Nonlinear Analysis: Real World Applications 11 (2010) 1704–1713

Contents lists available at ScienceDirect

Nonlinear Analysis: Real World Applications

journal homepage: www.elsevier.com/locate/nonrwa

Setting margin levels in futures markets: An extreme value method

Tzu-chuan Kao [a,1], Chu-hsiung Lin [b,*]

[a] *Kun Shan University, Department of Finance and Banking, 949, Da Wan Road, Yung-Kang City, Tainan Hsien, 710, Taiwan*

[b] *National Kaohsiung First University of Science and Technology, Department of Risk Management and Insurance, 2, Juoyue Road, Nantz District, Kaohsiung, Taiwan*

ARTICLE INFO

Article history:
Received 15 February 2007
Accepted 23 March 2009

Keywords:
Extreme value theory
Margin setting
Stock index futures
Value at Risk

ABSTRACT

There are of course different types of margin requirements in futures clearinghouses, and this study focuses on setting initial and maintenance margin levels. This study provides an approach, the VaR-x method that incorporates a modification of the Hill estimator based on extreme value theory (EVT) into a Student-*t* distribution, for setting the unconditional and conditional margin levels (i.e. initial and maintenance margin levels). Empirical applications are based on daily data for three stock index futures returns: the FTSE100, Nasdaq100 and Nikkei225. The empirical results demonstrate that given lower probabilities of margin violation, the VaR-x approach to setting unconditional margin levels is more accurate than either the normal approach or the Hill non-parametric approach proposed by Cotter [J. Cotter, Margin exceedences for European Stock Index Futures using extreme value theory, Journal of Banking and Finance 25 (2001) 1475–1502]. Additionally, this study demonstrates that using the conditional VaR-x approach to setting margin levels can better capture extreme events, thus ensuring adequate prudence, something that is particularly crucial in periods of strong fluctuation. These empirical findings suggest that the proposed approach is very useful to setting the initial and maintenance margin levels.

1. Introduction

Margin committees face the difficult task of appropriate margin levels to balance the costs of trader default against the benefits of increased market liquidity [1]. The key problem margin committee face is that setting the margin level too high will lead to high transaction costs and thus reduced trading volume. Meanwhile, if the margin level is set too low, it may not adequately cover extreme price changes, thus incurring default risk. For guarding against default, this paper focuses on setting prudent margins designed to protect futures positions from extreme price movements.

The academic literature has implemented two approaches to setting appropriate margin levels. First, the application of economic models that assume margin levels are endogenously determined for minimizing broker costs. For example, Brennan [2] and Fenn and Kupiec [3] used the concept of efficient contract design to identify economic factors determining the optimal margin level. Second is the application of statistical approaches, which is used to set margin levels that represent an amount not to be exceeded by a price change over a specified time period at an acceptable probability level. These statistical approaches include parametric and non-parametric methods that rely on Gaussian and non-normal distribution assumptions for the underlying distribution of futures price changes. Figlewski [4] and Gay et al. [5] are two examples of

* Corresponding author. Tel.: +886 7 6011000; fax: +886 7 6011046.
E-mail addresses: tzuchuan@mail.ksu.edu.tw (T.-c. Kao), chusiung@ccms.nkfust.edu.tw (C.-h. Lin).
1 Tel.: +886 6 2727175; fax: +886 6 2050622.

1468-1218/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.nonrwa.2009.03.025

studies that assume futures returns follow a normal distribution. Warshawsky [6] used a non-parametric analysis procedure, which does not rely on normal distributional assumptions, and shows that it may be inappropriate to assume normally distributed futures returns. Kholodnyi [7] developed a new approach, which models price changes with spikes as a non-Markovian stochastic process that allows for modeling spikes directly as self-reversing jumps. Recent studies on margin setting have increasingly studied the fat-tailed characteristics of returns distribution, and in doing so, applied extreme value theory (EVT) to setting margin levels. As extreme movements are central to margin setting problem, EVT directly models the tails of the returns distribution and thus could potentially yield better estimates and forecasts of default risk. Kofman [8], Longin [9,10], Booth et al. [1], Broussard and Booth [30] and Broussard [11] document that using EVT with a parametric method is appropriate for measuring the optimal margin levels. Furthermore, their studies also show that assuming normally distributed data underestimates the probabilities of margin violation because the empirical distribution of observed large price movements is too leptokurtic to be normal. Meanwhile, in EVT the limiting distribution of extreme values has non-parametric underlying assumption, thus Dewachter and Gielens [12] and Cotter [13] propose applying the Hill non-parametric method to generate measures of margin levels, showing that the margin levels estimated by the Hill non-parametric method are sufficient for futures contracts. Consequently, a consensus exists in the previous empirical research that using EVT with parametric and Hill non-parametric methods to determine margin levels can fully protect against default resulting from extreme price movements, but that for minimizing model risk the Hill non-parametric method is superior to parametric procedures which require assumptions regarding the exact distribution type of extreme price changes.

However, the Hill non-parametric method still suffers from two major limitations [14]. First, the Hill estimator is biased when applied to small samples. Second, the Hill estimator used in the estimation procedure must depend on the number of order statistics [15,16]. Traditionally, the number of order statistics is determined by simulating the mean squared error minimizing number, but generally this procedure produces biased estimates [12]. Recently, Jansen and de Vries [17], Koedijk and Kool [18] and Beirlant et al. [19] respectively proposed highly effective methods of resolving this problem. However, these methods still base their tail estimates on a specific number of tail observations [14]. To correct the Hill non-parametric method proposed by Cotter [13], this study specifically provides an approach to setting margin levels, known as VaR-x that incorporates a modified version of the Hill estimator into a Student-*t* distribution. In line with the works of Huisman et al. [20,14] and Pownall and Koedijk [21], this study is the first to use the modified Hill estimator, which is to correct the small sample bias in tail index estimates, and does not condition its tail observations as do the Hill [22], Beirlant et al. [19], and other tail index estimators [14], to estimate the tail index of returns distribution. The estimated tail index then can be used to parameterise the number of degrees of freedom of the Student-*t* distribution for estimating the margin level. The fact that the number of degrees of freedom reflects the degree of tail fatness enables the capture of extreme events, thus ensuring adequate margin level, something that is especially crucial during times of high fluctuation.

Additionally, studies on margin setting can consider two different returns distributions: the conditional and unconditional distributions. The unconditional analysis attempts to incorporate extreme events occurring over a long time period, therefore it is suited to the setting of initial margin levels (i.e. unconditional margin levels). While the conditional analysis reflects the change in market conditions over time, therefore it is suited to the setting of daily or maintenance margin levels (i.e. conditional margin levels) [23]. This study considers the adoption of both unconditional and conditional analyses to provide different but complementary information for the setting of initial and maintenance margin levels. In analyzing conditional margin setting, most previous studies focused on the GARCH model. For example, Cotter [13], Knott and Polenghi [24] and Cotter and Longin [25][2] considered a conditional process by applying several variants of the GARCH model to address issues relating to the time-varying behavior of futures price changes. Knott and Polenghi [24] showed that employing a GARCH model with innovations based on Student-*t* distribution could provide a timely and informative measure of conditional margin levels. Though the GARCH model focuses on accounting for volatility clustering, whereas extreme values do not actually cluster [26,13], setting margin levels can specifically reflect common volatility levels, but cannot deal with very low probability levels where the extreme values are located. As the problem of setting conditional margin levels is still related to the tails of the distribution of futures price changes, this study uses a conditional approach of VaR-x which simultaneously describe the tail fatness and time-varying behavior of conditional distribution to capture some of the additional upside and downside risk faced during more volatile periods.

The empirical investigation applies the proposed unconditional and conditional VaR-x approach to estimate the margin levels for three different daily stock index futures series: the US Nasdaq100, the British FTSE100 and the Japanese Nikkei225. Moreover, margin levels may differ between long and short positions owing to the behavior of left and right tail price movements. Therefore, this empirical investigation respectively deals with the estimation of the margin levels for long and short positions. The proposed VaR-x approach is compared with two different methods, which are the normal method [4,10] and the Hill non-parametric method [13].

The remainder of this paper is organized as follows. Section 2 presents the theoretical foundations used to estimate unconditional and conditional margin levels. Section 3 then details the stylized fact of the empirical data. Subsequently, Section 4 illustrates the empirical results. Finally, Section 5 presents conclusions.

[2] Cotter and Longin [25] extended the work of Cotter [13], applying modified Hill estimator based on EVT [14] to set daily margin levels by considering the intraday dynamics of market prices. They found that the modified Hill estimator could easily extend the multi-period margin estimation.