Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 5 Issue 11, November - 2018

Diffusion Of Investment Sentiment Considering Delayed Government's Intervention On Complex Networks

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Abstract— **Incorrect investment sentiment diffusion affects the stability of stock market and market economy. This paper considers the government's intervention to establish SCIR model based on the classic SIR model. Through stability analysis, we obtain investment sentiment diffusion threshold which is related to the topology structure of networks. Then numerical simulation of delayed SCIR model is carried out on the homogeneity and heterogeneous networks and the results show that the networks' topology structure affects the diffusion of investment sentiment.**

Keywords—component; investment sentiment diffusion; time delays; complex networks; stock market; epidemic models

I. INTRODUCTION

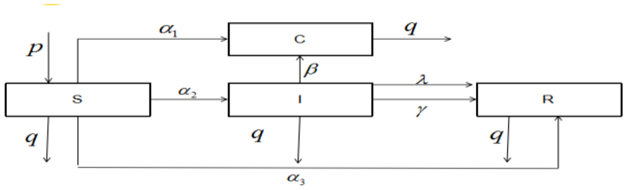
Behavior finance found that investors especially individual investors were not rational. In Chinese stock market, there are a large number of individual investors who do not have ability to judge the stock market quotation correctly [1][2]. Hence, they tend to spread wrong 'information' i.e. excessively positive or negative investor sentiment and they are more likely to be induced by other irrational investors due to lack of stock market experience and knowledge. Unfortunately, incorrect investment sentiment propagation may affect the stability of stock market. For example, if the investors believe that the stock price may keep increasing, they will trade frequently and persuade their friends or colleagues to do so. It means that the stock price is another form of investment sentiment since investors' behavior will affect it directly. As a result, it is necessary to investigate the rules in order to facilitate the government to manage the market.

Many previous studies did research on the investment sentiment based on the classic epidemic models. 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 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 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 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]. If we apply classic SIR model to describe the diffusion of investment sentiment, people who take part in the stock market could be divided into three groups: the ignorant, the active and the immune. However, it is unlikely that there are no counter people since the government or some institutional investors cannot adopt methods to maintain market economy. Reasonably, we should consider the diversities of groups. While the government takes actions such as releasing some official information, investors who accept this piece of information may have doubt on the investment sentiment and have possibility to be the counter which is also great difference from infectious disease model.

In addition, there is increasing attention to the application of the complex network. In fact, people take the form of networks to communicate with their friends and massive studies show that human's social networks are characteristic networks such as small world networks. Hence, it is reasonable to discuss the structure of networks. LIANG zhenzhong and HAN qinglan built the models based on the small world social network to study the effect of herb behavior [15]. LIU jiyun and LI hong established the stochastic evolution models of investment behavior on the homogeneous and heterogeneity networks [16]. Reference [17] concluded that the topology structure of networks affects the disease spreading. Therefore, we should take the networks into consideration to proof whether this rule may be correct in the diffusion of investment sentiment.

Although investment sentiment has great influence on the economy and stock market, we cannot predict when it will happen accurately. In other words, the government cannot realize investors spread this wrong 'information' until the scale of investment sentiment diffusion can be observed. Therefore, the government is unlikely to instruct the investors to the right direction immediately. Time delays can explain this factors well. As the government manage the market, they should take effective methods as possible which means that they should decide which group people are their target. In addition, we should distinguish different groups' behaviors when these groups receive the official information.

FIRGUE I. THE STRUCTURE OF SCIR MODEL



The structure is arranged as follows. In the section II, the investment sentiment diffusion SCIR model with time delays has been proposed. We calculate the investment sentiment spread threshold and analyze the stability of equilibrium points. We carry out the numerical simulation in the section III on the two types of networks. Then we conclude in the section IV.

II. SCIR MODEL

A. SCIR model

The population is divided into four groups: ignorant individuals(S) who are not aware of the negative investment sentiment; active individuals(I) who actively affect their friends' or colleagues' attitude towards the stock market; counter individuals(C) who reject active individuals' opinions and try to persuade them to be rational; immune people(R) who have no interest on the individual sentiment and cannot be affected by active people again. Let $S_k(t)$, $C_k(t)$, $I_k(t)$,and $R_k(t)$ be the relative density of ignorant ,counter, active and immune nodes with degree k at time t respectively, where $k=1,2\cdots n$ and n is the maximum number of connections at each node. They satisfy the normalization condition:

$$S_k(t)+C_k(t)+I_k(t)+R_k(t)=1 \qquad (1)$$

The structure of SCIR model is shown in the Fig. I. In the course of investment sentiment spreading, we can obtain the translations of different groups. Hence, we have the following assumptions:

1) The ignorant people who contact with active people may accept the incorrect sentiment information and translate into active people in the stock market with the probability α_2.

2) When ignorant people communicate with active people, the former may become counter individuals with the probability α_1 because of the government intervene; Meanwhile, active people may translate into counter people with the probability β when they know the correct sentiment information released by the government.

3) While ignorant people meet active people, the former could become immune with the probability α_3 since they have known the correct information released by officials or are rational; active individuals may be convinced by counter people and become immune with the probability λ ; active people may be immune by themselves for some reasons such as forgetting with the probability γ.

Based on the above assumptions, we proposed the SCIR mean-field equations:

$$\frac{dS_k(t)}{dt}=p-(\alpha_1+\alpha_2+\alpha_3)kS_k(t)\Theta_1(t)-pS_k(t)$$
$$\frac{dC_k(t)}{dt}=\alpha_1 kS_k(t)\Theta_1(t)+\beta I_k(t)-pC_k(t)$$
$$\frac{dI_k(t)}{dt}=\alpha_2 kS_k(t)\Theta_1(t)-(\beta+\gamma+p)I_k(t)-\lambda kI_k(t)\Theta_2(t)$$
$$\frac{dR_k(t)}{dt}=\alpha_3 kS_k(t)\Theta_1(t)++\gamma I_k(t)+\lambda kI_k(t)\Theta_2(t)-pR_k(t)$$
(2)

When $\alpha_1=0$, it is the classic SIR model this is because there are not counter people in the networks. The probability $\Theta_1(t)$ shows a link pointing to an infected individual,

$$\Theta_1(t)=\frac{\sum_k kP(k)I_k(t)}{\sum_s sP(s)}=\frac{1}{\langle k\rangle}\sum_k kP(k)I_k(t)$$
(3)

The probability $\Theta_2(t)$ represents that any given points lint to a counter individual,

$$\Theta_2(t)=\frac{\sum_k kP(k)C_k(t)}{\sum_s sP(s)}=\frac{1}{\langle k\rangle}\sum_k kP(k)C_k(t) \qquad (4)$$

where $\langle k\rangle=\sum_k p(k)k$ describes the average nod e degree and $P(k)$ is the connectivity distribution.

$S(t)=\sum_k P(k)S_k(t)$, $C(t)=\sum_k P(k)C_k(t)$,

$I(t)=\sum_k P(k)I_k(t)$, $R(t)=\sum_k P(k)R_k(t)$.

are the densities of ignorant, counter, active, immune people in the whole network respectively and meet the normalization condition:

$$S(t)+C(t)+I(t)+R(t)=1 \quad (5)$$

B. Delayed SCIR model

During the investment emotion diffusion, there are only two compartments having the tendency to spread the sentiment so that our paper only considers the government or some organizations take these two groups as their target in order to keep the stock market steady. However, the government should overcome much more difficulties in persuading the active than persuading the ignorant. This is because active people who are enthusiastic about incorrect investment sentiment should spend time distinguish the true from the false. However, the ignorant who receive the official information may be much fairer to deal with this problem and they are more likely to understand the correct information. Obviously, $\beta<\alpha_1$. Hence, we only discuss the situation that the government take the ignorant as their target. However, in the real life, the investor tends to spread the sentiment before the government enters in the stock market so time delays exist without doubt. According to this fact and the proposed SCIR model, we build the new delayed SCIR model and give the mean-field equations as follows.

