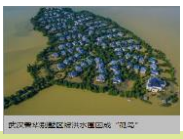
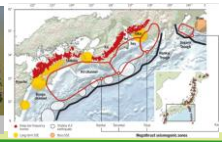
The Evolution of Public Perceptions about Disaster: A Perspective of Information





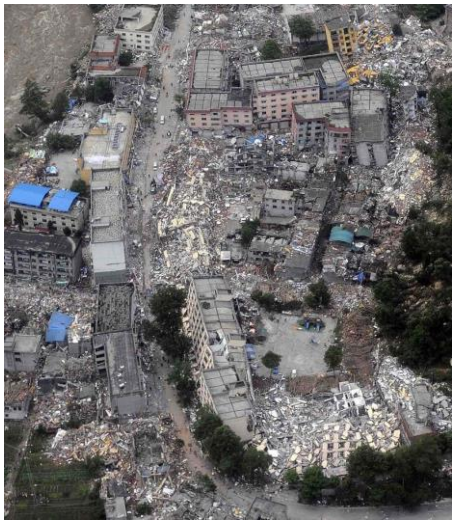
Jiuchang Wei

School of Management,
University of Science and Technology of China

Abstract

- This study proposes a diffusion model to measure the evolution of public perceptions about disaster by integrating the disaster information growth model, the public affected model, and the public memory model, which cover the process of information flow in a disaster.

1. Introduction



2008 Wenchuan Earthquake, China

- **On 12 May 2008, a magnitude 8.0 earthquake struck Wenchuan County in China's Sichuan Province. The official figures confirmed 69 197 people dead, 374 643 injured, 17 923 missing and 4.8 million becoming homeless.**

Table 1. Casualties and global donations to the five earthquakes

Variables	China Earthquake	Haiti Earthquake	Chile Earthquake	Japan Earthquake	Turkey Earthquake
Year	2008	2010	2010	2011	2011
Magnitude	7.9	7.0	8.8	9.0	7.1
People killed	69197	over 230,000	525	15883	604
Donation amount (million US$)	223.6	2306.6	43.6	152.3	26.8
Number of donors	86	128	40	55	31

Data sources: The data is mainly from Financial Tracking Service (http://fts.unocha.org/); http://www.cnn.com; and http://news.163.com/.

a. China's earthquake prone areas

b. College students were sitting on the ground on 12 May, 2008

c. Wenchuan Earthquake

d. Residents were on the street after a 3.8 M earthquake in Hefei

a. The building of China's Central Television Station

b. Public's protective behaviors

2. The process of protective action decision

- **Protective actions refer to "those actions that intentionally or unintentionally reduce risk from extreme events in the natural environment".**
- **For example, the protective actions toward city smog are the followings**:

-Protective actions included moving to an area without fog for working or life

-Wearing a mask outside

-Reducing outdoor activities

-Using air purifier indoors

-Paying attention to personal health care

-Reducing the use of private cars and saving resources.

Table 2. Protective actions constituting hazard adjustments for hazard types

Fire adjustments	Earthquake adjustments	Volcano adjustments
Fire insurance	Earthquake insurance	Volcano insurance
Know fire alert	Know earthquake alert	Know volcanic threat alert
Defensible space (100 ft fuel reduction)	Secure structure to foundation	Breathing protection
Fire resistant material use	Utility shut-off wrench	Reinforce structures against weight/water
Defensive tools	Secure furniture, cabinets, water heater	Defensive tools
Complete evacuation plan	Complete evacuation plan	Complete evacuation plan
Safe destination	Safe destination	Safe destination

Source: Perry & Lindell. Journal of Volcanology and Geothermal Research. 2008, 172(3-4): 170-178

City smog in Hefei, December, 2014

Evacuation in Hurricane Rita, Texas, September, 2005

YOU'RE INVITED!!

Planning for Real: Portland's Natural Hazard Mitigation Plan

What: Workshop to learn about natural hazard risks and how we can partner to make our city safer.

