An analysis framework for building commodity futures market simulation model based on heterogeneous traders

Tan Li, Weiwei Wu[*]

[1]*School of Management, Harbin Institute of Technology, 13 Fa Yuan Street, Harbin, China*

Received 6 June 2014, www.cmnt.lv

Abstract

Futures price volatility is always the hot topic for academic researchers and traders in futures market. For exploring the rules of futures price fluctuation, we try to develop a new analysing framework from the angle of the heterogeneous traders. We describe heterogeneous traders as four respects: trading motive, predict styles, risk-return preference, reaction speed, which can accurately describe the heterogeneous traders in futures market. According to the categories of heterogeneous traders, we construct traders' internal model, which is used in a commodity futures market simulation model to verify the framework, and the results show the framework is useful.

Keywords: bounded rationality, commodity futures markets, simulation model, heterogeneous traders

1 Introduction

The rules of futures prices movement has been the hot topic that academic researchers and traders have been interested in all the time. The deep understanding of this question not merely facilitates the futures price forecasts, but also favourable to the formulation of the futures market supervision rule, guarantee the market runs effectively. About the rules of futures prices volatility academic writing and actual operators have totally different understanding. In futures market, it is numerous traders that do a deal according to individual decision, forms market price. Studying actual operators' behaviour in futures market is a feasible route to understand price dynamic.

We make analysis to trader's behaviours in the market, and form a dynamic framework to analyse futures market price volatility. Then this framework is used for building a commodity futures market simulation model. The simulation results can be adopted to verify the validity of this analysis framework.

2 Review of commodity futures price theory

There are three main kinds of theoretical research of futures price volatility: (i) all these kinds of research beginning with 1930 of Keynes, he regarded the futures price as the function of the storage cost. The central idea of theory of price of storage is to analyse the composition of the futures price. Inherit the Keynes futures price theory, Working and Hicks developed the cost-of-carry theory to explain the relationship between spot price and futures price. (ii) the second kind of theoretical research mainly relate to core of the Capital Asset Pricing Model, risk premium problem, and think hedgers group in commodity futures market must pay risk premium to speculators group to make them enter position on the contrary

to total hedgers group. (iii) Because of remarkable development in econometrics in recent years, almost each new technology in econometrics is rapidly applied to research price fluctuates in various financial markets. A lot of econometrics models are developed to analyse the relationship between spot price and futures price. The results through these models generally show the lead-lag relationship and the long-term forecast result is better, but short-term forecast is relatively bad.

The above (i) and (ii) items can partly explain futures price phenomenon, such as backwardation and contango. Many econometrics models which describe the spot price and futures price relationship can be used to predict the futures price, though the short-time forecast result is not satisfied. But the intrinsic character of the futures price dynamic is still not clear. The key problem is hypothesis of rationality. Many researchers generally used the hypothesis that traders in the market are completely rational and homogeneous. Since the presence of Simon's bounded rationality theory, this hypothesis is constantly questioned by many scholars.

Since 1980s', two representative schools' opinion about bounded rationality have been appeared. First is financial behaviour. The representatives are Robert Shiller and Daniel Kahneman. They have inherited Simon's bounded rationality theory partly. Based on the results got from psychological and human subjective experiments, they studied the relationship between traders' bounded rational behaviour and price dynamics. They developed theories including prospect theory, noise trading model, etc. Behaviour finance theory broke the traditional assumption about rational traders which was dominated in academic cycles in the past, and studied trader's decision under the uncertain conditions, and offered a feasible road for exploring the intrinsic characters of price dynamics in the financial market. But behavioural finance cannot build a unified

[*]*Corresponding author's* e-mail: hit_wu@126.com

Operation Research and Decision Making

frame to explain all the price anonyms appeared in the financial market. It is an obstacle to further develops for behavioural finance. Actual traders always adopt fundamental or technical analysis as their forecasting approaches. In the noise trading model, the traders of technical analysis generally are viewed as noise traders or call as speculators. Noise is defined as a process leading to shadow information, i.e. market mechanisms which blur observations of the market [1]. Noise traders, however, do not transcend the categories of fundamentalists and chartists. Recently, some scholars adopted the questionnaire among the traders in foreign exchange market, and find the majority of traders adopt the technical analysis method for short-term forecasting. As the extension of time horizon changes, these traders take fundamental analysis as the main method gradually.

Other scholars take the method of experimental economics, simulate financial market through the computer program, study traders' strategies and the influence to financial market price, and call it agent-based computational finance. Santa Fe of USA is famous in this field, their artificial financial market can really recur the statistics characteristic of the data on real financial markets. In their artificial financial market model, traders are heterogeneous. Agent-based computational finance so is a feasible road to study the financial market price dynamic characteristic. Studies of Behaviour finance and agent-based computational finance have one important common characteristic to think traders of financial market are bounded and heterogeneous. But in agent-based computational finance field, the empirical study on heterogeneous traders is still lack. In this field, traders are classified as fundamental and chartist / technical ones according to perception, not to first-hand data. Several results from investigations about heterogeneous expectations are not analysed systematically. Just like what Goodhart said, Economists cannot just rely on assumptions and hypotheses about how speculators and other market agents may operate in theory, but should examine how they work in practice, by first-hand study of such market [2]. Some researchers used questionnaire and interview to study foreign exchange market traders' expectation. The further work is to use these methods for the research of the commodity futures markets, and use the results of investigations to construct artificial futures markets simulation model. The following part of the paper is arranged like this, section two will analyse the meaning of trader's heterogeneity, and evidence for it. Section four will describe all kinds of traders' heterogeneity in the market carefully, and construct the internal model of the traders used in the artificial futures markets simulation model. Section five analyses the futures market price dynamic based on the hypothesis of heterogeneous traders. In the last section, summarize the futures market price dynamic analysis frame of heterogeneous traders and propose the future research work.

3 Definition of heterogeneity of traders and evidences

3.1 DEFINITION OF HETEROGENEOUS TRADERS

One of the reasons to explore trader's heterogeneity is to explain anomies in financial market. These anomies

generally include aggregational Gaussianity, clustered volatility, fat-tailed return distributions, and long-term memory. Before define traders' heterogeneity, we will first discuss traders' rationality in financial market.

The bounded rationality theory first appears in Simon's "Management Behaviour". Simon thought, in broad sense, "rationality" refers to a behavioural manner: (i) Suitable for realizing the goal; (ii) And within the designated constraints. Economists use the word "rationality" to describe the attribution of action plans, not of decision process [3]. Kahneman and Tversky thought that people pay more attention to the amount of changes in their wealth, instead of their wealth final quantity. People incline to take the risk of gambling while facing the losses with suitable terms, and while facing the profit with suitable condition, incline to accept the determinacy and make profits. The happiness of making profits brings less than the agony that equal amount of losses. Yang Xiao-Kai summarizes Simon's bounded rationality theory to 3 main points: non-complete information cost of process information and some non-traditional goal function of decision makers. But Yang thought the 3 points of Simon' bounded rationality mentioned did not touch the nature of bounded rationality conception. Knight pointed out the foundation of bounded rationality lay in fundamental uncertainty, and this cannot be equal to non-complete information.

In this paper, traders' bounded rationality is the description of the decision-making process attribute. Traders' bounded rationality means two respects: (i) What traders faced is a complicated, uncertain market environment, this kind of uncertainty includes endogenous and exogenous uncertainty, endogenous uncertainty is caused by numerous trader's decision, endogenous uncertainty still exists even in such situation that not exogenous uncertainty; Exogenous uncertainty causes the uncertainty of the external factor of the financial market of various influence. So traders do not have complete information, have information asymmetry; (ii) Trader's computing capability and cognitive ability to the environment are limited, this one that includes to understanding that has already acquired knowledge and computing capability is limited.

Financial economics and new classical economics usually view individual traders as homogeneity, there are common risk preferences and beliefs between traders, or further assume traders have common knowledge. Under market equilibrium frame, several researchers study non-homogeneous traders' influence to market equilibrium. These researchers described heterogeneity of traders as heterogeneous beliefs or heterogeneous risk preferences, or both of them. According behavioural decision theory, a robust discovery is that the individual traders are heterogeneous in beliefs and risk-preferences [4-7].

The traders in the real financial market are bounded rational, and have different risk preferences, beliefs and information sets. According to the above-mentioned analysis, In this paper, trader heterogeneity of futures market refers to, the bounded rational traders, because the individual's risk preference, computing capability, information quantity and quality hold, difference level of affections by other traders, form different beliefs on futures price.

3.2 EVIDENCES FOR HETEROGENEITY OF TRADERS

Tests for heterogeneous traders mainly concentrate on the test for heterogeneous expectations in the futures market, and generally have two kinds of methods. One is "indirect test", while being so-called, because the method to estimate, receive through parameter trader have among the distribution or market that heterogeneity it is expected on the basis of constructing all kinds of and expecting the model heterogeneously Only allow reason to expect the proportion that traders account for verifies the existence of anticipated heterogeneity. Baak added bounded rational traders in the linear programming model that the standard reason of a financial market expects. In the model, bounded rational traders think the price obeys the AR(1) process. Finding market trend and traders' anticipated form in the market have close relations [8]. According to the calculation, when bounded rational traders' proportion "n" value exceeds a certain critical value in the market, the price can't converge to the equilibrium state. Frechette has adopted "indirect test" to examine heterogeneous expectations too, use the time series data of the commodity futures to test method validity [9]. One common point of the method is to divide traders into two or three groups, including fundamental and technical analysis traders, or rational expectation traders and bounded rational expectation traders, or is divided into naive traders, quasi-rational expectation traders and rational trader according to forecasting methods [10,11]. In addition, Hommes and Sorger assumed bounded rational traders form expectation according to the observed value of price time series, and this is similar to the traders who adopt the technical analysis to forecast in real market. Results of these research support market have heterogeneous expectations, but this kind of traders' categorized method is according to the general consciousness, not empirical investigation and statistical analysis, does not have convincingness, the accuracy of the result is queried.

Another test method for heterogeneous expectations can call "direct test". Oberlechner adopted questionnaire and interview method, studied the forecasting approaches used by European exchange market practical traders and financial journalists. His results confirm that most traders use both forecasting approaches (fundamental and technical analysis method), and that the shorter the forecasting horizon, the more important chartist/technical analysis is. In the past dozens of years, the importance of technical analysis in the foreign exchange market rises remarkably [12]. In addition, Lui studied the Hong Kong foreign exchange market dealers, and found technical analysis is considered slightly more useful in forecasting trends than fundamental analysis, but significantly more useful in predicting turning points and move average or other trend follow system is the most useful technical analysis method [13]. Cheung investigated traders' views on determination of exchange rate [14]. Cheung found a large part of traders thought that purchasing power parity (PPP) can be used to measure an foreign exchange rate's the fundamental value, however a much smaller percentage of traders would trade in such a way as to move

exchange rates closer to PPP levels. It means the fundamental value criterion of exchange rate that traders admit is inconsistent with their standards of estimating adopted at the time of real trade. Cheung mentions, he has experienced the divergence between academic writing and traders' views. The above researchers' questionnaire investigation result s are enough to prove traders are not homogeneous in the foreign exchange market, including forecasting approaches at different forecasting horizon, the admitted factors of fundamental values, traders' reaction speed, traders' motivations, etc.. The difference between traders is so huge, and homogeneity and rationality are unable to describe all traders. Have not found that carry on the studying of this kind of investtigation to commodity futures markets traders, according to the materials collected at present, but believe that will get the similar result.

4 Developing heterogeneous traders' internal model

According to above-mentioned researches, there are sufficient evidences to support traders' heterogeneity, how to accurately describe traders' heterogeneity in constructing the artificial market simulation model is very important. De la Maza and Yuret first researches artificial futures market price dynamic, put forward information set, algorithm set, model set, constraint set to describe heterogeneity, but they fixed algorithm set and model set in the model [15]. This kind of 4 sets of de la Maza and Yuret describes constructs a rough frame for trader's internal model. According to the reasons, describe and affection for traders' heterogeneous, this paper constructs heterogeneous traders' internal model.

