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The Research of the Impact of Unconventional Emergencies on the Yield of Stock and Bond Markets

RECHERCHE DE L'IMPACT CONCERNANT LES URGENCES NON-CONVENTIONNELLES

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Abstract
Unconventional emergencies will have an impact on financial markets. Studying on unconventional emergencies' impact on the financial markets is benefit to improve investors' risk awareness, and avoid the risks of unconventional emergencies. This paper uses ARIMA model to study the impact of Wenchuan earthquake on the stock market and bond market return. The results show that, because of investors' "flight-to-quality" behavior, Wenchuan earthquake had a negative impact on China's stock market, while had a positive impact on the bond market.

Key words: Unconventional emergencies; Stock market; Bond market; ARIMA model

Résumé
Les urgences non conventionnelles aura un impact sur les marchés financiers. Etudier sur les urgences non conventionnelles 'impact sur les marchés financiers est l'avantage d'améliorer les investisseurs sensibilisation aux risques, et d'éviter les risques d'urgences non conventionnelles. Ce document utilise le modèle ARIMA pour étudier l'impact du séisme de Wenchuan sur le marché boursier et de rendement du marché obligataire. Les résultats montrent que, parce que des investisseurs '«fuite vers la qualité» du comportement, séisme de Wenchuan a eu un impact négatif sur les marchés boursiers de la Chine, tandis eu un impact positif sur le marché obligataire.

Mots clés: Urgences non-conventionnelles; Bourse, Marché obligataire; Modèle ARIMA

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INTRODUCTION

Unconventional emergencies happened frequently during last several years, such as the floods in 1998, the SARS crisis in 2003, the South blizzards in 2008, the Wenchuan earthquake in 2008, the oil depot explosion in Dalian in 2009 and nuclear leak in Japan in 2011. They have significant impact on China's economy, society, as well as the financial market. China's stock market has suffered different degrees of decline after those emergencies happening. While, there was a certain rise in China's bond market. Therefore, the research about the impact of unconventional emergencies on market and bond markets is helpful for investors to know about the mechanism of emergencies and how to avoid their risks.

In C. F. Han, X. G. Wang and J. J. Kong (2009), unconventional emergencies are defined as emergencies from which society suffers scarcely and lacks the cognition and experience about their development law and solution measures, and most of which may induce serious secondary disasters. And they are classified as four kinds of emergencies, such as natural disasters, accidents, public health incidents and social safety incidents. Secondary disasters, gossip or rumors following unconventional emergencies will affect the mutation of public. G. Q. Ma and X. Y. Wang (2009) finds that unconventional emergencies will affect the behaviors of individual and colony in their behavior evolution model under unconventional emergencies. The changes of the behaviors of individual and colony lead to the panic of social psychology and pessimistic anticipation of the economic and social development. Right following pessimistic anticipation, panic and turbulence of the stock market make the stock market decline and fluctuate sharply. The increasing risk of the stock market makes some investors quit the stock market but choose bond market, whose risk is smaller. However, owing to no many studies on unconventional emergencies, the researchers did not seem to attach enough importance to the research about the impact of unconventional emergencies on the financial market, such as stock and bond markets.

1. LITERATURE REVIEW

Because of the high frequency of unconventional emergencies all over the world, the researches about them and their impact, especially on the financial market, are becoming the research hotspot. Nevertheless, the existing researches mainly focus on the impact of emergencies or extreme events on the financial market. Makinen (2002) regards that "9-11" terrorist incident unfavorably influenced the oil market mainly through popular fear. Cashell and Labonte (2005) thinks that the decrease of oil supply, American people psychic trauma and the pessimistic anticipation of economy, caused by dramatically destroyed oil facility because of Hurricane Katrina in American South and the Gulf of Mexico, lead to the turbulence of international oil market. Straetmans, Verschoor and Wolff (2008) analyzes that whether "9-11" terrorist incident change significantly the tail risk β of US Industry Stock Index using extreme value analysis method. They adopt the occurrence time of "9-11" terrorist incident as a midpoint and find that the tail risk β increases significantly after "9-11" incident.

Chinese scholars have also researched the impact of emergencies on the financial market. Q. F. Wu (2003) empirically studies the impact of SARS event on Chinese investment fund by Event Study. And the empirical results show that the impact of SARS event is limited insignificantly. M. L. Zhou (2004) researches the impact of "9-11" terrorist incident, Iraqi invasion of Kuwait in 1990 and Gulf War on the price of international oil, and forecasts the trend of crude oil price after the Gulf War using ARMAX model. S. P. Wang (2005) presents Autoregressive Integrated Moving Average Model-Generalized Autoregressive Conditional Heteroskedasticity (ARIMA-GARCH) model and discusses the impact of different war phases on the price of international oil. The results show that different phases of wars all significantly affect the oil price, but there are differences among different phases. X. H. Liu (2007) cites the case of "9-11" terrorist incident and constructs an intervention model to study its impact on China's stock market. The results show that "9-11" incident makes China's stock index have an instantaneous change, but its impact on Chinese stock market is a durative process. Based on the data of West Texas Intermediate (WTI) crude oil future price, S. P. Wang, Y. Chen and Y. J. Jin (2009) makes an empirical study about the impact of emergencies such as Iraqi invasion of Kuwait in 1990, "9-11" terrorist incident and Hurricane Katrina, etc. on the price of international oil through constructing ARIMA-GARCH transfer function and summarize some main principles of the impact of different types of emergencies on oil price. X. Zhang (2009) studies the impact of Iran Revolution, Gulf War and Iraq War on the crude oil price using Structural Breakpoint test and Standard Event Study methodology, and the results show that the three events all significantly influence the price of international oil and the impacting patterns on oil price all satisfy the crisis model.

In conclusions, most of the researches are focused on the effect of emergencies to financial market, especially oil and stock markets. However, the researches on the impact of emergencies on the bond market are few. Meanwhile, compared with emergencies, unconventional emergencies are more ruinous, paroxysmal and durative and affect economy, society and financial market more greatly. In a word, this paper studies the impact of unconventional emergencies on the yields of stock and bond markets using the econometric model to make investors and managements attach importance to the impact of the unconventional emergencies.

2. ECONOMETRIC MODELS

2.1 Introduction of ARIMA Model

ARMA model is a random time series model which is first proposed by Box and Jenkins (1976). ARIMA model is based on ARMA model.

ARMA Model, namely Auto-Regressive Moving Average Model. Time series is denoted by a linear function of autoregressive terms, an error term and lagged errors. The auto-regressive moving average model of time series is given as follows which is denoted as ARMA(p, q).

$$Y_t=\varphi_1 Y_{t-1}+\varphi_2 Y_{t-2}+\cdots+\varphi_p Y_{t-p}+\varepsilon_t+\theta_1\varepsilon_{t-1}+\theta_2\varepsilon_{t-2}+\cdots+\theta_q\varepsilon_{t-q} \quad (1)$$

or $$\varphi_p(L)Y_t=\theta_q(L)\varepsilon_t \quad (2)$$

where $\varphi_p(L)$ and $\theta_q(L)$, namely auto-regressive operator, moving average operator, denote the characteristic polynomial of p-th and q-th order of L, respectively.

ARIMA model, namely Autoregressive Integrate Moving Average model. ARIMA Model is mainly suitable for non-stationary time series. If a time series has d unit roots and can be transformed to a stationary autoregressive moving average process by d-order differences, it can be denoted as ARIMA model. ARIMA model can be given as follows which is denoted by ARIMA(p, d, q).

$$\varphi_p(L)(1-L)^d Y_t=\theta_q(L)\varepsilon_t \quad (3)$$

where $(1-L)^d Y_t$ denotes the stationary process which is transformed from time series Y_t by d-order differences. $\varphi_p(L)$ and $\theta_q(L)$ denote auto-regressive operator and moving average operator, respectively. The p, d and q in ARIMA(p, d, q) model denote the number of autoregressive terms, the number of difference and the number of lagged errors, respectively.

2.2 The Establishment of ARIMA Model

The establishment of ARIMA model includes three steps as follows.

Model Recognition

At first, take the logarithm of time series data to eliminate the possibly existent heteroscedasticity. Secondly, judge the stationarity of data using Augmented Dickey-Fuller (ADF) test or Phillips and Perron (PP) test. For non-stationary data, it should be transformed to stationary data by the difference method. Thirdly, make and analyze the correlogram and partial correlogram of time series data to confirm the ARIMA model, namely the value of p, d and q.

Parameter Estimation

It is easy to estimate the parameters of AR(p) model. Because of the independence between the autoregressive terms and error term, AR(p) model can be estimated by Ordinary Least Squares (OLS) method and we can get consistent estimators. However, it is harder to estimate MA(q) and ARMA(p, q). We rewrite (6) as follows:

$$\frac{\varphi_p(L)}{\theta_q(L)} Y_t = \varepsilon_t \quad (4)$$

Equ. (4) is a nonlinear model, so we cannot use OLS to estimate its parameters but iterative Nonlinear Least Square (NLS) method.

Diagnostic Check

After model recognition and parameter estimation, we diagnose and test the estimation results to detect whether the model is suitable for the data or not. If the model is not suitable, we will modify the model.

At first, construct T statistic to check the significance of the parameter estimators of the model. Secondly, check the randomness of residual series and the goodness of fit through Q statistic presented in Box-Pierce (1970). If the residual series is not random, we need to improve the model.

2.3 The Forecast of ARIMA Model

We can transform the non-stationary time series by introducing one-order difference operator as follows:

$$\nabla Y_t=(1-L)Y_t=Y_t-Y_{t-1} \quad (5)$$

$$\nabla^d Y_t=(1-L)^d Y_t \quad (6)$$

Non-stationary time series data through d-order differences can be obtained as follows.

The stationary time series obtained through difference method could be described by AR, MA or ARMA model, and the original time series is given by

$$\varphi_p(L)\nabla^d Y_t=\theta_q(L)\varepsilon_t \quad (7)$$

Then, we can make a study on prediction using (11).

3. EMPIRICAL ANALYSES

3.1 Data

The focus of this paper is on the impact of the Wenchuan earthquake, which happened in Sichuan province in 2008, on Chinese stock and bond markets. Because the issuers of Chinese enterprise bonds are mainly state-owned large and medium-sized enterprises, the credit of enterprise bonds is nearly the same as that of Treasury bond. Thus, we choose Treasury bond market to stand for the bond market. The data set, namely 126 groups of daily closing price data, for the period from Feb. 12, 2008 to Aug. 21, 2008 is provided by CSMAR database. The yield of stock and bond markets is calculated with the following formula.

$$R_{i,t}=(P_{i,t}-P_{i,t-1})/P_{i,t-1} \quad (i=1,2) \quad (8)$$

where $R_{i,t}$ and $P_{i,t}$ are the yield and closing price of i-th day of the stock or bond market, respectively.

The daily closing price of Shanghai Stock Exchange (SSE) Composite-Index and SSE Government Bond Index is shown in Fig.1, respectively. From Fig 1, we can see that SSE Composite-Index began to rise after Apr. 20, 2008. Because the occurrence of Wenchuan earthquake had huge impact on China's economy, the social development and public mentality, after that the stock market of China began to fall. In order to avoid the risk, investors sell stock and buy bond accelerating the bond market rise. Therefore, Wenchuan earthquake affects the yield of China's stock and bond markets significantly.

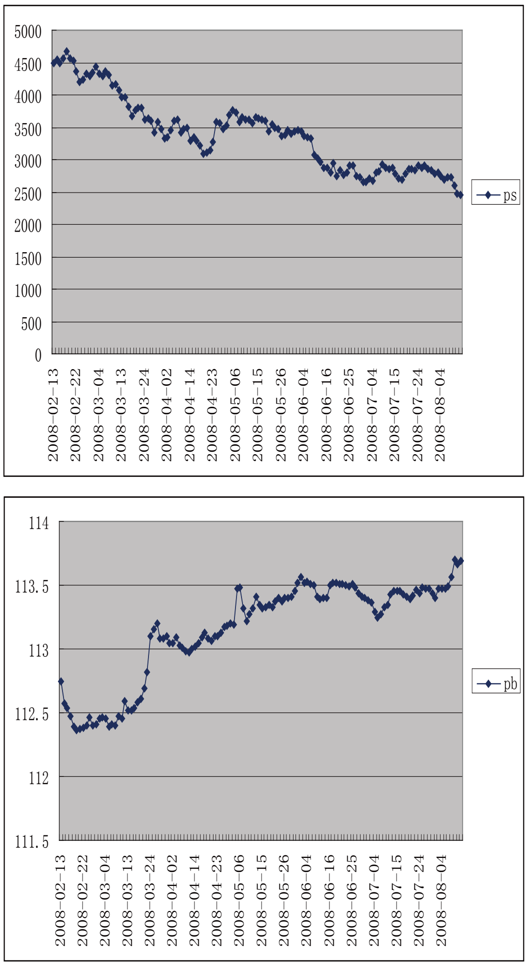


Figure 1
The Closing Price of the Stock Market and the Bond Market

Note: ps and pb denote the closing price of the stock and bond market, respectively.

3.2 Unit Root Test

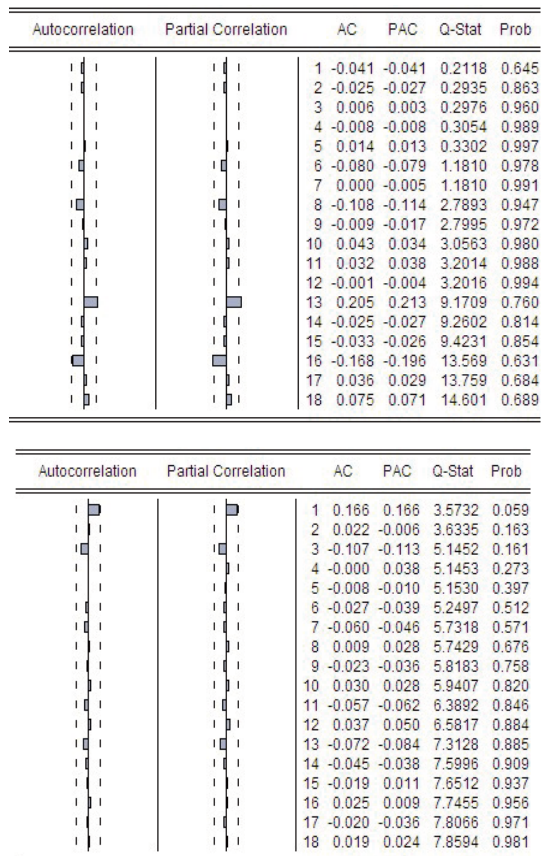
In order to avoid "Spurious regression" phenomenon, we need to inspect the unit root of data before modeling. We examine the closing price and yield of SSE Composite-Index and SSE Government Bond Index using ADF test and the results are given in Table 1. From Table 1, we can see that p values of the closing price of SSE Composite-Index and SSE Government Bond Index are 0.6778 and 0.8603, respectively. It is obvious that the closing price series is not stationary. While, the p-value of the closing price of one-order difference, namely that of the yield, is 0.0000, that is to say, the yield series is stationary. Thus, the closing price series of SSE Composite-Index and SSE Government Bond Index is a cointegrated series of one-order, that is to say, ps~I(1), pb~I(1).

Table 1
Stationary Test

Variables	Test type (c,t,p)	ADF Statistics	P-Value	Test results
ps	(c,0,0)	-1.1892	0.6778	Non-stability
pb	(c,0,0)	-0.6234	0.8603	Non-stability
rs	(c,0,1)	-11.5251	0.0000	Stability
rb	(c,0,0)	-9.3979	0.0000	Stability

3.3 Model and Estimation

To construct ARIMA(p, q) model, we need to determine the values of p and q. The autocorrelograms and partial correlograms of the yield of SSE Composite-Index and SSE Government Bond Index are shown as Fig.2.