Where: Lincoln High School, 1600 SW Salmon, Portland, OR 97205

When: Saturday, April 23rd, 2016 2:30pm - 5:30pm

Why: You'll learn about hazards, help your city choose projects, connect with your neighbors - and there will be snacks!

www.portlandoregon.gov/pbem

2. The process of protective action decision

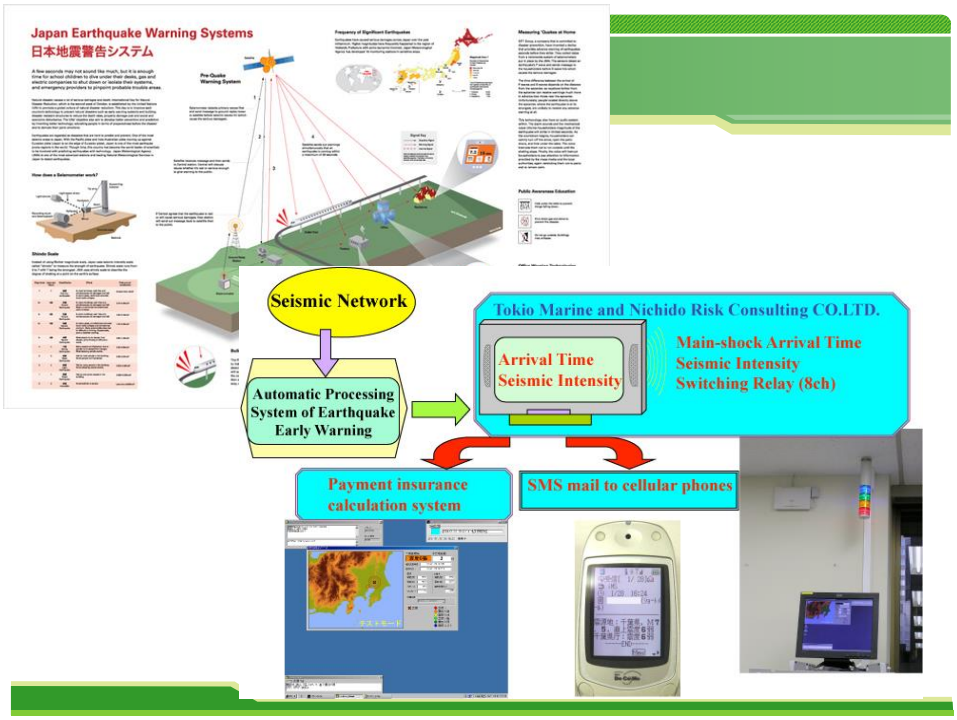
- **Risk perception.** People respond to a risk or hazard in ways consistent to their perception of that risk. It is their perception that influences behavior or action. Understanding public perception of natural hazards is necessary in order to impact hazard preparedness.
- **Risk perceptions** were assessed in terms of:
- damage to personal health and longevity
- damage to personal psychological health
- damage to children's growth and development
- damage to personal or family normal life
- damage to work efficiency and work performance
- damage to personal property.

YE Zhiping, the principal of Sangzao Middle School, has been credited with proactive action that spared the lives of all 2,323 pupils in attendance when the earthquake happened. During a three-year period that ended in 2007, he obtained more than 400,000 yuan (US$60,000) to widen and strengthen concrete pillars, floors, as well as secure its concrete floors.

2. The process of protective action decision

- **Information sources** refer to the extent to which the relied on each of following sources in obtaining information about disasters, including:
- local television stations
- national television stations
- local newspapers
- radio stations
- local government news websites
- national news websites
- peers (friends, relatives, neighbors, and co-workers)
- community information (eg. ad column, leaflet)

Information sources



2. The process of protective action decision

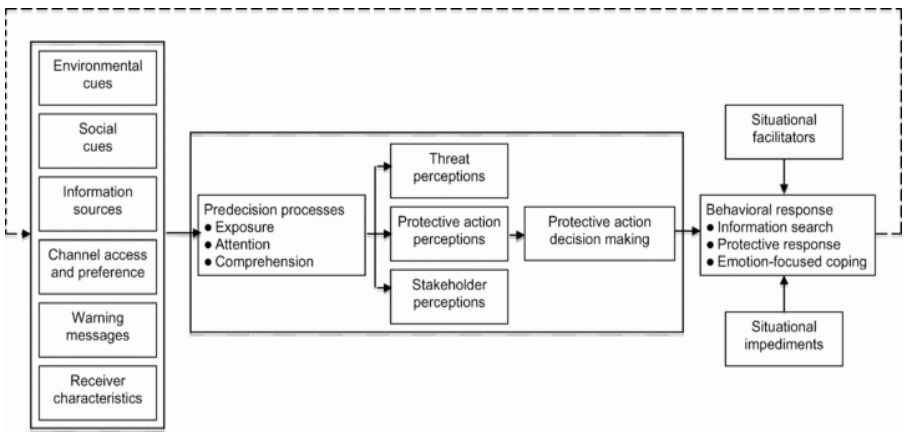


Fig.1 The Protective Action Decision Model

Source: Lindell & Perry, 2012

2. The process of protective action decision

Lindell and Perry (1992, 2004, 2012) proposed the Protective Action Decision Model (PADM), as a multistage model based on findings from research on people's responses disasters.

Fig. 2 Information flow of public perceptions in the PADM

The PADM integrates the processing of information derived from social and environmental cues with messages that social sources transmit through communication channels to those at risk. This model identifies three critical predecision processes (reception, attention, and comprehension of warnings or exposure, attention, and interpretation of environmental/social cues)—that precede all further processing.

3. The evolution of public perception of risk

- Public perceptions of disaster may differ depending on the type of risk, the risk context, the personality of the individual, and the social context. message certainty, source credibility, and familiarity. Public perceptions are highly dependent on how messages are framed, who communicates them, and how they are communicated.

- To influence public perceptions of risk, news messages should contain information about the threat, especially the hazard agent (type, specific threats and potential impacts), and affected populations so people can form a perception of certain, severe and immediate personal risk.

3. The evolution of public perception of risk

3.1 Conceptual model

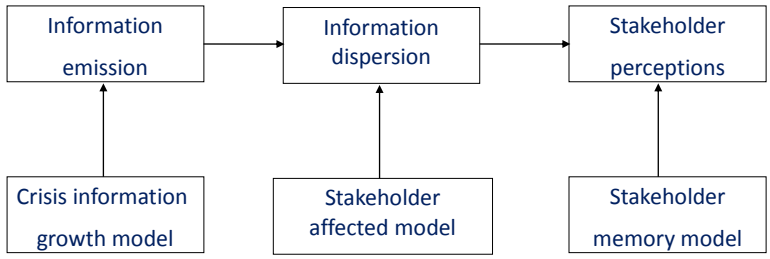
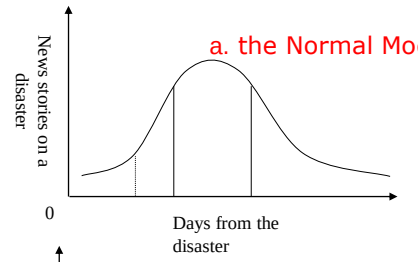


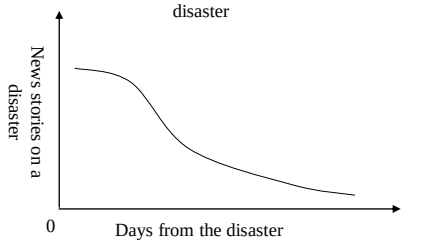
Fig. 3 The process of public perceptions about disaster

The evolution of public perceptions about a disaster begins with information emission from information sources such as social cues, environmental cues, news stories and rumors. The number of disaster-relevant messages created by the information producers (e.g. emergency managers, news agencies, affected people) change over time after a disaster strikes. We use a disaster information growth model to describe the process of information emission.

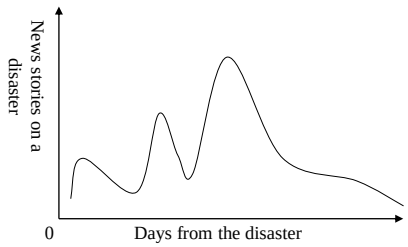
3. The evolution of public perception of risk

3.2 The Disaster Information Growth Model





b. the Damped Exponential Model



c. the Fluctuating Model

3. The evolution of public perception of risk

3.3 The Public Affected Model

3.3.1 The Public Affected Model of One Message

$$Y(t)=\frac{K}{1+ce^{-rt}} \quad \text{where} \quad c=\frac{K-Y_0}{Y_0} \quad Y_0=Y(0)$$

In this formula, Y_0 represents the initial number of the affected individuals (NAI) and c denotes the diffusion time scale of the initial NAI.

This model assumes that some information communication barriers affect message influence, which is the maximum number of individuals affected by the message, commonly referred to as *K*. When NAI reaches the message influence capacity, namely the *K* value, NAI no longer increases. In this sense, the growth of NAI will be an S-shaped rather than a J-shaped curve.

3. The evolution of public perception of risk

3.3 The Public Affected Model

3.3.2 The Public Affected Model of *n* Messages

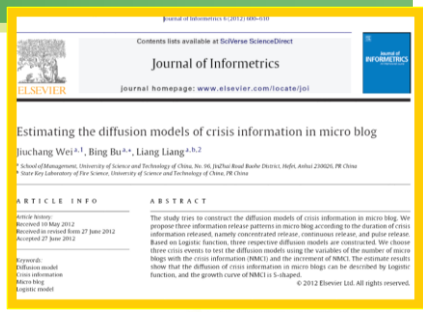
In times of disaster, disaster information is multi-leveled continual, and it can only be partially disseminated at one time. Supposing the daily numbers of disaster messages are the $A=\{a_1,a_2,\cdots,a_i,\cdots,a_{n-1},a_n\}$, whose elements diffuse following one of the three kinds of growth models of disaster messages, namely the Damped Exponential Model, the Normal Model, or the Fluctuating Model. If we assume the diffusion models of the disaster messages in a day are the same, then the public affected model for day i is:

$$N(t)=\sum_{i=1}^{p(t)}N(i)=\frac{a_1K_1}{1+c_1e^{-r_1(t-1)}}+\frac{a_2K_2}{1+c_2e^{-r_2(t-2)}}+\ldots+\frac{a_iK_i}{1+c_ie^{-r_i(t-i)}}+\ldots+\frac{a_{p(t)}K_{p(t)}}{1+c_{p(t)}e^{-r_{p(t)}(t-p(t))}}$$

$$=\sum_{i=1}^{p(t)}\frac{a_iK_i}{1+c_ie^{-r_i(t-i)}}$$

❖3.3.3 The diffusion models of crisis information in micro blog

- If the number of micro blogs is boundless, and no factor restricts the diffusion of the crisis information, then the number of the micro blogs containing the crisis information will increase rapidly.
- We use the variable of the number of micro blogs with the crisis information (hereafter "NMCI") to measure the crisis information diffusion status at one moment.
- The three crisis information release patterns - concentrated release, continuous release, and pulse release.



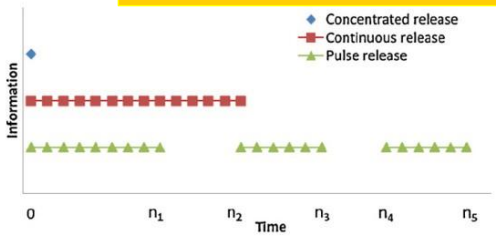


Fig. The three crisis information release patterns

❖3.3.3 The diffusion models of crisis information in micro blog

Concentrated release

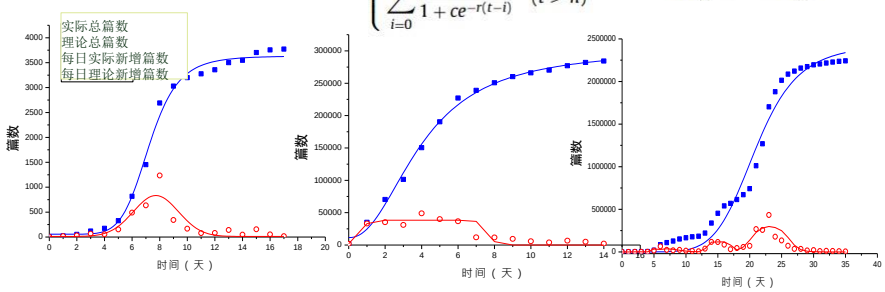
$$N(t) = \frac{K}{1 + ce^{-rt}}$$

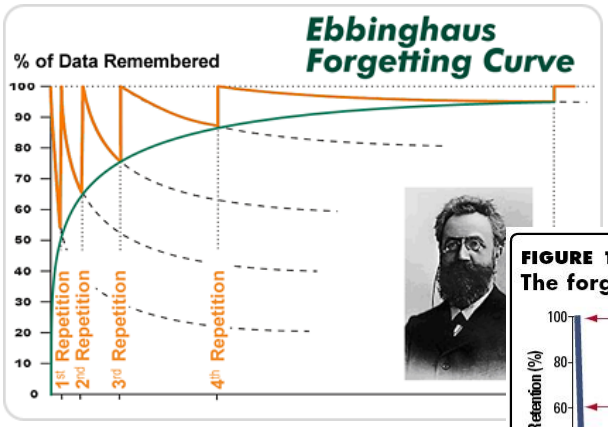
Continuous release

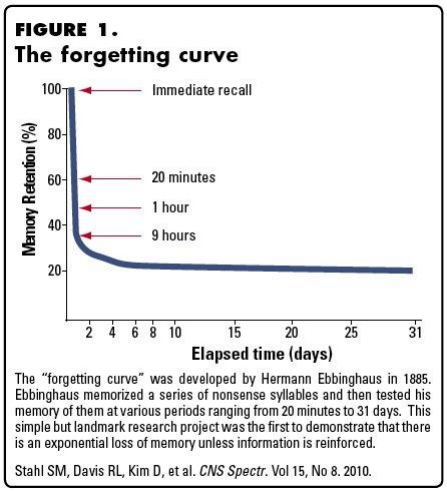
$$N(t) = \begin{cases} \sum_{i=0}^{t} \frac{K}{1 + ce^{-r(t-i)}} & (t \le n) \\ \sum_{i=0}^{n} \frac{K}{1 + ce^{-r(t-i)}} & (t > n) \end{cases}$$

Pulse release

$$N(t) = \sum_{i \in S(t)} N_i(t) = \sum_{i \in S(t)} \frac{a_i K_i}{1 + c_i e^{-r_i(t-i)}}$$







3. The evolution of public perception of risk

3.4 The Public Memory Model

- Public perceptions will not remain constant because people gradually forget the information they received during the disaster and this memory loss will decrease their perceptions. In this study, we use the process of memory attenuation to describe the attenuation of public perceptions.
- Assuming that all individuals have identical memory laws that follow the Ebbinghaus forgetting curve (Ebbinghaus, 1885).
- Though this model ignores difference in individuals' ages, occupations and social classes in the public memory, it also exhibits the effect of recency which means memory declines over time. For the individual memories, this model may be used to gauge the degree of attenuation of individual memories on day *i* during the disaster period.

3. The evolution of public perception of risk

3.5 Constructing the Diffusion Model of Public Perceptions

We construct the diffusion model of public perceptions by integrating the three models - namely the disaster information growth model, public affected model, and public memory model - to measuring the evolution of public perceptions about a disaster.

$$D(t)=m\sum_{j=2}^{t}\sum_{i=2}^{p(j)}\frac{\left(e^{-\frac{(i-\mu)^2}{2\sigma^2}}-e^{-\frac{(i-1-\mu)^2}{2\sigma^2}}\right)e^{-\rho(t-j)}}{1+ce^{-r(j-i)}}+m\sum_{j=1}^{t}\frac{e^{-\frac{(1-\mu)^2}{2\sigma^2}}e^{-\rho(t-j)}}{1+ce^{-r(j-1)}}.$$

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4. Simulation of the Diffusion Process of Public perceptions

Table 1 The parameters used in the simulation

Parameters	Expression
$r=0.6,\rho=0.6$	High values of and refer disaster messages that disseminate very quickly. There are no other newsworthy stories attracting public attention, so the public quickly forgets these disasters. Some minor natural disasters, such as localized floods are examples.
$r=0.3,\rho=0.1$	Like some food safety incidents, these accidents do not generates too much news coverage, but the public will be concerned since they are relevant to most of people.
$r=0.6,\rho=0.1$	For some disasters, dissemination is very fast and the public also will pay more attention to them, for example school shooting.
$r=0.3,\rho=0.6$	In situations where is low and is high disaster messages disseminate slowly, and there is no other newsworthy stories attracting public attention. Consequently, people receive the information slowly and forget it quickly. For example, the natural disasters that happened in distant countries.

4. Simulation of the Diffusion Process of Public perceptions

4.1 The Public Perceptions Diffusion Process with the Normal Model

The baseline of protective actions

the incremental rate of NAI (r), the rate of forgetting(ρ).

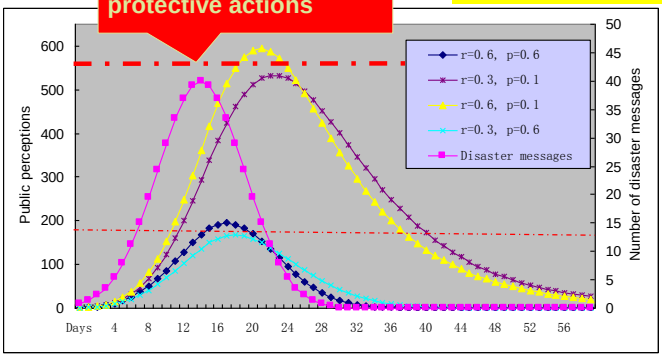

Fig. 4 The simulation of public perceptions diffusion process with the Normal Model

4. Simulation of the Diffusion Process of Public perceptions

4.2 The Public Perceptions Diffusing Process with the Damped Exponential Model

The baseline of protective actions

the incremental rate of NAI (r), the rate of forgetting(ρ).

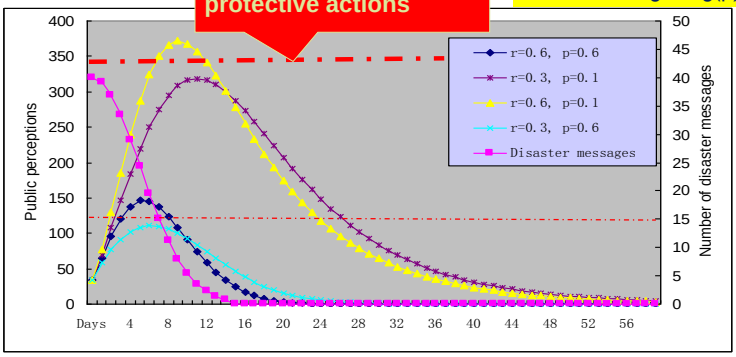

Fig. 5 The simulation of public perceptions diffusion process with the Damped Exponential Model

4. Simulation of the Diffusion Process of Public perceptions

4.3 The Public Perceptions Diffusing Process with the Fluctuating Model

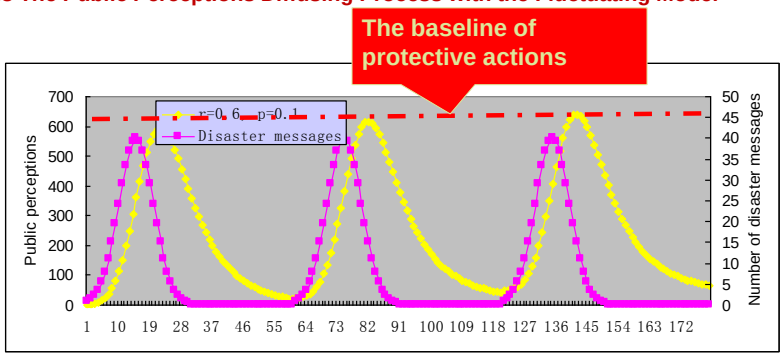

Fig. 6 The simulation of public perceptions diffusion process with the Fluctuating Model

5. Empirical Analysis

In this study we use corporate disaster news coverage to measure the disaster information, and we use cumulative average abnormal returns (CAR) to gauge stock market responses to corporate disasters to indicate the evolution of public perception. And, we collect messages about the disasters via a search engine.

We then obtained a sample of 119 listed firms' disasters during the 2005-2012 period. Finally, we collected data from the China stock market trading database using daily return with cash dividend reinvested as the observed returns and daily aggregated market returns with cash dividend reinvestment (equal-weighted) as the daily market returns.

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5. Empirical Analysis

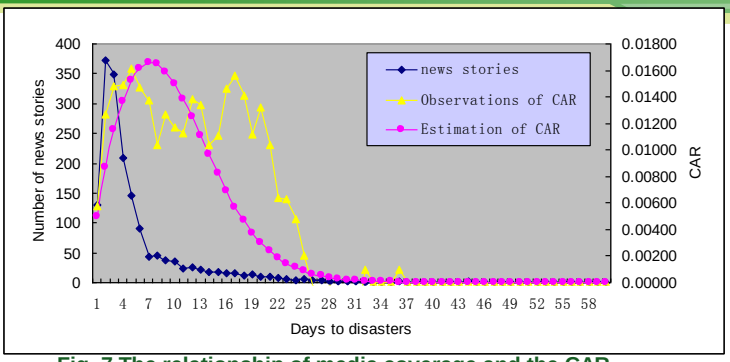

Fig. 7 The relationship of media coverage and the CAR

We calculated the Pearson correlation between our prediction of CAR values and the actual CAR value to test the validity of the model. The first 30 observations range from 0 to 0.016, and the next 30 observations are mostly near 0. So we conducted two tests. The first test with 30 observations shows a correlation of 0.721, which is significant at $p<0.01$. The second test with all the 60 observations revealed a correlation of 0.852, which is significant at $p<0.01$ level (2-tailed).

6. The main findings

- Delay effects, stagnation effects, equality effect and cumulative effects in the evolution of public perceptions.

——The delay effect refers to the appearance of a maximum of a level of public perceptions after peak of the daily number of disaster messages.

—— The stagnation effect shows that the increase in the speed of public perceptions is greater than the decrease in the speed of those public perceptions.

—— The equality effect refers that the amount of public perception of a disaster will be equal if the rate of forgetting(ρ) is same.

—— The cumulative effect means that public perceptions of a second disaster will be merged into the perceptions of a previous disaster when the second disaster occurs before memories of the first one decay.

- There is a spike point at the beginning of the profile of public perceptions with the Damped Exponential Model.
- Management implications: Disaster managers can take visible actions to raise/mitigate the public perceptions in order to proactive/reduce the protective actions.

Thank You!