10. CAN VAR BE PREDICTIVE FOR REGULATION? EVIDENCE FROM THE FUTURES INDUSTRY IN TAIWAN

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Abstract

Financial authorities are monitoring the financial industries by their own capital to ensure that financial industries have sufficient equity capital to absorb a variety of financial business risks. The current method applied for regulating the capital adequancies of futures commission merchants (FCMs) in Taiwan is Adjusted Net Capital (ANC) ratio, which is also applied in the U.S. In this study, we add the Value-at-Risk (VaR) estimated by GJR-GARCH model and the delta-gamma approach to the calculation of ANC (VaR-based ANC), to compare it with ANC, and further to investigate the ability of prediction on VaR. The sample period is from 2006 through 2007, totally 495 trading days . We conclude that VaR-based ANC ratio in certain intervals ratio have better warning ability of prediction than ANC. Moreover, for the FCMs whose capital adequancies are more volatile and the FCMs with higher capital adequancies, the warning effects of inclusion of VaR into ANC ratio is even more significant.

Keywords: ANC; VaR; GJR-GARCH; futures industry
JEL Classification: G17; G28

I. Introduction

In recent years, the trading volume of futures and options increased rapidly in Taiwan, and more and more investors and firms use futures to hedge, invest and/or speculate. The number of accounts of individual investors increased from13 million in 1998 to 120 million in 2008, and the number of accounts of institutional investors also increased from 600 in 1998 to 7,000 in 2008. Thus, the financial markets will likely be in chaos and many investors and firms will probably be affected if futures commission

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merchants (FCMs) go into bankruptcy. Therefore, the risk management of futures industry has become one of the most important topics concerned by FCMs and financial supervisory authorities.

From the viewpoint of risk management, the financial supervisory authorities regulate financial industries by monitoring their own capital levels, so the early warning system of own capital of financial industries is common. For Taiwan's futures industry, in addition to the statutory minimum capital and minimum request of owners' equity, FCMs are regulated by Adjusted Net Capital (ANC) ratio, which is also applied by the Commodity Futures Trading Commission (CFTC) in the U.S. futures industry. In general, the application of ANC ratio regulates an FCM to maintain its capital at a minimum level, and to control its business risk.

On the other hand, many financial institutions try to quantify risk, e.g. some of them apply Value-at-Risk (VaR) to enhance risk assessment and control. In Taiwan, ANC ratio appears to be capable of ensuring sustainability of FCMs. However, it is criticized that market risk is not taken into consideration on real-time basis, thus it may cause bias on risk estimates. For example, a futures dealer may have long positions of call options. To monitor business risk of such a futures dealer by ANC ratio, the haircut[3] for the long positions of call options is a fixed percentage to deduct in the numerator of ANC ratio. Intuitively, the fixed percentage can not reflect the market risk of the long positions promptly, and might lead to an upward bias of real ANC ratio. Based on the perspective of risk management, the haircut should be larger as the market is more volatile. In other words, it makes sense that the adjusted value of risky assets should be decreased when market risk is increased in order to reflect the risk arising from movements in the market prices. Therefore, we argue that the existing ANC ratio used to regulate the business risk of FCMs is insufficient to disclose (regulate) the potential business risk of FCMs due to the fixed haircut in calculating adjusted net capital. This study sets out to incorporate Value-at-Risk (VaR) in the existing ANC ratio becasue of its widely usage by financial institutions to quantify the downside risk of their trading positions. We propose the VaR-based ANC ratio to examine whether it has better warning ability of prediction for the capital adequancy level of FCMs than the existing ANC ratio does. In particular, we attempt to apply VaR into the calcuation of ANC (VaR-based ANC) ratio. In addition, we compare VaR-based ANC ratio with ANC ratio to examine whether VaR is predictive for regulation. Such comparison offers academicians and regulators empirical results to better understand the effectiveness of VaR in regulation.

The remainder of this study is organized as follows: Section II outlines the literature review; Section III describes the methodology; Section IV and V detail the data description and main findings; and the last section presents the conclusion.

[3] *Haircut, which refers to the discount rate of a risky asset, is a commonly used term in the U.S. and other countries. See e.g. http://www.nfa.futures.org/nfa-compliance/publication-library/regulatory-requirements-appendix-a.pdf.*

II. Literature Review

There are scholars researching on Basel II capital adequacy, the application of VaR and other related research topics (e.g. Blum, 1999; Rime, 2001). However, few studies focus on VaR and ANC for FCMs, in the Basel II capital adequacy management system. Blum (1999) points out that in order to meet the standard capital adequacy, banks may raise capital and further result in increasing banks' risk. Rime (2001), finds that the Swiss banks have the tendency to raise capital to comply with minimum capital requirements, but it will not affect the risk of the banks. Furthermore, the impact for pressure of raising capital in Swiss is not as large as in the U.S. and in the U.K. Johnston (2009) extends a single factor model to strengthen the Basel II capital formula to calculate credit risk capital requirements for equity investments, and he finds that the capital requirement of equity investments is significantly higher than the capital requirement for credit risk. The findings of Blum (1999) and Rime (2001) are not the same because different models are used in different countries. In Taiwan, however, the regulating mechanisms for FCMs and banks are not exactly the same. ANC ratio is adopted to regulate and monitor the business risk of FCMs, and it is conceptually similar with the Basel II capital adequacy for regulating banks. To begin with, ANC ratio is simple to calculate and easy to understand. On the contrary, though the numerator of Basel II capital adequacy ratio is also easy to calculate, the denominator which includes market risk, crdeit risk, and operational risk, is relatively difficult to calculate.

Comparing banks and FCMs in Taiwan, the credit risk component of denominator plays an important role for the banks because the loans to customers form the majority of the banks' business. However, the credit risk is less important for the futures industry since regulators request pre-margin for those who trade futures and options in Taiwan, and thus lower the counterparty credit risk for FCMs. Therefore, the difficulty in calculation of Basel II capital adequacy ratio makes it less applicable for the futures industry, and this study attempts to introduce VaR to enhance the predictivity of the early warning system for FCMs, and it is also suitable the futures industry. Cuoco and Liu (2006) find that financial institutions that use VaR-based capital requirement to calculate the Basel II capital adequacy ratio for internal control is effective, and it not only controls portfolio risk but also effects on risk disclosure. Hendricks (1996) estimates VaR by applying the three methods: Equally Weighted Moving Average Approach (EWMAA), Exponentially Weighted Moving Average (EWMA), and Historical Simulation (HS). Among the three methods, he basically supports the validity of VaR. However, Berkowitz and O'brien (2002) conclude that the VaR forecasts do not outperform forecasts based simply on an ARMA + GARCH model of the banks' P&L. In addition, Alexander and Baptista (2006) conclude that using the VaR model to determine the the minimum capital of a bank may increase the bank's fragility.

To sum up, most studies focus on examining the influences of capital requirements on financial institutions, such as risk-taking attitude, risk reporting behavior, investing activities and the likelihood of bank failure. Dissimilar with past studies, this study investigates whether the monitoring mechanism of captial adequacy for FCMs could be more effective by incorporating VaR into the existing ANC ratio, and contributes on

the predictivity and vadility of VaR for the capital adequancy of futures industry in Taiwan. Moreover, literature is not fully consistent in usefulness of VaR. Thus, this study contributes on verification of predictivity and vadility of VaR for capital adequancy in the futures industry in Taiwan by conducting VaR into calculation of ANC, and the conclusion is referrable to other futures industries in the world.

III. Methodology

A. VaR Calculation for Options

Because the most positions for FCMs in Taiwan are TAIEX[4] futures (TX) and TAIEX options (TXO)[5] , the main risk that FCMs face is market risk. In this study, following Jorion (1997), we use the delta-normal approximation to calculate the nonlinear VaR of option positions for FCMs. If an underlying asset return (dS/S) follows a normal distribution with zero mean (assumption when time horizon is short) and standard deviation σ, then the VaR at the 99% confidence level can be expressed in dollar losses as

$$\mathrm{VaR}(dS) = \alpha S\sigma \tag{1}$$

where: S and dS denotes asset price and price difference, and α = 2.323 for 99% confidence level under standard normal distribution. If an option depends on only one risk $C = C(S)$, i.e. the price of underlying asset, the delta-gamma method can be used to approximate the nonlinear VaR of an option and is given in dollar losses as

$$\mathrm{VaR}(dC) = |\Delta|\,\mathrm{VaR}(dS) - \frac{1}{2}\Gamma\mathrm{VaR}(dS)^2 \tag{2}$$

where: Δ and Γ denote delta and gamma risk of $C = C(S)$ and can be calculated as $\Delta = \left.\frac{\partial C}{\partial S}\right|_{S=S_0}$ and $\Gamma = \left.\frac{\partial^2 C}{\partial S^2}\right|_{S=S_0}$. Long option positions have positive gamma and, hence, slightly lower risk than using a linear model. Conversely, negative gamma translate into quadratic VaRs that exceed linear VaRs. Given the B-S option pricing formula as $C = Se^{-t}N(d_1) - Ke^{-t}N(d_2)$, Δ and Γ can be obtained as

[4] *TAIEX is similar to the Standard & Poor's 500 (S&P 500), a stock index weighted by the number of outstanding shares. TAIEX is the most widely quoted of all Taiwan Stock Exchange (TWSE) indices. The base year value as of 1966 is set at 100. TAIEX is adjusted in the event of new listing, de-listing and new shares offering to offset the influence on TAIEX owing to non-trading activities. TAIEX covers all of the listed stocks excluding preferred stocks, full-delivery stocks and newly listed stocks, which are listed for less than one calendar month.*

[5] *TAIEX Futures (TX) is the most active futures contract on Taiwan Futures Exchange (TAIFEX). TX is a stock index future whose underlying asset is TAIEX. In 2009, the trading volume of TX is 24,625,062 contracts. Institutional investors are responsible for 29.38% of TX trading volume. On the options markets, TAIEX options (TXO) is even more liquid. In 2009, TXO's trading volume reaches 72,082,548 contracts, ranked 17 on the equity index futures and options worldwide.*

$$\Delta = \frac{\partial C}{\partial S} = \mathrm{N}(\mathrm{d}_1) \tag{3}$$

and

$$\Gamma = \frac{\partial^2 \mathrm{C}}{\partial \mathrm{S}^2} = N^{'}(d_1) \times \frac{\partial d_1}{\partial S} \tag{4}$$

where: $\mathrm{N}(\mathrm{d}_1) = \int_{-\infty}^{\mathrm{d}_1} \Phi(x)dx = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{d_1} e^{-\frac{1}{2}x^2} dx$ and $\mathrm{d}_1 = \frac{ln(Se^{-t} / Ke^{-t})}{\sigma\sqrt{\tau - t}} + \frac{\sigma\sqrt{\tau - t}}{2}$ and $d_2 = d_1 - \sigma\sqrt{\tau - t}$. Note that, following Basel II capital adequacy, the VaR is calculated for 20 trading-day (1 month) at 1% significance.

B. GJR-GARCH Model for Time-varying Volatility

With regard to obtaining time-varying volatility, GARCH(1,1) model is widely adopted to capture the volatility clustering effect among finance literature. In order to capture leverage effect, the GJR model (Glosten, Jagannathan, and Runkle, 1993) is selected in this study to estimate time-varying volatility for the return of Taiwan stock index. The specifications of conditional mean and variance equation for the GJR model can be formulated as

$$\mathrm{r}_t = \mu + \varepsilon_t, \ \ \varepsilon_t = \sigma_t \mathrm{z}_t, \ \ \mathrm{z}_t \mid \Omega_{t-1} \overset{\text{iid}}{\sim} \mathrm{N}(0,1) \tag{5}$$

$$\sigma_t^2 = \omega + (\alpha + \gamma \ \mathrm{I}_{\{\varepsilon_{t-1}<0\}})\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{6}$$

where: r_t represents the compounded daily return, and is computed by $\mathrm{r}_t = \log(\mathrm{S}_t / \mathrm{S}_{t-1}) \times 100$, in which pt and pt-1 denote price at time t and t-1 respectively. ε_t denotes the innovation process, while N(0,1) is a standard normal distribution. Ω_{t-1} denotes the information set up to time t-1, i.e. $\Omega_{t-1} = \{\mathrm{r}_{t-1}, \mathrm{r}_{t-2}, \cdots, \mathrm{r}_1\}$. When γ takes a positive (negative) value, it is clear that from GJR-GARCH model that a negative ε_{t-1} value has a larger (smaller) impact on σ_t^2.

C. Method for Comparing Predictive Ability

We test the ANC and VaR-based ANC by paired samples. That is, for each FCM in the sample period, first we calculate its ANC and VaR-based ANC, and then we rank FCMs' ANC ratios and VaR-based ANC ratios for each trading day. We have the ranking difference:

$$\overline{D}_{\mathrm{a,t}} = (\overline{X}_{1,a,t} - \overline{X}_{2.a.t}) \tag{7}$$

where: $\overline{X}_{1,a,t}$ is the ranking of ANC ratio for FCM a on day t, and $\overline{X}_{2,a,t}$ is the ranking of VaR-based ANC ratio for FCM a on day t. Thus, the t- statistic is:

$$t = \frac{\overline{D}_{\mathrm{a,t}} - \mu_{D_{a,t}}}{S_{\overline{D}_{a,t}}} \tag{8}$$

where: $S_{\bar{D}} = \frac{S_D}{\sqrt{n}}$, $S_D = \sqrt{\frac{\sum D_{a,t}{}^2 - (\sum D_{a,t})^2 / n}{n-1}}$

IV. Data

We obtain the data, which covers from July 2006 through December 2007, totally 375 trading days from the TAIFEX. We select the sample period because the TAIFEX requests all FCMs to submit their ANC data since. The sample period contains 33 FCMs. First, we calculate ANC ratios and VaR-based ANC ratios for each FCM on each trading day.

ANC ratio=Adjusted Net Capital/Margins Required for the Unsettled Positions (9)

VaR-based ANC ratio=(Adjusted Net Capital-VaR)/Margins Required for the Unsettled Positions (10)

Adjusted Net Capital=Adjusted Net Assets-Liabilities (11)

$$\text{Adjust Net Assets}=\sum_{i=1}^{n} \text{Asset}_i \times (1-\text{haircut}_i)^{6} \quad (12)$$

The denominator of ANC ratio represents of the risk an FCM involved. The higher the denominator, the riskier the FCM. The numerator of ANC reflects the risk an FCM invested. Note that the formula of the ANC ratio does not really include market risk because haircuts are fixed. Therefore, we modify (9) by substract VaR, which is the measure of market risk to (10).

In order to verify the validity of VaR, we select the days if FCMs' ANC ratios are below 15%, 20%, 25%, 30%, and 40% as basis days because the current rules in Taiwan restrict FCMs to submit new orders on the market, no matter for their clients or themselves. We compute the mean of the ANC and VaR-based ANC rankings of the FCM for the previous 20 trading days (1 month) and 40 trading days (2months), and then test whether there is significant difference between ranking of ANC and ranking of VaR-based ANC. Note that there may be overlaps for the violations. For example, there may be violation for 40% before the violation for 20% occurs. We omit the overlaps and keep the 20% violation as the basis day.

V. Empirical Results

Table 1 shows the basic statistics of ANC and VaR-based ANC for the 33 FCMs during the sample period. The mean of ANC ratio is higher than 20% for each FCM during the sample period. Among the FCMs, F034 has the most volatile ANC ratio,

[6] *The haircut (discount factor) of asset i, which is a fixed number, depending on the kind of the asset. For example, it is 0.2% for the bonds issued by the Taiwan government, 15% for the stocks listed on the Taiwan Stock Exchange (TWSE), and 60% for the long positions of options listed on the TAIFEX. Note that the haircut for the long positions of options listed on the TAIFEX is higher than that of government bonds and stocks since options are riskier.*

whos standard deviation is 12690.89%, followed by S970's 4249.26%, S700's 4111.78%, S753's 2122.36%, S844's 2027.04% and S616's 1394.47%. With regard to VaR-based ANC ratio, the standard deviations of the FCMs shows similarity to ANC ratio. Standard deviation of the former six large FCMs are F034, S970, S700, S753, S844, and S616.

Table 1

Basic Statistics of ANC Ratio and VaR-based ANC Ratio

Fcm No.	Anc ratio					Var-based anc ratio				
	Mean	Standard Deviation	Max	Min	Range	Mean	Standard Deviation	Max	Min	Range
F001	388.79%	135.01%	1051.1%	171.2%	879.9%	271.67%	158.54%	1012.9%	36.9%	976%
F002	69.62%	16.43%	113.6%	32.8%	80.8%	6.18%	26.07%	84%	-56%	140%
F004	67.1%	26.35%	197.1%	22.8%	174.3%	-12.18%	41.16%	124.7%	-182.1%	306.80%
F005	281.49%	117.1%	1559.2%	114.6%	1444.6%	253.45%	111.91%	1501%	88.6%	1412.40%
F006	143.53%	43.08%	336.3%	65%	271.3%	84.95%	49.57%	274.7%	-20.1%	294.80%
F007	99.417%	36.35%	214%	20.6%	193.4%	34.21%	33.51%	141%	-52.9%	193.90%
F008	100.22%	30.11%	233.6%	43.9%	189.7%	70.27%	31.61%	180.2%	5.5%	174.70%
F013	66.56%	30.88%	259.2%	15.1%	244.1%	49.69%	27.45%	233.2%	6.6%	226.60%
F014	233.71%	108.84%	750.8%	92.6%	658.2%	190.37%	95.98%	670.3%	55%	615.30%
F018	115.76%	29.53%	226.4%	54.1%	172.3%	68.78%	30.16%	179%	-1.4%	180.40%
F020	66.55%	19.31%	139.4%	28%	111.4%	-0.83%	41.64%	73.2%	-180.4%	253.60%
F021	74.2%	27.16%	162.1%	17.9%	144.2%	16.96%	33.44%	86.7%	-133.4%	220.10%
F023	98.11%	34.7%	183.7%	23.8%	159.9%	37.25%	33.04%	133.2%	-35.6%	168.80%
F026	127.52%	36.59%	256.6%	64.5%	192.1%	82.63%	36.21%	218.9%	15.8%	203.10%
F029	124.16%	39.81%	263.9%	49.8%	214.1%	97.57%	35.92%	224.4%	31.9%	192.50%
F030	331.49%	113.98%	1128.7%	107.3%	1021.4%	271.54%	105.57%	850.6%	79.4%	771.20%
F034	2324.44%	12690.89%	187983%	20%	187963%	1406.58%	10859.38%	170912.8%	-7907%	178819.80%
S109	1119.43%	867.68%	8256.7%	196%	8060.7%	1076.79%	856.14%	8198.1%	143.6%	8054.50%
S116	885.93%	649.83%	5005.5%	194.4%	4811.1%	860.45%	640.5%	4804.5%	182.7%	4621.80%
S152	266.87%	109.05%	610%	63.8%	546.2%	200.78%	120.68%	554.1%	-17.9%	572.00%
S518	1056.15%	321.06%	2585.4%	407.5%	2177.9%	1005.73%	323.28%	2512.9%	347%	2165.90%
S526	2158.99%	432.16%	3316.8%	1056.7%	2260.1%	2084.14%	436.51%	3261.2%	1010%	2251.20%
S572	228.56%	132.24%	1056.4%	0.3%	1056.1%	156.04%	151.49%	1022.9%	-94%	1116.90%
S582	342.34%	358.76%	2446.6%	23.5%	2423.1%	273.54%	378.13%	2442%	-200.6%	2642.60%
S585	522.46%	421.13%	2989.5%	52.2%	2937.3%	436.59%	450.47%	2969.6%	-192.7%	3162.30%
S616	1203.36%	1394.47%	6821.7%	137.4%	6684.3%	1108.85%	1434.27%	6788.1%	-92.5%	6880.60%
S653	944%	573.06%	4051.9%	228.7%	3823.2%	879.63%	557.97%	3992.8%	125.7%	3867.10%
S700	2539.46%	4111.78%	34256.3%	142.3%	34114%	2525.58%	4115.56%	34256.3%	124.1%	34132.20%
S703	3343.88%	907.51%	5739.9%	1266.7%	4473.2%	3277.43%	912.88%	5692.4%	1207%	4485.40%
S753	1711.04%	2122.36%	39904.6%	626.9%	39277.7%	1627.25%	2125.74%	39903.2%	580.6%	39322.60%
S844	635.454%	2027.04%	39480.2%	81%	39399.2%	524.55%	1825.83%	35471.9%	-7.3%	35479.20%
S889	369.05%	217.66%	1737.9%	33.6%	1704.3%	239.74%	162.37%	909.3%	-211.1%	1120.40%
S970	1017.78%	4249.26%	47527.3%	21.2%	47506.1%	861.14%	4039.22%	46477.4%	-261%	46738.40%

