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Study on Stock Market Rumor Spread Model with Medium

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***Abstract*— *There is a similarity between the spread of rumors and the spread of infectious diseases. With the advent of the era of Internet, people can express opinions on the Internet and spread the information, and it provides a more convenient way for spreading rumors, rumors spread faster, wide transmission range, it's bad for People's life. Therefore, the construction of a realistic market rumor propagation mode is better to understand the spread of rumors, based on the research of the stock market investor sentiment, market rumors spread model is established. Combining the theory of transmission dynamics, we find the basic reproductive number, when $R_0<1$, the stock market rumors fade away, when $R_0>1$, the stock market rumors will continue to exist. The stability of the equilibrium point is discussed, A reasonable Lyapunov function is constructed to prove the global asymptotic stability of the equilibrium point. Finally simulation verifies the correctness of the conclusion.*

***Keywords*—** *Stock market rumor spread; basic reproductive numbers; simulation.*

I. Introduction

With the digital process of the information age, the stock investors' means of obtaining and exchanging information are also changing significantly. The spread of information in the market has also shifted from word-of-mouth to dissemination through the Internet and social networking services. Therefore, the speed and depth of information dissemination have been greatly developed. Many times can make full use of the rapid transmission of information to provide urgently needed stock information. However, it is precisely because of the rapid development of the network that many malicious information spread among investors, malicious information has great harm to the stock market, it greatly damages the stability of the stock market. So we have to control rumors in the investor network so as to avoid panic caused by sharp fluctuations in the stock market.

The spread of stock market rumors is similar to that of social networks. Firstly, Daley and Kendall[1] point out the difference between the spread of infectious diseases and the spread of rumors, and on the basis of the SIR infectious disease model, put forward the classic DK rumor spread model, in their model. Interested people are divided into three groups: those who know and spread rumors, those who do not know rumors, and those who know but do not spread rumors. Then Jen Hsi and Thomson[2] modified the DK model to the MT model, which becomes an immune (knowing but not spreading rumors) once the communicator contacts another communicator. Based on these early models, many researchers have studied the topological properties of rumors and related social networks [3-6]. Janet [3] studies the existence of rumor propagation models in small-world networks and discovered critical thresholds for rumor propagation. In addition, Moreno et al.[4,5] have studied the dynamics of scale-free network rumor propagation. Ashham[6] analyzed the final distribution of rumors on the general network. In the DK and MT models, the immune is the only way to assume rumors die.In reality, however, spreaders may forget to spread rumors or choose not to spread them because they have lost interest, which can also lead to the cessation of rumors. On the basis of considering the network topology, Scientists began to seriously consider the role of rumors in human behavior and the spread of different mechanisms[7-13]. Zhao et al.[7] considered and analysed the impact of forgetfulness rates on the dynamics of rumors spread, The results show that the rate of forgetting will affect the spread of rumors. Xia et al.[8] proposed a SEIR rumor propagation model considering hesitation mechanism. The conclusion shows that reducing the fuzziness of rumors can effectively improve the spread of SEIR model. Wang et al. [9]proposed a new SIR rumor propagation model by introducing the trust mechanism between the unknown and the propagator. They concluded that the introduction of trust not only greatly reduced the impact of rumors, but also delayed the end of rumors. In most previous studies, the forgetfulness rate was considered a constant. In reality, however, the longer the rumor is held, the more likely it is to forget it. Therefore, the oblivion mechanism shows a strong time-dependence. Zhao et al.[10]proposed a variable forgetting rate rumor propagation model based on exponential forgetting function. In this paper, we discuss the influence of individual forgetfulness rate on rumor propagation when the rate of forgetfulness does not change with time. Wang et al.[11]consider the SIHR rumor propagation model based on forgetting mechanism and memory mechanism. It is concluded that the forgetting and memory mechanism can affect the final rumor size. Wang et al.[12] proposed a SIRaRu rumor propagation model and discussed the immune strategy of the rumor, and obtained the immune threshold and transmission threshold. Comey[13] takes into account the influence of the group's education rate on the spread of rumors, and the results show that the group The more educated people in the body, the smaller the final size of the rumor. In recent years, scientists have found that in the stock market, investor sentiment has a great impact on the spread of stock market rumors, investors spread rumors more based on their emotional changes. Wang et al.[14] proposed a 2SI2R model for

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spreading two kinds of rumors in the group. In this paper, it is found that more attractive rumors can suppress the spread of another kind of rumors. Huo [15] introduces a dynamic model of rumor propagation called I2SR, in which the activity of nodes is considered and the communicators are divided into those with high active transmission rate and those with low active transmission rate. Based on the proof of LaSalle invariance, it is the global stability principle of the internal equilibrium point of the model. The influence of the delay effect advantage on the spread of rumors is also very obvious.

The above model has made a great contribution to the spread of rumors on the social network, but unlike the stock investor network, the spread of rumors in the investor network is closely related to the sentiment of the investors. Because the information or rumors are related to their vital interests, emotional changes directly affect the spread of rumors. With this new pattern of rumor spreading, we establish an IHSRW dynamical model including spreading between individuals and medium-to-individuals to describe more accurately the actual pattern of transmission, which has not been studied in previous papers. Then the mechanism under spreading between individuals and by medium can be investigated by resorting to the model. Furthermore, we also give the main influence factors of transmission to government that can propose efficient measures to keep the stabilization of society and development of economy.

II. Model Formulation

In this section, the total number of investors we consider is a time-varying representation $N(t)$, when the stock market rumors spread, similar to the spread of rumors in the social network, in the investor network, because of changes in investor sentiment, investors will be divided into four types of people: the ignorant $I(t)$, the hesitant $H(t)$, the spreader $S(t)$ and immune persons $R(t)$. They represent investors who have no contact with stock market rumors, investors who hear rumors but are hesitant to participate in the rumors, investors who spread rumors, and investors who have lost interest in stock market rumors and stopped spreading stock market rumors. Rumors spread not only through human contact, but also through the media. The number of rumors Media spread is recorded as $W(t)$.

The rules governing the spread of stock market rumours are as follows:

(1) We assumed that the ignorant crowd has a constant input/recruitment rate B which is named immigration constant, Where B is the number of individuals entered in the whole group per unit time, and it does not represent the proportion of input individuals in the entire population. Each class has a same emigration rate which is denoted by a positive constant μ .

(2) When ignorant investors are in contact with spreaders, they have three possible options: to spread rumors immediately, to refuse to spread rumors, and to hesitate to participate in the spread of rumors. The probability transformation is β ;

(3) The ignorant may also be affected by rumors spread in the media. They have three possible options: to spread rumors immediately, to refuse to spread rumors, and to hesitate to participate in the spread of rumors. If he is neutral to rumors, he becomes a hesitant, the probability is θ_1 , $\theta_1 \in (0,1)$; If he spreads rumors, he becomes the communicator, the probability is θ_2 , $\theta_2 \in (0,1)$; If he chooses not to spread rumors, he becomes immune, with a probability of $1-\theta_1-\theta_2$, $\theta_1+\theta_2 \in (0,1)$。

(4) After consideration for a period of time, the hesitant has a probability to become a spreader or immune ,when they believe in rumors and choose to spread, thus becoming spreaders; when they do not believe in rumors, thus becoming immune, set the ratio of the former is φ , the ratio of the latter is $1-\varphi$,where $\varphi \in (0,1)$.

(5) At any time, some affected individuals lose their interest in spreading rumors or identifying rumors, and they no longer spread, thus becoming resistant individuals at a rate ε , reducing the number of affected individuals.

All rates are positive constants.

Based on the above assumptions and assumptions, the flow chart of the model is drawn, as shown in figure 1; the meaning of each symbol is shown in Table 1.

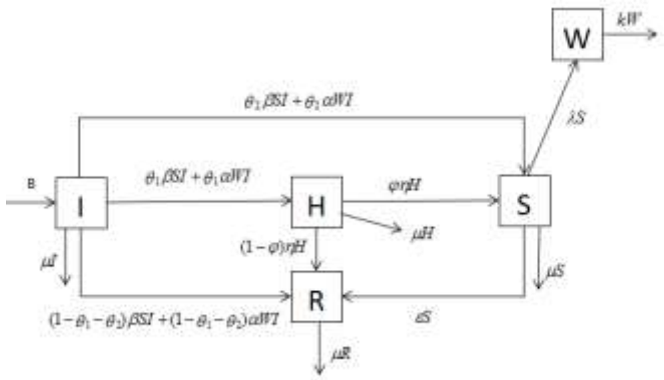

Fig. 1. The flow diagram of the model

TABLE 1. The notations of the model.

Notation	Description
I	The number of susceptible individuals at the time t
H	The number of hesitating individuals at the time t.
S	The number of affected individuals at the time t.
R	The number of resistant individuals at the time t.
W	The quantity of messages by medium
B	The number of individuals entered in the whole group per unit time.
θ_1	The proportion of susceptible individuals to hesitating individuals.
θ_2	The proportion of susceptible individuals to affected individuals.
β	Rumor transmitting rate from spreader.
α	Rumor transmission rate from medium.
μ	The proportion of individuals moving out per unit time.
η	Progression rate, conversion rate of hesitating individuals to affected or resistant individuals.
ε	The rate of affected individuals becoming resistant individuals.
φ	The proportion of hesitating individuals to affected individuals.

Therefore, based on the above discussion, the following mathematical models are established:

$$\begin{cases}\frac{dI}{dt}=B-\beta SI-\alpha WI-\mu I\\ \frac{dH}{dt}=\theta_1\beta SI+\theta_1\alpha WI-\eta H-\mu H\\ \frac{dS}{dt}=\theta_2\beta SI+\theta_2\alpha WI+\varphi\eta H-\varepsilon S-\mu S\\ \frac{dR}{dt}=(1-\theta_1-\theta_2)\beta SI+(1-\theta_1-\theta_2)\alpha WI+(1-\varphi)\eta H+\varepsilon S-\mu R\\ \frac{dW}{dt}=\lambda S-kW\end{cases} \quad (1)$$

Where, $B>0,\beta>0,\alpha>0,\mu>0,\eta>0,\varepsilon>0,\theta_1\in(0,1)$ $\theta_2\in(0,1),\theta_1+\theta_2\in(0,1),\phi\in(0,1)$

$S(t)+H(t)+I(t)=N(t)$

It is easy to know that $\frac{dN}{dt}=B-\mu N$,

so $N(t)=(N_0-\frac{B}{\mu})e^{-\mu t}+\frac{B}{\mu}$,where $N_0=N(0)$,and

then $\lim_{t\to\infty}N(t)=\frac{B}{\mu}$.The positive invariant set of

system(1)is: $\Gamma=\left\{(I,H,S,R)\in R_4^+ : I+H+S+R\le\frac{B}{\mu}\right\}$

III. Analysis of the Model

3.1 Non-propagation equilibrium point and basic reproduction number

It is easy to observe that the model has a non-propagation equilibrium point given by the following: $E_0=(\frac{B}{\mu},0,0,0,0)$.

Then, we will find the basic reproduction number R_0 of system (1) by the next generation matrix . Here, R_0 is defined as the expected number of a new generation of rumor spreaders produced by a single spreader. The basic reproduction number plays a very important and significant role in designing the control intervention for a system.

Let $X=(H,S,W,R,I)^T$, then system（1）can be written as：

$$\frac{dX}{dt}=F(X)-V(X) \quad (2)$$

Where

$$F(X)=\begin{bmatrix}\theta_1\beta SI+\theta_1\alpha WI\\ \theta_2\beta SI+\theta_2\alpha WI\\ 0\\ 0\\ 0\end{bmatrix},$$

$$V(X)=\begin{bmatrix}\eta H+\mu H\\ -\varphi\eta H+\varepsilon S+\mu S\\ kW-\lambda S\\ -(1-\theta_1-\theta_2)\beta SI-(1-\theta_1-\theta_2)\alpha WI-(1-\varphi)\eta H-\varepsilon S+\mu R\\ -B+\beta SI+\alpha WI+\mu I\end{bmatrix} \quad (3)$$

We can get:

$$F=\begin{bmatrix}0 & \theta_1\beta\frac{B}{\mu} & \theta_1\alpha\frac{B}{\mu}\\ 0 & \theta_2\beta\frac{B}{\mu} & \theta_2\alpha\frac{B}{\mu}\\ 0 & 0 & 0\end{bmatrix},$$

$$V=\begin{bmatrix}\eta+\mu & 0 & 0\\ -\varphi\eta & \varepsilon+\mu & 0\\ 0 & -\lambda & k\end{bmatrix} \quad (4)$$

Hence, the basic reproduction number of system (1) is the spectral radius of matrix FV^{-1}, which denoted by R_0 and it is given:

$$R_0=\rho(FV^{-1})=\frac{(\alpha\lambda+\beta k)B[\theta_2(\mu+\eta)+\theta_1\varphi\eta]}{\mu k(\mu+\varepsilon)(\mu+\eta)} \quad (5)$$

Theorem 3.1 The non-propagation equilibrium point E_0 is locally asymptotically stable for $R_0<1$ and unstable for $R_0>1$.

3.2 Global stability of non-propagation equilibrium point

Theorem 3.2 The non-propagation equilibrium point E_0 is globally asymptotically stable if $(\beta k+\alpha\lambda)B\le k\mu^2$.

Proof. We consider the Lyapunov function: $L(t)=H(t)+S(t)+R(t)$

$$\begin{aligned}L'(t)&=\theta_1\beta SI+\theta_1\alpha WI-\eta H-\mu H+\theta_2\beta SI+\theta_2\alpha WI+\varphi\eta H-\varepsilon S-\mu S\\ &+(1-\theta_1-\theta_2)\beta SI+(1-\theta_1-\theta_2)\alpha WI+(1-\varphi)\eta H+\varepsilon S-\mu R\\ &=\beta SI+\alpha WI-\mu H-\mu S-\mu R\\ &=(-\mu+\beta I)S+\alpha WI-\mu(H+R)\end{aligned}$$

Since $I\le\frac{B}{\mu}$,we have

$$L'(t)=(-\mu+\beta I)S+\alpha WI-\mu(H+R)<(-\mu+\beta I+\alpha\frac{\lambda}{k}I)S$$

If $(\beta k+\alpha\lambda)B\le k\mu^2, L'(t)\le 0$

Moreover, since $\mu>0$, it follows that $L'(t)\le 0$ if $(\beta k+\alpha\lambda)B\le k\mu^2$.

