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碩 士 論 文

基於不對稱分佈模式的美國股市的市場風險

Market Risk of the United States Stock Market Based on Asymmetric Distribution Model

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Sincerely,

Nancy Quynh Nguyen 阮坤煇

Abstract

In this paper, the Value at Risk (VaR) approach is performed to analyze the investment risk of Dow Jones Industrial Average (DJIA) and its constituent stocks. Data on stock index and stock prices are collected from Thomson Reuters Datastream, and the study is divided into the financial crisis period and tranquil period. By applying the following three distribution models: Skewed-T Distribution (ST), Generalized Hyperbolic Distribution (GH), and Normal Inverse Gaussian Distribution (NIG) on daily stock returns, empirical evidence shows that the VaR of the skewed distributions are better than that of the normal distribution.

Furthermore, as expected, the distribution of the return on stock value during the financial crisis has a fatter tail compared to the tranquil period, and out of the three models, the NIG Distribution provides the most satisfactory result.

Keywords: value at risk, financial crisis, skewed distribution

摘要

在本文中，將採用風險價值（VaR）方法來分析美國道瓊股價指數及成分股之市場投資風險。研究中股價指數及股票價格由 Datastream 資料庫取得，並將研究期間區分為金融危機期和平靜期。本研究利用三種不同的一般化厚尾分配配使本研究之資料，三種分配模型為正態偏差 t 分佈（ST），一般化 Hyperbolic Distribution（GH）和 Normal Inverse Gaussian Distribution（NIG）。實證結果基本上說明這些偏態分佈的風險值衡量績效優於常態分配的結果。

其次，研究結果也如同我們期望，與非金融風暴期間相比，在金融風暴期間股價報酬率具有較厚的尾部分配，三中模型分配又以 Normal Inverse Gaussian Distribution 的結果最令人滿意。

關鍵字: **風險價值，金融風暴，偏態分佈**

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Chapter 1 Introduction

1.1 World financial background

The global financial crisis, which began in the United States in 2007, is known as the worst financial crisis in history. It heavily affected global stock markets, leading to many bankruptcies and even collapses of stock markets at that time. To this day, the number of people who are still willing to invest their money in stocks is a lot fewer than the number prior to the crisis, due to the high risk and low return. However, the main economic variables, including growth rates, exchange rates, inflation rates and interest rates, show a significantly higher volatility (Butler and Okada, 2007). In short, financial markets have become more complex, uncertain and riskier. In response to this problem, new derivative financial instruments (futures, options, swaps, etc.) were suggested to enhance risk analysis and management. Currently, the derivatives market is huge because of its potential role in investment and risk management. Yet, the economic changes and financial market reacted vigorously, reflecting the complexity and opacity of the financial system. Despite bringing opportunities into the market, new derivatives with non-linear returns also come with vulnerability, risks and complexity. That is to say, due to the increase in complexity and connectivity, financial organizations are more vulnerable to risks from price fluctuations in the financial market. As a result, organizations began searching for alternative solutions in risk management. In addition, with the recent financial and economic turmoil, financial institutions have proposed a plethora of rules and regulations to force organizations to take preventive measures in order to improve risk management and modeling systems.

1.2 Risk, Value at Risk and Asymmetrical Distribution

According to Malz (2001), risk is defined as the possibility of occurrence of the low rate of income or when consumption or losses are occurred. In other words, ‘risk’ is the possibility of unexpected results or quantities deviating from its original expectations. However, this deviation has a negative effect on the economy. Positive deviations in economics are profitable and there are no risk problems. Risk modeling uses a variety of techniques such as market risk, Value at Risk (VaR), or Extreme Value Theory (EVT) to analyze the portfolio and measure risks. These risks are usually classified into credit risk, liquidity risk, market risk, and operational risk. Many large financial service companies use risk modeling to help portfolio managers assess the amount of capital reserves to maintain and purchase financial assets.

Managers use formal risk modeling under the Basel II proposal (Chorafas, 2004) in all major international banking systems. In the past, analysts often used qualitative methods to measure risk, which took up much effort, but nowadays, risk can be evaluated quickly and easily with the help of advanced hardware and computing software. In this paper, Value at Risk (VaR) is used as the main risk measurement. In brief, VaR is the maximum loss at a given confidence level for a given period of time. Pérignon and Smith (2010) measured risk and VaR through two ways: volatility and percentile. Volatility of financial returns means that there is a great likelihood of loss, but there is also a chance of gaining greater profits. Percentile describes tail behavior. VaR estimation is a complex task. It is essential to recognize the main features of financial data and choose the best model. The range of existing documents is extremely wide and may even be controversial, but it helps draw a general picture of the problem. It is commonly believed that financial data is characterized by heavy-tail, time-varying fluctuations, asymmetric responses to bad and good news, and skewness. Overlooking any of these factors may lead to the underestimation of VaR and possibly end in a bad result for companies, banks, and/or investors.

In recent years, skewness has gained more and more attention, and giving rise to the open problem of time-varying skew detection and modeling. Is skewness constant or are there any significant variabilities which in turn affects the VaR estimation? The distribution has symmetry (Berim and Ruckenstein, 2009). It is called a "normal distribution" and its pattern is recognized as a Gaussian bell curve. The asymmetric data is unbalanced because the data is more heavily weighted on one side than the other; it has a larger value on the left, right or both sides rather than concentrated in the middle. Risk and return curves are usually plotted in histograms, such as bell curves, for data analysis. Market return curves do not demonstrate a perfect balance of symmetry, according to the modern academic theory of modern finance. Stock return curves are irregular, for they do not fall into the Gaussian normal distribution. However, the asymmetry of market return curves is distorted because they have a "fat tail". Also, the market return graph shows that the losses are immense, and they often seem to fit the normal distribution of equilibrium symmetry.

However, when applying a normal distribution, VaR may have undesirable characteristics (Artzner et al., 1997, 1999), as in lack of sub-addition (i.e. the VaR of a portfolio with two tools may be greater than a single VaR). Figure 1 shows that the tail of the generalized hyperbolic distribution, or even the tail of the normal Gaussian inverse distribution, is heavier

than the tail of the normal distribution. Thus, we can see that the VaR of the GH Distribution and its subcategories is parametrically closer to the empirical observational risk value. In summary, the asymmetric distribution used to calculate the VaR provides a more reasonable result than the classical distribution (Eberlein & Karsten, 1998). This is one of the many reasons why I chose to use the asymmetric distribution model to measure the market risk of the United States' stock market.

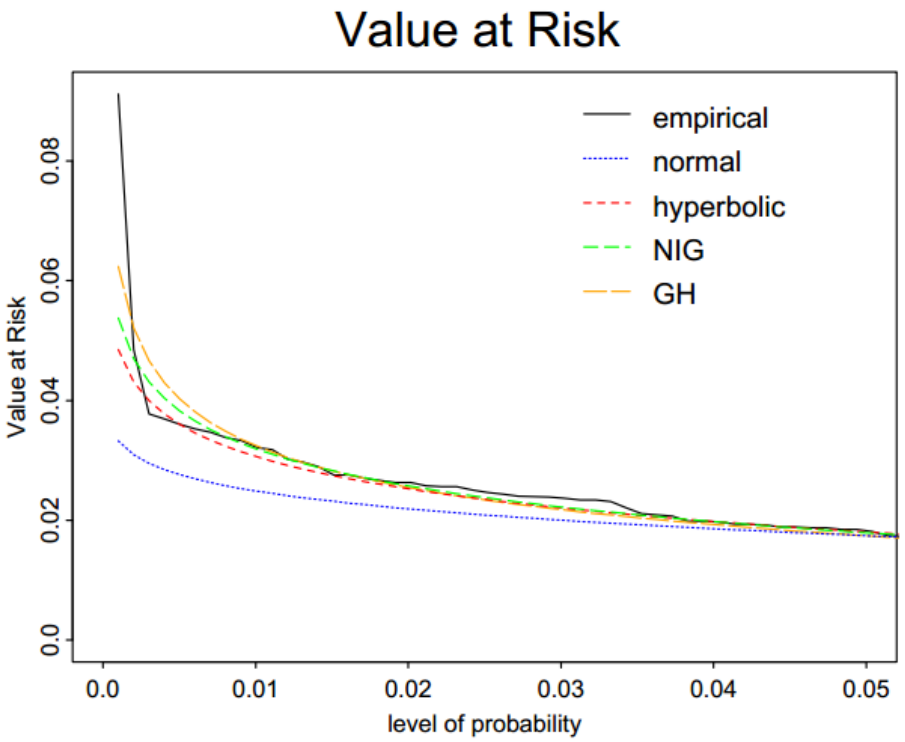

Figure 1. DAX price from 1993 to 1997

1.3 Research purpose

The purpose of this research is to investigate some unrevealed aspects of the market risk of the U.S. stock market based on the asymmetric distribution. Applying the one-day forecast of VaR at both 95% and 99%, the following VaR distribution models are compared: Skewed T distribution (ST), Generalized Hyperbolic distribution (GH), and Normal Inverse Gaussian distribution (NIG). When selecting the most suitable model, a back-testing analysis is carried out. This research attempts to demonstrate that risk measuring is based on asymmetric distribution. Additionally, this research aims to provide comprehensive information on the economy and stock markets of the United States. The problems proposed in this study can be expressed as follows: