

# Evolutionary Game Theory and Stock Market Investment Behavior: Based on the Empirical Analysis and the Multiple Regression Analysis of Chinese Household Finance Survey

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**Abstract:** Combined with evolutionary game theory, this paper analyzes the stock investment income of individual and household investors. In this paper, multiple linear regression model is utilized to analyze the data based on the Chinese Household Finance Survey (CHFS). The results demonstrate that education level and whether the subjects are working in a securities company are the most significant factors that affect individuals and household stock investment returns. Thus, whether individual and household stock investment can be profitable is mainly affected by the attitudes towards risks and whether the subjects to work in the securities company, and the return rate of individual and household stock investment is mainly affected by the education level.

**Keywords:** Evolutionary game theory; Behaviors of investing in stock market; Multiple linear regression model

## 1 INTRODUCTION

In the past two decades, the participation of Chinese households in the stock market has risen sharply, and individual and household investors have played an increasingly important role in the stock market. Analyzing and explaining the influencing factors that affect the investment income of individual and household investors has become a hot issue in academia. Stock investment is a game behavior, which is suitable for the analysis of game theory. However, the volatility of the stock market shows that the rational expectation assumption in traditional game theory is not suitable for the analysis of individual and household stock investment behavior. The investment strategies of individual and household is often affected by personal characteristics and household environment. For example, in the classic investment income theory, risk preference is an important factor that affects investment behavior, and to a certain extent determines the level of investment income. In the stock investment behavior of individual and household, it is impossible to separate individual risk preferences from those of household members. Therefore, the overall investment behavior of the household may not be completely rational as individual investment behaviors. Based on the above situation, this paper relies on traditional economic theories to analyze the evolution of investment behavior from the perspective of individual and household characteristics, and points out that there are diversified purposes for individuals and families to participate in stock market investment. Different from the previous analysis, this paper combines the data of individual and household stock investment in the Chinese stock market to conduct an

empirical analysis, and draws conclusions of individual and household stock market investment behavior that are different from previous studies.

## 2 LITERATURE REVIEW

Many scholars have deeply studied the evolutionary game theory and the investment returns of individual and household stock markets. Among them, some scholars separately discussed the development of evolutionary game theory, the role of individuals and families in stock market investment, and some scholars applied evolutionary game strategies to the analysis of financial markets such as stock markets.

Jiang Zhengfeng and He Shounan (2009) focused on the analysis of the rational person hypothesis in game theory in their paper "Analysis of Rational Issues in Game Theory", and the authors analyzed based on theoretical analysis methods such as the payout matrix. Research has pointed out that due to some rational restrictions, the players of the game often cannot choose the optimal strategy. When the research object expands from individuals to groups, the local dynamic method can be considered to analyze the group's decision-making behavior, and the analysis results are more in line with reality.[2] Long Jing and Zeng Yadong (2018) analyzed the investment behavior of individual investors in China's stock market in their paper "Analysis of Individual Investors' Investment Behavior in China's Stock Market Based on Behavioral Finance". Research has found that although individual investors in the Chinese stock market still have obvious overconfidence and herding effects, they have improved to a certain extent. The anchoring effect and policy dependence effect are more obvious, and the psychological factors that produce these effects It is unavoidable that investors can only reduce the degree of their own cognitive bias by improving their own psychological awareness and strengthening their ability to analyze investment. [6] Qin Wenlong (2020) analyzes the investment behavior of Gerti investors in the Chinese stock market in his paper "Research on Individual Emotional Choice Based on Big Data Stock Market". The author analyzes the investment behavior of the Chinese stock market based on the big data of investment in the Chinese stock market. The results show that the irrational behavior caused by investor sentiment is directly proportional to the stock price in the short term. But in fact, from a long-term perspective, individual emotions are divergent from individual choices. Choices made under the influence of individual emotions and choices made under the influence of rationality, the latter gains 3%-4% higher than the former. [3] Zhang Xiaoyan (2021) studied a simple algorithm for identifying retail investors from public transaction data in his paper "Tracking Retail Investors" and analyzed it based on this algorithm. Research has found that retail investors in developed countries (such as the United States) have shown certain stock picking capabilities and can correctly anticipate future stock trends. The thesis has made an original contribution to the literature of retail investors in developed countries, and at the same time has important reference significance for the future development of China's stock market. [8]

Ma Weifeng et al. (2007) analyzed the fragility and stability of China's financial system in their paper "China's Financial Fragility Paradox". The author analyzed the issue based on evolutionary game theory and combined with the dynamic equation phase diagram. Studies have shown that although China has not established a deposit insurance system, the national credit guarantee behind the original state-owned banking system functions as a stable financial system similar to

the deposit insurance system. The national credit guarantee is actually an implicit deposit insurance mechanism. This finding explains the paradox of the coexistence of fragility and stability in China's financial system. [1] Wang Bin and Zhao Jianjun (2007) analyzed the path dependence problem in the change of financial system in their paper "Evolutionary Game Theory Analysis of China's Financial Industry Development". The authors made a theoretical analysis based on the evolutionary game model. The study found that for different countries, even if the most efficient financial systems are different, they all affect the level of a country's financial industry development. Even if such an equilibrium is not Pareto efficient, it will be at In a stable state, there is an optimal equilibrium of Pareto efficiency. [7] Li Cheng et al. (2009) analyzed the regulatory coordination behavior of the People's Bank of China and three financial regulatory agencies in their paper "Interpretation of my country's Financial Regulatory Coordination Mechanism Based on Evolutionary Game Theory". The author based on the payment matrix and dynamic phase diagram in game theory. Perform analysis. The study found that the current China's financial regulatory coordination mechanism is in a low-efficiency state, and the regulatory parties have a "free rider" phenomenon in the game process. The initial state of the benefits of financial supervision cooperation or not determines the strategic choice of the supervisory body to a certain extent. [5] Ouyang Hui (2014) studied the contradiction between my country's financial innovation and financial supervision in his paper "Research on China's Financial Innovation and Financial Supervision Based on Evolutionary Game Theory". The author analyzed the contradiction between China's financial innovation and financial supervision based on the evolutionary game model. The study believes that the traditional high-cost and low-efficiency regulatory model should be changed, financial innovation should be encouraged, financial institutions' innovation enthusiasm should be increased, and financial regulatory agencies' penalties should be properly set up to improve the competitiveness of China's financial system and promote the healthy development of China's financial industry.[4]

### 3 METHODOLOGY AND DATA

This paper uses multiple linear regression models to analyze the stock investment income of individual and household investors.. Multiple linear regression models are often used to analyze multivariate disturbance problems, that is, the dependent variable in a problem is affected by changes in multiple independent variables. Individual and household investors' stock investment issues are typical of this category. Investment strategies are affected by many factors such as education level, gender, risk attitude, number of stocks held, and whether they are employed in securities companies. Under such circumstances, it is particularly important to establish multiple linear regression models through econometric methods and to accurately analyze the impact of the above factors on the stock investment strategies of individual and household investors. The specific model form is shown in equation (1).

$$y_i = \beta_0 + \beta_1 x_i + \beta_2 z_i + u_i \dots \dots \dots (1)$$

In equation (1), the dependent variable  $y_i$  is whether the stock investment is profitable or the stock investment rate of return, and the independent variable  $x_i$  is the level of education. The coefficient  $\beta_1$  represents the degree of influence of education level on the profitability of stock investment or the rate of return of stock investment. In this paper, a series of control variables  $z_i$  are added to equation (1), including gender, risk attitude, number of stocks held, and Whether in

a securities company. In the estimation process of the model, this paper uses the least square method in the mathematical optimization technique to find the best function match of the parameters by minimizing the square sum of the error. The least squares method can be used to easily obtain the parameters to be estimated, and minimize the sum of squared errors between the obtained parameters and the actual parameters. According to the Gauss-Markov theorem, given the assumption of classical linear regression, the least squares estimator is a linear unbiased estimator with the smallest variance. Therefore, when the classical assumption holds, there is no need to look for other unbiased estimators, and none of them will be better than ordinary least squares estimators. That is to say, if there is a good linear unbiased estimator, the variance of this estimator is at most as small as the variance of the ordinary least squares estimator, and will not be less than the variance of the ordinary least squares estimator.

The data used in this paper comes from the China Household Finance Survey (CHFS) database. The China Household Finance Survey is a nationwide sample survey project carried out by the China Household Finance Survey and Research Center. It aims to collect relevant information on the micro-level of household finance. The main contents include: housing assets and financial wealth, liabilities and credit constraints, income Information related to consumption, social security and insurance, intergenerational transfer payments, demographic characteristics and employment, and payment habits, etc., in order to provide high-quality micro-household financial data for academic research and government decision-making, and comprehensive and detailed household economic and financial behavior Characterization. The samples are distributed in 29 provinces, 367 counties (districts, county-level cities), and 1,481 communities; it covers 4,011 households and 1,270,12 individuals; it is representative of cities at the national, provincial and sub-provincial levels. The variables contained in the data can meet the data needs of this paper.

## 4 RESULTS

This paper uses the commonly used measurement analysis software Stata to realize the model establishment and data processing. The output results of the multiple linear regression model are shown in Table 1.

**Table 1** Multiple linear regression model results

VARIABLES	(1)	(2)
	Profit or Loss	Rate of Return
<b>Education</b>	0.0140 (0.0139)	0.0430* (0.0235)
<b>Gender</b>	-0.0240 (0.0510)	0.0679 (0.0862)
<b>Risk</b>	0.100*** (0.0194)	-0.0135 (0.0342)
<b>Number of Stocks</b>	0.000444 (0.000574)	-7.37e-05 (0.000907)
<b>Occupation</b>	0.271*	0.103

	(0.154)	(0.259)
<b>Constant</b>	1.511***	-0.339
	(0.325)	(0.548)
<b>N</b>	979	853
<b>R2</b>	0.031	0.006

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

In Table 1, the dependent variables are the profitability of stock investment and the rate of return on stock investment. The independent variables and control variables include education level, gender, risk attitude, number of stocks held, and whether they are employed in a securities company.

Column (1) of Table 1 reports the regression results of whether stock investment can be profitable. From the perspective of profitability, risk attitudes have a significant positive impact on the profitability of stock investment, with an average impact coefficient of 0.1. This means that compared to risk-neutral stock investors, stock investors with a risk appetite are 10% more likely to make a profit. Whether or not to work in a securities company has a significant positive impact on the profitability of stock investment, with an average coefficient of 0.271. This means that compared with stock investors who do not work in securities companies, stock investors who work in securities companies are likely to make an average of 27.1% higher profits. Education level, gender and the number of stocks held have no significant influence on the profitability of stock investment.

Column (2) of Table 1 reports the regression results of stock investment returns. From the perspective of the rate of return, the level of education has a significant positive impact on the rate of return on stock investment, with an average impact coefficient of 0.043. This means that for every additional year of education, the return on stock investment increases by an average of 4.3%. Gender, risk attitude, number of stocks held, and whether to hold a position in a securities company did not have a significant impact on the return on stock investment.

The results of the multiple linear regression model show that: Firstly, the investment strategies of individual and household investors in the stock market will be affected by individual and household characteristics, including education level, risk attitude, and whether they are employed in securities companies. Secondly, the factors that affect the profitability of stock investment are mainly risk attitude and whether it is in a securities company. The risk attitude to a certain extent represents the interest and enthusiasm of individual and household investors in stock investment, while whether to hold a position in a securities company represents investment experience and information. Finally, the main factor that affects the rate of return on stock investment is education. The level of education indicates to a certain extent the knowledge level and investment ability of investors.

## 5 CONCLUSIONS AND FUTURE RESEARCH

This paper combines evolutionary game theory to study the influencing factors of individual and household stock investment returns and the results of empirical analysis. This paper believes that:

First of all, the strategy of individual and household investors to participate in stock market investment depends on the characteristics of the individual and household, as well as the individual. Different from the purpose of household participation in stock investment, the purpose of investment is different, and the investment strategy adopted will also change accordingly. Specifically, the purpose of individual and household investors participating in stock investment can be divided into two categories. One type of individual and household investors participate in stock market investment to obtain relatively stable profits, and the other type of individual and household investors participate in the stock market. Investment is to obtain higher immediate returns. We recommend that families with different stock investment goals adopt different stock market investment strategies. Secondly, consider the first type of individual and household investors. They participate in stock market investment to obtain stable income, which means that they are more concerned about the long-term profitability of stock investment. Based on the research results, we believe that such individual and household investors should consider household members with high risk appetite and experience in securities companies to decide on stock investment strategies. The high degree of personal risk appetite means that individuals prefer to invest in stocks and securities, which represents the motivation and enthusiasm to participate in stock investment. Individuals with experience in securities companies mean that they have rich knowledge and experience in securities investment. It also means that individuals who have no experience in securities companies have more investment decision-making information, and they are more likely to make profits when they participate in stock investment. Finally, consider the second type of individual and household investors. They participate in stock market investment to obtain higher immediate returns, which means they pay more attention to the rate of return of short-term stock investment. Based on the research results, we believe that such individual and household investors should consider allowing household members with higher education levels to decide on stock investment strategies. A high level of education means that individuals have a higher level of IQ and a more rational expectation ability, which represents stronger analytical and decision-making abilities, and they can obtain higher immediate returns by participating in stock investment.

At the same time, it should be noted that the Chinese household financial survey data used in the analysis of individual and household stock market investment behaviors in this article are cross-sectional data and cannot be dynamically analyzed. The individual and household stock market investment strategies may be adjusted at any time. Based on the subsequent acquisition of richer data, this article will establish a dynamic model to analyze individual and household stock market investment behaviors, so as to obtain more accurate analysis results.

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