Furthermore, $L'(t)=0$ if and only if $H=S=R=0$.

The only solution of system (1) in Γ on which $L'(t)=0$ is E_0. Thus, by LaSalle's Invariance Principle, every solution of system (1) approaches E_0 as $t\to\infty$.

Hence, E_0 is globally asymptotically stable.

Volume 3, Issue 3, pp. 47-53, 2019. ISSN (Online): 2456-7361

3.3 The existence of propagation equilibrium point

Assuming $E^*(I^*,H^*,S^*,R^*,W^*)$ is the steady of system(1), it must satisfy the following equations:

$$\begin{cases} B-\beta SI-\alpha WI-\mu I=0 \\ \theta_1\beta SI+\theta_1\alpha WI-\eta H-\mu H=0 \\ \theta_2\beta SI+\theta_2\alpha WI+\varphi\eta H-\varepsilon S-\mu S=0 \\ (1-\theta_1-\theta_2)\beta SI+(1-\theta_1-\theta_2)\alpha WI+(1-\varphi)\eta H+\varepsilon S-\mu R=0 \\ \lambda S-kW=0 \end{cases} \tag{6}$$

Solving the last equation of (6),we get: $W=\frac{\lambda S}{k}$, Substituting for $W=\frac{\lambda S}{k}$ in the equation (6),then we can obtain:

$$\begin{cases} B-\beta SI-\alpha\frac{\lambda S}{k}I-\mu I=0 \\ \theta_1\beta SI+\theta_1\alpha\frac{\lambda S}{k}I-\eta H-\mu H=0 \\ \theta_2\beta SI+\theta_2\alpha\frac{\lambda S}{k}I+\varphi\eta H-\varepsilon S-\mu S=0 \\ (1-\theta_1-\theta_2)\beta SI+(1-\theta_1-\theta_2)\alpha\frac{\lambda S}{k}I+(1-\varphi)\eta H+\varepsilon S-\mu R=0 \end{cases} \tag{7}$$

Solving the first and the second equation of (7), we can find that:

$$I^*=\frac{Bk}{S^*(\alpha\lambda+\beta k)+\mu k},\quad H^*=\frac{\theta_1(\alpha\lambda+\beta k)S^*I^*}{k(\mu+\eta)} \tag{8}$$

Substituting for (4) in the third equation of (3), we can obtain:

$$S^*=\frac{B[\theta_2(\mu+\eta)+\theta_1\varphi\eta]}{(\mu+\varepsilon)(\mu+\eta)}-\frac{\mu k}{\alpha\lambda+\beta k} \tag{9}$$

In terms of the basic reproduction number, S^* is rewritten as $S^*=\frac{\mu k}{\alpha\lambda+\beta k}(R_0-1)$.Hence, we summarize this result in the following theorem.

Theorem 3.3. If $R_0>1$, the system (1) has the propagation equilibrium $E^*(I^*,H^*,S^*,R^*,W^*)$,where

$$I^*=\frac{B}{\mu R_0},\ H^*=\frac{B\theta_1}{R_0(\mu+\eta)}(R_0-1),\ S^*=\frac{\mu k}{\alpha\lambda+\beta k}(R_0-1),$$

$$R^*=(R_0-1)[\frac{(1-\theta_1-\theta_1)B}{\mu R_0}+\frac{(1-\varphi)\eta\theta_1 B}{(\mu+\eta)\mu R_0}+\frac{\varepsilon k}{\alpha\lambda+\beta k}],$$

$$W^*=\frac{\lambda\mu}{\alpha\lambda+\beta k}(R_0-1)$$

3.4. Local stability of the propagation equilibrium

Theorem 3.4. The propagation equilibrium point E^* is locally asymptotically stable if

$$\frac{(\alpha\lambda+\beta k)B}{\mu}\cdot\max\{\frac{\theta_2}{\mu k},\frac{\theta_1\varphi\eta}{\mu k\varepsilon}\}<R_0(R_0-1)<2$$

Proof. We have the Jacobin matrix at E^* is

$$J(E^*)=\begin{bmatrix} -\beta S^*-\alpha\frac{\lambda S^*}{k}-\mu & 0 & -\beta I^*-\frac{\alpha\lambda I^*}{k} & 0 \\ \theta_1\beta S^*+\frac{\theta_1\alpha\lambda S^*}{k} & -(\mu+\eta) & \theta_1\beta I^*+\frac{\theta_1\alpha\lambda I^*}{k} & 0 \\ \theta_2\beta S^*+\frac{\theta_2\alpha\lambda S^*}{k} & \varphi\eta & \theta_2\beta I^*+\frac{\theta_2\alpha\lambda I^*}{k}-\varepsilon-\mu & 0 \\ (1-\theta_1-\theta_2)\beta S^*+\frac{(1-\theta_1-\theta_2)\alpha\alpha S^*}{k} & (1-\varphi)\eta & (1-\theta_1-\theta_2)\beta I^*+\frac{(1-\theta_1-\theta_2)\alpha\alpha I^*}{k}+\varepsilon & -\mu \end{bmatrix} \tag{10}$$

It is found that the characteristic roots of Jacobin matrix $J(E^*)$ are $-\mu$ and the roots of the equation:

$$k h^3+x_1h^2+x_2h+x_3=0 \tag{11}$$

Here,

$$x_1=k(3\mu+\eta+\varepsilon)+(\alpha\lambda+\beta k)(S^*-\theta_2 I^*) \tag{12}$$

$$x_2=3k\mu^2+2\mu k(\eta+\varepsilon)+\eta\varepsilon k+(\alpha\lambda+\beta k)(\varepsilon S^*-\theta_1\varphi\eta I^*)$$
$$+(\alpha\lambda+\beta k)(\eta+2\mu)(S^*-\theta_2 I^*) \tag{13}$$

$$\chi_3=(\mu+\eta)(\alpha\lambda+\beta k)[(\mu+\varepsilon)S^*-\theta_2\mu I^*]+\mu k[(\mu+\varepsilon)(\mu+\eta)$$
$$-\theta_1\varphi\eta(\alpha\lambda+\beta k)I^*] \tag{14}$$

$$\chi_1\chi_2-\chi_3=k^2(3\mu+\eta+\varepsilon)(3\mu^2+2\mu\eta+\mu\varepsilon+\eta\varepsilon)$$
$$+(\alpha\lambda+\beta k)^2(2\mu+\eta)(S^*-\theta_2 I^*)^2$$
$$+k(3\mu+\eta+\varepsilon)(\alpha\lambda+\beta k)(\varepsilon S^*-\theta_1\varphi\eta I^*)$$
$$+(\alpha\lambda+\beta k)^2(\varepsilon S^*-\theta_1\varphi\eta I^*)(S^*-\theta_2 I^*)$$
$$+k(\alpha\lambda+\beta k)(S^*-\theta_2 I^*)(12\mu^2+7\mu\eta+\eta^2+2\varepsilon\eta+4\mu\varepsilon)$$
$$+I^*(\alpha\lambda+\beta k)(\mu+\eta)[\theta_2\mu+\mu k\theta_1\varphi\eta]+[(\mu+\varepsilon)(\mu+\eta)(2-R_0) \tag{15}$$

By substituting $I^*=\frac{B}{\mu R_0}$, $S^*=\frac{\mu k}{\alpha\lambda+\beta k}(R_0-1)$ into (11) ~ (15), we can get:

If $\frac{(\alpha\lambda+\beta k)B}{\mu}\cdot\max\{\frac{\theta_2}{\mu k},\frac{\theta_1\varphi\eta}{\mu k\varepsilon}\}<R_0(R_0-1)<2$,then $\chi_1>0,\chi_3>0,\chi_1\chi_2-\chi_3>0$ and hence the Routh-Hurwitz criteria are satisfied.According to the Routh-Hurwitz stability judgment, E^* is locally asymptotically stable.

3.5 Global stability of the propagation equilibrium

Construct Lyapunov function:

$$L(t)=[(I-I^*)+(H-H^*)+(S-S^*)+(R-R^*)]^2$$
$$L'(t)=2[(I-I^*)+(H-H^*)+(S-S^*)+(R-R^*)][I'+H'+S'+R']$$
$$=2[(I-I^*)+(H-H^*)+(S-S^*)+(R-R^*)][B-\mu I-\mu H-\mu S-\mu R]$$

Because E^* satisfy (6), so it follows that $B-\mu I^*-\mu H^*-\mu S^*-\mu R^*=0$, in other words, $B=\mu I^*+\mu H^*+\mu S^*+\mu R^*$.

Then, we can get:

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$$\begin{aligned}L'(t) &= 2[(I-I^*)+(H-H^*)+(S-S^*)\\&\quad+(R-R^*)][B-\mu I-\mu H-\mu S-\mu R]\\&=2[(I-I^*)+(H-H^*)+(S-S^*)\\&\quad+(R-R^*)][\mu I^*+\mu H^*+\mu S^*+\mu R^*-\mu I-\mu H-\mu S-\mu R]\\&=-2[(I-I^*)+(H-H^*)+(S-S^*)\\&\quad+(R-R^*)][\mu(I-I^*)+\mu(H-H^*)+\mu(S-S^*)+\mu(R-R^*)]\\&=-2\mu[(I-I^*)+(H-H^*)+(S-S^*)+(R-R^*)]^2\le 0\end{aligned}$$

Thus, for system (1), the rumor existence equilibrium E^* is globally asymptotically stability by LaSalle Invariance Principle.Hence, we summarize this result in the following theorem.

Theorem 3.5. The rumor existence equilibrium E^* is globally asymptotically stability.

IV. NUMERICAL SIMULATION

In this section, we will present some numerical simulations to illustrate the previous theoretical models and results.

First of all, we choose $B=0.5, \beta=0.2, \alpha=0.5, \theta_1=0.3, \theta_2=0.2, \mu=0.5,$ $\eta=0.2, \varepsilon=0.1, \varphi=0.1$,then $R_0=0.1043<1$. Theorems 3.1 and 3.2 show that the rumor dies out and the non-spreading equilibrium is stable. Figure 2 validates this conclusion.

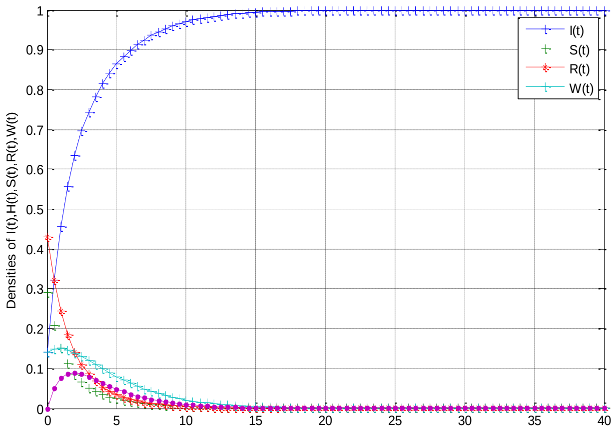

Fig. 2.

Second, we choose $B=2, \beta=0.2, \alpha=0.5, \theta_1=0.2, \theta_2=0.4, \mu=0.25,$ $\eta=0.3, \varepsilon=0.2, \varphi=0.3$then $R_0=7.402>1$。 Theorems 3.4 and 3.5 show that rumor is persists and stable. Fig. 3 further validates this conclusion.

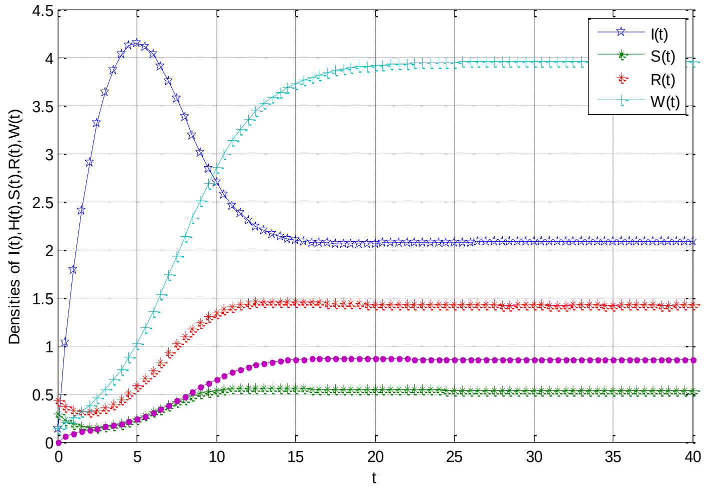

Fig. 3.

Finally, we come to discuss how the parameters associated with rumor propagation affect the spreading of rumors in the model outlined in the present paper.

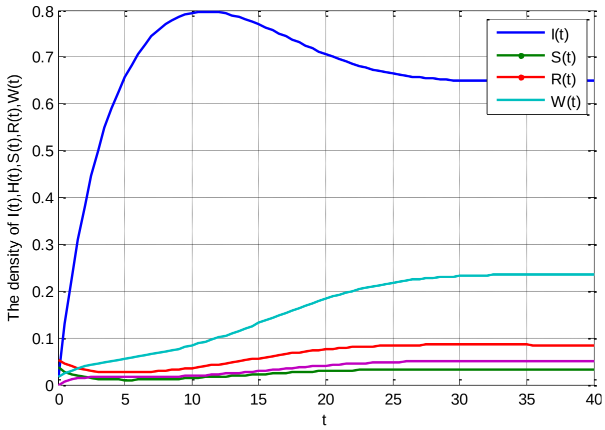

Fig. 4(a). $\alpha=0$

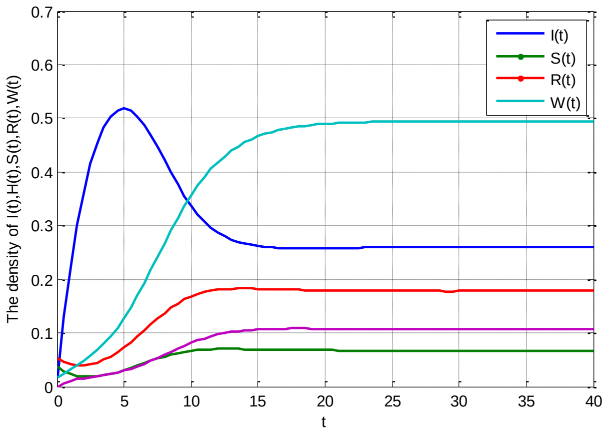

Fig. 4(b). $\alpha=0.5$

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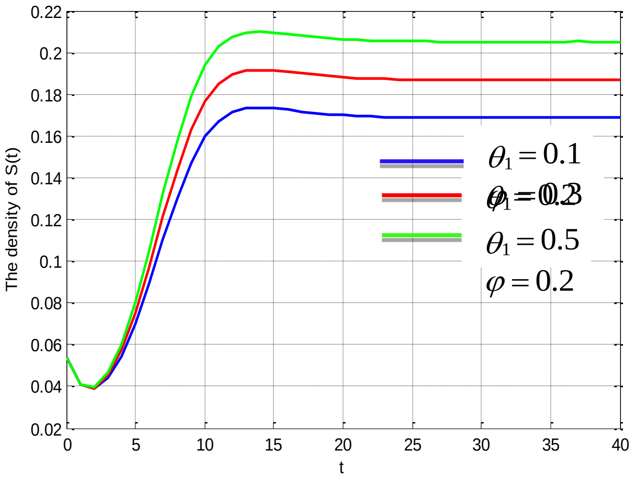

Fig. 5.

Separate consideration $\theta_1 = 0.1, \theta_1 = 0.3, \theta_1 = 0.5$, the density of the spreader varies with time. As you can see from the graph, when as θ_1 increases, the density of the propagator increases. Finally, a stable state is achieved. In other words, reducing the proportion of hesitation in investment networks is an effective way to reduce the spread of rumors.

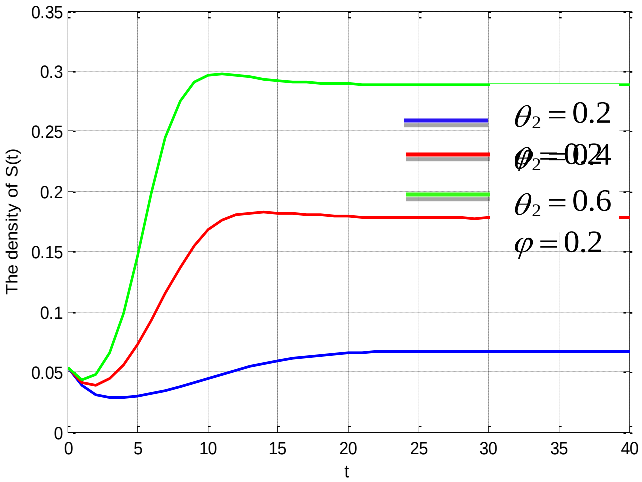

Fig. 6.

Separate consideration $\theta_2 = 0.2, \theta_2 = 0.4, \theta_2 = 0.6$, the density of the propagator varies with time. As you can see from the graph, when as θ_2 increases, the density of the propagator increases. Finally, a stable state is achieved. In other words, in the investment network, it's not hard to find out The reduction is beneficial to reduce the spread of rumors, can effectively control and reduce rumors.

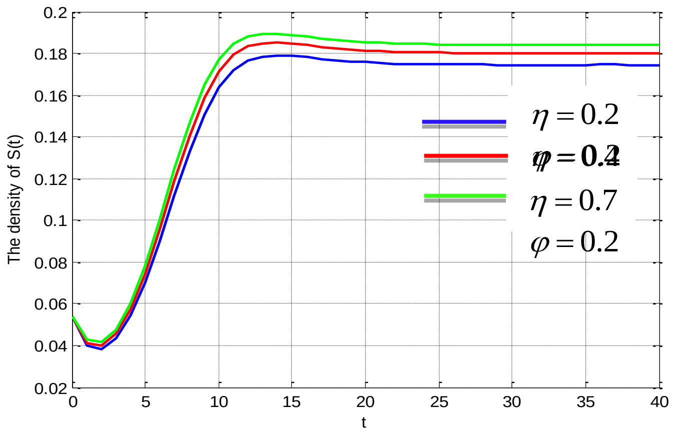

Fig. 7.

Separate consideration $\eta = 0.2, \eta = 0.4, \eta = 0.7$, the density of the propagator varies with time. As you can see from the graph, when as η increases, the density of the propagator increases. Finally, a stable state is achieved.

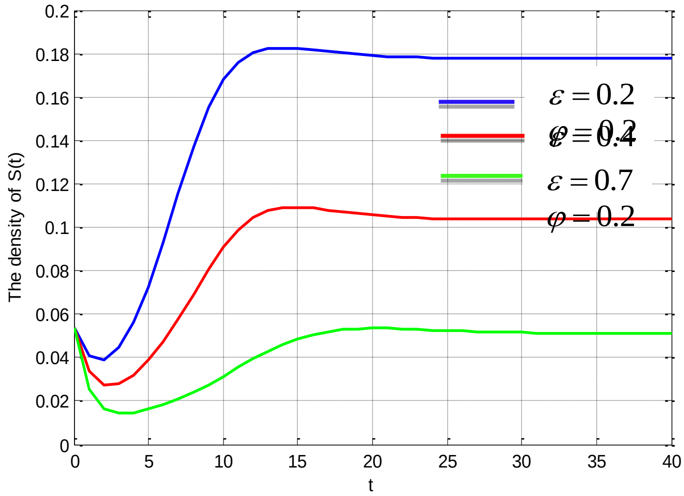

Fig. 8.

Separate consideration $\varepsilon = 0.2, \varepsilon = 0.4, \varepsilon = 0.7$, the density of the propagator varies with time. As you can see from the graph, when as ε increases, the density of the propagator decreases. Finally, a stable state is achieved. Finally, a stable state is achieved. In other words, in the investment network, it is not difficult to find that the increase ε is conducive to reduce the spread of rumors, can effectively control and reduce rumors.

Volume 3, Issue 3, pp. 47-53, 2019.
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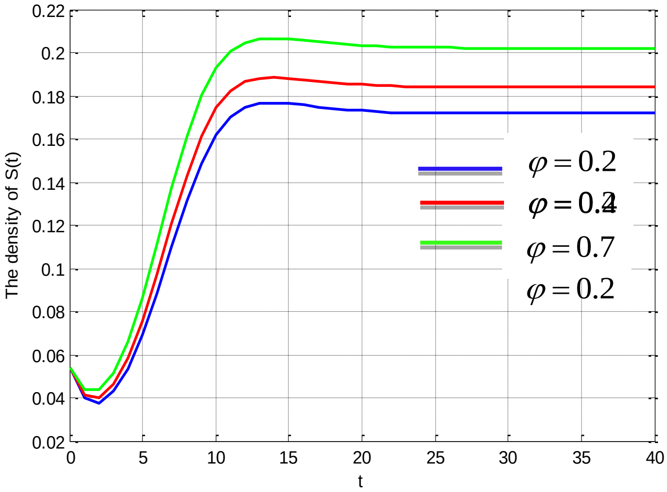

Fig. 9.

Consider separately $\varphi = 0.2, \varphi = 0.4, \varphi = 0.7$, the density of the propagator varies with time. As you can see from the graph, when as φ increases, the density of the propagator increases. Finally, a stable state is achieved.

V. Conclusion

In this paper, the media reporting effect is taken into account in the spread of stock market rumors, and the different attitudes of investors to rumors are taken into account, and a corresponding model is put forward. The basic regeneration number of stock market rumors is obtained, and the stability of the non-propagation equilibrium point and the propagation equilibrium point of the system are analyzed at the same time. The numerical simulation is carried out by Matlab software. The following conclusions have been reached:

Due to the emergence of the Internet and the increase of the spread of rumors, we spread rumors from word of mouth to expand the media, the media play an important role in the spread of rumors in the stock market; Through numerical simulation, it is found that the process of rumor propagation becomes complicated because of the introduction of media. To control the spread of rumors, we should not only control the propagator, but also control the media news. Therefore, it is difficult to control the information media of rumors. By comparing the influence of different parameters on the process of rumor propagation, we find out the parameters θ_2, ε, had a greater impact. It is hard to change people's attitudes in a short period of time, but we can lead people's reaction to rumors in a positive direction. For example, strengthen the popularization and dissemination of knowledge, increase people's access to knowledge, impose harsher penalties on those who spread rumors, and so on.

In fact, in the process of spreading rumors, there are more human behaviors, such as forgetting mechanism, which are not considered in our model. This paper is only a preliminary work, a lot of work needs to study more perfect model.

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