4.1 REASONS FOR HETEROGENEITY OF TRADERS

Researchers hold different views on what lead to trader's heterogeneity. Chavas' opinion was there were fundamental analysis traders (rational) and technical analysis traders (bounded rational) and different traders received and different experience caused trader's difference in knowledge [16]. Frechette attributed traders' heterogeneity to different traders' priori beliefs and filtration way in information, regarded individual's expectations difference as the expression of trader's heterogeneity. Oberlechner found trader's different prediction styles were related to individual background (such as age, gender, professional rank, years of work experience), but have no relations with trading locations. Author thought this because of in will obtain more information and training, etc. close to global transaction place of banking centre. We divide reasons into the internal factors and external factors. Internal factor refers to trader's education and training experience, individual risk-preference, predict style, etc. which are determined by individual characteristic. External factors refer to the differences between individual caused by individual trading motivation. According to the differences, we can divide traders group into several sub-groups.

According to the external factors, traders can be divided into hedgers, risk management traders, speculators.

1) Hedgers generally hold stock for production, or themselves are stock manufacturers. The aim of hedgers is just to hedge the position of the stock using futures contracts. In theory, hedgers will not adjustment position frequently, so they might not intraday traders. Hedgers including every industry's manufacturers, such as Jiangxi copper industry group in China.

2) Risk management traders refer to futures broker who engage agency business and clear their position in a day for risk avoidance need, they deal in order to guarantee their own position minimum risk in market. Three domestic futures exchanges (not including Hong Kong and Taiwan areas) implement the member system at present. There are two kinds of members, self-operation member, managers, and no comprehensive type. Therefore, in our country at present there is no market maker whose purpose is to minimize the risk by adjusting intraday position.

3) Speculators refer to who do not need to hold the stock for production, may hold stock for speculation, trading purely with the purpose of making a profit in speculation among futures market. This kind of traders can adjust their position for maximizing profit at any time. All hedge funds which invest in derivative markets belong to this kind of traders. Some domestic funds raised privately belong to this group at present.

According to the internal factors, individual traders can be distinguished as hedgers, risk management traders, speculators. Each trader among his group, because internal factor cause individual difference trade behaviour of the course reflect according to heterogeneous traders' behaviour.

4.2 REPRESENTATION OF HETEROGENEITY OF TRADERS

Sager and Taylor researched on foreign exchange market and got the results that heterogeneity of traders included information asymmetries, different reaction speed to information innovations, diverse trading opportunity sets and risk-return expectations [17]. Klitgaard and Weir used private information and public information to distinguish heterogeneous traders [18]. The private information here is analogous to traders and form all contents included price expectations. De la Maza and Yuret's research adopted information set, algorithm set, model set, constraint set, to describe traders' heterogeneity. We use forecast style, risk-return preference, and reaction speeds, totally three respects to describe traders' heterogeneity.

1) Forecast style. Oberlechner adopted clustering analysis method to obtain four forecast styles: chartist, ascending (technical analysis method is more popular in short-term, as time horizon is lengthened, change direction and fundamental analysis gradually becomes more popular when time horizon become longer than one year), fundamental, ascending (adopt the basic analytical method more than the technical analysis of rising in short-term, as the time horizon is lengthened, change direction and rely mainly on the fact that the foundation is analysed gradually, level become extreme foundation

analysis trader longer than one year, in time), constant chartist (no matter time level grow section, pay attention to technical analysis even more, does not change much, this and Cheung, Chinn and Marsh, 2004 research conclusion the same), inverse middle (adopt the foundation to analyse more in a short time, but turn in long-term forecast to and adopt the technical analysis method finally). Through interview traders, Oberlechner found traders view the charts as "visual representations of mass psychology".

2) Risk-return preference. Generally speaking, hedgers should carry on the middle or long-term trading in the futures market, and belong to risk neutral traders, because their trading motive lies in hedging stock value, but not in order to earn the great amount of profit through futures trading. Risk management traders generally do intraday transaction, and the purpose is for voiding business risk. It is generally acknowledged, speculators do short-term transaction, and their purpose to buy or sell futures contracts is just for earning great amount of profit. According to modern finance theory, more return with more risk, congenial profit-making traders, just traders have offered flow ability in order to hedge. But Haigh, Hranaiova and Overdahl studied speculators in futures market. They found the original common consensus that speculators do short-term transaction was not true, such as hedge fund mostly did middle or long-term transaction, but hedgers more frequently changed their positions than speculators did [19].

TABLE 1 Risk preference of three groups

Time Level	Hedgers	Risk Manager	Speculators
Short	RISK AVERSION	RISK AVERSION	RISK AVERSION
Middle or Long	RISK NEUTER	–	RISK APPETITE

Cheung, Chinn and Mars investigated traders in foreign exchange market and found that traders in market thought the predictability of price movement increased with time horizon extended. They also found the next day or intraday trade has little predictability. This result proved these traders thought next day or intraday trade was very risky, but interview results showed these traders felt little risk in the next day or intraday. These results appear to contradict each other, and the reason may be that at least for part of traders, the risk measurement index may not be the variance, but the changes of assets. Because intraday or next day transaction even though makes loss, change percentage is very small for total amount of assets. Although it have more predictability for a long-time horizon, for an exact time level, traders think the predictability is extremely limited too. So we should adopt a new risk measurement method for describing trader's risk-return preference, which is different from the past to adopt price variance of change estimate the risk. And what traders think is too risky to bring the higher income maybe not higher income. Such as risk management traders do intraday transaction, but they are risk-aversion. Three groups of risk management traders, hed-

gers and speculators are divided according to time horizons (see Table 1).

3) Reaction speed. Sager and Taylor thought some hedge funds had the fastest reaction speed to information innovations. But in Haigh, Hranaiova, and Overdahl's research hedge funds adjusted their positions after hedgers' position changed, that was to say hedgers have a faster reaction speed than hedge funds. It is still unclear what causes this each other contradictory result, but the fact is that traders really have different reaction speeds to new information. So reaction speed can become one aspect of trader's heterogeneity.

The traders are influenced by market sentiment mentioned in some literatures, and this is a kind of behaviour of heterogeneity too. Find through interview trader think "chart masses psychology but view ", can think traders adopt the technical analysis method to include his receiving the mood effect of the market while predicting. Using trading motive, predict styles, risk-return preference, reaction speed, totally four respects to describe heterogeneous traders.

4.3 IMPLICATIONS OF TRADERS' HETEROGENEITY

Trader's heterogeneity influence is divided into two parts, including the influence on producing between traders, i.e. the interaction between traders, and trader's overall influence on producing dynamically at the market price.
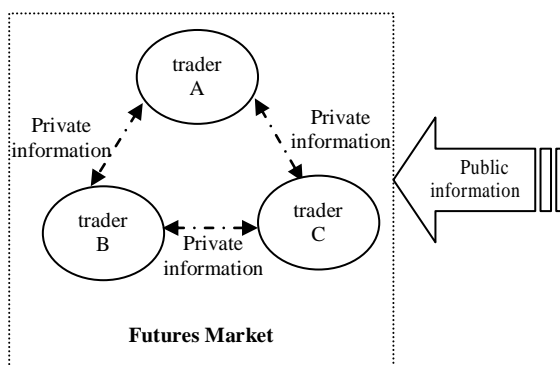

FIGURE 1 Relationship between internal model and outside environment

Because of difference predict style, deal motivation, risk-return preference, reaction speed, heterogeneous traders constantly influence each other. Traders who adopt technical analysis experience the mood in market by chart, influenced indirectly by mood in market. But as for individual, the influence received is the common influence which other heterogeneity traders produce in the market, traders react in the market price according to the decision that technical analysis is made, thus have an influence on other traders. So the heterogeneity traders in the market are the interaction, influence each other. Because of traders' heterogeneity, individual traders' decision exerts an influence on the price commonly at the same moment.

The reasons, representation and influence, totally three respects form commodity futures market trader internal model of artificial model of heterogeneity. The

internal model exists in the whole market system, there is exchange of information and energy with the whole market, influence each other (Figure 1).