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.041	-0.041	0.2118	0.645
		2	-0.025	-0.027	0.2935	0.863
		3	0.006	0.003	0.2976	0.960
		4	-0.008	-0.008	0.3054	0.989
		5	0.014	0.013	0.3302	0.997
		6	-0.080	-0.079	1.1810	0.978
		7	0.000	-0.005	1.1810	0.991
		8	-0.108	-0.114	2.7893	0.947
		9	-0.009	-0.017	2.7995	0.972
		10	0.043	0.034	3.0563	0.980
		11	0.032	0.038	3.2014	0.988
		12	-0.001	-0.004	3.2016	0.994
		13	0.205	0.213	9.1709	0.760
		14	-0.025	-0.027	9.2602	0.814
		15	-0.033	-0.026	9.4231	0.854
		16	-0.168	-0.196	13.569	0.631
		17	0.036	0.029	13.759	0.684
		18	0.075	0.071	14.601	0.689

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.166	0.166	3.5732	0.059
		2	0.022	-0.006	3.6335	0.163
		3	-0.107	-0.113	5.1452	0.161
		4	-0.000	0.038	5.1453	0.273
		5	-0.008	-0.010	5.1530	0.397
		6	-0.027	-0.039	5.2497	0.512
		7	-0.060	-0.046	5.7318	0.571
		8	0.009	0.028	5.7429	0.676
		9	-0.023	-0.036	5.8183	0.758
		10	0.030	0.028	5.9407	0.820
		11	-0.057	-0.062	6.3892	0.846
		12	0.037	0.050	6.5817	0.884
		13	-0.072	-0.084	7.3128	0.885
		14	-0.045	-0.038	7.5996	0.909
		15	-0.019	0.011	7.6512	0.937
		16	0.025	0.009	7.7455	0.956
		17	-0.020	-0.036	7.8066	0.971
		18	0.019	0.024	7.8594	0.981

Figure 2
The Autocorrelogram and Partial Correlogram of SSE Composite-Index and SSE Government Bond Index

In Fig.2, the autocorrelograms and partial correlograms of the yield of SSE Composite-Index and SSE Government Bond Index have the characteristic of tailing decay and are close to zero by the Sine law. We can construct an ARMA(p, q) model using Box-Jenkins model recognition method. From Fig. 4 and 5, we can see that the yields of SSE Composite-Index and SSE Government Bond Index approach zero quickly but are different with zero insignificantly. We suppose p=1 or q=1 to select initial parameters as few as possible. Therefore, this paper chooses ARIMA(1,1,1) model for SSE Composite-Index and SSE Government Bond Index.

We estimate the parameters of ARIMA(1,1,1) using Eviews 6.0 and obtain the ARIMA(1,1,1) models of SSE Composite-Index and SSE Government Bond Index as follows.

$$\nabla p_{s,t}=-0.4479-0.4738\nabla p_{s,t-1}+\varepsilon_{s,t}+0.4586\varepsilon_{s,t-1} \qquad (9)$$

t=(2.8287)   (-3.7574)   (3.5508)

$$\nabla p_{b,t}=0.0067-0.3737\nabla p_{b,t-1}+\varepsilon_{b,t}+0.5127\varepsilon_{b,t-1} \qquad (10)$$

t=(3.2560)   (-3.5124)   (1.9844)

3.4 The Test of Model

We test the efficiency of ARIMA(1,1,1) model constructed-above using Q statistic. Let the null hypothesis be: residual series e_t does not exist p-order autocorrelation. Q statistic can be expressed as:

$$Q = N(N+2)\sum_{j=1}^{p}\frac{r_j^2(e)}{N-j} \qquad (11)$$

Where N is the sample size, $r_j^2(e)$ is the coefficient of the j-order autocorrelation and p is the number of lagged errors of the model. Through the results, we can know that the probability of Q statistic of the model is greater than 0.05. That means the residuals of the ARIMA(1,1,1) model do not exist autocorrelation, that is to say, the model is effective.

3.5 Forecast and Comparative Analysis

The prediction and comparative analysis on the impacts of unconventional emergencies on stock and bond markets are to forecast the closing price of SSE Composite-Index and SSE Government Bond Index. If the stock and bond markets were not affected by unconventional emergencies, the predictive value is the theoretical value of closing price series, and the difference between predictive and actual values is a variable affected by unconventional emergencies. We can find that the impact of unconventional emergencies on Chinese stock and bond market through analyzing the difference.

We fit the closing price of SSE Composite-Index and SSE Government Bond Index using model (9) and (10) and the fitting charts are shown as Fig.3. From Fig. 3, we can see that the goodness of fit of model (9) and (10) is good.

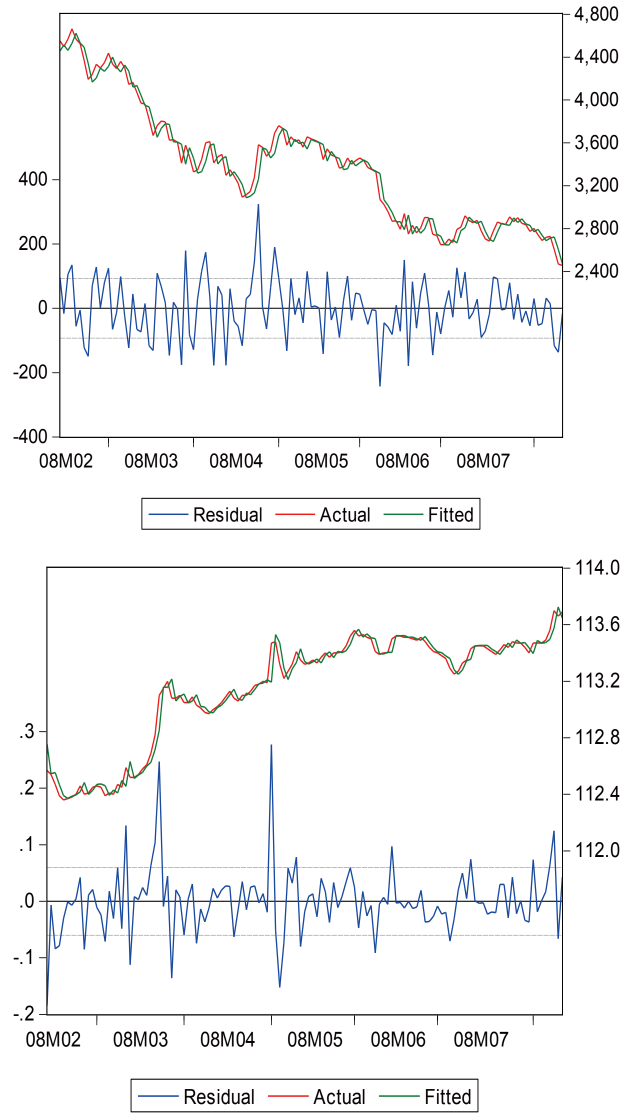


Figure 3
The Fitting Chart of the Closing Price of SSE Composite-Index and SSE Government Bond Index

We forecast the closing price of SSE Composite-Index and SSE Government Bond Index within three months after Wenchuan earthquake using model (9) and (10). (For space consideration, the forecasting result is not presented here.) From the results, it can be found that, when the earthquake occurred, the differences between the real values and the predicated ones of SSE Composite-Index are mostly negative, while the differences between the real values and the predicated ones of SSE Government Bond Index are mostly positive. This analysis shows that the unconventional emergencies, namely Wenchuan earthquake, had a negative impact on China's stock market, but had a positive impact on the bond market. The confidence and expectation of investors to economic development are important factors influencing stock market. After unconventional emergencies, investors would have pessimistic expectations on economic and social development, and then there would be some negative impact on the anticipation of enterprises' profit. Meanwhile, the unconventional emergencies would also have tremendously negative impact on the confidence of investors. All of these will lead to increased risk of the stock market, and investors may withdraw from the market probably. However, the treasury-bonds are guaranteed by the national credit. In general, bonds with high credit have little probability of default. To avoid the risk of the decline of stock market, investors would transfer their investment from the stock market to the bond market for risk hedging. Therefore, the unconventional emergencies increase the risk of the stock market, and the transfer behaviors of investors make the stock market fall and yields fall, treasury-bond market prices and yields rise.

CONCLUSIONS

This paper studies the impact of Wenchuan earthquake on the yields of stock and bond market using ARIMA model. We test the ARIMA model and find that the fitting and prediction accuracies of the model are good. And the forecasting results show that Wenchuan earthquake is negatively correlative with the stock market, but positively with the bond market.

We simulate the impact of unconventional emergencies on stock and bond market using ARIMA model and calculate the influence. This paper could be helpful to the investors and administrators for their decision-making and taking measures to reduce the risk of unconventional emergencies and cultivate strong consciousness of risk.

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