The Basel Accord's Puzzle: Do the Risk Weights Reflect the Financial Risk Properly？*

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Abstract

We estimate the VaRs for all marketable financial assets in Taiwan and contrast these VaRs with their corresponding risk weights to examine the propriety of the risk weights set by the Basel Accord. Next, actual portfolios of the securities firms' trading books are used to compare the capital charges between the standardized and the internal model approaches. Our empirical findings suggest that the weights set by the Basel Accord do not reflect the financial risk properly since the risk riskier the asset is, the lower is the "capital charge markup." The prevailing international risk weights are favorable to the riskier assets relative to the riskless assets. As a result, the regulators will fail to reduce the insolvency risk of the financial institutions to an acceptable level to achieve their capital regulation goal. Moreover, the internal model approach does not necessarily provide capital savings relative to the standardized method that encourages the financial institutions to develop internal models that can reflect the riskiness of a portfolio efficiently. Whether the internal model approaches can provide capital savings depends on the characteristics of the portfolios of the financial institutions. The capital savings will occur only in the case of low-risk financial institutions. The high-risk financial institutions will choose the standardized method as their calculation tool of capital requirements. To solve the moral hazard problem of "supervisory discrimination", we propose the "VaR-based risk weights" which can ensure capital savings of adoption of the internal model and thereby encourage the financial institutions to develop internal models.

***Keywords**:* VaR, Risk weight, Standardized method, Internal model, Supervisory discrimination

1. Introduction

Increased competition has forced banks to search for more income at the expense of added risk, with the result that, over the past decade, banks have enlarged the scope of their trading activities in the highly-volatile financial markets. The rapid increase in the relative importance of market risk has also led to a number of unfavorable events, as exemplified by Orange County, Barings and LTCM, etc. Supervisory institutions have been spurred by such experiences to reconsider the guidelines related to capital requirements that were agreed upon in the 1988 Basle Capital Accord which was designed primarily to deal with credit risk and had noticeable drawbacks in that it neglected market risk. Thus, the 1996 Amendment to the Basle Accord to incorporate market risk, which remained effective in the 2000 Basle II, has required banks to maintain levels of capital adequacy to cover the market risk in their trading accounts. In particular, the capital requirement, which serves as a method of coinsurance whereby a higher capital level requires the bank to absorb greater losses in the event of failure, thus encouraging additional prudence in management, has also become a key topic of concern.

Many of the previous studies have discussed the relationship between bank asset risk or failure risk and bank capital requirement standards. Koehn and Santomero (1980); Sharp (1978); Kareken and Wallace (1978); Dothan and Williams (1980); Furlong and Keeley (1989); Bhattacharya, Plank, Strobl, and Zechner (2001)) However, only a few studies have compared the capital adequacy requirements between the standardized building block method and the internal (VaR) model approach. Dangl and Lehar (2004) develop a continuous time framework to compare regulations based on the Basel I building block approach to Value-at-Risk or 'internal model' based capital requirements. The main findings are that Value-at-Risk based capital regulation creates a stronger incentive to reduce asset risk when banks are solvent, and solvent banks that reduce their asset risk reduce the current value of the deposit insurance liability significantly. Soczo (2001) compares these two alternatives and argues that firms would be expected to choose the Standardized Methods in Hungary to define capital charges even though the other method applies superior tools and could explain the riskiness of a portfolio. As far as we know, no further evidence provides explanation for this unexpected finding. In the meanwhile, although existing regulatory capital requirements are often criticized for being only loosely linked to the economic risk associated with the banks' assets, there is still little empirical evidence related to the propriety of the risk weights set up by the Basel Accord. These form the central topic of our article.

In view of the more risk-sensitive capital requirements, we argue that the "theoretically correct" risk weights of different assets should precisely reflect the intrinsic risk of the financial assets. Besides, any reasonable VaR-based model should in general provide capital savings, i.e. the reduction in capital charges realized by adopting the internal model instead of the standardized method, in order to provide the incentives to banks to develop their own internal models that can reflect the riskiness of a portfolio efficiently.

The paper is set up as follows to justify and demonstrate these claims. In the next section we describe our research design. Empirically, we first estimate the VaRs for all marketable financial assets in Taiwan and contrast these VaRs with their corresponding risk weights to examine the propriety of the risk weights set by the Basel Accord in Section III. Section IV investigates the diversification effects of portfolios for the securities firms and compares the capital charges between the standardized and the internal model approaches. In Section V, we propose the "theoretically correct VaR-based risk weights" which can more precisely reflect the true risk of the trading books and encourage the firms to develop their own internal models. Our concluding remarks are presented in the final section.

2. Research design

Here, the research design is referred to as the theoretical rationale for the empirical study that follows. We discuss the rationale for risk weights, which can capture the risk of various assets and achieve the solvency goal. To investigate the measurement of the different risk and diversification effects, the individual VaR vs. portfolio VaR, general market risk vs. specific risk, as well as the diversification benefits within and between asset classes are defined and described. Finally, we illustrate the sample data and the VaR models.

2.1. Rationale for risk weights

Regulatory authorities set capital requirements to cover the position of firms and to protect against losses arising from fluctuations in the value of their holdings. To do this, capital requirements should precisely reflect the risk, or volatility, of the firm's trading book. In view of the attempts of 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 behavior of banks and derive the "optimal" risk weights based on the solvency goal. The optimal risk weights are determined by two factors, namely, the solvency parameters and the market-determined parameters. Since the higher-yield but riskier asset would be assigned larger risk weights under the Risk-Based Capital Regulation (RBCR), the risk weights should be positively correlated with the asset returns. 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 (or excess returns), in the sense that they are "market-based," can the RBCR redress the bank's bias toward riskier assets and effectively reduce the insolvency risk to the desired level. Otherwise, a "moral hazard" problem might arise, as with the uniform capital ratio requirement, and fail to achieve the solvency goal (Rochet (1992)). Liu, Kuo and Wu (1996) combine the "market-based" approach (Rochet (1992)) and the solvency standard (Kim and Santomero (1988)) to derive the "optimal" risk. The optimal risk weights are determined by two factors: (a) solvency parameters: the required ratio of equity to total risk-weighted assets and the supervisory upper bound of the probability of insolvency, and (b) market-determined parameters: the expected excess return and the variance-covariance of the risk of asset returns, and thus can reduce the insolvency risk to an acceptable level.

As suggested by Rochet (1992), the "market-based" risk weight should be a linear function of systematic risk. However, there still is no proxy index for the market portfolio including various different financial asset classes, such that the estimation of β for all different kinds of financial assets is unavailable in practice. Under the VaR vs. variance-covariance risk measurement framework, the individual VaR corresponds to the standard deviation of the asset return, while β corresponds to the component VaR. That is, 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. Since the main problem with the building block approach proposed by the Basel Committee is that it gives no credit for diversification, to maintain the homologue between the risk weight setting and the VaR measurement[1], we hereinafter employ the individual VaR but not the component VaR as the measure of risk for financial instruments.

2.2. The measurement of the diversification effects

By taking into account the diversification benefits between components, the portfolio VaR is diversified and can be expressed in dollar terms as

$$VaR_p = Z(\alpha)\sigma_P V_p = Z(\alpha)\sqrt{\mathbf{w'\Sigma}\, w}\, V_p = Z(\alpha)\sqrt{\mathbf{V'\Sigma V}} \tag{1}$$

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, w is the vector of weights, $\mathbf{\Sigma}$ is the variance-covariance matrix and V is the vector of holdings in terms of dollars.

By taking one component in isolation without any diversification benefits, we can define the individual risk of each component, i.e. individual VaR or stand-alone VaR , as

$$VaR_i = Z(\alpha)\sigma_i |V_i| \tag{2}$$

Note that we take the absolute value of the holding value V_i since it can be negative (a short position), whereas the risk measure must be positive.

Equation (1) shows that the portfolio VaR depends on the variances, the covariance and the number of assets. The magnitude of the covariance, however, depends on the variances of the individual components, and is ambiguous and not easily interpreted. The correlation coefficient ρ is a more convenient, scale-free measure of linear dependence. Lower portfolio risk can be achieved through low individual risk, a large number of assets, or more importantly, low correlation. Let us take a simple example in the case of two assets to illustrate the diversification benefits of low correlation. From equation (1) the portfolio VaR is then

[1] The other reason is that the component VaR of a specific asset will change as the portfolio changes. The unique component VaR of a specific asset is immeasurable.

$$VaR_P = Z(\alpha)\sqrt{V_1^2\sigma_1^2 + V_2^2\sigma_2^2 + 2V_1V_2\rho_{12}\sigma_1\sigma_2} \quad (3)$$

where ρ_{12} denotes the correlation coefficient of the two asset returns. This can be related to the individual VaR as defined in equation (2).

When $\rho = 1$, the portfolio VaR reduces to

$$VaR_P = VaR_1 + VaR_2 \quad (4)$$

Equation (4) indicates that the portfolio VaR is equal to the sum of the individual VaR measures if the two assets are perfectly positively correlated. In other words, the benefit from diversification is zero.

When $\rho = -1$, the portfolio VaR reduces to

$$VaR_P = \left| \ VaR_1 - VaR_2 \ \right| \quad (5)$$

Equation (5) indicates that the portfolio VaR is equal to the absolute value of one individual asset's VaR minus that of the other one if the two assets are perfectly negatively correlated. In such a case, the benefit from diversification can achieve its maximum value. In general, correlations are typically imperfect, 1＜ρ＜1, 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.

$$DB = \sum_{i=1}^{n} VaR_i - VaR_P \quad (6)$$

The portfolio diversification effect is determined by two factors: (a) the holdings of each asset, and (b) the variance-covariance matrix of asset returns, and can thus result in infinite combinations of outcomes with widely differing degrees of diversification. Other things being equal, the diversification benefits will decrease as the number of securities increases and as the correlation coefficient increases in the case where all assets are in the long position. 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[2]. If we extend the scope of the portfolio to all assets in the market, i.e. the market portfolio, then this leads to a total-risk decomposition of

$$\sum_{i=1}^{n} VaR_i = VaR_m + DB_T \tag{7}$$

Equation (7) indicates that the sum of the individual VaRs equals the market portfolio VaR plus the diversifiable VaR. The market index will be used as the proxy for the market portfolio in practice since it is unobservable. Empirically, we then employ the market index VaR, VaR_m, as the VaR measurement for the general market, or the systematic risk, and use the diversifiable VaR, DB_T, as the VaR measurement of the unique, unsystematic, or specific risk[3] (Basel, 1996).

To examine the source of risk reduction from the perspective of different asset classes, we further employ the ANOVA analysis framework to decompose the total diversification benefits DB_T into two components: the diversification benefits within the asset class DB_w and the diversification benefits between the asset classes DB_b. If we consider m asset classes and l asset for each class, the DB_T, DB_w as well as DB_b can be given by

$$\begin{aligned} DB_T &= \sum_{i=1}^{m}\sum_{j=1}^{l} VaR_{ij} - VaR_P \\ &= (\sum_{i=1}^{m}\sum_{j=1}^{l} VaR_{ij} - \sum_{i=1}^{m} VaR_{ip}) + (\sum_{i=1}^{m} VaR_{iP} - VaR_P) \\ DB_T &= DB_w + DB_b \end{aligned} \tag{8}$$

[2] 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, e.g., on a take-over bid or some other shock event; such events would also include the risk of “default”) (Basel, 1996).

[3] Banks may select their own technique for identifying the specific risk component of the value-at-risk measure for purposes of applying the multiplier of 4. Techniques would include:

- using the incremental increase in value at risk arising from the modeling of specific risk factors;
- using the difference between the value-at-risk measure and a measure calculated by substituting each individual equity position with a representative index; or
- using an analytic separation between general market risk and specific risk implied by a particular model.

where, $DB_w = (\sum_{i=1}^{m}\sum_{j=1}^{l} VaR_{iJ} - \sum_{i=1}^{m} VaR_{ip})$

$$DB_b = \sum_{i=1}^{m} VaR_{iP} - VaR_P$$

VaR_{ij} is the VaR of the jth security belonging to the asset class i, and VaR_{ip} denotes the ith class VaR. DB_w refers to the intra-class diversification, i.e. 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, i.e. 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.

2.3. Data and the VaR models

Our empirical study is performed by employing three common VaR approaches－the variance-covariance approach,[4] the historical simulation approach, and the Monte-Carlo simulation approach of RiskMetrics 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 1999/01/01 to 2004/06/30. We then contrast these VaRs with their corresponding risk weights to examine the propriety of the risk weights set by the Basel Accord. According to the guidelines of the Basel Accord, we set the confidence levels needed as 99% and the rolling window length as one-year (about 250 business days). RiskMetrics uses the standard exponential weighted moving average (EWMA) method to produce forecasts of variances and covariances[5]. The decay factor λ is set to 0.94 for the daily returns. It is very common that there will be missing or corrupted data in the market-data feeds. RiskMetrics sets the price the same as the previous day (i.e. the return is set as zero) in the case where data are missing. Consequently, the VaR will be underestimated once the missing data become serious. To remedy this

[4] Variance-covariance VaR is also known as parametric VaR, linear VaR, delta-normal VaR or Greek-normal VaR. The approach is parametric in that it assumes that the probability distribution is normal and then requires calculation of the variance and covariance parameters (Marrison, 2002). For further details of the pros and cons of these three methods, refer to Jorion (2000).

[5] In RiskMetrics, we assume that the mean value of daily returns is zero. That is, standard deviation estimates are centered around zero, rather than the sample mean. Similarly, when computing the covariance, deviations of returns are taken around zero rather than the sample mean. (RiskMetrics, 1996)

problem, we delete the sample observations with missing data for over 10 business days. The stochastic processes of the asset returns must be selected to implement the Monte-Carlo method. As in the case of the variance-covariance method, we employ the Monte-Carlo approach based on the assumption that the asset returns are characterized by a joint normal distribution[6].

Our sample portfolio data consist of the actual composition of 11 trading books, collected from securities firms within Taiwan, as on various dates between December 2000 and June 2004. There are one or two trading books per firm, including equity securities, foreign exchange, fixed-income securities as well as the derivatives which were provided to us on condition of anonymity. The individual books range in net value from NT$49,160 million to NT$9,955 million. 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.

3. VaR estimation and the risk weights based on the Basel Accord for different financial assets

3.1. VaR comparison of the three approaches

The overall average of individual VaR estimated results for all financial assets in Taiwan are shown in Table 1. These VaRs are obtained by means of the following steps. The VaRs are first estimated day-by-day from 2000/01/01 to 2004/06/30 (the original period from 1999/01/01 to 2004/06/30 minus the one-year VaR horizon) for all marketable financial assets in Taiwan using the three approaches. Next, we calculate the market value weighted average of individual VaRs for different financial asset classes to obtain the daily cross-sectional value weighted average individual VaR series for each asset class, and then compute the simple averages of each daily cross-sectional average VaR series for each of the three approaches. Finally, the

[6] Most banks operate Monte-Carlo simulation methods based on the assumption that the asset returns are normally distributed. Given the sizeable evidence that financial asset returns are non-normal and have tails that are fatter than those in the case of normal distributions, this assumption is indeed questionable. Other multivariate distributions, for instance the *t*-distribution, which can capture the fat-tailed nature of most return series, are therefore preferred. However, more complicated models may make simulation difficult to implement (see Engel and Gizycki (1999)).

averages of the VaRs estimated using the three approaches yields the overall average VaR estimates in Table 1.

It is instructive to compare the VaRs obtained using the three methods. Significant differences exist between the parametric VaR and Monte Carlo VaR, which would indicate that the portfolio (asset) has a significant nonlinear[7] sensitivity to price changes. Significant differences also exist between the Monte Carlo VaR and historical VaR, which would suggest that the correlations assumed in the Monte Carlo VaR may not be stable or that the kurtosis may be high. Differing from the other two methods – the variance-covariance approach, and the Monte-Carlo approach – the historical approach without the normality assumption produces a different volatility pattern of estimated VaR and has a significant 'window effect[8]' as expected. On the whole, our variance-covariance approach and the Monte-Carlo simulations with the same normality assumption appear to yield closer VaR estimates relative to the historical simulation method except for option & warrant instruments, which would indicate that these assets may have significant nonlinear sensitivity to price changes. There exist significant differences between the historical VaR and the other two VaRs for the interest rate and the foreign exchange instruments, while for equity securities the differences are insignificant. These results suggest that non-normality is significant for the interest rate and the foreign exchange instruments but not serious for equity securities. Furthermore, the volatility skew is observed for options and warrants as theoretically expected. In this situation, options that are out-of-the-money appear to have a higher volatility and thereby VaR than options that are in-the-money. This may be because of supply-and-demand effects in the market that tend to increase the value of out-of-money options relative to in-the-money options (Marrison, 2002).

Table 1

The individual VaR estimation for all financial assets in Taiwan- Average of the three approaches

2000.01.01 – 2004.06.30 VaR: %

	Asset Class	Sub-asset Class	Var-Covar Approach	Historical Approach	Monte-Carlo Approach	Overall Average

[7] Nonlinearity refers to the price change not being a linear function of the change in the risk factors.

[8] The reported VaR suddenly increases from one day to the next when some recent, specific crisis observation moves into the rolling window for historical data and suddenly drops when it drops out of the window.

Equity						
Primary Securities	TSE Stocks	—	6.2551	6.3997	6.0388	6.2312
	OTC Stocks	—	7.2517	6.5683	6.9625	6.9275
	Emerging Stocks	—	6.2835	8.8478	5.8226	6.9846
	Fully Delivered & Managed Stocks	—	9.9787	7.4141	9.4750	8.9560
Mutual Funds	TSE Funds	—	3.9424	4.0727	3.8397	3.9483
	OTC Funds	—	4.0570	4.1674	3.9539	4.0594
Derivatives	Index Futures	—	41.1187	47.3343	40.0684	42.8405
	Index Options	In-the-money	50.2111	49.4977	42.2455	47.3181
		Out-of-the-money	81.7243	65.1641	57.5389	68.1424
	Warrants	In-the-money	20.7489	20.2626	18.9416	19.9844
		Out-of-the-money	24.4813	23.3047	21.6368	23.1409
Interest Rate						
Primary Securities	Government Bond (coupon rate above 3%)	Below 1M	0.0019	0.0018	0.0019	0.0019
		1-3 M	0.0082	0.0099	0.0083	0.0088
		3-6 M	0.0164	0.0188	0.0164	0.0172
		6 M -1Y	0.0358	0.0407	0.0359	0.0375
		1-2 Y	0.1102	0.1581	0.1102	0.1262
		2-3 Y	0.1928	0.2949	0.1926	0.2268
		3-4 Y	0.2302	0.3061	0.2294	0.2552
		4-5 Y	0.3047	0.4055	0.3045	0.3382
		5-7 Y	0.4333	0.6002	0.4342	0.4893
		7-10 Y	0.6623	0.8598	0.6626	0.7282
		10-15 Y	0.8295	1.0699	0.8262	0.9085
		15-20 Y	1.0337	1.3507	1.0254	1.1366
		Above 20 Y	1.7502	2.4730	1.7283	1.9838
	Government Bond (coupon	Below 1M	0.0028	0.0042	0.0028	0.0033
		1-3 M	0.0070	0.0104	0.0071	0.0082

	rate below 3%)	3-6 M	0.0089	0.0140	0.0089	0.0106
		6 M -1Y	0.0337	0.0325	0.0336	0.0333
		1-1.9Y	0.1329	0.2198	0.1327	0.1618
		1.9-2.8 Y	0.2616	0.4526	0.2615	0.3252
		2.8-3.6 Y	0.2627	0.3755	0.2633	0.3005
		3.6-4.3 Y	0.3152	0.4042	0.3140	0.3445
		4.3-5.7 Y	0.4075	0.5371	0.4083	0.4510
		5.7-7.3 Y	0.6683	0.7952	0.6733	0.7123
		7.3-9.3 Y	0.8472	1.3863	0.8493	1.0276
		9.3-10.6 Y	0.8265	1.2073	0.8298	0.9545
		10.6-12 Y	None	None	None	None
		12-20 Y	1.3717	2.0317	1.3555	1.5863
		Above 20 Y	None	None	None	None
	Bills	below 1M	0.0051	0.0092	0.0052	0.0065
		1-3M	0.0114	0.0141	0.0115	0.0124
		3-6M	0.0224	0.0281	0.0224	0.0243
		Above 6M	0.0534	0.0641	0.0534	0.0570
Mutual Funds	Bond Funds	—	0.0370	0.0036	0.0369	0.0258
Derivatives	Bond Futures	—	35.6444	67.2598	35.7215	46.2086
	Bill Futures	—	5.1335	17.4418	5.2012	9.2589
Foreign Exchange						
	Foreign Exchange	—	1.1561	1.3671	1.1458	1.2230

