Financial risk and capital adequacy: The moral hazard problem

Received (in revised form): 14th October, 2008

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Abstract This paper estimates the values at risk for marketable assets in order to examine the propriety of the risk weights set by the Basel Accord and compare the capital charges between the standardised and the internal model approaches using the actual positions of institutions. The paper finds that the risk weights exhibit a risk-encouraging concave function of financial risk, and tend to favour risky assets over riskless assets. Such 'supervisory discrimination' in terms of risk weights gives rise to a moral hazard problem in that the regulator fails to reduce the risk-taking incentives of institutions. The internal model approach does not necessarily provide the capital savings to encourage institutions to develop internal models. As capital savings will occur only in the case of low-risk institutions, high-risk institutions, which need to introduce an internal model to improve their risk management, will choose the standardised method as their tool for calculating capital requirements.

Keywords: *VaR, risk weight, standardised approach, internal model approach, supervisory discrimination*

INTRODUCTION

The core idea behind risk-based capital regulation (RBCR) is to relate banks' capital requirements to the financial risk associated with their assets. Only if the regulatory capital can properly reflect the financial risk of the bank can the RBCR reduce the bank's insolvency risk to an acceptable level and achieve the regulatory goal. The discrepancies between the true financial risk of assets and the regulatory measures of risk embodied within the capital requirements are brought into regulatory capital arbitrage (RCA). As Merton (1995) suggests, the basic insight behind RCA follows from the observation that capital standards are not based on any consistent standard of economic soundness.[1] Unless these economic and regulatory measures of risk are brought into closer alignment, the underlying factors driving RCA are likely to remain unabated and this will lower the effectiveness of the RBCR.[2] Thus, seeking ways to more closely align the regulatory measures of risk with a bank's true financial risks becomes the supervisor's most important task.

To strengthen the soundness and stability of the international banking system, the Bank for International

Settlements (BIS) initially developed a common measure of solvency, the 8 per cent risk-based capital ratio that only provides coverage in relation to credit risk. The 1996 amendment, however, required banks to measure and hold capital to cover their exposure to market risk in their trading books. Moreover, the banks were permitted to choose between the internal value-at-risk (VaR) models approach and the standardised approach to determine the required capital associated with market risk. In 2001, the BIS proposed replacing the 1988 Accord with a new capital adequacy framework, known as the Basel II Accord, which rests on three pillars. The new Accord encompasses a three-stage reform process: an external-based approach, an internal-based approach, and internal credit risk models to improve the measurement of credit risk for banks. In addition, the risk coverage is extended to operational risk. From the multi-stage reform process of the Basel Accord, one can find that the Basel Committee on Banking Supervision concentrates on the following directions for achieving the aims of the RBCR. The first is concerned with the way in which the Committee intends to extend the coverage of the different sources of risk accruing from the operating activities of the bank. The second focuses on how it attempts to refine the techniques of risk measurement. However, the supervisory work involved in risk measurement and management is tremendously difficult.

The existing regulatory capital requirements have received a great deal of criticism. One of the main criticisms is that they are only loosely linked to the financial risk associated with banks' assets.[3–6] Jones (2000) discusses the principal techniques of risk unbundling and repackaging, including securitisation and credit derivatives, which are used to undertake capital arbitrage under the current capital framework.[2] Altman and Saunders (2001) present some empirical evidence to show that the current Basel 'one-size-fits-all' approach is not sufficiently modified in the new approach.[4] The similar 'risk-shifting' incentives (ie RCA) still exist under the new plan. The current risk-based bucketing proposal lacks a sufficient degree of granularity. Altman *et al.* (2002) analyse the revised capital requirements for credit risk under the standardised approach proposed by the BIS.[7] They find that the new Accord overcharges the risk of high-quality debt relative to low-quality debt and still contains inherent risk-taking incentives for banks. However, these developments are all related to the new Accord's revised credit risk proposal. As with the market risk, there is still little empirical evidence to identify the relationship between the risk weight and the financial risk associated with each asset category when examining the propriety of the capital adequacy of the institutions. This forms the first central topic of the present paper. To the author's knowledge, this paper is the first to provide a comprehensive analysis of the actual volatility of each asset category. The study observes a concave relationship between the capital charges (risk weight) and the financial risk associated with the assets, which is an important contribution to the existing literature.

The standardised method and the internal model method are the two regulatory capital requirement alternatives attributed to the market risk of bank assets under the Basel Accord. To build up a more risk-sensitive capital

regulation and acquire a better understanding of the current regulation, a comparison and analysis of the two alternatives is required. Dangl and Lehar (2004) develop a continuous time framework to compare the effectiveness of regulations between the building block approach and the VaR-based internal model, and find that the VaR-based capital regulation creates a stronger incentive to reduce asset risk when banks are solvent.[6] As the refined method applies superior tools and can explain the riskiness of a portfolio efficiently, the concern of the present study is whether the internal model method can bring about capital saving, ie a reduction in capital charges realised by adopting the internal model instead of the standardised method, in order to encourage institutions to develop their own internal models. In general, it is believed that any reasonable internal model method can produce different amounts of capital saving depending on the diversification of the portfolios as mentioned in the popular textbooks on risk management.[3,8] However, the available evidence does not necessarily confirm the common belief (many studies conclude that credit risk capital requirements are expected to decrease when an internal-rating based approach is used[9–12]). Some evidence from emerging markets shows that the internal model method generates a larger capital charge than the standardised approach and cannot provide sufficient capital saving to encourage institutions to develop their own models.[13,14] What, then, contributes to the difference in saving or the addition in the capital charges generated by the two alternatives under the prevailing capital regulatory framework? It would appear that there is no further evidence that can provide an explanation for this unexpected finding. What is the rationale for the setting of regulatory parameters to achieve the supervisory goal? These key issues are the concern of the present study and represent an important contribution to the existing literature. Unlike most other studies, this paper uses the institutions' actual trading positions instead of their hypothetical portfolios to compare the capital charges between the standardised and the internal model approaches.

To justify and demonstrate these claims, the paper is set up as follows. The forthcoming section examines the issues related to the capital charge alternatives to the market risk of the Basel Accord. The subsequent section describes the data and methodology. The VaRs for all marketable financial assets in Taiwan are estimated and contrasted with their corresponding risk weights to examine the propriety of the risk weights set by the Basel Accord. Next, the paper investigates the portfolio diversification effects for the institutions and compares the capital charges between the standardised and the internal model approaches. The penultimate section proposes the 'theoretically correct VaR-based risk weights', which can more precisely reflect the true risk of the trading books and encourage firms to develop their own internal models. Concluding remarks are presented in the final section.

CAPITAL REQUIREMENTS FOR THE MARKET RISK ELEMENT OF THE BASEL ACCORD

Standardised approach

Capital charged using the building block method

The standardised approach employs a

'building block' methodology. The risk weight, which determines the capital charge ratio for each risk category, is first assigned by the regulator. The capital charge for each asset category can then be obtained by multiplying the market value of the position by its corresponding risk weight. Finally, the measures are summed up to obtain the global capital charge for the bank's market risk.

From the viewpoint of portfolio theory, the implicit assumption behind the building block method is that the asset returns are perfectly positively correlated. In the real world, however, the asset returns are partially correlated such that they overestimate the portfolio risk. For this reason, the approach is criticised for neglecting the diversification benefit of the portfolio. Moreover, it fails to charge appropriate capital for different instruments and leads to capital arbitrage through strategic transactions.

Rationale for risk weights

In view of the attempts by international regulators to introduce more risk-sensitive capital requirements, Kim and Santomero (1988) use a mean-variance framework to theoretically examine the effect of risk-based capital requirements on the risk-taking behaviour of banks and derive the 'optimal' risk weights based on the solvency goal.[15] The incentive for a bank to increase asset risk, however, declines as the correlation between asset risks and risk weights increases. Only if the risk weights are proportional to the systematic risks, in the sense that they are market-based, can the RBCR redress the bank's bias towards riskier assets and effectively reduce the insolvency risk to the desired level. Otherwise, there is a risk of moral hazard, as with the uniform capital ratio requirement, and the solvency goal may not be achieved.[16]

Based on the above-mentioned theoretical foundation, the rationale behind the setting of risk weights is now illustrated. To introduce the risk-sensitive capital requirements, building up the risk weight should satisfy the two conditions of 'sufficiency' and 'correctness'. 'Sufficiency' means that the capital requirement can provide sufficient capital cushion to protect against losses arising from fluctuations in the value of the bank's holdings. 'Correctness' indicates that the risk weights can reflect the financial risk accurately. This is demonstrated in what follows by showing that the risk weight should confirm the uniform supervision that proportionately aligns the regulatory capital with financial risk.

As the riskier asset should be assigned a larger risk weight underlying the RBCR, the risk weight must be an increasing function of financial risk, as measured by VaR in the present paper. The pattern of the risk weight function involves the supervisory stringency of different assets and can describe the risk attitude of the regulator towards different risk-level assets. The different supervisors' risk attitudes in relation to the risk weight function are presented in Figure 1. The concave function will encourage institutions to hold high-risk assets as it charges less capital for the riskier assets than the less risky assets per unit of risk. Meanwhile, the convex risk weight function, which requires more capital for the riskier assets than the less risky assets per unit of risk, will discourage institutions from holding high-risk assets. The linear risk-neutral case, which charges the same amount of

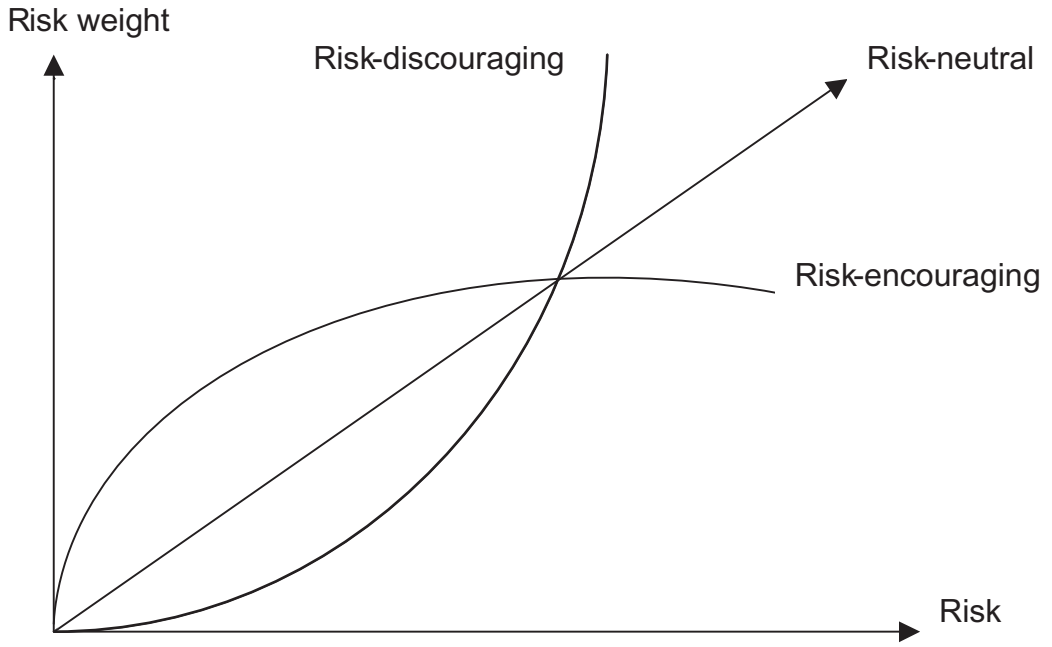

Figure 1: Alternative supervision risk attitudes towards risk weights

capital per unit of risk along the ray, imposes the same stringency of supervision on all instruments independent of the different risk levels. The nonlinear risk weight functions, which are either concave or convex, cause the stringency of supervision to be discriminatory among instruments. As suggested by Kim and Santomero[15] and Rochet,[16] only the linear risk weight function confirms the uniform supervision that could preclude the opportunity for capital arbitrage.