5 Commodity futures markets simulation

Since middle period of the 1990s last century, a lot of scholars have adopted the heterogeneous actor to suppose the research of carrying on artificial modelling to the financial market trend already. For instance Hommes, Le Baron, Lux, et al. adopt agent-based financial markets model to study a lot of market prices which accord with the result of study of experience count the characteristic. Carry on to commodity futures market price artificial research still relatively getting little dynamically[20], futures market and stock market are in the trade mechanism, the participant in the market, the structure of market, and the decision of basic value has a lot of differrence. In the research of de la Maza and Yuret, adopt and fix model collecting and algorithm collection on two scholar's treatment to trader's internal model, observe trader information set restrain situation to collect change from, evolution trends of the market. Discover the traders with fund advantage and relative information advantage are easier to obtain in the market, two scholar in propose, should break through to some extent in constructing the more careful model of participant in the market to the further investigation of field here in their article.
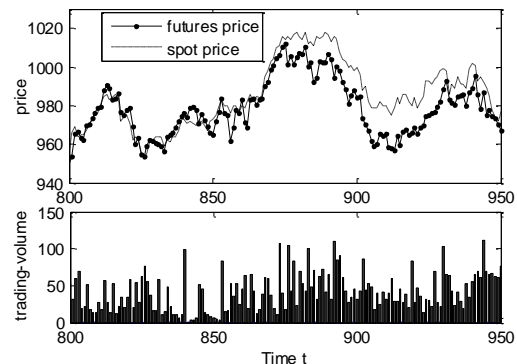

FIGURE 2 Market price and trading-volume in simulation

We apply the above framework to construct a simulation model to certificate the framework is useful. The software of Matlab is used for simulation analysis in the paper and Figure 2 shows the output. We use the actual spot price and simulation, and then we get the futures price series. Finally, we use the futures price series to test whether or not the framework can explain the anomies in futures market.

In the simulation, we choose real wheat spot price and the data can be obtained from wheat database on the website http://www.czce.com.cn.

From the simulation, we got the futures price and trading-volume which is showed in Figure 2. The test results have listed in Table 2. The simulation generates the futures price series have these characters: aggregational Gaussianity, clustered volatility, fat-tailed return distributions, and long-term memory. These results can partly verify the framework which is constructed in this paper (see Table 2).

TABLE 2 Futures prices series tests results

Statistics index	Futures price	Spot price
Sample size	960	960
Max (Min)	0.05(-0.04)	0.07(-0.04)
Standard variance	0.01	0.01
Skewness	0.60	3.76
Kurtosis	12.28	51.16
JB statistic	3477.86 [0.00]	94521.02 [0.00]
Q-statistic	98.62 [0.00]	52.66 [0.00]
Q^*-statistic	185.27 [0.00]	29.31 [0.00]
Hurst	0.69	0.64
Hurst*	0.50	0.52
LM test	6.76 [0.009]	0.12 [0.73]

In Table 2, Hurst index can be calculated by R/S analysis. Hurst* can be calculated by R/S analysis with using rearranged original sequence; Q is Box-Pierce Q-statistic used for autocorrelation test, Q* is Box-Pierce Q-statistic with using absolute return; LM test is a test for heteroskedastic in time series. All the values in square brackets are the probability of relevant test.

6 Conclusion

This paper summarizes the current literature about heterogeneous expectation test in financial markets and about financial market price dynamics simulation based on heterogeneous behaviour hypothesis, and analyses the reasons for heterogeneity, the representation of heterogeneous traders, as well as the influence of heterogeneity on the market, put forward the analysis framework of commodity futures market price dynamics based on heterogeneous traders.

We will further adopt direct examine method, use questionnaire and interview method to investigate traders' heterogeneity in the commodity futures market. The investigation may include all kinds of traders' risk preferences, forecasting technology, trade level, judgment of contract value, reaction speed, learning capability, etc. The results will be used for representation of heterogeneous traders in commodity futures market simulation model. Using artificial method to study micro pricing mechanism in futures market will be an effective route. This is the content that we will study further.

