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Diffusion of Investor Sentiment Considering Hesitating and Forgetting Mechanism

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Abstract: Excessively optimistic and negative investor sentiment will affect the stability of stock market. In this paper, we investigate investor sentiment diffusion considering hesitating and forgetting mechanism on homogeneous network. Different from previous studies, we introduce the exponent form forgetting rate into SEIR model and figure out the basic reproduction number and existence of equilibrium point. Meantime, the locally asymptotic stability and global stability of internal equilibrium point are established. Finally, we illustrate the impact of forgetting rate on the investor sentiment diffusion through carrying out numerical simulations.

Keywords: Investor sentiment, SEIR model, Forgetting mechanism.

1. Introduction

According to individual investors report released by the Shenzhen stock exchange in 2015, China's securities market is dominated by small and medium investors. Minority investors who lack risk aversion are emotionally vulnerable and their abilities to judge the market are not accurate [1,2]. Their overconfidence tends to result in their incorrect judgment of the market. However, classical economic theory believes that investors' economic behavior is " rational", which obviously does not apply to China's securities market. In China's securities market, even if the individual investor's personal education level, educational background and life experience are different, the individual investors' sentiments agree with common option gradually when investors are concerned about the same event due to the spreading of investor emotion infection. It is more convenient for investors to communicate with other people because of the development of social media which also accelerates the diffusion of investor sentiment infection process. In addition, behavioral economics shows that investors' emotions and psychological factors affect stock market prices and stability to a large extent [3]. Therefore, it is helpful to study the mechanism and ways of investor's emotional transmission in order to ensure the stable development of the stock market.

Several researchers have carried out relevant works to uncover the mechanism of investors' emotion spreading. Shiller et al utilized infectious diseases spreading model and rumor model to establish interest transmission model, explaining why investors were interested in a particular asset in the financial market [4]. Lux et al described the herd behavior of investors and the process of mutual imitation and contagion with nonlinear dynamics method [5]. Through the simulation and causality of investor psychology and stock market, Shang-Jun Y found investors' psychology may seriously affect the stability of stock market and the trend intensity of stock market is linearly related to investor psychology [6]. The stock market can also be seen as a typical complex network of different types of investors. Garas studied SIR model of crisis propagation in country-based economic network, which shows that economic crisis in developed and developing countries can spread to the whole world through the network, causing global economic crisis [7]. Xu-Chong G used multi-agent technology and complex network theory to analyze the small-world network, rule network and real-world market emotion transmission model [8]. Yuan-Yuan M built SIR epidemic model to demonstrate the crisis communication in the stock market [9]. What is more, many researchers have improved the classic SIS and SIRS infectious disease models [10]. For instance, Tchuenche et al. considered the effects of unstable birth and death rates on the population which was more realistic [11]. Jun-Hong L et al considered the non-linear transmission process of infection rate and cure rate [12-14].

However, there are great differences between traditional infectious diseases spreading and investor sentiment diffusion. Firstly, the spreading of infectious diseases is unconscious because infected people cannot stop disease or virus spreading. Obviously, in the process of investor sentiment contagion, people's psychological factors such as forgetting, interests and so on, have a great influence on the transmission of emotion. Meanwhile, because the development of network media makes people accept a large amount of

information every day, forgetting has become an important factor in the process of information and sentiment diffusion. In previous studies, the forgetting rate was regarded as a constant parameter, but the forgetting speed of human beings should be 'fast before slow', so the constant forgetting rate does not accord with the actual situation. Considering Ebbinghaus's forgetting data curve, the index forgetting rate fits the actual situation. Besides, previous studies neglected the population diversity. Compared with SIR model, SEIR model can illustrate the investor emotion contagion more reasonably. This is because people are more likely to stay the sidelines before participating in the stock market. For example, if the market keeps going on, several investors may be optimistic and attempt to persuade their friends or relatives who may hesitate for a while rather than engaging in the stock market immediately. Hence, a dynamic model of investor sentiment diffusion is proposed considering hesitating and forgetting mechanism [15]. The organization of this paper is managed as follows. In the section 2, we establish the mean-filed equation about investor sentiment diffusion. In section 3, we study the model by calculating the basic reproduction number and analyzing the stability of equilibrium point. In the section 4, numerical simulation of $SEIR$ model is given to display the diffusion of investor sentiment [16]. Finally, we conclude the paper in section 5.

2. SEIR mode

The investors are divided into four groups: S,E,$I$and R, which stand for the investors who have adequate funding but do not open accounts(potential investor), the investors who have opened accounts but hesitate to transact(hesitate investor), the investors who are excitedly and actively spread emotion(active investor), and investors who are calm and do not spread investor sentiment(removed or calm investor) respectively. The process of $SEIR$ investor sentiment spreading is shown in Fig.1.

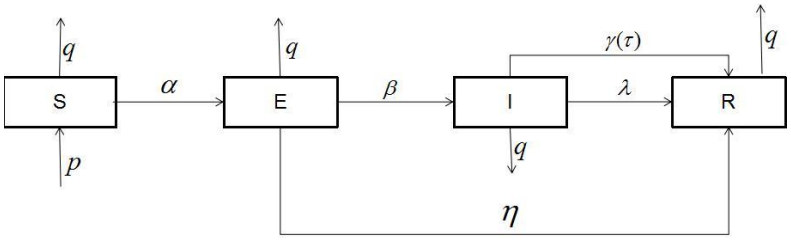

Fig. 1: The structure of $SEIR$ investor sentiment diffusion model.

When potential investor(S) meets his neighboring node(I), because of his knowledge of the stock market, the former open his stock account with probability $\alpha$and do not instantly begin stock transaction. According to the attitude of investor sentiment, hesitate investor(E) starts stock market transactions with probabilityβ. On the contrary, hesitate investor (E) who disagrees with the sentiment exits the stock market with probabilityη. The active investor(I) exit the stock market with probability λ. As time goes on, the investor will forget the emotion, calm down gradually and exit the stock market with probability $\gamma(\tau)$ which we define as the forgetting rate. In this paper, we use exponential form to represent forgetting rate[17,18]:

$$\gamma(\tau)=\begin{cases} a-e^{-b\tau}, 0<a-e^{-b\tau}<1 \\ 1 \qquad\quad , a-e^{-b\tau}\geq 1 \end{cases} \tag{1}$$

a,b are parameters which embody the feature of forgetting curve. When $\tau=0$, $\gamma(0)=a-1$ is constant which we define as the initial forgetting rate. When$\tau\neq 0$, the forgetting rate changes over time. If the value of $a-1$ is larger, the investor sentiment is less attractive to investors and investors are less interested in spreading it. Therefore, a reflects the investor's interest on investor sentiment. b that decides forgetting curve's shape denotes the forgetting speed which means that forgetting speed becomes larger as b gets larger [19]. Denote by $S(t)$, $E(t)$,$I(t)$, $R(t)$ the density of potential investors, hesitate investors, active investors, and calm investors at time $t$respectively, they satisfy the normalization condition: $S(t)+E(t)+I(t)+R(t)=1$. Based on the above condition of hypothesis, the system dynamics equations are described as follows: