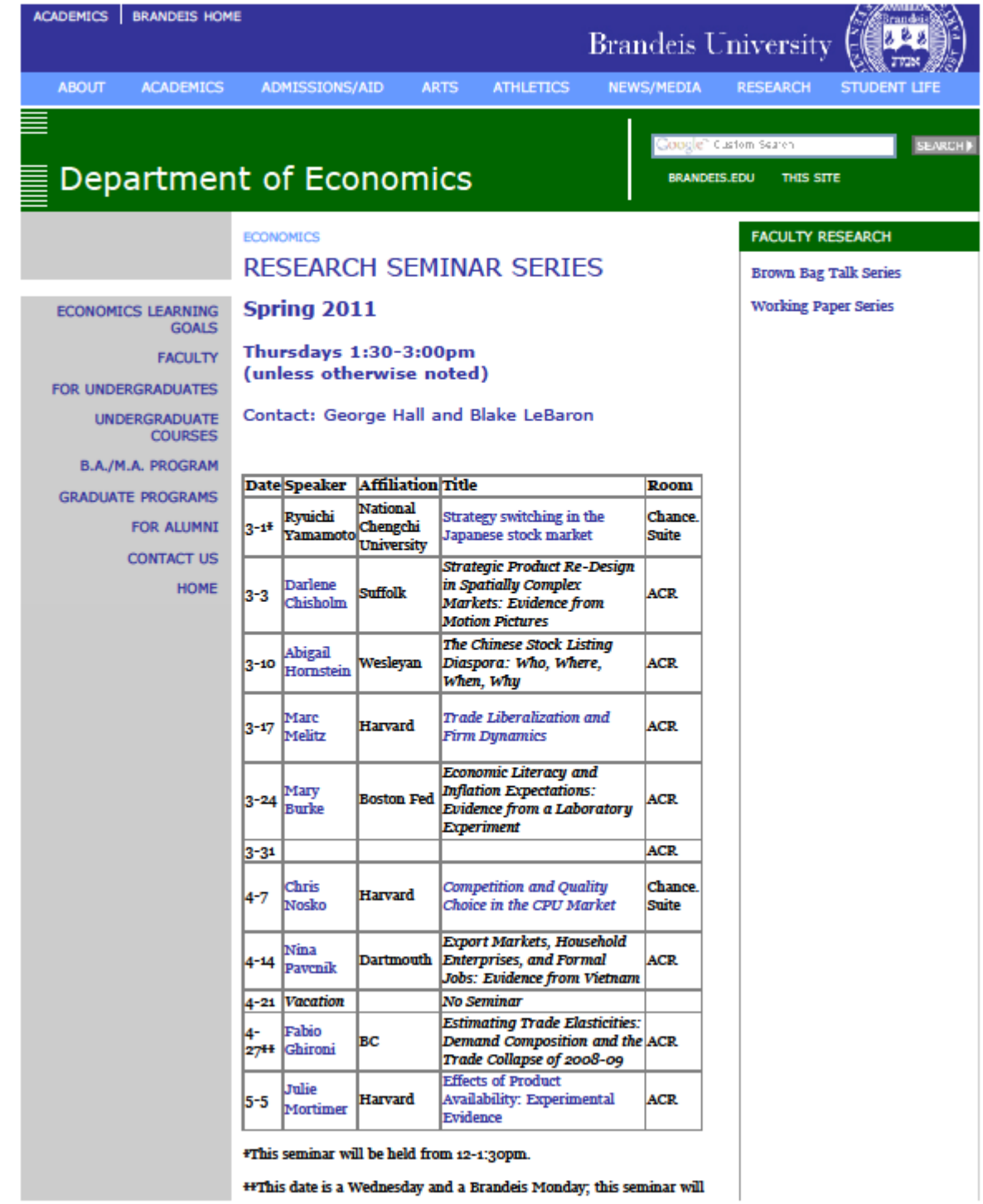
Fumihiko Hiruma
Waseda University
Tokyo Japan

Research seminar program at Brandeis University is given at:

http://www.brandeis.edu/departments/economics/seminarseriesS11.html

The program is attached here:

Research Seminar Series | Brandeis University



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RESEARCH SEMINAR SERIES

Spring 2011

Thursdays 1:30-3:00pm
(unless otherwise noted)

Contact: George Hall and Blake LeBaron

Date	Speaker	Affiliation	Title	Room
3-1*	Ryuichi Yamamoto	National Chengchi University	Strategy switching in the Japanese stock market	Chance. Suite
3-3	Darlene Chisholm	Suffolk	*Strategic Product Re-Design in Spatially Complex Markets: Evidence from Motion Pictures*	ACR
3-10	Abigail Hornstein	Wesleyan	*The Chinese Stock Listing Diaspora: Who, Where, When, Why*	ACR
3-17	Marc Melitz	Harvard	*Trade Liberalization and Firm Dynamics*	ACR
3-24	Mary Burke	Boston Fed	*Economic Literacy and Inflation Expectations: Evidence from a Laboratory Experiment*	ACR
3-31				ACR
4-7	Chris Nosko	Harvard	*Competition and Quality Choice in the CPU Market*	Chance. Suite
4-14	Nina Pavcnik	Dartmouth	*Export Markets, Household Enterprises, and Formal Jobs: Evidence from Vietnam*	ACR
4-21	*Vacation*		*No Seminar*	
4-27**	Fabio Ghironi	BC	*Estimating Trade Elasticities: Demand Composition and the Trade Collapse of 2008-09*	ACR
5-5	Julie Mortimer	Harvard	Effects of Product Availability: Experimental Evidence	ACR

*This seminar will be held from 12-1:30pm.

**This date is a Wednesday and a Brandeis Monday; this seminar will

FACULTY RESEARCH

Brown Bag Talk Series

Working Paper Series

http://www.brandeis.edu/departments/economics/seminarseries511.html[9/22/2011 3:15:55 PM]

The paper presented at the Japanese Economic Association conference is summarized as follows:

Title: Belief changes and expectation heterogeneity in buy- and sell-side professionals in the Japanese stock market

In contrast with the common assumption about the traditional rational representative agent, several papers investigate survey data on professional forecasts of such macroeconomic series as inflation and GDP, as well as such financial series as stock prices and foreign exchange rates and find expectations to be heterogeneous.[1] While Mankiw, Reis, and Wolfers (2003) suggest that "disagreement may be a key to macroeconomic dynamics (p.242)," several recent agent-based models demonstrate that heterogeneity drives observed features in real stock markets that have not yet been sufficiently explained by traditional asset-pricing models under efficient market and rational expectation hypotheses, such as clustered volatility and fat tails of the return distribution.[2] Thus, providing better explanations of the factors determining the differences in expectations can facilitate a better understanding of risk management and option pricing in financial markets. While several studies have examined the determinants of expectation heterogeneity in inflation, GDP or foreign exchange rates, recent empirical research has faced the challenge of explaining expectation heterogeneity among stock market professionals.[3] This paper empirically examines the determinants of expectation heterogeneity or "dispersion" in the Japanese stock market utilizing a panel dataset of monthly surveys of market professionals on the TOPIX forecasts, conducted by QUICK Corporation, a Japanese financial information vendor in the Nikkei Group.

The academic literature offers three explanations of the sources of expectation

[1] For example, Allen and Taylor (1990), Ito (1990), and Frankel and Froot (1990) identify expectation heterogeneity in foreign exchange markets, while Mankiw, Reis, and Wolfers (2003) and Capistran and Timmermann (2009) find heterogeneity in inflation expectations. Patton and Timmermann (2008) demonstrate expectation heterogeneity for GDP growth and inflation.

[2] For example, Hommes (2006) and LeBaron (2006) survey the literature on agent-based computational finance and explain the importance of heterogeneity in generating financial market phenomena.

