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Estimating the VaR of a portfolio subject to price limits and nonsynchronous trading

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Abstract

Price limits and nonsynchronous trading are two main features in emerging markets. Price limits cause stock returns to be restricted within a prespecified range whereas infrequent trading induces spurious autocorrelation and biased estimate of the return variance. Both factors cause traditional measures of Value at Risk (VaR) to be biased. In this paper, we propose VaR measures based on a two-limit type Tobit model incorporating Scholes and Williams' [Scholes, M., & Williams, J. (1977). Estimating betas from nonsynchronous data, *Journal of Financial Economics* 5, 309–328] estimator that adjusts for price limits and nonsynchronous trading. Based on the simulation design of Brown and Warner [Brown, S., & Warner, J. (1985). Measuring security price performance, *Journal of Financial Economics* 8, 205–258], we compare the performance of our proposed methods with two traditional methods, one based on naive OLS estimates and the other based on historical simulation. Using daily data of all stocks listed on the Taiwan Stock Exchange and the OTC markets, the simulation results indicate that all methods perform reasonably well. The only exception is that the naive OLS yields a slightly higher failure rate when the portfolio under consideration is composed of only a few stocks. Thus, despite the potential problems induced by nonsynchronous trading and price limits, their practical impacts seem limited.

JEL classification: G0; G1; G2
Keywords: Value at risk; Price limits; Nonsynchronous trading; Variance–covariance method; Historical simulation

1. Introduction

During the past decade, Value at Risk (VaR) has become one of the standard measures of risk used by financial institutions and regulators. Conceptually, VaR measures the potential loss of a

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portfolio that will not be exceeded with a specified probability over a specified time horizon. Thus, VaR is merely the quantile of the distribution of a portfolio's future returns, conditional on any information available. Despite its conceptual simplicity, however, the measurement of VaR is by no means an easy statistical exercise, but a very challenging statistical problem (see, e.g., the review of VaR by Duffie and Pan, 1997).

The estimation of VaR may be even more difficult for emerging markets because trading in those markets is typically subject to varying degrees of regulatory restrictions and market imperfections. In this paper, we focus on the problems resulting from two most common and important forms of regulatory constraints and market imperfection, namely price limits and infrequent trading. Without considering microstructure factors such as infrequent trading and regulations like price limits, the traditional estimates of distribution parameters may be biased, thereby resulting in biased estimates of VaR measures.

Used ostensibly to prevent prices from fluctuating too much during a given trading session and thereby preventing defaults and reducing the contract cost, price limits are a common regulation associated with futures contracts and can also be found in many stock markets in Asia and Europe, such as Austria, Belgium, China, France, Greek, Italy, Japan, South Korea, Malaysia, Mexico, the Netherlands, Spain, Switzerland, Taiwan, and Thailand. Price limits cause two potential problems. First, under daily price limits, changes in the value of a portfolio over a given day are constrained to a prespecified range. But this does not mean that the VaR is *effectively* lowered with the imposition of price limits. Chou, Lin, and Yu (2003) show that when a price limit is triggered, the "unrealized" shock will be spilled over to the next trading days until it is fully reflected in asset prices. Second, as the *observed* stock returns are limited to a certain range under price limits, the usual estimates of risk and return are biased. Chou (1997), Lee and Kim (1997), and Wei and Chiang (2002) show that the usual estimates of variance, covariance, and systematic risk are biased downward, which results in a downward bias in the VaR estimate and a higher failure rate.

Another feature we consider is infrequent trading, also known as nonsynchronous trading or thin trading in the literature. Scholes and Williams (1977) show that estimates of variance and systematic risk are inconsistent and biased downward in the presence of thin trading. Thus, as in the case of price limits, the usual VaR measures without considering the impact of nonsynchronous trading are also biased downward.

We propose portfolio VaR measures based on the variance–covariance method that adjusts for the effects of price limits and/or nonsynchronous trading. Specifically, an estimation method combining Scholes and Williams' model and the two-limit Tobit model is proposed to provide more accurate estimates of model parameters.

To measure the real effects of both factors, we follow the design of Brown and Warner (1985) by conducting Monte Carlo simulations to compare the performance of our methods with some traditional methods, including the variance–covariance method based on naive OLS estimate and the historical simulation. The sample for simulations is real data constructed from the daily returns of all stocks listed on the Taiwan Stock Exchange and the Taiwanese OTC markets from 1998 to 2003. The OTC data are included because the trading in the OTC markets is typically less frequent than in the Exchange. During the sample period, Taiwan's stock markets impose a 7% price limit regulation, and about 9% of the observations hit either up or down limits.

Our simulation results show that the naive OLS estimates of betas and variances–covariances are biased downward. Nevertheless, all methods perform reasonably well, except in the case where the portfolio is composed of only a few stocks, the VaR based on OLS yields a slightly higher failure rate than the nominal value (i.e., 1% or 5%).