References

[1] Fisher B 1986 Noise *Journal of Finance* **41** (3) 529-44
[2] Goodhart C 1988 The foreign exchange market: a random walk with a dragging anchor *Economica* **55** (11) 437-60
[3] Simon H. A 1960 *The New Science of Management Decision* New York: Harper and Row
[4] Timothy C, Thomas J S, Viktor T 2014 Wealth Dynamics in a Bond Economy with Heterogeneous Beliefs *Economic Journal* **124** (575) 1-30
[5] Cvitanić J, Jouini E, Malamud S, Napp C 2011 Financial markets equilibrium with heterogeneous agents *Review of Finance* **16** (1) 285-321
[6] Chien Y, Lustig H 2010 The market price of aggregate risk and the wealth distribution *Review of Financial Studies* **23**(4) 1596-650
[7] Bhamra H S, Uppal R 2013 Asset prices with heterogeneity in preferences and beliefs *CEPR Discussion Papers*.
[8] Saang J B 1999 Tests for bounded rationality with a linear dynamic model distorted by heterogeneous expectations *Journal of Economic Dynamics and Control* **23** (9-10) 1517-43
[9] Frechette D L, Weaver R D 2001 Heterogeneous expectations of traders in speculative futures markets *The Journal of Futures Markets* **26**(5), 429-446
[10] Frechette D L 1999 The Supply Of Storage Under Heterogeneous Expectations *Journal of Agricultural and Applied Economics* **31**(3) 461-74
[11] Weaver R D, Zhang Y 1999 Volatility of market prices: the role of heterogeneous expectations *The Annual Meetings of the American Agricultural Economics Association* Nashville TN

[12] Oberlechner T 2001 Importance of Technical and Fundamental Analysis in the European Foreign Exchange Market *International Journal of Finance and Economics* **6**(1) 81-93
[13] Lui Y, Mole D 1998 The use of fundamental and technical analyses by foreign exchange dealers: Hong Kong evidence *Journal of International Money and Finance* **17**(3) 535-545
[14] Cheung Y-W, Chinn M D, Marsh I W 2004 How do UK-based foreign exchange dealers think their market operates? *International Journal of Finance & Economics* **4**(4) 289-306
[15] de la Maza M, Yuret D 1994 A futures market simulation with non-rational participants *Artificial life IV* MIT Press 325-30
[16] Chavas J P 1999 On the economic rationality of market participants: the case of price expectations in the U.S. pork market *Journal of Agricultural and Resource Economics* **24**(1) 19-37
[17] Sager M J, Taylor M P 2006 Under the microscope: the structure of the foreign exchange market *International Journal of Finance & Economics* **11**(1) 81-95
[18] Klitgaard T, Weir L 2004 Exchange rate changes and net positions of speculators in the futures market *Economic Policy Review Federal Reserve Bank of New York* May 2014 17-28
[19] Haigh M, Hranaiova J, Overdahl J 2005 Price Dynamics, Price Discovery and Large Futures Trader Interactions in the Energy Complex *Staff Research Report Commodity Futures Trading Commission* Washington DC
[20] Ussher L 2004 An agent based model of a speculative futures market: do margin requirements and transaction taxes affect price volatility? *PhD thesis*

Authors

Tan Li, August 1978, Harbin City, Heilongjiang Province, P.R. China.

Current position, grades: lecturer at the School of Management, Harbin Institute of Technology, China.
University studies: BSc, MSc and DSc in Management at Harbin Institute of Technology in China.
Scientific interests: agent-based computational finance, risk management, behavioral finance
Publications: more than 7 papers
Experience: Teaching experience of 5 years, 7 scientific research projects.

Weiwei Wu, November 1978, Taiyuan City, Shanxi Province, P.R. China

Current position, grades: associate professor at the School of Management, Harbin Institute of Technology (HIT), China.
University studies: BSc, MSc and DSc in Management at Harbin Institute of Technology in China.
Scientific interest: innovation management, agent-based computational finance.
Publications: more than 20 papers.
Experience: Teaching experience of 7 years, 6 scientific research projects.

Operation Research and Decision Making