[3] For example, Menkhoff, Rebitzky, and Schroder (2009) and Reitz, Stadtmann, and Taylor (2009) examine the causes of heterogeneity in exchange rate expectations. Mankiw, Reis, and Wolfers (2003) and Capistran and Timmermann (2009) analyze the determinants of forecast heterogeneity in inflation, while Patton and Timmermann (2008) and Döpke and Fritsche (2006) examine the source of heterogeneity in both GDP and inflation. In addition to GDP and inflation, Lamont (2002) provides evidence for heterogeneity in unemployment as well.

heterogeneity.[4] One explanation is based on the idea that forecasters share the same information-processing technology, but have access to different sets of information about the current state of the economy (see, for example, Carroll, 2003; Kyle, 1985; Lucas, 1973; Mankiw and Reis, 2002). The second explanation in the literature indicates that agents who share the same information about the current state of the economy interpret it differently (see, for example, Laster, Bennett, and Geoum, 1999; Patton and Timmermann, 2010). A third possibility offered (for example, in the noise-traders and rational-arbitrageurs model presented by DeLong, Shleifer, Summers, and Waldmann (1990) and a series of fundamentalists and chartists models[5]) is that the forecast dispersion arises due to the existence of fundamentally different types of agents in the market. Due to the difference in types, agents in the third strand of literature not only observe different information, but also have different ways to interpret the same information. Thus, an implication in the third strand of literature overlaps the explanations in the first and second strands of literature. We investigate whether or not this third assertion in literature can be empirically validated in the Japanese stock market. In particular, we explore why professionals' expectations are heterogeneous by disaggregating the forecasts in our sample offered by professionals into those of fundamentally different types, namely, into buy- and sell-side professionals.

Buy-side professionals are those who work for investing institutions, such as mutual funds, pension funds, and insurance firms, which purchase securities on their own account. Buy-side analysts research and make recommendations to institutional investors regarding purchasing securities. Buy-side recommendations are usually not available to the public. Sell-side professionals work for companies which sell investment services to asset management firms, that is to say, the buy-side professionals, and provide recommendations to the public. Sell-side analysts work for brokerage firms; their research is used to promote securities to individual, usually buy-side investors.[6] We demonstrate that our results are consistent with the explanations offered by the third strand of the literature in ways outlined below.

We first demonstrate that buy-side and sell-side professionals utilize different information

[4] We refer to Frijns, Lehnert, and Zwinkels (2010) for categorizing the literature into three strands.

[5] See, for example, Hommes (2006) and LeBaron (2006), who survey papers on agent-based computational finance. Boswijk, Hommes, and Manzan (2007), Branch (2004), Frankel and Froot (1990), Menkhoff, Rebitzky, and Schroder (2009), and Reitz, Stadtmann, and Taylor (2009) empirically demonstrates that the existence of fundamentalists and chartists in the same market generates the forecast dispersion.

[6] For more information on the different activities in which buy-side and sell-side professionals engage, see Groysberg, Healy, and Chapman (2008) and Busse, Green, and Jegadeesh (forthcoming).

to make their forecasts. Even if they observe the same information, they often interpret the information differently, resulting in varied expectations. Secondly, we demonstrate that certain forms of information exchanges take place between the buy-side and the sell-side professionals that generates heterogeneity in expectations. More precisely, we demonstrate that the buy-side professionals refer to the way in which sell-side professionals evaluate the market, particularly when the sell-side professionals share opinions that are similar to those of the buy-side professionals. Meanwhile, the buy-side professionals do not take this action when attempting to relate Japanese firms' business conditions to future stock prices. On the other hand, sell-side professionals seek to share market views similar to those of their customers, that is to say, to buy-side professionals. Our results imply that expectation heterogeneity arises because professionals with different business goals, namely, the buy-side and the sell-side professionals, interact with one another, but they differentiate the contents of the information as well as their interpretations of the same information in their forecasts. Thus, we conclude that the existence of fundamentally different types of professionals within the same market is a key to the generation of the dispersion.

In addition, we demonstrate the robustness of our results after controlling for important events in the Japanese economy during our sample periods, such as the Lehman shock, the Bear Stearns shock, the Resona shock, the merger of the Mitsubishi Tokyo Financial Group and UFJ Holdings, the quantitative easing monetary policy, the settlement of the account in each fiscal year, and the January effect.

This paper makes the following six contributions. First, we empirically explain the determinants of the expectation dispersion among the Japanese stock market professionals. Several papers investigate the sources of the dispersion in expectations of exchange rates, inflation, GDP, and unemployment, but not specifically of the expectations of Japanese stock market professionals.[7] Second, we demonstrate the causes of the forecast dispersion related to the stock index using professionals' opinions about the various macroeconomic, political, and psychological factors that influence future stock prices. The QUICK corporation asks respondents to select the factors that influence future stock prices from among the following

[7] See, for example, Menkhoff, Rebitzky, and Schroder (2009) and Reitz, Stadtmann, and Taylor (2009) for heterogeneity in exchange rate expectations, Mankiw, Reis, and Wolfers (2003) and Capistran and Timmermann (2009), for heterogeneity in inflation, Patton and Timmermann (2008) and Döpke and Fritsche (2006) for heterogeneity in both GDP and inflation, and Lamont (2002) for the heterogeneity in GDP, inflation, and unemployment.

factors: “Business conditions,” “Interest rates,” “Foreign exchange rates,” “Politics and diplomacy,” “Internal factors and market psychology in stock markets,” and “Stock and bond markets abroad.” These macroeconomic, political, and psychological factors are among the most likely candidates to explain the index price forecasts. Our panel dataset enables us to directly relate professionals’ ideas on these factors to the expectation dispersion. This approach is different from that in previous papers, such as Lamont (2002), which explains the expectation dispersion by using the forecasters’ age and reputation.

Third, we empirically analyze both buy-side and sell-side professionals’ dispersions of the stock index forecasts. Several papers investigate the behavior of sell-side investors from a cross-sectional viewpoint, but their efforts focus exclusively on the sell-side professionals.[8] Accordingly to Groysberg, Healy, and Chapman (2008), this action is due to a lack of data on buy-side professionals. Among the relatively limited amount of research conducted on buy-side professionals, Cowen, Groysberg, and Healy (2006) and Groysberg, Healy, and Chapman (2008) examine the forecasts made by both buy-side and sell-side professionals, but focus on individual stocks and do not characterize the forecast dispersion of buy-side and sell-side professionals.

Fourth, we empirically identify the types of professionals who actually drive the forecast dispersion. We demonstrate that the different types of professionals, that is to say, the buy-side and sell-side professionals, significantly impact the dispersion. The third strand of literature mentioned above poses the idea that the existence of different types of professionals within the same market generates the forecast dispersion, such as noise traders and rational arbitrageurs in the noise-trader model and fundamentalists and chartists in agent-based models. Nonetheless, those papers identify neither the type of financial institutions to which noise traders, rational arbitrageurs, fundamentalists, and chartists specifically belong nor their respective business categories.

Fifth, we demonstrate that a form of information exchange between buy-side and sell-side professionals exists, which determines the forecast dispersion. The research of sell-side professionals is usually available to the public in reality, whereas that of buy-side professionals is conducted exclusively for buy-side firms’ portfolio managers (Cheng, Liu, and Qian, 2006). However, it is not empirically validated as to whether or not they utilize each other’s analyses in making their forecasts. Even if they do, the information from the sell-side professionals that the

[8] See, for example, Clement (1999) and Hong and Kubik (2003).

buy-side professionals use and the information from the buy-side professionals that the sell-side professionals utilize in making their forecasts remain unknown.[9]

Sixth, in addition to analyzing the relationship between professionals' behavior and the expectation dispersion, we examine the impacts on the dispersion from several economic and financial events, such as the global financial crises, the nationalization of Resona Bank, and the merger of the Mitsubishi Tokyo Financial Group and UFJ Holdings, that have caused important structural changes in the Japanese financial markets. Such an approach can be taken with our dataset, as our sample covers the past 10 years in which these events have occurred.

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[9] Busse, Green, and Jegadeesh (forthcoming) find sell-side analysts' recommendations to be informative to the buy-side professionals but do not find the reverse to be true.

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The paper presented at Brandeis University is summarized as follows:

Title: Strategy switching in the Japanese stock market

Since the financial market liberalization of the 1990s, we have observed remarkable increase in trading volume by institutional investors in the Japanese stock market, who have been seeking for short-term profits. Certain previous empirical studies show that the short-term trading, simultaneously conducted by institutional investors, is mainly responsible for destabilizing the stock markets that often involves larger deviation of the stock price from the fundamental

value.[10] Practitioners try to figure out the sources of the unstable stock price movements for better risk management in financial markets. The liberalization of global financial markets that increases the number of market participants indicates that investors' expectations are more likely to be incorporated in the asset prices. Therefore, providing better explanations of the expectation formation process of investors and how investors' expectations are related to asset price movements can facilitate better understanding the sources of risk in financial markets. This paper provides empirical evidence for understanding both the determinants of expectations and the causes of stock price movements by using a monthly forecast survey dataset on the TOPIX distributed by QUICK Corporation, a Japanese financial information vendor in the Nikkei Group.

We first demonstrate that the professionals involved in the Japanese stock market utilize both fundamental and technical trading strategies through their expectation formation processes and switch between fundamental and technical trading strategies over time. We then empirically show that the strategy switching is key in understanding the persistent deviations of the TOPIX price from the fundamental value. Our conclusions are consistent with what several agent-based models predict as follows. Recent agent-based theoretical models successfully explain the causes of stock market instability, such as larger price fluctuations than those of the fundamental price, that are still not explained sufficiently by traditional asset-pricing models with efficient market and rational expectation hypotheses.[11] Many agent-based theoretical models assume that agents form their expectations by combining several investment strategies. Stock market instability is explained in an environment in which agents switch the level of dependence on the strategies over time. Standard agent-based models, popularly exemplified by a model created by Brock and Hommes (1998), assume that agents combine fundamental and technical trading strategies in their forecasting. Investors using the fundamental strategy expect that future prices will always hover around the fundamental or intrinsic value of the asset, which is often measured by a firm's earnings or dividends. The technical trading strategy is developed using past price information, and it suggests that expectations are positively related to recent price movements if agents are

[10] Several recent studies, such as Chen, Jagadeesh, Wermers (2000), Nofsinger and Sias (1999), Sias (2004), and Wermers (1999) show a strong positive relation between institutional ownership and stock returns. Shiller (1981) measures the fundamental price, and demonstrates that the stock price often deviates from the fundamental price and its variations are much greater than those of the fundamental price.

[11] Agent-based models also replicate volatility clustering, fat tails of return distribution, non-zero volume, autocorrelations of volume, and positive contemporary cross-correlations between the volume and the squared returns. See, for example, LeBaron, Arthur, and Palmer (1999). Hommes (2006) and LeBaron (2006) survey the literature on agent-based computational finance and explain its usefulness in generating financial market phenomena.

momentum traders, while they are contrarians when the relation is negative. The models demonstrate that, when most agents select the technical strategy, the stock market tends to be unstable, which explains larger deviations from the fundamental price such phenomena as bubbles and crashes. When most agents adopt the fundamental strategy, the market will be stabilized by moving the market price back to the fundamental price, leading the market to be informationally efficient. Standard agent-based theoretical models demonstrate that investors interchangeably utilize the two strategies over time, and this "strategy switching" is a major factor in explaining unstable price movements of financial assets.[12] Our paper provides empirical evidence on strategy switching in Japanese stock markets, and we further demonstrate that the strategy switching explains persistent price deviations from economic fundamentals well.

We explore them by sorting forecasters into buy-side and sell-side professionals.[13] Buy-side professionals are those who work for investing institutions, such as mutual funds, pension funds, and insurance firms, which purchase securities on their own account. Sell-side professionals work for companies which sell investment services to asset management firms, that is to say, the buy-side professionals, and provide research including their recommendations to their clients.[14] We empirically identify the strategy switching of buy-side and sell-side professionals, and we demonstrate that their strategy switching is key in understanding persistent price deviations from economic fundamentals. Previous studies on expectation formations in stock markets focus on measuring the characteristics of the central tendency of the forecasts.[15] However the distribution of the forecasts may not be symmetrical and the distribution may vary over time. Thus, if we use the mean or median forecast series, we cannot characterize the expectation formation of professionals forecasting different from the mean. In addition, previous studies that use the mean or median forecast series cannot identify the types of professionals who are actually destabilizing the market.

Most significantly, this paper contains the following five contributions. First, this paper

[12] Kirman (1991), Lux and Marchesi (1999, 2000), and Gaunersdorfer, Hommes, and Wagner (2008) also explain the strategic interactions and volatility. In addition, Chiarella, Iori, and Perelló (2009) and Farmer and Joshi (2002) show that trend-following strategies amplify noise and cause stylized phenomena in financial markets such as excess and clustered volatility.

