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An Empirical Study on the Volatility of Public Opinion on Coal Mine Safety Accidents

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Abstract
This paper empirically studies the volatility of public opinion evolution on coal mine safety accidents based on weekly average data of coal mine accidents from January 2011 to May 2014 in Baidu search index. The findings are as follows: The volatility of public opinion evolution of coal mine safety accidents shows some characteristics such as aggregation, ARCH effect. And, the estimation of a GARCH model shows that public opinion evolution of coal mine safety accidents has conditional heteroscedasticity character, and this GARCH model successfully portrays the volatility of the public opinion on coal mine safety accidents.

Key words: Coal mine safety; Public opinion; Volatility; GARCH model

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INTRODUCTION
"Public Opinion" indicates that how does the public focus on some incidents. The news is spread at first, and then being lack of interested makes us believe that the characteristics of its transforming processes are in a significant cyclic way. It can also be used in coal mine safety accidents, with characteristics of aggregation and asymmetry. In order to successfully depict the volatility features of public opinion, we need to employ GARCH models.

For about using the model GARCH to study the volatility of stock market, they fitted the volatility of each share such as Zakoian (1994), Basel and Valentina (2005) and believe that there is an asymmetry of the share volatility. Sabiruzza-Man (2010) compared the accuracy of the share volatility between GARCH and the TGARCH based on Hong Kong stock market index. In their point of view, the TARCH is superior to the GARCH in the asymmetry effect of the share volatility. Liu and Huang (2010) analyzed the accuracy of the prediction of volatility functions by using GARCH disturbing terms in different distributions.

Furthermore, there are so many scholars in China analyze the volatility in Chinese stock market by using models such as GARCH, such as Yue (2001), Chen and Zhou (2002), Liu and Cui (2001). They empirically tested the GARCH effect of the share volatility in Chinese stock market. Gu and Cen (2011) compared the two models, which are the GARCH and the TARCH about describing the volatility and its asymmetry effect to measure and predict the Chinese stock market, and the result turned out to the GARCH is superior. Zhang, Jinlin and He (2012) inspected the ARCH effect of the volatility of main board market of Shanghai and Shenzhen in China Growth Enterprise Market. Yang and Liu (2012) analyzed how domestic Macroeconomic policy factors effects its volatility and asymmetry effect in those two main Chinese stock markets.

1. DATA AND VARIABLE STATIONARY TEST

1.1 Data

Public opinion representation index comes from all kinds of reports by various media departments. In this paper, based on the data availability, we have chosen the Baidu search index as proxies of coal mine safety accidents, which expressed by SI_t. The sample length is from 2011-01-01 to 2014-05-16, the data frequency is average weekly. The evolving of public opinion of coal mine safety accidents not only has the general characteristic of the normal accidents but also appears cyclically. When the accident happens, the public would focus on it by the web click and search, and it leads to public consensus fluctuate, which shows volatility like higher in some time but somehow lower in the next period, so there is an aggregation in such situation (Figure 1).

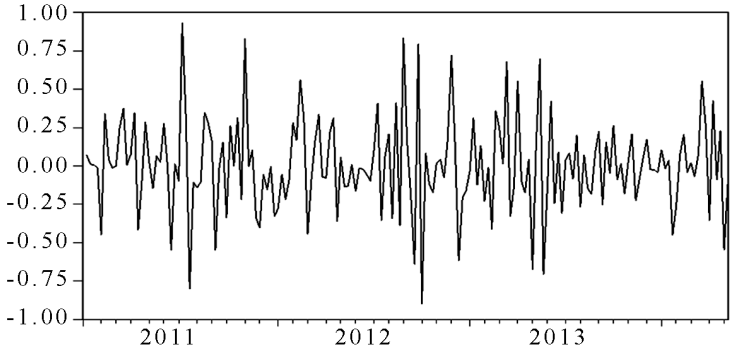

Figure 1
Rate of the Baidu Search Index of Coal Mine Incidents

1.2 Variable Stationary Test

The data we use to establish a model should be stable to make sure its accuracy. So, in order to avoid drawing spurious conclusions, we need to do stationarity test for the series. Table.1 shows the stationarity test result of the series of coal mine incidents search index: The probability of the null hypothesis that the series has a unit root is 0.00, less than the significance level of 1%, thus, reject the null hypothesis. So the series (SI_t) is $I(0)$ process.

Table 1
Stationary Test of Series

Variable	Test form (c,t,n)	ADF Test value	1% Critical value	p	Conclusion
SI_t	(c,0,0)	-6.236	-3.468	0.000	Stationary

2. ARCH EFFECT TEST OF THE PUBLIC OPINION EVOLUTION OF COAL MINE INCIDENTS

2.1 ARCH Effect Test

We established ARCH models to grasp its auto-regression character of the public opinion evolution of coal mine safety accidents. Due to the partial autocorrelation coefficient PAC truncated when the lag order is 1，so that the auto-regression order of the conditional mean's equation of public opinion of coal mine safety incidents is chosen by 1. Correspondingly, the function of the conditional mean equation of the public opinion evolution of coal mine safety accidents estimated by OLS (Ordinary Least Squares) method is as below:

$$SI_t = 129.297 + 0.637 SI_{t-1} + e_t$$
$$[5.728]\ \ [10.963] \qquad R^2 = 0.4099,\ \text{Log likelihood} = -1087.867 . \tag{1}$$

The t test value of the regression parameters in Equation (1) (numbers in square brackets) shows that the two regression parameters are significant. In addition, the residual series of Equation (1) presents obvious aggregation, shows that the ARCH effect which is conditional heteroskedasticity may exist, the test can be conducted through the Lagrange multiplier test. The auxiliary regression of ARCH LM test is given by Equation (2) as below:

$$\hat{u}_t^2 = 11489.89 + 0.221 u_{t-1}^2 + \varepsilon_t \tag{2}$$
$$(4.294) \qquad (2.969) \qquad R^2 = 0.049,\ \text{Loglikelihood} = -2051.896$$

So we have Lagrange Multiplier Statistics: $LM = TR^2 = 8.48$，and T is the number of sample observation, and R^2 is the goodness of fit by given Equation (2). Because the P-value of accepting the null hypothesis which means conditional heteroscedasticity does not exist is 0.0036, and based on the principle of "Small probability events is not easy to happen", we can draw a conclusion of rejecting the null hypothesis, that is the ARCH effect exist in the residual of the regressive Equation (1) .

2.2 GARCH Model Estimation

In order to depict better the characteristics of the public opinion evolution on coal mine safety accidents such as clustering and conditional heteroscedasticity, this part is going to employ GARCH model to make an empirical analysis.

Table 2
GARCH Models Selection

	GARCH (1,1)	GARCH (1,2)	GARCH (2,1)	GARCH (2,2)
Loglikelihood	-1073.630	-1075.076	-1073.857	-1083.747
AIC	12.335	12.355	12.341	12.466
SC	12.440	12.463	12.450	12.592
R^2	0.3979	0.3935	0.3998	0.3536

The optimal selection rule of GARCH models is the model's logarithmic likelihood value is bigger and both AIC and *SC* information criterion are smaller, and in the meanwhile parameters are significant. From Table 2 above, we know that the optimal model would be GARCH (1,1), and the estimation result is as below:

$$SI_t = 65.867 + 0.791 SI_{t-1} + \hat{u}_t ,$$
$$\quad (3.056) \quad (12.418)$$
$$\hat{\sigma_t}^2 = 740.213 + 0.214 u_{t-1}^2 + 0.780\ \sigma_{t-1}^2 ,$$
$$\quad (1.990) \quad (3.908) \quad (19.779)$$
$$R^2 = 0.3879, \text{Loglikelihood} = -1073.63, AIC = 12.335, SC = 12.440. \quad (3)$$

Compared with the Equation (1) mentioned above, the mean equation has larger logarithmic likelihood value and smaller the AIC and *SC* in Equation (3) of GARCH(1,1), in addition, the three parameters of the conditional variance equation in Equation (3) are positive and statistically significant, therefore, the GARCH(1,1) model is more reasonably estimated and has a better performance. From Figure 2, we may find out that, the GARCH(1,1) model successfully portrayed and grasped the mutation and mutation strength of the public opinion evolution of the coal mine safety accidents, therefore, the GARCH(1,1) model successfully describes the characters of the public opinion evolution of the coal mine safety accidents, which can provide precondition for coal mine safety accidents early warning information.

In addition, the GARCH(1,1) model overcame the conditional heteroscedasticity in the auto-regressive

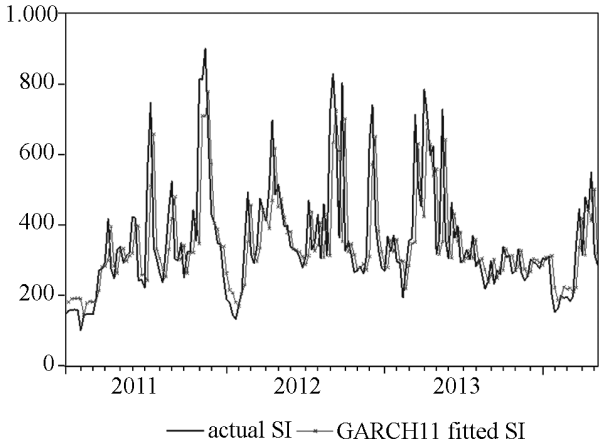

Figure 2
Description of GARCH (1,1) on Public Opinion Evolution of Coal Mine Accidents

residual series of the coal mine safety accident search index: *P*-value of ARCH LM test accepting the null hypothesis of none conditional heteroscedasticity is 0.8286 (in Table 3), highly degree of confidence, and the autocorrelation coefficient AC and partial autocorrelation coefficient PAC both are approximate to zero, the probabilities of the *Q* statistics insignificance are almost bigger than 0.827 (in Figure 3).

Table 3
ARCH LM Test of the GARCH (1,1) Model

ARCH LM test			
F-statistic	0.0463	Prob. *F* (1,172)	0.8299
Obs**R*-squared	0.0468	Prob. Chi-Square (1)	0.8286

Autocorrelation	Partial correlation		*AC*	PAC	*Q*-stat	Prob
		1	-0.016	-0.016	0.0478	0.827
		2	-0.007	0.007	0.0568	0.972
		3	-0.054	0.055	0.5902	0.899
		4	-0.016	-0.014	0.6338	0.959
		5	-0.046	-0.047	1.0195	0.961
		6	-0.056	-0.061	1.5994	0.953
		7	-0.006	-0.006	1.6071	0.978
		8	-0.045	-0.040	1.9891	0.981
		9	0.039	0.043	2.2766	0.986
		10	-0.047	-0.048	2.6832	0.988

Figure 3
Residual Square Correlation Diagram of the GARCH (1,1) Model

CONCLUSION

This paper empirically testifies the characteristics of public opinions on coal mine accidents based on Baidu search index by weekly data and we find out that:

(a) The public opinion evolution on coal mine safety accidents shows aggregation characteristics by analyzing the variation of Baid search index.

(b) The public opinion evolution on coal mine safety accidents shows conditional autoregressive characteristics. We test the residual of a first-order autoregressive model, and found that conditional heteroscedasticity exists, namely the public opinion evolution on coal mine safety incidents has ARCH effect.

(c) The GARCH (1,1) model successfully portrays the volatility of the public opinion on coal mine safety accidents, and conquered the conditional heteroscedasticity in the auto-regressive residual series of the coal mine safety accident search index.

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