Graphically, the linear risk weight function can be exhibited as the iso-stringency line along which the stringency of supervision towards instruments is uniform. The slope of the iso-stringency line, defined here as the 'mark-up', can demonstrate the capital charged per unit of risk and be used to measure the 'sufficiency' of capital required. The steeper the iso-stringency line, the greater the mark-up, and the more stringent the supervisory standard. A stringent supervisory policy may overcharge capital and interfere with the earnings from operations and hence the survival of the institution, while a relaxed supervisory policy may not provide an appropriate buffer for the institution's asset risk. Figure 2 illustrates different levels of stringency for the uniform supervision of risk weights. The line with the steepest slope represents a stringent supervisory policy, where relatively more capital is charged. The 45-degree line, along which financial risk is equal to regulatory capital, presents the lower bound reference of the capital required. The moderate one should therefore be steeper than the 45-degree line, ie the mark-up is greater than 1. In such a case, the capital requirement could provide sufficient coverage for the cumulative losses arising from adverse market conditions over an extended period of time. Conversely, for the case where the iso-stringency line is flatter than the 45-

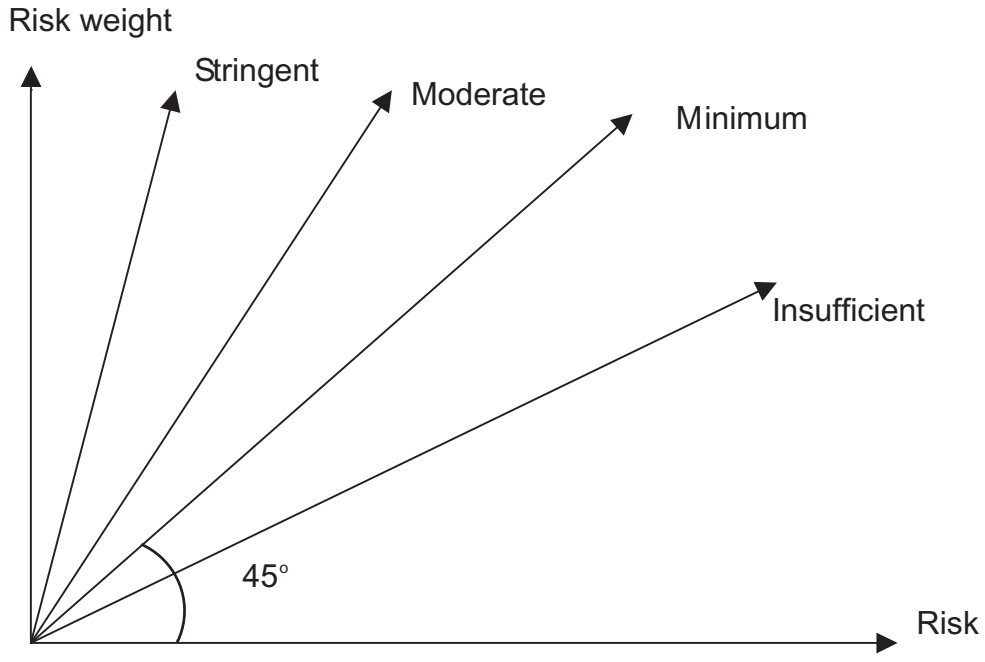

Figure 2: Alternative supervision stringency standards of risk weights

degree line, the capital requirement defined by the risk weights will be insufficient and will not be able to provide appropriate coverage for the possible losses of institutions.

As suggested by Rochet,[16] the 'market-based' risk weight should be a linear function of systematic risk. However, there still is no proxy index for the market portfolio across different risk categories, such that the estimation of β for all different kinds of financial assets is unavailable in practice. Under the VaR versus variance-covariance risk measurement framework, the individual VaR corresponds to the standard deviation of the asset return, while β corresponds to the component VaR. In other words, the individual VaR then refers to the total risk while the component VaR refers to the systematic risk. The difference between the two VaRs is the specific risk or diversifiable risk. As the main problem with the Basel Committee's proposed building block approach is that it gives no credit for diversification, to maintain the homologue between the risk weight setting and the VaR measurement, the study hereinafter employs the individual VaR but not the component VaR as the measure of risk for instruments. This measure of risk is also useful as the component VaR of a specific asset will change as the portfolio changes, while the unique component VaR of a specific asset is immeasurable.

Internal model approach

Capital charged using the VaR-based approach

The internal models use VaR as the capital requirement measure, which imposes a 99 per cent confidence level over a ten business-day horizon. The capital requirement under the internal model method corresponds to the higher of the previous day's VaR and the average for the preceding 60 business

days, multiplied by a safety factor k of at least 3 which may increase up to 4 according to the results of back-testing. Thus:

$$\text{capital charged for market risk} = \max[\text{VaR}_{-1}, k\frac{1}{60}\sum_{t=-1}^{-60} VaR_t] \quad (1)$$

Solvency parameters of the internal model approach

The length of the holding period should correspond to the time required for corrective action as losses start to develop, which reflects the trade-off between the costs of frequent monitoring and the benefits from the early detection of potential problems. The multiplicative factor is designed to account for potential additional risks in the VaR modelling process. As there are infinite combinations of the horizon and the multiplicative factor that would yield the same capital charge,[3] one can regard them together as a measure of supervisory stringency. The choice of these supervisory parameters reflects the trade-off concern of regulators between ensuring the soundness of the financial system and the adverse effect of capital requirements on bank returns. They depend on the degree of risk aversion of the supervisory authorities. Higher risk aversion should lead to a higher parameter.[3] Moreover, to achieve a more comprehensive and consistent capital requirement framework, the supervisory parameters of the internal model approach should to some extent align with the risk weights of the standardised approach, as is proposed hereafter, as they represent alternatives that determine the capital charged.