[13] Pfajfar and Santoro (2010) sort forecasters' expectations in each period in ascending order with respect to value, and construct time series of percentiles from the empirical distribution. They adopt the approach to investigate the effect of strategy switching on inflation expectations.

[14] For more information on the different activities in which buy-side and sell-side professionals engage, see Groysberg, Healy, and Chapman (2008) and Busse, Green, and Jegadeesh (forthcoming).

[15] For example, see Lux (2009, 2010).

validates the strategy switching and demonstrates the significant relation between the strategy switching and stock market instability that is an important contribution by several agent-based models to the literature. Some laboratory experiments with human subjects support this important observation in theoretical agent-based stock markets.[16] Some survey studies in financial markets provide evidence of strategy switching among the market professionals.[17] Although we have seen theoretical and laboratory work, the direct evidence is still needed to empirically support the strategy switching and its contribution on generating the empirical features in stock markets.

Second, we empirically identify the types of professionals who actually switch the strategies and destabilize the market. Previous research on agent-based models concludes such investors' behavior to be key for explaining several empirical features in stock markets. Nonetheless, those papers identify neither the type of financial institutions to which those agents specifically belong nor their respective business categories.

Third, we empirically analyze the strategy switching by both buy-side and sell-side professionals. Several papers, such as Clement (1999) and Hong and Kubik (2003), investigate the behavior of sell-side investors from a cross-sectional viewpoint, but exclusively on the sell-side professionals. Accordingly to Groysberg, Healy, and Chapman (2008), this is due to a lack of data on buy-side professionals. Among the relatively limited amount of research conducted on buy-side professionals, Cowen, Groysberg, and Healy (2006) and Groysberg, Healy, and Chapman (2008) examine the forecasts made by both buy-side and sell-side professionals, but do not characterize the strategy switching by buy-side and sell-side professionals. In addition, by analyzing the expectation formations by types, we can characterize the forecast behavior of professionals expecting different from the cross-sectional mean or median of the forecasts.

Fourth, we validate the strategy switching in the Japanese stock market at a monthly frequency. Boswijk, Hommes, and Manzan (2007) find strategy switching behavior at a yearly frequency. But it is still not known at what frequency stock investors actually change their strategies. Fifth, we demonstrate that the professionals in the Japanese stock market have

[16] See, for example, Hommes, Sonnemans, Tunstra, and van de Velden (2008) and Heemeijer, Hommes, Sonnemans, and Tuinstra (2009)

[17] In the literature on foreign exchange markets, Frankel and Froot (1990), Westerhoff and Reitz (2003), and Gilli and Winker (2003) empirically show strategy switching, while Boswijk, Hommes, and Manzan (2007) investigates that in the US stock market. In the literature on inflation expectations, Branch (2004) and Pfajfar and Santoro (2010) provide empirical evidence that agents switch prediction regimes using a survey on inflation expectations.

systematic prediction biases and anchoring in some observable priors, contradicting the prediction of the efficient market hypothesis. Our results indicate that professional forecasters combine the technical and fundamental strategies, meaning that they refer to past price information in predicting future prices. The efficient market hypothesis suggests that a market is informationally efficient when the market price already reflects all known information at any point in time. The beliefs of all investors regarding future prices are fully incorporated into the current price. Thus, the market price is an unbiased estimate of the true asset value in a sense that past price information cannot be used to predict future prices. While Shiller (1999) argues that past price information helps to explain current prices in stock markets, several studies examine this hypothesis by using survey data for professional forecasters but have shown systematic prediction biases.[18] The empirical results are consistent with the findings of laboratory studies conducted by Kahneman and Tversky (1973). Thus, our results help to improve the robustness of the findings in laboratory studies conducted by Kahneman and Tversky (1973) by using survey data for Japanese stock markets.

Boswijk, Hommes, and Manzan (2007) provide evidence of the strategy switching in stock markets. They estimate Brock and Hommes's (1998) type of agent-based model in which agents switch their strategies between fundamental and trend-following regimes based on recent past performance. They use the yearly S&P 500 and its earning data from 1871-2003 and show that trend-following behavior explains the persistence of the deviation of stock prices from their fundamental value, which is estimated based on the Gordon growth model using earnings data, while the fundamental strategy tends to revert the prices back to their historical mean.

Our paper differs from that of Boswijk, Hommes, and Manzan (2007) as follows. First, we characterize expectation formations of the buy-side and sell-side professionals. Thus, we demonstrate the mechanisms of the strategy switching in different types of professionals. Second, Boswijk, Hommes, and Manzan (2007) assume an agent-based model itself in estimating

[18] Among many, for example, Nordhaus (1987) finds a significant positive autocorrelation of forecast revisions on GDP growth. When new information arrives, forecasters do not incorporate it into their new expectations immediately but gradually adjust their view in accordance with the new information. Campbell and Sharpe (2009) also investigate Money Market Services (MMS) consensus forecasts and find that expectations are systematically biased and anchored on recent past values. A survey study of financial market professionals and university students conducted by Kaustia, Alho, and Puttonen (2008) provides evidence that professionals and university students anchor their long-term stock return expectations to an initial value. In survey studies on foreign exchange markets, for example, Frankel and Froot (1990), Lui and Mole (1998), and Menkoff and Taylor (2007), professionals often combine technical trading strategies with the fundamental strategy in their forecasting.

strategy switching such that the market is in equilibrium, on average. As we see in the following section, we follow the approach of Boswijk, Hommes, and Manzan (2007) to derive a fundamental price and construct a fundamental strategy. However, our estimation equation is not an equilibrium pricing equation but, rather, uses forecast survey data for stock market professionals to investigate strategy switching. Thus, compared to Boswijk, Hommes, and Manzan (2007), we impose fewer assumptions in validating strategy switching.

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國科會補助計畫衍生研發成果推廣資料表

日期:2011/09/29

國科會補助計畫	計畫名稱: Agent-based models以及股票市場的實證現象
	計畫主持人: 山本彶市
	計畫編號: 99-2410-H-004-056- 學門領域: 財務與金融

無研發成果推廣資料

99 年度專題研究計畫研究成果彙整表

計畫主持人：山本栈市	計畫編號：99-2410-H-004-056-
計畫名稱：Agent-based models 以及股票市場的實證現象	

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	0%	篇	
		研究報告/技術報告	0	0	0%		
		研討會論文	0	0	0%		
		專書	0	0	0%		
	專利	申請中件數	0	0	0%	件	
		已獲得件數	0	0	0%		
	技術移轉	件數	0	0	0%	件	
		權利金	0	0	0%	千元	
	參與計畫人力（本國籍）	碩士生	1	0	10%	人次	
		博士生	0	0	0%		
		博士後研究員	0	0	0%		
		專任助理	0	0	0%		
國外	論文著作	期刊論文	2	0	90%	篇	From this NSC research project, I have published two papers to the following SSCI journals: 1) Yamamoto, Ryuichi. 2011. ’Order aggressiveness, pre-trade transparency, and long-memory in an order driven market,’ Journal of Economic Dynamics and

							Journal of Economic Interaction and Coordination 6, 41-59 (Impact factor: 0.759).
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)		Other than these, I jointly worked with Professor Shu-Heng Chen (Department of Economics, National Chengchi University) and Professor Takao Terano (Tokyo Institute of Technology) for publishing an edited book as follows: ’Agent-Based Approaches in Economic and Social Complex System VI: Post-proceedings of the AESCS International Workshop 2009’ with Shu-Heng Chen Takao Terano, Springer, 2011 (ISBN number: 978-4-431-53906-3). This is a collection of papers, which were presented at the AESCS International conference in 2009 and were accepted after a peer review process for the publication. Professor Shu-Heng Chen, Professor Takao Terano, and I organized this conference at NCCU on November 13 and 14, 2009 where we had 39 presentations, 3 keynote speeches, and 3 tutorials. We had the tutorials on softwares for software-agent simulations and human-subject experiments.					

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估 ■達成目標 □未達成目標（請說明，以 100 字為限） □實驗失敗 □因故實驗中斷 □其他原因 說明：
2. 研究成果在學術期刊發表或申請專利等情形： 論文：■已發表 □未發表之文稿 □撰寫中 □無 專利：□已獲得 □申請中 ■無 技轉：□已技轉 □洽談中 ■無 其他：(以 100 字為限)
3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）(以 500 字為限)