$$\begin{aligned}
\frac{dS_k(t)}{dt} &= p-\alpha_1 kS_k(t)\Theta_1(t-\tau)e^{-p\tau}-(\alpha_2+\alpha_3)kS_k(t)\Theta_1(t)-pS_k(t)\\
\frac{dC_k(t)}{dt} &= \alpha_1 kS_k(t)\Theta_1(t-\tau)e^{-p\tau}+\beta I_k(t)-pC_k(t)\\
\frac{dI_k(t)}{dt} &= \alpha_2 kS_k(t)\Theta_1(t)-(\beta+\gamma)I_k(t)-\lambda kI_k(t)\Theta_2(t)-pI_k(t)\\
\frac{dR_k(t)}{dt} &= \alpha_3 kS_k(t)\Theta_1(t)+\gamma I_k(t)+\lambda kI_k(t)\Theta_2(t)-pR_k(t)
\end{aligned} \quad (6)$$

where, $\tau>0$ is the length of delayed period.

C. Theoretical analysis

We calculate the basic reproduction number and study the stability of the investment sentiment free equilibrium point in this section.

Theorem1. If $R_0=\frac{\alpha_2\langle k^2\rangle}{(\beta+\gamma+p)\langle k\rangle}>1$,the mean-field equations have a positive equilibrium solution $E_*=(S^*,I^*,C^*,R^*)$.

Proof: To obtain the positive equilibrium point, we should let the right side of system (6) equal 0. It is obvious that the positive equilibrium point should meet:

$$\begin{cases}
p-(\alpha_1+\alpha_2+\alpha_3)k\Theta_1^\infty S_k^\infty-pS_k^\infty=0\\
\alpha_1 k\Theta_1^\infty S_k^\infty+\beta I_k^\infty-pC_k^\infty=0\\
\alpha_2 k\Theta_1^\infty S_k^\infty-\beta I_k^\infty-\gamma I_k^\infty-\lambda k\Theta_2^\infty I_k^\infty-pI_k^\infty=0\\
\alpha_3 k\Theta_1^\infty S_k^\infty+\gamma I_k^\infty+\lambda k\Theta_2^\infty I_k^\infty-pR_k^\infty=0
\end{cases}$$

(7)

where

$$\Theta_1^\infty(t)=\frac{\sum_k kP(k)I_k^\infty(t)}{\sum_s sP(s)}=\frac{1}{\langle k\rangle}\sum_k kP(k)I_k^\infty(t)$$

(8)

$$\Theta_k^\infty(t)=\frac{\sum_k kP(k)C_k^\infty(t)}{\sum_s sP(s)}=\frac{1}{\langle k\rangle}\sum_k kP(k)C_k^\infty(t)$$

(9)

Because immune people do not affect the propagation of investment sentiment, we only consider the first three equations of (7) and have

$$\begin{cases}
S_k^\infty=\dfrac{p}{(\alpha_1+\alpha_2+\alpha_3)k\Theta_1^\infty+p}\\
I_k^\infty=\dfrac{\alpha_2 k\Theta_1^\infty S_k^\infty}{\beta+\gamma+\lambda k\Theta_2^\infty+p}\\
C_k^\infty=\dfrac{\alpha_1 k\Theta_1^\infty S_k^\infty+\beta I_k^\infty}{p}
\end{cases}$$

(10)

Take the second and third equation of (10) into (8), (9), respectively. We can obtain:

$$\Theta_1^\infty(t)=\frac{\sum_k kP(k)}{\langle k\rangle}\frac{\alpha_2 pk\Theta_1^\infty}{mn}$$

(11)

$$\Theta_2^\infty(t)=\frac{\sum_k kP(k)}{\langle k\rangle}\frac{\alpha_1 nk\Theta_1^\infty(t-\tau)+\alpha_2\beta k\Theta_1^\infty}{mn} \quad (12)$$

where $m=[\alpha_1 k\Theta_1^\infty(t-\tau)e^{-p\tau}+(\alpha_2+\alpha_3)k\Theta_1^\infty+p]$, $n=(\beta+\gamma+\lambda k\Theta_2^\infty+p)$

Equation (11) divided by (12),

$$\frac{\Theta_2^\infty}{\Theta_1^\infty}=\frac{\alpha_1 k\Theta_1^\infty(t-\tau)n+\alpha_2\beta k\Theta_1^\infty}{\alpha_2 pk\Theta_1^\infty}$$

$$\Theta_2^\infty=\frac{\alpha_1(\beta+\gamma+p)\Theta_1^\infty(t-\tau)e^{-p\tau}+\alpha_2\beta\Theta_1^\infty}{\alpha_2 p-\alpha_1\lambda k\Theta_1^\infty(t-\tau)e^{-p\tau}} \quad (13)$$

Inserting (13) into (8),

$$\Theta_1^\infty = \frac{\sum_k kP(k)}{\langle k\rangle}\frac{\alpha_2 kp\Theta_1^\infty}{m(\beta+\gamma+\lambda k\Theta_2^\infty+p)}$$

$$= \frac{\sum_k kP(k)}{\langle k\rangle}\frac{\alpha_2 pk\Theta_1^\infty}{mh} \quad (14)$$

$$h=\beta+\gamma+\lambda k\frac{\alpha_1(\beta+\lambda+p)\Theta_1^\infty(t-\tau)e^{-p\tau}+\alpha_2\beta\Theta_1^\infty}{\alpha_2 p-\alpha_1\lambda k\Theta_1^\infty(t-\tau)e^{-p\tau}}+p$$

Letting

$$\Theta_1^\infty = f(\Theta_1^\infty) \quad (15)$$

Obviously, $\Theta_1^\infty = 0$ is the solution of $f(\Theta_1^\infty)=\Theta_1^\infty$. $f(\Theta_1^\infty)=\Theta_1^\infty$ has positive solution, i.e. $0<\Theta_1^\infty\le 1$ if $\left.\frac{df(\Theta_1^\infty)}{d\Theta_1^\infty}\right|_{\Theta_1^\infty=0}>1$ and $f(\Theta_1^\infty)\le 1$.

We can obtain the basic reproduction number

$$R_0=\frac{\alpha_2\langle k^2\rangle}{(\beta+\gamma+p)\langle k\rangle}>1 \quad (16)$$

Hence, if $R_0>1$, (15) has the positive solution.

Inserting the nontrivial solution of (15) into (10), we can obtain I_k^∞. And we can conclude

$$0<S_k^\infty<1,\ 0<I_k^\infty<1,\ 0<C_k^\infty<1,\ 0<R_k^\infty<1.$$

Then, the positive equilibrium point exists only if $R_0>1$.

Theorem2. If $R_0<1$,the investment sentiment-free equilibrium $E_0=(1,0,0,0)$ is globally asymptotically stable.

Proof. Because the group immune people do not affect the spreading of investment sentiment, we can rewrite the system (6) as

$$\begin{cases}\frac{dS_k(t)}{dt}=p-\alpha_1 kS_k(t)\Theta_1(t-\tau)e^{-p\tau}-(\alpha_2+\alpha_3)kS_k(t)\Theta_1(t)-pS_k(t)\\ \frac{dC_k(t)}{dt}=\alpha_1 kS_k(t)\Theta_1(t-\tau)e^{-p\tau}+\beta I_k(t)-pC_k(t)\\ \frac{dI_k(t)}{dt}=\alpha_2 kS_k(t)\Theta_1(t)-(\beta+\gamma+p)I_k(t)-\lambda kI_k(t)\Theta_2(t)\end{cases} \quad (17)$$

The Jacobian matrix of the system (17) at $(1,0,0)$ is a $3k_{\max}\times 3k_{\max}$ matrix which is as follows:

$$J=\begin{pmatrix} A_1 & B_{12} & B_{13} & \cdots & B_{1k_{\max}}\\ B_{21} & A_2 & B_{23} & \cdots & B_{2k_{\max}}\\ \vdots & \vdots & \ddots & & \vdots\\ B_{k_{\max}1} & B_{k_{\max}2} & B_{k_{\max}3} & \cdots & A_{k_{\max}}\end{pmatrix}$$

(18)

where

$$A_j=\begin{pmatrix} -p & 0 & -\frac{(\alpha_1 e^{-p\tau}+\alpha_2+\alpha_3)j^2P(j)}{\langle k\rangle}\\ 0 & -p & \frac{\alpha_1 e^{-p\tau}j^2P(j)}{\langle k\rangle}+\beta\\ 0 & 0 & \frac{\alpha_2 j^2P(j)}{\langle k\rangle}-\beta-\gamma-p\end{pmatrix} \quad (19)$$

$$B_j=\begin{pmatrix} 0 & 0 & -\frac{(\alpha_1 e^{-p\tau}+\alpha_2+\alpha_3)ijP(j)}{\langle k\rangle}\\ 0 & 0 & \frac{\alpha_1 e^{-p\tau}ijP(j)}{\langle k\rangle}\\ 0 & 0 & \frac{\alpha_2 ijP(j)}{\langle k\rangle}\end{pmatrix} \quad (20)$$

We calculate the characteristic equation as follows via mathematical induction method.

$$(p+\lambda)^{k_{\max}-1}[\frac{\alpha_2\langle k\rangle^2}{\langle k\rangle}-\beta-\gamma-p-\lambda]^{k_{\max}-1}$$
$$\times(p+\lambda)[\frac{\alpha_2\langle k\rangle^2}{\langle k\rangle}-\beta-\gamma-p-\lambda]=0 \quad (21)$$

Then, we can obtain

$$(p+\lambda)[\frac{\alpha_2\langle k\rangle^2}{\langle k\rangle}-\beta-\gamma-p-\lambda]=0$$

$$(p+\lambda)[(\beta+\gamma+p)(1-\frac{\alpha_2\langle k\rangle^2}{(\beta+\gamma+p)\langle k\rangle}+\lambda)=0 \quad (22)$$

$$(p+\lambda)[(\beta+\gamma+p)(1-R_0+\lambda)=0$$

All real-valued eigenvalues are negative when $R_0<1$ i.e. E_0 is locally asymptotically stable if $R_0<1$. We will proof that E_0 is global attractive. Firstly, we can define the equation as follows:

$$\frac{d\Theta_1(t)}{dt}=\frac{1}{\langle k\rangle}\sum_k kP(k)\frac{dI_k(t)}{dt} \quad (23)$$

Secondly, we can substitute the third equation of the system (6) into (23) and get

$$\frac{d\Theta_1(t)}{dt} = \frac{1}{\langle k\rangle}\sum_{k=1}^{n} kP(k)[\alpha_2 kS_k(t)\Theta_1(t) - \beta I_k(t) - \gamma I_k(t) - \lambda k I_k(t)\Theta_2(t) - pI_k(t)]$$

$$< [\frac{1}{\langle k\rangle}\sum_{k=1}^{n} kP(k)\alpha_2 kS_k(t) - (\beta+\gamma+p) - \lambda k\Theta_2(t)]\Theta_1(t)$$

$$= [\frac{1}{\langle k\rangle}\sum_{k=1}^{n} kP(k)\alpha_2 kS_k(t) - \frac{\lambda k}{\langle k\rangle}\sum_{k=1}^{n} kP(k)C_k(t) - (\beta+\gamma+p)]\Theta_1(t) \quad (24)$$

$$< [\frac{\langle k^2\rangle \alpha_2}{\langle k\rangle} - (\beta+\gamma+p)]\Theta_1(t)$$

$$= \frac{\Theta_1(t)}{\beta+\gamma+p}[\frac{\langle k^2\rangle}{\langle k\rangle}\frac{\alpha_2}{\beta+\gamma+p} - 1]$$

$$= \frac{\Theta_1(t)}{\beta+\gamma+p}[R_0 - 1]$$

Then, we define that $\Theta_1(t) = \varphi(0)$ and obtain

$$\frac{d\varphi(t)}{dt} = \frac{R_0 - 1}{\beta+\gamma+p}\varphi$$

(25)

Integrating from (25) to t yields

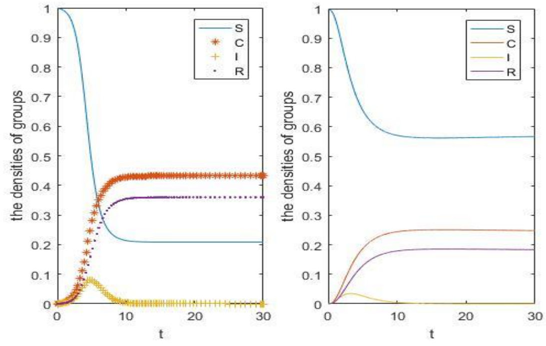
$$\varphi = \varphi(0)e^{\frac{R_0-1}{\beta+\gamma+p}t} \quad (26)$$

Due to $R_0 < 1$,when $t \to 0$, $\varphi(t) \to 0$ exists. According to the comparison theorem of functional differential equation, we can obtain that $0 \le \Theta_1(t) \le \varphi(t)$ for all $t > 0$ .Therefore, $\Theta_1(t) \to 0$ as $t \to \infty$ which means that $I_k \to 0$ as $t \to \infty$,for $k = 1,2\cdots n$.The investment sentiment-free equilibrium E_0 is globally attractive. This completes the proof.

III. NUMERICAL SIMULATION

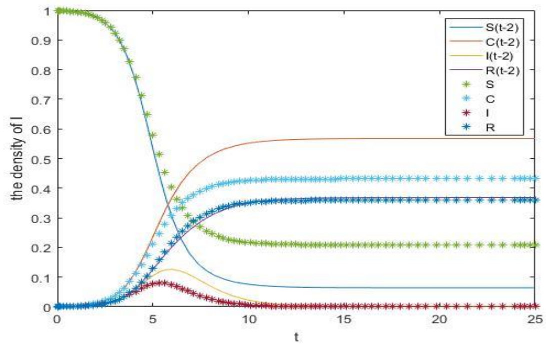
We carry out numerical stimulation on the homogeneity and heterogeneous networks which have the same size i.e. V=1000. And we set the values of parameters as follows: α_1 =0.4, α_2 =0.3, α_3 =0.2, β =0.3, λ =0.3, γ =0.2, p =0.001. The assumption is that there is only one active individual initially and other people are unknown about the investment sentiment on the stock market. Finally, there are three groups on the stock market such as immune people, counter people and ignorant people. From the Fig. II, the tendency of same groups on the different networks is similar but the stable states of groups are different. This is because that the topology structure of networks affect the investment sentiment diffusion. In addition, on the homogeneity network, the investment sentiment has much bigger effect on the stock market.

FIRGUE II. (A),(B) SHOW THE DYNAMIC SYSTEM ON THE HOMOGENEOUS AND HETEROGENEITY NETWORKS ,RESPECTIVELY



(A) (B)

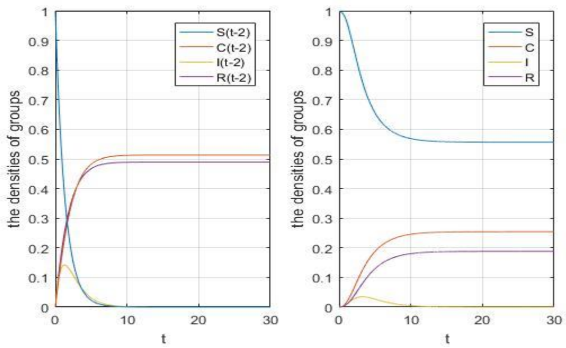
FIRGUE III. ON THE HOMOGENEOUS NETWORK, THE DENSITIES OF ACTIVE GROUP CHANGES OVER TIME WITH TIME DELAYS.



Firstly, we analyze the effect of time delays $\tau = 2$ on the homogeneity network. Obviously, time delay affects the stable state of active people and immune people slight due to the definition of time delay which we give in the section 3. However, it affects the stable state of ignorant people and counter people dramatically. When $\tau = 2$, the peak value of active people is larger than the situation without time delay which fits the fact. While the government or some organizations cannot take actions immediately, the population of active people may become larger and larger. According to the Fig. III, if the government intend to control the situation of the investment sentiment, they should actively encourage rational people to persuade the active people.

We compare the situation with time delays and without time delay on the heterogeneous networks in the Fig. IV. Time delays have dramatic effect on the sentiment spreading. However, the basic rule that the decrease of active groups is rely on the increase of counter people have not changed. With time delay, the active group arrive the stable state more quickly than that without time delay but the peak value of active group when $\tau = 2$ is much higher than that without time delays. It is very necessary to take the topology structure of network and time delays into consideration.