Table 2

Ranking of FCMs by ANC Ratio and VaR-based ANC Ratio

FCM No.	ANC ratio				VaR-based ANC ratio			
	Median	Max	Min	Max-Min	Median	Max	Min	Max-Min
F001	13	21	6	15	14	24	7	17
F002	30	33	25	8	30	33	24	9
F004	32	33	21	12	31	33	20	13
F005	15	26	4	22	14	22	4	18
F006	21	28	14	14	22	33	14	19
F007	27	33	17	16	28	32	17	15
F008	26	33	17	16	23	30	13	17
F013	31	33	22	11	25	33	16	17
F014	17	24	9	15	16	23	8	15
F018	24	29	19	10	23	31	17	14
F020	31	33	22	11	30	33	23	10
F021	30	33	23	10	29	33	22	11
F023	27	33	17	16	26	32	19	13
F026	23	32	14	18	21	30	15	15
F029	23	29	16	13	20	27	14	13
F030	13	22	5	17	13	22	7	15
F034	22	33	1	32	33	33	1	32
S109	7	16	2	14	6	15	2	13
S116	8	17	1	16	7	16	1	15
S152	16	27	7	20	16	30	8	22
S518	6	11	3	8	6	11	3	8
S526	3	9	1	8	3	9	1	8
S572	18	33	8	25	18	33	8	25
S582	17	32	3	29	17	33	3	30
S585	11	26	2	24	11	33	2	31
S616	13	23	1	22	13	33	1	32
S653	7	16	3	13	7	14	2	12
S700	6	16	1	15	6	14	1	13
S703	1	9	1	8	1	8	1	7
S753	4	11	1	10	5	10	1	9
S844	10	22	1	21	10	29	1	28
S889	13	32	7	25	14	33	8	25
S970	18	32	1	31	18	33	1	32

Table 2 shows that during the sample period, the top six ranking of ANC for FCMs in full ranking range order are F034, S970, S582, S572, S889, S585. The rankings are slightly different with the rsnking in full range order of ANC ratio's standard deviation: F034, S970, S700, S753, S844, and S616. Regardless of the ANC ratio of range or ranking range, we find that F034 and S970 are the two most volatile FCMs, measured by standard deviation and range. In Table 3, we examine the violation frequencies for FCMs.

Table 3

Violation Frequencies for FCMs

FCM No.	30%≦ANC<40%	25%≦ANC<30%	20%≦ANC<25%	10%≦ANC<20%	ANC<15%
F001	0	0	0	0	0
F002	4	0	0	0	0
F004	44	4	1	0	0
F005	0	0	0	0	0
F006	0	0	0	0	0
F007	10	2	2	0	0
F008	0	0	0	0	0
F013	53	2	1	1	0
F014	0	0	0	0	0
F018	0	0	0	0	0
F020	24	11	0	0	0
F021	8	2	2	4	0
F023	7	0	1	0	0
F026	0	0	0	0	0
F029	0	0	0	0	0
F030	0	0	0	0	0
F034	7	4	2	0	0
S109	0	0	0	0	0
S116	0	0	0	0	0
S152	0	0	0	0	0
S518	0	0	0	0	0
S526	0	0	0	0	0
S572	2	0	0	0	1
S582	0	0	1	0	0
S585	0	0	0	0	0
S616	0	0	0	0	0
S653	0	0	0	0	0
S700	0	0	0	0	0
S703	0	0	0	0	0
S753	0	0	0	0	0
S844	0	0	0	0	0
S889	3	0	0	0	0
S970	1	2	1	0	0

Table 3 shows that there are 12 FCMs whose ANC ratio ever falling behind 40%. Thus, we pick out the event days and test the ranking on ANC ratio and VaR-based ANC for the previous 20 and 40 trading days. Excluding the overlap of event days, the events which ANC ratios are between 35% and 40% happen to 10 FCMs (F002, F004, F007, F013, F020, F021, F023, F034, S889, and S970) ; the events which ANC ratios are between 30% and 25% happen to 6 FCMs (F004, F013, F020, F021, F034, and S970); the events which ANC ratios are between 25% and 20% happen to 6 FCMs (F004, F007, F023, F034, S582, and S970); the events which ANC ratios are between

20% and 15% happen to 2FCMs (F013 and F021); the events which ANC ratios are behind 15% happen to S572 only.

Panel A of Table 4 shows the average rank difference between ANC ratio and VaR-based ANC ratio in previous 20 trading days of event days, which include violation of 40%, 35%, 30%, 25%, 20%, and 15%. For those event days that violations lie between 40% and 30%, there are 4 FCMs (F020, F023, F034, and S970) that ranking in VaR-based ANC ratios are larger than ANC ratio at 5% significance. Furthermore, for those event days that violations lie between 30% and 25%, there are 3 FCMs (F020, F034, and S970) that ranking in VaR-based ANC ratios are larger than ANC ratio at the 5% significance level. For those event days that violations lie between 25% and 20%, there are 4 FCMs (F004, F034, S582, and S970) that ranking in VaR-based ANC ratios are larger than ANC ratio at 5% significance. For those event days that violations lie between 20% and 15%, there is no FCM that ranking in VaR-based ANC ratio is larger than ANC ratio at the 5% significance level. Finally, violation of 15% only occurs to S572, and ranking in VaR-based ANC ratio is larger than ANC ratio at 1% significance. We further divide FCMs into 2 groups. Group A is those FCMs (F020, F023, F034, S970, and S572) that ranking in VaR-based ANC ratios are larger than ANC ratio at 5% significance, and Group B is those FCMs (F002, F013, F021, and S889) that ranking in VaR-based ANC ratios are smaller than ANC ratio at the 5% significance level. We find that during the sample period, the mean of ANC ratio of Group A is 622.38%, while the mean of ANC ratio of Group B is 52.60%. This indicates that the inclusion of VaR in ANC improves the warning ability for those FCMs with higher capital adequacy ratio. However, the effect of the inclusion are limited for those FCMs that long-term capital adequacy ratios are at low level.

Panel B of Table 4 shows the average rank difference between ANC ratio and VaR-based ANC ratio in previous 40 trading days of event days, which include violation of 40%, 35%, 30%, 25%, 20%, and 15%. For those event days that violations lie between 40% and 30%, there are 3 FCMs (F023, F034, and S970) that ranking in VaR-based ANC ratios are larger than ANC ratio at the 5% significance level. In addition, for those event days that violations lie between 30% and 25%, there are 2 FCMs (F034 and S970) that ranking in VaR-based ANC ratios are larger than ANC ratio at 5% significance. For those event days that violations lie between 25% and 20%, there are 3 FCMs (F034, S582, and S970) that ranking in VaR-based ANC ratios are larger than ANC ratio at the 5% significance level. For those event days that violations lie between 20% and 15%, there is no FCM that ranking in VaR-based ANC ratio is larger than ANC ratio at 5% significance. Finally, violation of 15% only occurs to S572, and ranking in VaR-based ANC ratio is larger than ANC ratio at 1% significance. Like Panel A, we divide FCMs into 2 groups. Group A is those FCMs (F007, F023, F034, S970, and S572) that ranking in VaR-based ANC ratios are larger than ANC ratio at 5% significance, and Group B is those FCMs (F004, F013, and F021) that ranking in VaR-based ANC ratios are smaller than ANC ratio at the 5% significance level. We find that during the sample period, the mean of ANC ratio of Group A is 840.66%, while the mean of ANC ratio of Group B is 69.29%. This also indicates that the inclusion of VaR in ANC improves the warning ability for those FCMs with higher capital adequacy ratio. However, the effect of the inclusion seems to be limited for those FCMs that long-term capital adequacy ratios are at low level.

Table 4

Average Ranking Difference between ANC and VaR-based ANC in Previous 20 and 40 Trading Days of Event Days

FCM No.	ANC Ranking	VaR-based ANC Ranking	T value	P value
Panel A Previous 20 trading days				
30%≦ANC<40%				
F002	29.05	27.85	2.6623	0.0077
F004	32.30	31.90	1.9024	0.0362
F007	27.30	27.80	-0.8649	0.1989
F013	30.60	24.95	10.7716	0.0000
F020	29.85	30.40	-1.6754	0.0551
F021	31.40	28.95	6.9701	0.0000
F023	23.15	23.85	-1.703	0.0524
F034	25.15	33.00	-11.6494	0.0000
S889	16.75	14.50	5.3287	0.0000
S970	18.20	26.35	-4.7934	0.0000
25%≦ANC<30%				
F004	32.45	30.55	7.0246	0.0000
F013	31.00	24.80	12.0142	0.0000
F020	26.45	28.95	-4.4304	0.0001
F021	31.65	29.80	4.0690	0.0003
F034	30.05	31.30	-2.4157	0.0130
S970	18.85	27.15	-5.0022	0.0000
20%≦ANC<25%				
F004	31.60	32.20	-1.6096	0.0620
F007	28.60	28.20	0.7766	0.2235
F023	23.95	24.00	-0.0934	0.4633
F034	29.20	31.75	-3.7582	0.0007
S582	20.35	24.35	-3.7173	0.0007
S970	20.15	28.8	-5.5697	0.0000
15%≦ANC<20%				
F013	32.35	26.15	17.5919	0.0000
F021	31.90	30.05	4.0690	0.0003
ANC<15%				
S572	16.50	21.20	-3.9203	0.0005
Panel B Previous 40 trading days				
30%≦ANC<40%				
F002	29.250	28.850	0.8163	0.2072
F004	31.950	31.600	1.6826	0.0462
F007	24.375	25.500	-1.4916	0.0679
F013	30.600	24.950	10.7716	0.0000
F020	30.200	30.200	0.0000	0.5000

FCM No.	ANC Ranking	VaR-based ANC Ranking	T value	P value
F021	31.500	28.925	9.5771	0.0000
F023	23.825	25.000	-2.2438	0.0124
F034	24.600	32.875	-15.0762	0.0000
S889	14.600	13.375	1.2138	0.1124
S970	17.275	20.850	-2.8055	0.0025
25%≦ANC<30%				
F004	32.650	31.275	6.3530	0.0000
F013	30.975	24.525	17.6239	0.0000
F020	28.250	28.425	-0.2877	0.3868
F021	31.850	29.525	6.2910	0.0000
F034	28.600	31.775	-4.6395	0.0000
S970	17.775	21.425	-2.7598	0.0029
20%≦ANC<25%				
F004	29.675	28.925	1.0637	0.1437
F007	26.300	26.975	-0.9291	0.1764
F023	24.100	24.850	-1.3455	0.0892
F034	28.350	32.250	-5.1850	0.0000
S582	19.650	25.725	-3.8318	0.0000
S970	18.750	22.525	-2.7036	0.0034
15%≦ANC<20%				
F013	32.200	26.700	17.6899	0.0000
F021	31.925	29.675	5.9976	0.0000
ANC<15%				
S572	17.250	21.225	-5.3772	0.0000

Table 5 shows the percentages of trading days when FCMs' ANC ratios are less than 40% during the sample period. For those FCMs (F004, F013, and F021) that ANC ranking is significantly (at the 5% significance level) larger than VaR-based ANC ranking both in previous 20 and 40 trading days, their percentages are obviously higher (F004: 13.07%, F013: 15.20%, and F021: 4.27%). However, for those FCMs (F023, F034, and S970) that VaR-based ANC ranking is significantly (at the 5% significance level) larger than ANC ranking both in previous 20 and 40 trading days, their percentages are obviously lower (F023: 2.13%, F034: 3.47%, and S970: 1.07%). The result demonstrates that the inclusion of VaR into ANC does help in the early warning ability for those FCMs with less capital adequacy.

In conclusion, we find that VaR-based ANC is most effective in early warning for those FCMs violate the ANC ratio between 30% and 40%. For those FCMs violate 15% and 20%, however, VaR-based ANC does not show good ability. We find that it may be due to the long-term low capital adequacy. From the perspective of financial supervision, the authority should request those FCMs that are low in capital adequacy for long-term to raise their capital adequacy.

Table 5

Percentage of Trading Days when ANC Ratio<40%

FCM	30%≦ANC<40%	25%≦ANC<30%	20%≦ANC<25%	15%≦ANC<20%	ANC<15%	30%≦ANC<40%	25%≦ANC<30%	20%≦ANC<25%	15%≦ANC<20%	ANC<15%	Freq. of ANC<40%	% of ANC<40% in trading days
	20 trading days					40 trading days						
F002	ANC>VaR-based ANC***					ANC=VaR-based ANC		ANC=VaR-based ANC			4	1.07%
F004	ANC>VaR-based ANC**	ANC>VaR-based ANC**	ANC<VaR-based ANC*			ANC>VaR-based ANC**	ANC>VaR-based ANC***				49	13.07%
F007	ANC=VaR-based ANC		ANC=VaR-based ANC			ANC<VaR-based ANC*		ANC=VaR-based ANC			14	3.73%
F013	ANC>VaR-based ANC**	ANC>VaR-based ANC**		ANC>VaR-based ANC***		ANC>VaR-based ANC***	ANC>VaR-based ANC***		ANC>VaR-based ANC***		57	15.20%
F020	ANC<VaR-based ANC*	ANC<VaR-based ANC***				ANC=VaR-based ANC	ANC=VaR-based ANC				35	9.33%
F021	ANC>VaR-based ANC***	ANC>VaR-based ANC***		ANC>VaR-based ANC***		ANC>VaR-based ANC**	ANC>VaR-based ANC***		ANC>VaR-based ANC***		16	4.27%
F023	ANC<VaR-based ANC*		ANC=VaR-based ANC			ANC<VaR-based ANC***		ANC<VaR-based ANC*			8	2.13%
F034	ANC<VaR-based ANC***	ANC<VaR-based ANC**	ANC<VaR-based ANC***			ANC<VaR-based ANC***	ANC<VaR-based ANC***	ANC<VaR-based ANC***			13	3.47%
S552					ANC<VaR-based ANC***						3	0.80%
S572										ANC<VaR-based ANC***	3	0.80%

FCM	30%≦ANC<40%	25%≦ANC<30%	20%≦ANC<25%	15%≦ANC<20%	ANC<15%	30%≦ANC<40%	25%≦ANC<30%	20%≦ANC<25%	15%≦ANC<20%	ANC<15%	Freq. of ANC<40%	% of ANC<40% in trading days
	20 trading days					40 trading days						
S582			ANC<VaR-based ANC***					ANC<VaR-based ANC***			1	0.27%
S889	ANC>VaR-based ANC***					ANC=VaR-based ANC					3	0.80%
S970	ANC<VaR-based ANC***	ANC<VaR-based ANC***	ANC<VaR-based ANC***			ANC<VaR-based ANC***	ANC<VaR-based ANC***	ANC<VaR-based ANC***			4	1.07%

*Note: ANC<VaR-based ANC ***: ANC ranking is lower than VaR-based ANC ranking at the 1% significance level; ANC<VaR-based ANC **: ANC ranking is lower than VaR-based ANC ranking at the 5% significance level; ANC<VaR-based ANC*: ANC ranking is lower than VaR-based ANC ranking at the 10% significance level; ANC>VaR-based ANC ***: ANC ranking is larger than VaR-based ANC ranking at the 1% significance level; ANC>VaR-based ANC **: ANC ranking is larger than VaR-based ANC ranking at the 5% significance level; ANC>VaR-based ANC*: ANC ranking is larger than VaR-based ANC ranking at the 10% significance level; ANC=VaR-based ANC the difference between ANC ranking and VaR-based ANC ranking is not different at the 10% significance level.*

Thus, the inclusion of VaR into ANC ratio is undoubtedly effective in early warning for those FCMs normal in capital adequacy. In addition, VaR-based ANC ratio is more effective in early warning for those FCMs with fewer violations. We conjecture that those FCMs with more violations use a lower capital to maintain their business operations, which leads lower ANC ratio and thus more violation.

VI. Conclusions

Financial authorities are monitoring the financial industries by their own capital to ensure that financial industries have sufficient equity capital to absorb a variety of financial business risks. The current method applied for regulating the capital adequacies of FCMs in Taiwan is ANC ratio, which is also applied in the U.S. In this study, we add the VaR estimated by GJR-GARCH model and the delta-gamma approach to the calculation of ANC (VaR-based ANC), to compare it with ANC, and further to investigate the ability of prediction on VaR.

We find that VaR-based ANC ratio in certain intervals ratio have better warning ability of prediction than ANC. In addition, the warning effects of inclusion of VaR into ANC ratio is even more significant for the FCMs whose capital adequacies are more volatile and the FCMs with higher capital adequacies.

Moreover, we find that VaR-based ANC is most effective in early warning for those FCMs violate the ANC ratio between 30% and 40%. However, those FCMs violating 15% and 20%, VaR-based ANC shows less predictive power. It may be due to the long-term low capital adequacy. Thus, regulators should request those FCMs in low capital adequacy for long-term to raise their capital adequacy. Therefore, the inclusion of VaR into ANC ratio is undoubtedly effective in early warning for those FCMs normal in capital adequacy. Finally, we find that VaR-based ANC ratio is more effective in early warning for those FCMs with fewer violations. The reason may be that those FCMs with more violations use a lower capital to maintain their business operations, which leads lower ANC ratio and thus more violation.

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References

Alexander, G.J. and Baptista, A.M., 2006. Does the Basel Capital Accord Reduce Bank Fragility? An Assessment of the Value-at-Risk Approach. *Journal of Monetary Economics* ,53: 1631–1660.

Berkowitz, J. and O'brien, J., 2002. How Accurate Are Value-at-Risk Models at Commercial Banks?. *Journal of Finance*, 57, pp. 1093-1111.

Blum, J., 1999. Do Capital Adequacy Requirements Reduce Risks in Banking? . *Journal of Banking and Finance*, 23, pp. 755-771.

Brooks, C., Clare, A.D., and Persand, G., 2000. A Word of Caution on Calculating Market-based Minimum Capital Risk Requirements. *Journal of Banking and Finance*, 24, pp. 1557-1574.

Cuoco, D. and Liu, H., 2006. An Analysis of VaR-based Capital Requirements. *Journal of Financial Intermediation*, 15, pp. 362–394.

El-Jahel, L., Perraudin, W. And Sellin, P., 1999). "Value at Risk for Derivatives. *Journal of Derivatives*, 6, pp. 73-89.

Glosten, L., Jagannathan, R. and Runkle, D., 1993. On the Relation Between the Expected Value and the Volatility on the Nominal Excess Returns on Stocks. *Journal of Finance*, 48, pp. 1779-1801.

Hendricks, D., 1996. Evaluation of Value-at-Risk Models Using Historical Data. *Economic Policy Review*, Apr, pp. 39-69.

Johnston, M., 2009. Extending the Basel II Approach to Estimate Capital Requirements for Equity Investments. *Journal of Banking and Finance*, 33, pp. 1177-1185.

Hull., J.C., 2007. *Risk Management and Financial Institutions*, Pearson Education.

J.P. Morgan (1996. *RiskMetrics Technical Document*, 4th edition, Morgan Guaranty Trust Company.

Jorion, P., 1997. *Value at Risk: The New Benchmark for Controlling Market Risk*, McGraw-Hill.

Jorion, P., 2007. *Financial Risk Manager Handbook*, 4th edition, John Wiley.

Rime, B., 2001. Capital Requirements and Bank Behaviour Empirical Evidence for Switzerland. *Journal of Banking and Finance*, 25, pp. 789-805.

Zakoian, J.M., 1994. Threshold Heteroskedastic Model. *Journal of Economic Dynamics and Control*, 18, pp. 931-955.