The VaR measurements

To analyse the measurement of the different risk and diversification effects, the paper defines and describes the individual VaR vs portfolio VaR, general market risk vs specific risk, as well as the diversification benefits within and across asset classes. By taking into account the diversification benefits among components, the portfolio VaR is diversified and can be expressed in dollar terms as:

$$VaR_p = Z(\alpha)\sigma_p V_p = Z(\alpha)\sqrt{\mathbf{V}'\mathbf{\Sigma}\mathbf{V}} \quad (2)$$

where $Z(\alpha)$ represents the standard normal variant at the significance level α, V_P is the initial portfolio value, σ_p is the standard deviation of the portfolio rate of return, $\mathbf{\Sigma}$ is the variance-covariance matrix, and $\boldsymbol{V}$ is the vector of initial holdings in terms of dollars.

By taking one component in isolation without any diversification benefits, one can define the individual risk of each component, ie individual VaR as:

$$VaR_i = Z(\alpha)\sigma_i|V_i| \quad (3)$$

This takes the absolute value of the holding value V_i as it can be negative (a short position), whereas the risk measure must be positive.

Lower portfolio risk can be achieved through low individual risk, a large number of assets, or more importantly, low correlation. In general, correlations are typically imperfect so that the portfolio risk (or diversified VaR) must be lower than the sum of the individual VaRs (or undiversified VaRs):

$$VaR_p < \sum_{i=1}^{n} VaR_i$$

The benefit from diversification can be measured by the difference between the

diversified VaR and undiversified VaR, which is typically represented in the VaR reporting system:

$$DB = \sum_{i=1}^{n} VaR_i - VaR_p \qquad (4)$$

From the perspective of the market model, the total risk of any security, as measured by its variance, consists of two parts: (1) general market (or systematic) risk, and (2) specific (unsystematic or unique) risk. Specific risk can be defined as risk that is due to issuer-specific price movements, after accounting for general market factors. Specific risk includes the risk associated with an individual debt or equity security moving by more or less than the general market in day-to-day trading (including periods when the whole market is volatile), and event risk (where the price of an individual debt or equity security moves precipitously relative to the general market, eg on a takeover bid or some other shock event; such events would also include the risk of default).[17]

If the scope of the portfolio is extended to all assets in the market, ie the market portfolio, then this leads to a total-risk decomposition of:

$$\sum_{i=1}^{n} VaR_i = VaR_m + DB_T \qquad (5)$$

Equation (5) indicates that the sum of the individual VaRs equals the market portfolio VaR plus the diversifiable VaR. Empirically, one then employs the market index VaR, VaR_m, as the VaR measurement for the general market, or the systematic risk, and uses the diversifiable VaR, DB_T, as the VaR measurement of the unique, unsystematic, or specific risk.

To examine the source of risk reduction from the perspective of different asset classes, one can decompose the total diversification benefits DB_T into two components: the diversification benefits within the asset class DB_w and the diversification benefits across the asset class DB_b. If one considers m asset classes and l assets for each class, the DB_T, DB_w as well as DB_b can be given by:

$$DB_T = \sum_{i=1}^{m}\sum_{j=1}^{l} VaR_{ij} - VaR_p = DB_w + DB_b \qquad (6)$$

where:

$$DB_w = \left(\sum_{i=1}^{m}\sum_{j=1}^{l} VaR_{ij} - \sum_{i=1}^{m} VaR_{ip}\right)$$

and:

$$DB_b = \sum_{i=1}^{m} VaR_{ip} - VaR_p$$

VaR_{ij} is the VaR of the jth security belonging to asset class i, and VaR_{ip} denotes the ith class VaR. DB_w refers to the intra-class diversification, ie the reduction in risk resulting from the portfolio of the same asset class, which can be measured by the difference between the sum of the individual VaRs and the sum of the asset class VaRs. DB_b refers to the inter-class diversification, ie the reduction in risk resulting from the portfolio of different asset classes, which can be measured by the difference between the sum of the asset class VaRs and the total portfolio VaR.

DATA AND METHODOLOGY

To estimate the VaRs of the daily returns for all marketable financial assets, including the equity securities, fixed-income securities, foreign exchange and

the related derivatives in Taiwan for the period from 1st January, 1999 to 30th June, 2004, the study employs three common VaR approaches: the variance-covariance approach, the historical simulation approach, and the RiskMetrics Monte-Carlo simulation approach. These VaRs are then contrasted with their corresponding risk weights to examine the propriety of the risk weights set by the Basel Accord. As per the Basel Accord guidelines, the confidence levels are set at 99 per cent and the rolling window length at one year (about 250 business days). RiskMetrics uses the standard exponential weighted moving average method to produce forecasts of variances and covariances. This assumes the mean value of daily returns to be zero. In other words, standard deviation estimates are centred on zero, rather than on the sample mean. Similarly, when computing the covariance, deviations of returns are taken around zero rather than the sample mean.[18]

The decay factor λ is set to 0.94 for the daily returns. It is very common for there to be missing or corrupted data in the market-data feeds. In the event of missing data, RiskMetrics sets the price to that of the previous day (ie the return is set as zero). Consequently, the VaR will be underestimated once the missing data become serious. To remedy this problem, the study deletes those sample observations with data missing for more than ten business days.

The sample portfolio data consist of the actual composition of 11 trading books, collected from securities firms within Taiwan, on various dates between December 2000 and June 2004. There are one or two trading books per firm, including equity securities, foreign exchange and fixed-income securities, as well as derivatives, which were provided on condition of anonymity. The individual books range in net value from NT$49,160m to NT$9,955m. The firms are free to run a bullish (long), balanced (market-neutral) or bearish (short) book, depending on market conditions and their business judgment. The ratio of long to short exposure varies from a very bullish 98:2 to a moderately bullish 65:35.

EMPIRICAL RESULTS

VaRs, risk weights and mark-ups

Table 1 summarises the average estimated results of individual VaRs for all financial assets in Taiwan and their corresponding risk weights. These VaRs are obtained via the following steps. The VaRs are first estimated day-by-day from 1st January, 2000 to 30th June, 2004 (the original period of 1st January, 1999 to 30th June, 2004 minus the one-year VaR horizon) for all marketable financial assets in Taiwan using the three approaches. Next, the market value weighted average of individual VaRs for different financial asset classes is calculated to obtain the daily cross-sectional weighted average individual VaR series for each asset class, and then the simple average of each daily cross-sectional average VaR series for each of the three approaches is computed. Finally, the averages of the VaRs estimated using the three approaches yield the overall average VaR estimates. As the derivatives, including forwards, futures and swaps, could be decomposed into a combination of long and short positions and do not correspond to a specific risk weight, only the estimated results of

Table 1: Asset risk (VaRs), risk weights and mark-ups based on the Basel Accord — Average of the three approaches

Asset class	Assets	VaRs (%)	Risk weights (%)	Mark-ups
High-level risk				
Equity securities	Fully delivered & managed stocks	8.9560	16.00	1.79
	Emerging stocks	6.9846	16.00	2.29
	OTC stocks	6.9275	16.00	2.31
	TSE stocks	6.2312	16.00	2.57
Equity index	OTC	4.2565	12.00	2.82
	TSE	4.0446	12.00	2.97
Equity	OTC	4.0594	16.00	3.94
mutual funds	TSE	3.9483	16.00	4.05
Government bonds	Over 20 years	1.9838	6.00	3.02
(long term)	15–20 years	1.1366	5.25	4.62
	10–15 years	0.9085	4.50	4.95
	7–10 years	0.7282	3.75	5.15
Medium-level risk				
Foreign exchange	Foreign currency	1.2230	8.00	6.54
Government bonds	5–7 years	0.4893	3.25	6.64
(medium term)	4–5 years	0.3382	2.75	8.13
	3–4 years	0.2552	2.25	8.82
	2–3 years	0.2268	1.75	7.72
	1–2 years	0.1262	1.25	9.91
Low-level risk				
Government bonds	6 months to 1 year	0.0375	0.70	18.67
(short term)	3–6 months	0.0172	0.40	23.26
	1–3 months	0.0088	0.20	22.73
	Under 1 month	0.0019	0.00	0.00
Bills	6 months to 1 year	0.0570	1.70	29.83
	3–6 months	0.0243	0.65	26.75
	1–3 months	0.0124	0.45	36.29
	Under 1 month	0.0065	0.25	38.46

VaR, value-at-risk; OTC, over-the-counter; TSE, Taiwan Securities Exchange

primary securities are listed, based on the order of their risk level.

From Table 1, one can see that the mark-ups are different but all greater than one, indicating that the capital charges based on risk weight can offer proper coverage for extreme risk but only with 'discrimination'. However, it is worth noting that the relationship between the VaRs and their corresponding risk weights set by the Basel Accord exhibits a highly nonlinear pattern. The asset risks and their required capital adequacy are described in Figure 3, which displays the risk-encouraging concave function between the VaRs and their corresponding risk weights. The mark-up increases as the risk level of the assets decreases, which illustrates that the riskier assets are charged less capital than the less risky assets per unit of maximum possible loss (VaR). In other words, the risk weights of the standardised method set by the Basel Accord are more favourable to the risky assets than the riskless assets. To some extent, this result corresponds to the finding of Altman *et al.*[7]

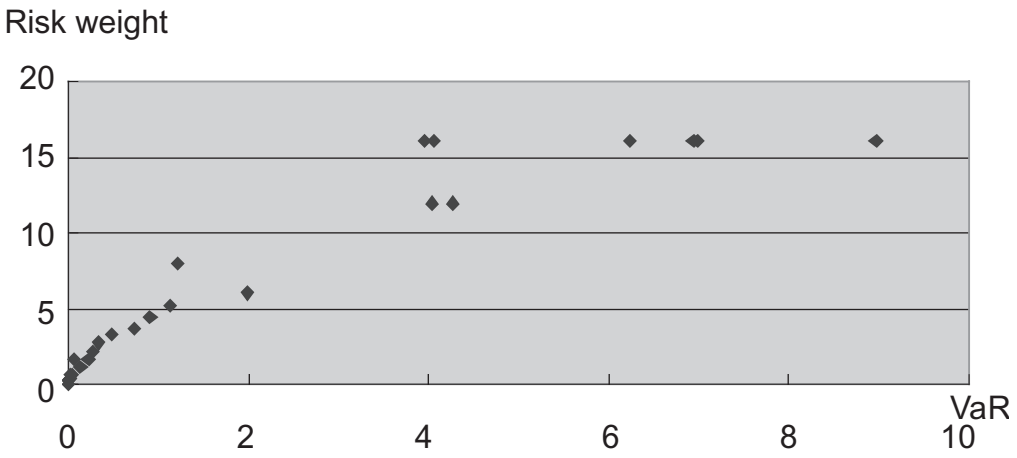

Figure 3: VaRs and the risk weights of the Basel Accord

regarding the revised capital requirements for credit risk under the new Basel Accord. The finding of significant supervisory discrimination among different assets confirms the previous concern that the risk weights are unable to properly explain the riskiness of financial assets. As a result, the regulators will fail to reduce the incentives of institutions to take risks to achieve their capital regulation goal. Moreover, this will contribute to the capital saving/addition between the two capital requirement alternatives — the standardised approach and the internal model method — as will be discussed below.

Now the study evaluates the set of risk weights for the general market risk and specific risk. Table 2 displays the estimated VaRs for the equities in Taiwan, risk weights and mark-ups set by the Basel Accord for the specific risk and general market risk. The VaRs in relation to the specific risk and general market risk are 2.09 per cent and 4.14 per cent for Taiwan Securities Exchange (TSE) stocks, and 2.40 per cent and 4.52 per cent for over-the-counter (OTC) stocks (in 2004, there were 695 and 495 stocks in the TSE and OTC markets, respectively). However, the mark-ups for specific risk and general market risk are 3.83 and 1.93 for TSE stocks, and

Table 2: Specific risk and general market risk — Equity securities

	Specific risk	General market risk	Total risk
TSE stocks			
VaRs (%)	2.09	4.14	6.23
Risk weights (%)	8	8	16
Mark-ups	3.83	1.93	2.57
OTC stocks			
VaRs (%)	2.40	4.52	6.93
Risk weights (%)	8	8	16
Mark-ups	3.33	1.77	2.31

VaR, value-at-risk
Mark-up = risk weight/VaR; OTC, over-the-counter; TSE, Taiwan Securities Exchange

3.33 and 1.77 for OTC stocks. Likewise, the risk weights set for the specific risk and general market risk exhibit the same phenomenon of supervisory discrimination as found previously.

VaR estimation for the securities firm portfolios

Portfolio VaR, individual VaR and diversification effects

Table 3 presents the average results of the VaR estimation for the securities firm portfolios using the three approaches. The second to fourth columns are the positions in terms of the percentage of the total portfolio value for the equity position, the interest rate instruments and the foreign exchange, respectively. The fifth to seventh columns list the value-weighted averages of the individual asset VaRs, $\overline{VaR_{ij}}$, the value-weighted averages of the class asset VaRs, $\overline{VaR_{ip}}$, and the total portfolio VaRs, VaR_p, in order. The values vary between 6.27 per cent and 0.71 per cent for average individual asset VaRs; between 1.51 per cent and 0.38 per cent for average class asset VaRs; and between 1.38 per cent and 0.23 per cent for the total portfolio of institutions, which indicates that the different business strategies across the firms leads to a significant difference in the degree of portfolio risk even within the same asset class.

The diversification benefits range from 4.77 per cent to 0.15 per cent for the 'within the asset class', from 0.36 per cent to 0.09 per cent for the 'between the asset classes', and from 4.89 per cent to 0.37 per cent for the overall portfolio. As with the ratios of diversification benefits 'within the asset class' compared with those 'between the asset classes', the values range from 97.41:2.59 to 42.24:57.76. The widely-differing degrees of risk diversification show the importance of risk management in the institutions. Notice that the hedging effects result mainly from the firms' issues of warrants, as a result of which

Table 3: VaR estimation for securities firm portfolios — Average of three approaches

	Position			Individual asset	Class asset	Total portfolio	Diversification effects		
Portfolio	Equities	Interest rates	FX	$\overline{VaR_{ij}}$	$\overline{VaR_{iP}}$	VaR_p	Within class DB_w	Between classes DB_b	Total DB_T
A	37.79	60.29	1.93	6.27	1.51	1.38	4.77	0.12	4.89
B	31.06	51.56	17.38	4.08	0.93	0.84	3.15	0.09	3.24
C	31.02	66.62	2.36	4.53	1.17	0.93	3.37	0.24	3.60
D	28.69	67.35	3.96	5.21	0.86	0.64	4.35	0.22	4.57
E	26.81	68.28	4.91	3.04	0.64	0.43	2.41	0.21	2.61
F	10.13	84.14	5.73	1.61	0.99	0.62	0.62	0.36	0.98
G	9.98	87.72	2.30	1.00	0.72	0.48	0.28	0.24	0.53
H	9.21	88.88	1.91	1.71	0.58	0.39	1.13	0.18	1.32
I	6.85	90.80	2.34	0.94	0.38	0.23	0.56	0.15	0.71
J	5.34	87.63	7.03	1.20	0.49	0.34	0.71	0.15	0.85
K	5.31	94.69	0.00	0.71	0.55	0.34	0.15	0.21	0.37
Average	18.38	77.09	4.53	2.75	0.80	0.60	1.95	0.20	2.15
STDEV	12.53	14.58	4.71	1.97	0.33	0.34	1.71	0.07	1.69

VaR, value-at-risk
Positions and VaRs are reported in terms of percentages (or loss rates), ie VaR % = VaR (dollars)/portfolio value

the short position of equities contributes to considerable risk reduction benefits. This is the reason why the diversification benefits within the asset class are very large for some firms.

Comparison of capital charges between the standardised and internal model methods

The VaRs of 11 portfolios from actual securities firms are estimated to compare the capital charges for various portfolios based on the two alternatives. Among the riskier assets, the equity risk is the dominant risk factor in the market risk of the securities firms. To take account of the financial leverage effects of considering the margin transactions, the risk position of equity in terms of both its original position value and the contract value position is hereby illustrated. Table 4 compares the capital charges between the standardised and internal model approaches. It can be seen that the capital savings arising from the internal model approach tend to occur in the case of relatively low-risk (VaR) portfolios, namely, portfolios D, E, H, J, K and I, which suggests that the internal model method is relatively more favourable to safer portfolios and more unfavourable to riskier portfolios. By contrast, the standardised method is relatively more favourable to high-risk institutions and more unfavourable to low-risk institutions. Given the previous findings regarding supervisory discrimination among different assets in the Basel Accord, one might infer that the risk weights set by the Basel Accord in the standardised method favour the risky assets over the riskless assets. This is because the capital requirement of the standardised method is based on the risk weight whereas that in the internal model is VaR-based.

Based on this comparison, the conclusion is that the internal VaR-based model approaches do not necessarily result in capital savings as compared with the standardised method. Whether or not the internal model approaches can give rise to capital savings depends on the individual characteristics of the institutions' portfolios. The capital savings will be realised in the case of low-risk institutions and will be high only when

Table 4: Comparison of capital charges between the standardised and the internal model approaches

Portfolio	Equity position Original value	Contract value	VaR	Internal models (1)	Standardised method (2)	Difference (3) = (1) – (2)
A	37.79	45.16	1.38	13.08	7.42	Addition (5.66)
C	31.02	32.16	0.93	8.83	6.73	Addition (2.10)
B	31.06	29.42	0.84	8.00	7.15	Addition (0.85)
D	28.69	23.90	0.64	6.05	7.03	Saving (–0.98)
F	10.13	10.18	0.62	5.91	4.39	Addition (1.52)
G	9.98	9.86	0.48	4.52	4.22	Addition (0.30)
E	26.81	15.00	0.43	4.08	6.34	Saving (–2.26)
H	9.21	7.28	0.39	3.73	5.42	Saving (–1.69)
J	5.34	5.51	0.34	3.26	6.64	Saving (–3.38)
K	5.31	5.18	0.34	3.22	3.36	Saving (–0.14)
I	6.85	6.33	0.23	2.19	4.91	Saving (–2.72)
Average	8.38	17.27	0.60	5.72	5.78	Saving (–0.07)

VaR, value-at-risk
Ratios reported in the table are in terms of the percentage of the original value of the overall portfolio

the portfolio is highly diversified across assets, across maturities and across countries and, more importantly, well hedged in a VaR sense, ie where the VaR exposure is small, so that only the low-risk institutions will choose the internal model approach and the high-risk institutions will still choose the standardised method to calculate the capital charges. The Accord fails to provide incentives for high-risk institutions to develop their own internal models.

THE DERIVATION OF VAR-BASED RISK WEIGHTS

This section proposes the 'VaR-based risk weight', which captures financial risk by means of the VaR measure and links the solvency parameters of the internal model to those of the standardised method. In such a way, one can resolve the problem of supervisory discrimination among the risk weights of different assets and ensure that there are capital savings within the internal VaR-based model that will provide incentives for institutions, especially those taking high risks, to develop their own internal models.

As found previously, the relationship between the VaRs and their corresponding risk weights set by the Basel Accord exhibits the concavity that illustrates the existence of significant risk-encouraging supervisory discrimination among different assets, as shown in Figure 4. Based on the risk weights set by Basel, the capital requirements of low-risk assets will be overcharged whereas those of high-risk assets will be undercharged. Only if the risk weights of the assets are set in proportion to their financial risk can

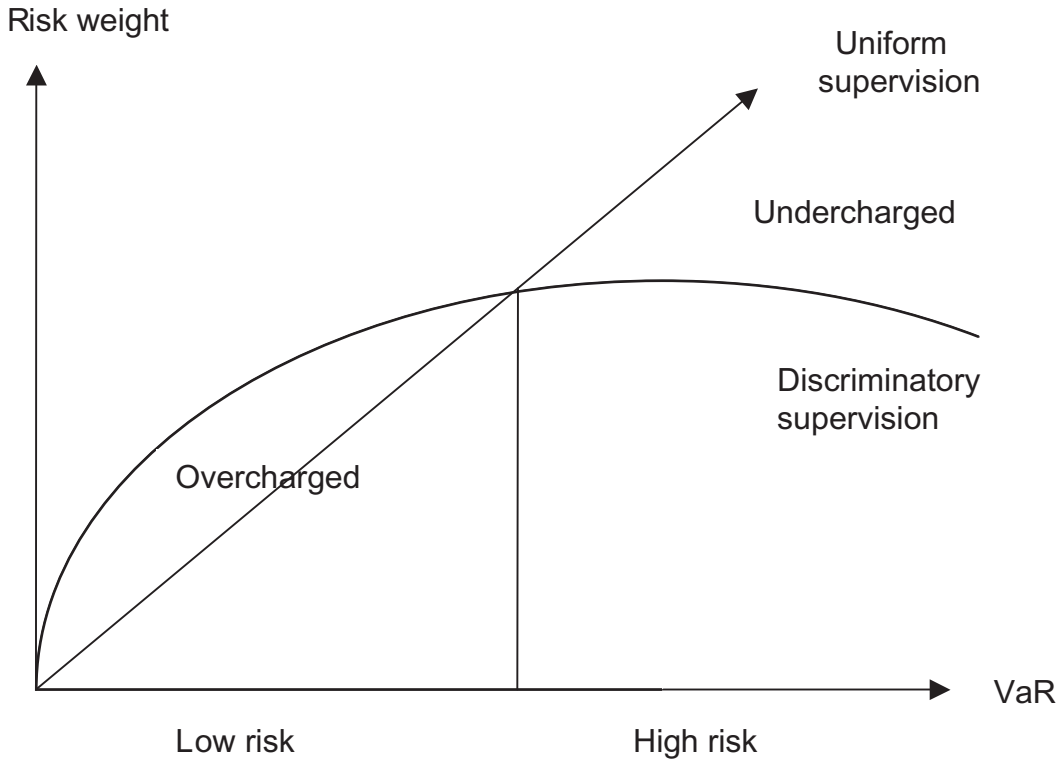

Figure 4: Basel's discriminatory supervision of risk weights

they redress the supervisory discrimination in the Accord's attitude towards risky assets and reduce the insolvency risk to an acceptable level. In other words, the regulator should establish a linear relationship between the risk weights and VaRs to align regulatory capital with financial risk to provide uniform supervision stringency among different risk-level instruments, in the sense that they are 'VaR-based'.

In designing the 'theoretically correct risk weight', one starts with the rationale for capital requirements whereby, as stated previously, the risk weights should be based on VaR in compliance with the uniform supervision standard. To do so, the mark-up (which can be regarded as the supervisory price of unit risk) for all assets should be the same and the risk weight should satisfy:

$$m = m_i = \frac{W_i}{VaR_i} \tag{7}$$

That is, by setting a linear relationship between the risk weights and VaRs:

$$W_i = mVaR_i \tag{8}$$

where m_i is the mark-up of asset i; m is the same common mark-up for all assets under the standardised approach; W_i is the risk weight attached to asset i; and VaR_i is the VaR of asset i.

According to the standardised approach, the capital requirement should be as follows:

$$CS = \sum_{i=1}^{n} V_i mVaR_i = m\sum_{i=1}^{n} V_i VaR_i \tag{9}$$

On the other hand, the capital charge under the internal model approach is given by:

$$CI = V_p VaR_p\sqrt{TM}$$

$$= \sum_{i=1}^{n} V_i VaR_i(1 - \mathrm{D})\sqrt{TM} \tag{10}$$

where V_p is the initial portfolio value; T is the holding period of VaR; M is the multiplication factor of the internal model approach; and D is the magnitude of the diversification effect in terms of the percentage of the initial portfolio value, so that $0 < D < 1$.

The major advantage of the capital requirement of the internal model method relative to the standardised building block approach is the diversification effect. To enable the diversification effect to result in capital savings for the internal model approach, Equation (9) is combined with Equation (10) to set the same common mark-up for the risk weights of all assets as:

$$m = \sqrt{TM} \tag{11}$$

such that CI $= (1 - \mathrm{D})$ CS

$$S = CS - CI = D \times CS \tag{12}$$

Equation (12) finds that the capital savings S arising from the internal model approach relative to the standardised approach depend on the magnitude of the portfolio diversification effect. The larger the portfolio diversification effect, the greater the capital savings resulting from using the internal model approach. Substituting Equation (11) into Equation (7) yields the 'theoretically correct VaR-based risk weights' as:

$$W_i^* = VaR_i\sqrt{TM} \tag{13}$$

where the VaR_i of different assets can be estimated from historical data, while the value settings of the two solvency parameters, namely, the holding period

T and the multiplication factor M of the internal model approach, are determined by means of the supervisory solvency standard. In concrete terms, whether or not the capital regulation can achieve its solvency goal depends on the joint impact of the propriety of the risk weights used in the standardised approach and the multiplication factor that forms an integral part of the internal model. The risk weights refer to the relative supervisory stringency among different assets, while the risk weights together with the multiplication factor refer to the relative supervisory stringency between the standardised approach and the internal model method.

CONCLUSION

The regulatory authorities set capital requirements to cover the positions of firms and to protect against losses arising from fluctuations in the value of their holdings. To achieve these objectives, capital requirements should precisely reflect the risk, or volatility, of a firm's trading book. The internal VaR-based model approach provides well-capitalised institutions with a stronger incentive to reduce asset risk than the building block method, which is driven by a reward that takes the form of lower capital requirements for low-risk institutions. As the internal VaR-based model provides the firm with stronger incentives as far as risk management is concerned, less of an auditing effort is required to maintain the risk reduction behaviour. Such an approach may thus benefit both the regulatory authority and the equity holders.

However, the empirical findings suggest that the risk weights set by the Basel Accord do not properly reflect the financial risk. The risk weights under the standardised method exhibit a risk-encouraging concave function of financial risk, and are more favourable to risky assets than to riskless assets. Such supervisory discrimination in relation to risk weights gives rise to the moral hazard problem in that the regulators fail to reduce the risk-taking incentives of institutions in achieving their regulatory goal. The internal VaR-based model approach does not necessarily provide capital savings to encourage institutions to develop their own internal models that can efficiently reflect the riskiness of a portfolio. Whether or not the internal model approach can provide capital savings depends on the characteristics of the portfolios of the institutions. The capital savings will occur only in the case of low-risk institutions. In developed countries, most large international institutions have well-diversified low-risk portfolios. In the emerging markets, however, the portfolios of domestic institutions may not be so well diversified and may also entail high risk. Such institutions will thus choose the standardised method as their calculation tool in regard to the capital requirements. As one of the main goals of the new Basel Capital Accord is to improve the efficiency of institutions' risk management, it is more important for high-risk institutions to develop their own internal model as a superior risk management tool. The implementation of the internal model involves many technological investments in order to obtain up-to-date data for their trading books and VaR models. Unless the high cost involved can be offset by a lower capital charge, the institutions will have no incentive to develop their home models.

This study proposes the adoption of 'VaR-based risk weights' that link the solvency parameters of the internal model with those of the standardised method. Thus, these weights can resolve the moral hazard problem of supervisory discrimination that arises from the risk weights adopted internationally in accordance with the Basel Accord. In addition, these weights can ensure that capital savings result from the internal VaR-based model, thereby encouraging institutions to develop their own internal models.

ACKNOWLEDGMENT

This work is supported by the Taiwan Securities Exchange. The author would like to thank *Taiwan Economic Journal* for supporting the data processing, SysJust Co., Ltd. for providing the RiskMetrics system and all the securities firms that made available the compositions of their trading books. The author is also grateful for the constructive suggestions from Professor John Peter Chateau. All remaining errors are the author's own responsibility.

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