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Modeling the distribution of extreme returns in the Chinese stock market[☆]

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ABSTRACT

It is well known that extreme share returns on stock markets can have important implications for financial risk management. In this paper, we are concerned with the distribution of the extreme daily returns of the Shanghai Stock Exchange (SSE) Composite Index. Three well-known distributions in extreme value theory, i.e., Generalized Extreme Value (GEV), Generalized Logistic (GL) and Generalized Pareto distributions, are employed to model the SSE Composite index returns based on the data from 1991 to 2013. The parameters for each distribution are estimated by using the Power Weighted Method (PWM). Our results indicate that the GL distribution is a better fit for the minima series and that the GEV distribution is a better fit for the maxima series of the returns for the Chinese stock market. This is in contrast to the findings for other markets, such as the US and Singapore markets. Our results are robust regardless of the introduction of stock movement restriction and the global financial crisis. Further, the implications of our findings for risk management are discussed.

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1. Introduction and literature review

Extreme movements in share returns rarely occur. However, they can have devastating consequences when they do occur. Thus, it is important for investors, speculators and risk managers to comprehend extreme market movement events. Modeling the distribution of extreme stock returns has become a hot research topic, and it can contribute to the improvement in risk management.

In the finance literature, it is common to assume that the stock returns follow a Gaussian distribution. For example, [Markowitz \(1952\)](#) and [Sharpe \(1964\)](#) assume normality of the distribution for the stock returns in studying portfolio selection and deriving the capital asset pricing model; [Black and Myron \(1973\)](#) and [Merton \(1973\)](#) assume that the stock price follows the geometric Brownian motion in their option pricing model. More recently, Value at Risk (VaR) models developed and implemented by financial institutions also rely heavily on the Gaussian distribution.

The normality assumption implies that the stock return distribution is symmetric, which may not be true for right-skewed or left-skewed financial data. Previous studies including [Longin \(1996\)](#), [Jondeau and Rockinger \(2003\)](#) and [Tolikas and Gettinby \(2009\)](#) have indicated that this assumption may lead to the underestimation of risk. It has been widely accepted

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that stock returns tend to be fat tailed rather than normally distributed. Thus, the normal distribution assumption is often inadequate in accounting for the catastrophic events and must be dropped for modeling the extreme stock returns.

The extreme value theory (EVT) is appealing for modeling the distribution of extreme stock returns because it focuses only on the extreme returns rather than all returns. EVT is a study on the distribution of extreme values of a random variable, and it has been applied widely in many fields such as hydrology, insurance and finance. It was first introduced by Fisher and Tippett (1928) and applied by Longin (1996), Embrechts et al. (1999) and Poon et al. (2004) in finance.

EVT is used to model the distribution of stock returns by specifically focusing on the tails. Parkinson (1980) reveals that the tail of the empirical distribution contains important information for the variance of returns. The fatness of the tails of the return distribution can be used to calculate the probabilities of a market crash and thus can contribute to the early warning of market risk (Jansen and De Vries, 1991). EVT is also used to the calculation of VaR. Further details can be seen in Cotter (2007), Allen et al. (2013), Marimoutou et al. (2009) and Karmakar (2013). These studies use the Peak Over Threshold (POT) method to model the extreme behavior in financial markets. The POT method considers the sorting of clustered phenomena that are frequently found in data. In contrast, there has been a decline in the number of studies of EVT by using the Block Maxima Minima (BMM) method, which defines extreme events as the maximum (minimum) value in each sub-period.

This research is concerned with the Chinese stock market and aims to identify the best distribution in modeling extreme stock returns by using the BMM method. The main distributions assigned to BMM are the Generalized Extreme Value (GEV), Generalized Logistic (GL) and Generalized Pareto (GP). Studies by Longin (1996), Jondeau and Rockinger (2003) and Gençay and Selçuk (2004) find that extreme stock returns in the US can be characterized by the GEV distribution, which can be used for calculating VaR measures and capital requirements. Gettinby et al. (2004, 2006) find Generalized Logistic (GL) distribution fits better for extreme daily share return in the US, UK and Japan compared to GEV, in contrast to the previous research. More recently, Tolikas and Gettinby (2009) find that GL distribution is the best fit for the distribution of the extreme daily share returns in Singapore. In sum, the literature confirms that the best distribution for extreme share returns varies across share markets. This may be due to the economic environment and market mechanism of each market. Thus, it is of particular interest to consider the emerging markets such as the Chinese stock market.

This research aims to fill the gap in the literature by modeling the extreme stock returns in the Chinese stock market. Due to the similarity between the Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE), we focus on the SSE Composite Index, which consists of 950 stocks listed on the SSE.

Using the data of Shanghai Stock Exchange Composite Index (SSE Composite) from 1991 to 2013 (23 years), we model the extreme share daily returns of the SSE composite index by employing an EVT approach. Based on the literature review, we focus on the Generalized Pareto (GP), Generalized Extreme Value (GEV) and Generalized Logistic (GL). The parameters of each distribution are estimated by using the Probability Weighted Moments (PWM) method. Our research reveals that the GL distribution fits the empirical data better than the GEV and GP distribution for most intervals in minima series, while GEV distribution fits better for the maxima series of the returns for all intervals.

As a robustness check, we consider two important events during the period: the introduction of the restriction on the stock movement in Chinese stock market and the global financial crisis (GFC) of 2007–2008. For each event, we consider the pre- and post-event periods. It is demonstrated that there is no change in terms of the best distribution due to these events, though the GFC does have an impact with respect to the best distribution of the extreme stock returns during the GFC period.

Our findings have important implications for VaR calculation, risk managers, speculators and risk policies in understanding the distribution of extreme stock returns in the Chinese stock market.

The remainder of this paper is organized as follows. A background on the Chinese stock market is provided in Section 2. Section 3 describes the data and sample statistics. The research methodology is discussed in Section 4. Specifically, we discuss block maxima sampling, L-moment ratio diagram, parameters estimation and the goodness of fit test. Section 5 presents the empirical results. Section 6 discusses the implications of the findings for the Chinese stock market. A summary and concluding remarks are given in Section 7.

2. The Chinese stock market

The Chinese stock market has grown enormously in the past two decades due to its miraculous economic development, and it has become more and more influential among world stock markets. In terms of capitalization, the Chinese stock market has surpassed Japan and become the second largest stock market behind the US stock market since the end of 2007. There are two main stock exchanges in China, namely, the Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE). Both stock exchanges started trading in 1990. At the end of 2010, the total market capitalization for the Shanghai Stock Exchange was approximately 18,238 billion RMB with 901 listed companies (Chong et al., 2012).

The Chinese stock market is an emerging market with many interesting features. There are two types of shares in the Chinese stock market: A Shares and B Shares. A shares are restricted to domestic investors only, and B shares are available to both domestic and foreign investors. Initially, B Shares were stocks that were designated for foreign investors that were denominated in the Chinese local currency, the Renminbi (RMB), and were payable in foreign currency. However, the regulation changed in 2001; domestic traders can now trade B shares in US dollars as well. When the regulation was introduced, a great deal of B share prices went up significantly (Chen et al., 2007).

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