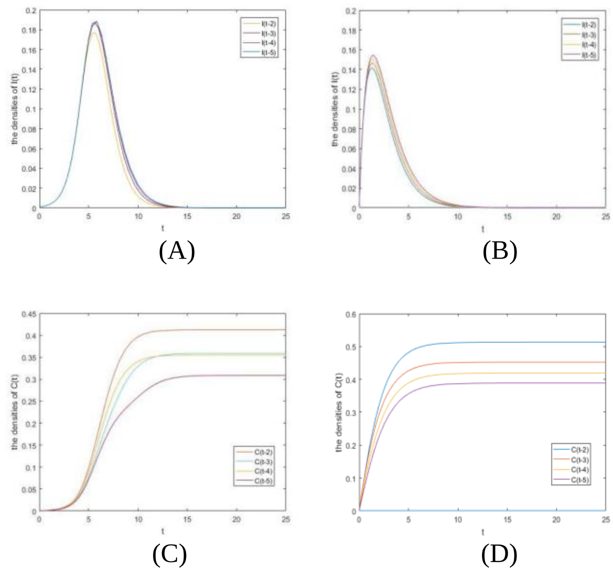
FIRGUE IV. CONSIDERING TIME DELAY, THE ACTIVE GROUP VARIES OVER TIME ON THE HETEROGENEITY NETWORK.



In the Fig. V, we do research on the effect of time delays on the densities of different groups. When time delay become larger, more and more people engage in the investment sentiment diffusion and less people hold the opposite points which means that the scale of investment sentiment turns larger with delayed government's intervention. On the homogeneity networks, when time delay arrives the critical value, its effect on the densities of active people and counter people become slight. However, on the heterogeneous networks, when τ exists, its effect seems to be uniform change. In addition, when the active group arrives the peak value, the population of counter people is increasing dramatically no matter on which networks. Then, when the population of active individuals decreases to nearly zero, the counter people arrive the stable state. Therefore, the decrease of active people is dependent on the increase of counter people. In other words, counter people plays an important role on the stability of stock market i.e. countering mechanism. Meanwhile, time delays have slight effect on the densities of active people initially in the Fig V (A), (B) but affect the population of counter people remarkably because in the beginning, there are no counter people in the networks and countering mechanism functions when active group nearly arrive the peak value. In other words, it is very critical to increase the counter group's population.

According to the above research, some suggestions can be given to the government and some organization such institutional investors. Firstly, the government should observe the stock market all the time and adopt measures immediately when the investors spread incorrect sentiment. Secondly, countering mechanism can be beneficial weapon for the government when they control the market so they should encourage more people to be the counter. For example, the government can give awards to these people or educate individual investors in order to make sure their judgement about the stock is rational.

FIRGUE V. (A), (B) REPRESENT THE VARIATION OF ACTIVE PEOPLE WITH TIME DELAYS ON THE HOMOGENEOUS AND HETEROGENEITY NETWORKS RESPECTIVELY. FROM (C), (B), THE TRANSLATION OF ACTIVE PEOPLE WITH TIME DELAYS ON THE HOMOGENEOUS AND HETEROGENEITY NETWORKS RESPECTIVELY CAN BE SEEN.



IV. CONCLUSION

We can have the following conclusions:

a) It is necessary to apply different networks to the investment sentiment diffusion. The topology structure of networks will affect the densities groups but will not affect the condition of stable state.

b) If the government regards the ignorant as targets, these methods may not function immediately. However, when the population of active and counter groups becomes large enough, counter mechanism functions.

c) In fact, when the investment sentiment diffusion end, people cannot ensure that this situation will not happen again. Hence, it is reasonable that the government cultivate the counter because these people who are rational and have ability to judge the stock information can facilitate the government to deal with the next crisis.

In this paper, we only consider the investment sentiment diffusion during one period with continuous time. Hence, we can focus on discrete time to discuss investment sentiment diffusion during different periods. Additionally, we only build the investment sentiment models on the single-layer networks but in fact, multi-layer network can explain the practical problems well. Hence, the future study can concentrate on the application of multi-layer networks.

ACKNOWLEDGEMENTS

The authors would like to express gratitude to the referee for valuable comments and suggestions. This research is supported by National Natural Science Foundation of China (Grant No.71701082).

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