3.2. VaRs, risk weights and markups of the Basel Accord

The results of the VaR estimates for various financial instruments and their corresponding risk weights are summarized in Table 2. To evaluate the relative supervisory stringency among different assets, we define the capital charge markups as being equal to the risk weights divided by the VaR. From Table 2 we find that the markups are all greater than one, which indicates that the capital charges based on risk weight can offer proper coverage for extreme risk. 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 1, which displays the concave function between the VaRs and their corresponding risk weights. Furthermore, the VaRs as well as their "capital charge markups" are shown in Figure 2. The riskier an asset is, the lower the "capital charge markup" is, which illustrates that with the same maximum possible loss (VaR), the riskier assets are charged less capital than the less risky assets. In other words, the risk weights of the standardized method set by the Basel Accord are more favorable to the riskier assets than the riskless assets. There may thus exist significant "supervisory discrimination" among different assets according to the Basel Accord. This situation thus provides the opportunity for "regulatory capital arbitrage" through "inter-bucket" risk shifting, i.e. increasing the risk of the bank's assets without increasing the capital requirements. These results confirm our previous concern that the risk weights are unable explain the riskiness of financial assets properly. As a result, the regulators will fail to reduce the insolvency risk of the financial institutions to an acceptable level to achieve their capital regulation goal. Several regulatory agencies have therefore proposed linking minimum capital requirements to economic risk more closely.

Table 2
Asset Risk (VaRs), risk weights and markups based on the Basel Accord
－ Average of the three approaches

Degree of risk	Asset class	Assets	VaR (%)	Risk weights (%)	Markups
High-level	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 mutual funds	OTC	4.0594	16.00	3.94
		TSE	3.9483	16.00	4.05
	Government bonds - Long term	Over 20 years	1.9838	6.00	3.02
		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	Foreign exchange	Foreign Currency	1.2230	8.00	6.54
	Government bonds-Medium term	5-7 years	0.4893	3.25	6.64
		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	Government bonds - Short term	6 months -1 year	0.0375	0.70	18.67
		3-6 months	0.0172	0.40	23.26
		1-3 months	0.0088	0.20	22.73
		Under1 month	0.0019	0.00	0.00
	Bills	6 months -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

Note: The Markup = VaR (%)/ Risk weight(%)

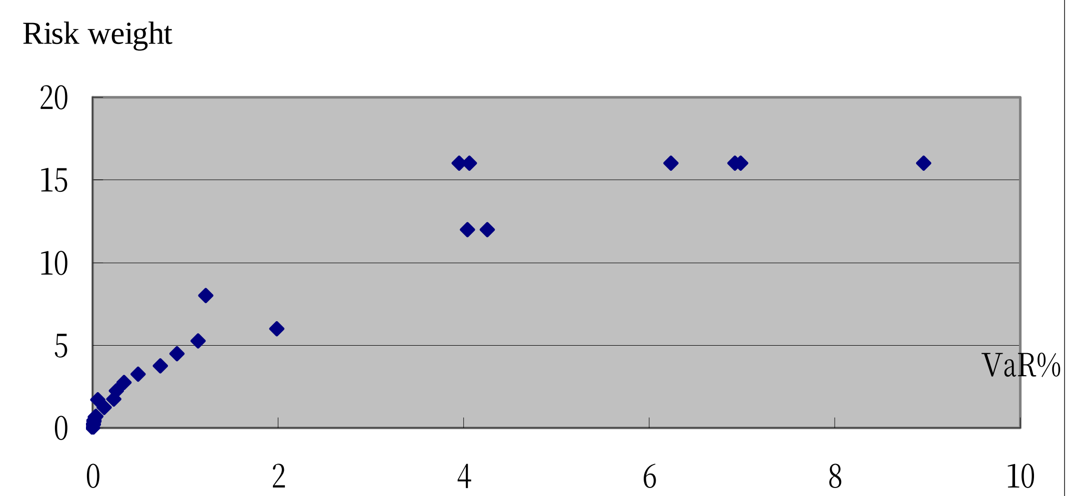

Figure 1 VaRs and the risk weights of the Basel Accord

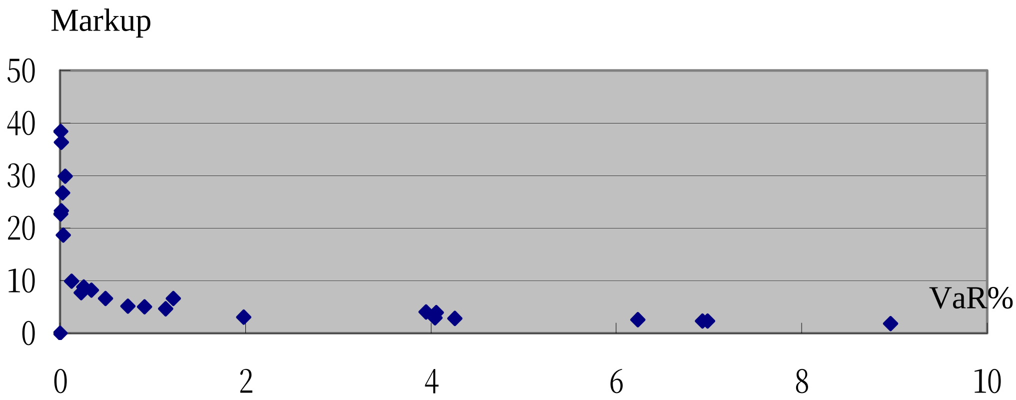

Figure 2 VaRs and the markups of the Basel Accord

Now we turn to evaluate the set of risk weights for the general market risk and specific risk. Recall that the general market risk and specific risk can be measured from the market index VaR and from the difference between individual VaR and market index VaR, respectively. The estimated VaRs for the equities in Taiwan, risk weights[9] and markups set by the Basel Accord for the specific risk and general market risk are displayed in Table 3. The VaRs in relation to the specific risk and general market risk are 2.0888% and 4.1424% for TSE[10] stocks, and 2.4048% and 4.5227% for OTC stocks. However, the markups for specific risk and general market risk are 3.83 and 1.93 for TSE stocks, and 3.3267 and 1.7689 for OTC stocks. Likewise, the risk weights set for the specific risk and general market risk exhibit the same "supervisory discrimination" phenomenon among different financial assets as found previously.

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[9] According to the Basel Accord, specific risk is defined as the bank's gross equity positions and general market risk as the overall net position in an equity market. The long or short position in the market must be calculated on a market-by-market basis. The capital charge for specific risk will be 8%, unless the portfolio is both liquid and well-diversified, in which case the charge will be 4%. Given the different characteristics of national markets in terms of marketability and concentration, the national authorities will have discretion to determine the criteria for liquid and diversified portfolios. The general market risk charge will be 8%.

[10] For the time being, there are 695 and 495 stocks in the TSE and OTC markets, respectively.

Table 3
Specific risk and general market risk － equity securities
2000.01.01－2004.06.30

	Specific risk	General market risk	Total risk
TSE stocks			
VaRs (%)	2.0888	4.1424	6.2312
Risk weights (%)	8	8	16
Markups	3.8300	1.9312	2.5677
OTC stocks			
VaRs (%)	2.4048	4.5227	6.9275
Risk weights (%)	8	8	16
Markups	3.3267	1.7689	2.3096

Note: The Markup = VaR (%)/ Riskweight (%)

4. VaR estimation for the securities firm portfolios

4.1. Portfolio VaR, individual VaR and diversification effects

Table 4 displays the VaR estimation results for the securities firm portfolios using the variance-covariance approach, historical simulation approach and Monte-Carlo simulation approach, as well as their averages. Moving horizontally from left to right, the third to sixth columns are the position or asset class VaR for the equity position, interest rate instruments as well as foreign exchange & others, respectively. The next column lists the value-weighted averages of the individual asset VaRs, $\overline{VaR_{ij}}$. The eighth column reports the value-weighted averages of the class asset VaRs. The last column presents the total portfolio VaRs. The class asset VaRs vary between 4.8231% and 1.6178%, for equity securities; between 0.5414% and 0.0955%, for the interest rate; between 3.4732% and 0.42% for foreign exchange & others; as well as between 1.3790% and 0.23%, for the total portfolio of financial institutions, which shows that equity securities are the most highly volatile assets in the trading books. With regard to the individual VaRs and portfolio VaRs, the values range from 6.6124% to 0.643%, for average individual asset VaRs, from 1.6558% to 0.3353% for average asset class VaRs, and from 1.5599% to 0.218% for portfolio VaRs, which indicates that the different business strategies across the firms lead to a wild difference in the degree of portfolio risk even within the same asset class.

Table 4
VaR estimation for financial institutions
—three Approaches

Unit: %

Portfolio	Position/Approach	Equities VaR_{1P}	Interest Rates VaR_{2P}	FX & Others VaR_{3P}	Individual Asset $\overline{VaR_{ij}}$	Class Asset $\overline{VaR_{iP}}$	Portfolio VaR_p
A	Position	37.7862	60.286	1.9278	—	—	100
	Var-Covar	3.4955	0.148	2.9896	6.3701	1.4676	1.3582
	Historical	3.0642	0.312	2.4497	5.8312	1.3932	1.2189
	Monte-Carlo	3.9986	0.1479	2.8926	6.6124	1.6558	1.5599
	Average	3.5194	0.2026	2.7773	6.2713	1.5055	1.379
B	Position	31.0585	51.5604	17.3811	—	—	100
	Var-Covar	1.5328	0.0556	1.7799	3.9614	0.8141	0.7514
	Historical	2.266	0.1742	2.18	4.2863	1.1725	1.0272
	Monte-Carlo	1.6744	0.0567	1.4964	4.0057	0.8094	0.7521
	Average	1.8244	0.0955	1.8188	4.0844	0.932	0.8436
C	Position	31.0232	66.6213	2.3556	—	—	100
	Var-Covar	2.4907	0.2473	4.209	4.4261	1.0366	0.8618
	Historical	3.2388	0.4859	3.2047	4.6674	1.404	1.0444
	Monte-Carlo	2.6451	0.2486	3.006	4.5027	1.057	0.8847
	Average	2.7915	0.3273	3.4732	4.5321	1.1659	0.9303
D	Position	28.6908	67.3541	3.9551	—	—	100
	Var-Covar	1.9445	0.2779	0.9821	5.2576	0.7839	0.5922
	Historical	2.1642	0.3409	0.8639	4.7802	0.8847	0.5937
	Monte-Carlo	2.3555	0.2883	0.937	5.5843	0.9071	0.7285
	Average	2.1547	0.3024	0.9277	5.2074	0.8586	0.6381
E	Position	26.8117	68.2818	4.9065	—	—	100
	Var-Covar	1.2937	0.1796	0.8178	2.6273	0.5096	0.3375
	Historical	2.1978	0.3184	1.4283	3.8418	0.8768	0.6029
	Monte-Carlo	1.3618	0.179	0.779	2.6618	0.5256	0.3509
	Average	1.6178	0.2257	1.0084	3.0437	0.6373	0.4304
F	Position	10.1311	84.1364	5.7325	—	—	100
	Var-Covar	4.401	0.5579	1.9615	1.708	1.0277	0.6732
	Historical	4.068	0.5167	1.6768	1.4412	0.943	0.5278

	Monte-Carlo	4.1551	0.5497	1.8036	1.671	0.9869	0.6666
	Average	4.208	0.5414	1.814	1.6067	0.9859	0.6225
G	Position	9.9813	87.7212	2.2975	—	—	100
	Var-Covar	3.7941	0.2255	4.6111	0.9606	0.6825	0.4834
	Historical	4.0706	0.3316	4.8604	1.0907	0.8088	0.4797
	Monte-Carlo	3.6705	0.2307	4.4599	0.9556	0.6712	0.467
	Average	3.8451	0.2626	4.6438	1.0023	0.7208	0.4767
H	Position	9.2072	88.8832	1.9097	—	—	100
	Var-Covar	2.3796	0.2845	1.8558	1.6129	0.5074	0.3523
	Historical	2.6647	0.4764	1.8782	1.8907	0.7046	0.4556
	Monte-Carlo	2.5132	0.2815	1.745	1.6257	0.5149	0.3701
	Average	2.5192	0.3475	1.8263	1.7097	0.5756	0.3927
I	Position	6.8547	90.8007	2.3446	—	—	100
	Var-Covar	1.7859	0.1929	1.6611	0.7789	0.3365	0.2239
	Historical	2.6148	0.255	2.8558	1.267	0.4777	0.2497
	Monte-Carlo	1.8732	0.1848	1.6681	0.7843	0.3353	0.218
	Average	2.0913	0.2109	2.0617	0.9434	0.3832	0.2305
J	Position	5.338	87.6289	7.0331	—	—	100
	Var-Covar	3.8802	0.1092	3.3269	1.2417	0.5368	0.4039
	Historical	2.8925	0.0993	2.2999	1.1151	0.4032	0.2401
	Monte-Carlo	3.9495	0.1106	3.1641	1.231	0.5303	0.3879
	Average	3.5741	0.1064	2.9303	1.1959	0.4901	0.344
K	Position	5.3076	94.6924	0	—	—	100
	Var-Covar	4.4482	0.2815	0	0.643	0.5026	0.3069
	Historical	5.5134	0.3658	0	0.794	0.639	0.4071
	Monte-Carlo	4.5077	0.2879	0	0.681	0.5119	0.3039
	Average	4.8231	0.3117	0	0.706	0.5512	0.3393

Notes: 1. The positions and VaRs are both reported in terms of percentages (or loss rates), i.e. VaR (%) ＝VaR (dollars)/portfolio value.

As stated previously, the difference between the individual VaR and the asset class VaR can measure the diversification benefits within the asset class while the difference between the asset class VaR and the portfolio VaR can measure the diversification benefits between the asset classes. The risk profiles and diversification effects of the securities firm portfolios are summarized in Table 5. The diversification benefits range from 4.77% to 0.15% for “within the asset class,” range from 0.36% to 0.09% for “between the asset classes,” as well as range from 4.89% to 0.37% for the overall portfolio. As with the ratios of the diversification benefits "within the asset class" compared to those "between the asset class," 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 financial institutions. Notice that the hedging effects result mainly from the firms' issues of warrants, as a result of which the short position of equities contributes to considerable risk reduction benefits. This is the reason why the diversification benefits within the asset class for some firms are very large.

Table 5
VaR estimation and diversification effects of the securities firm portfolios
—Average of the three approaches

Unit: VaR%

Portfolio	VaR				Diversification effects		
	Equities	Interest rates	FX & others	Portfolio	Within class DB_w	Between classes DB_b	Total DB_T
A	3.5194	0.2026	2.7773	1.3790	4.77	0.12	4.89
	(37.78)	(60.29)	(1.93)	(100)	(97.41)	(2.59)	(100)
B	1.8244	0.0955	1.8188	0.8436	3.15	0.09	3.24
	(31.06)	(51.56)	(17.38)	(100)	(97.27)	(2.73)	(100)
C	2.7915	0.3273	3.4732	0.9303	3.37	0.24	3.60
	(31.02)	(66.62)	(2.36)	(100)	(93.46)	(6.54)	(100)
D	2.1547	0.3024	0.9277	0.6381	4.35	0.22	4.57
	(28.69)	(67.35)	(3.96)	(100)	(95.18)	(4.82)	(100)
E	1.6178	0.2257	1.0084	0.4304	2.41	0.21	2.61
	(26.81)	(68.28)	(4.91)	(100)	(92.08)	(7.92)	(100)
F	4.208	0.5414	1.814	0.6225	0.62	0.36	0.98
	(10.13)	(84.14)	(5.73)	(100)	(63.08)	(36.91)	(100)
G	3.8451	0.2626	4.6438	0.4767	0.28	0.24	0.53
	(9.98)	(87.72)	(2.30)	(100)	(53.56)	(46.44)	(100)
H	2.5192	0.3475	1.8263	0.3927	1.13	0.18	1.32
	(9.21)	(88.88)	(1.91)	(100)	(86.11)	(13.89)	(100)
I	2.0913	0.2109	2.0617	0.2305	0.56	0.15	0.71
	(6.86)	(90.80)	(2.34)	(100)	(78.59)	(21.41)	(100)
J	3.5741	0.1064	2.9303	0.344	0.71	0.15	0.85
	(5.34)	(87.63)	(7.03)	(100)	(82.84)	(17.15)	(100)

K	4.8231	0.3117	0	0.3393	0.15	0.21	0.37
	(5.31)	(94.69)	0	(100)	(42.24)	(57.76)	(100)

Note: The composition percentages of the various assets and the diversification effects are reported in parentheses.

4.2. Comparison of capital charges between the standardized and the internal model method approches

The VaRs of 11 actual portfolios of the securities firms are estimated to compare the capital charges for various portfolios based on the two alternatives, namely, the standardized and the internal model approaches. Let us recall that the risk weights of the standardized method set by the Basel Accord are more favorable to the riskier assets than to the riskless assets. As a result, the capital savings resulting from the internal model method, relative to those arising from the standardized approach, depend on the characteristics of the portfolios of the financial institutions. 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, we hereby illustrate the risk position of equity in terms of both its original position value and the contract value position. Table 5 compares the capital charges between the standardized 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, I, which suggests that the internal model method is relatively more favorable to safer portfolios and more unfavorable to riskier portfolios. In contrast, the standardized method is relatively more favorable for high-risk financial institutions and unfavorable for low-risk financial institutions. This might thus be inferred from our previous findings regarding the “supervisory discrimination” among different assets in the Basel Accord that the risk weights used in the standardized method set by the Basel Accord favor the riskier assets more than the riskless assets.

Our conclusion from this empirical comparison is that the internal VaR-based model approaches do not necessarily result in capital savings as compared with the standardized method. Whether the internal model approaches can give rise to capital savings depends on the characteristics of the portfolios of the financial institutions. The capital savings would be realized in the case of low-risk financial institutions and would be high only when the portfolio is highly diversified across assets, across maturities and across countries, and more importantly well hedged in a VaR sense, i.e. where the VaR exposure is small. So that only the low-risk financial institutions will choose the internal model approach and the high-risk financial institutions still choose the standardized method as the methods of calculation of capital charges. It may cause a similar moral hazard problem and fail to provide incentive for high-risk financial institutions to develop their own internal models.

Table 6
Comparison of capital charges between the standardized and the internal model approaches

Unit: %

Portfolio	Equity position		VaR	Internal models (1)	Standardized method (2)	Difference (3)=(1)-(2)
	Original value	Contract value				
A	37.79	45.16	1.379	13.0823	7.42	Addition (5.6623)
C	31.02	32.16	0.9303	8.8256	6.73	Addition (2.0956)
B	31.06	29.42	0.8436	8.0028	7.15	Addition (0.8528)
D	28.69	23.9	0.6381	6.0539	7.03	Saving (-0.9761)
F	10.13	10.18	0.6225	5.9059	4.39	Addition (1.5159)
G	9.98	9.86	0.4767	4.5224	4.22	Addition(0 .3024)
E	26.81	15	0.4304	4.0834	6.34	Saving (-2.2566)
H	9.21	7.28	0.3927	3.7252	5.42	Saving (-1.6948)
J	5.34	5.51	0.344	3.2632	6.64	Saving (-3.3768)
K	5.31	5.18	0.3393	3.2189	3.36	Saving (-0.1411)
I	6.85	6.33	0.2305	2.187	4.91	Saving (-2.7230)

Note: The ratios reported in the table are in terms of the percentage of the original value of the overall portfolio.

5. The derivation of "VaR-based risk weights"

To provide the incentives to financial institutions to develop their own internal models, any reasonable VaR-based model should in general provide capital savings. However, the moral hazard problem of “supervisory discrimination” in setting risk weights that arises in the standardized method based on the Basel Accord contributes to the indeterminate capital addition/capital savings relationship between the two capital charge alternatives. Here we will attempt to propose the “VaR-based risk weight” which links the solvency parameters of the internal model with those of the standardized method. In such a way, it can solve 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 in order to encourage financial institutions to develop their own internal models.

In designing the “theoretically correct risk weight,” we start with the rationale for capital requirements stated in the previous section that the risk weights should be set based on VaR in compliance with the homogeneous supervision standard. The reason for this is that the risk weights should reflect their true risk on the condition that the assets with the same risk should be charged the same capital. To do so, the risk weight should satisfy

$$\mathrm{m} = \mathrm{m}_i = \frac{W_i}{VaR_i} \tag{9}$$

$$\mathrm{W}_i = \mathrm{m} \cdot \mathrm{VaR}_i \tag{10}$$

where, m_i : the markup of asset i.

m: the same common markup for all assets under the standardized approach.

W_i : the risk weight attached to asset i.

VaR_i ： the value-at-risk of asset i.

The same common markups set in equations (9) and (10) for all financial assets are designed for the homogeneous supervision standard.

The capital requirement according to the standardized approach should be as follows

$$\mathrm{CS} = \sum_{i=1}^{n} V_i m VaR_i = \mathrm{m} \sum_{i=1}^{n} V_i VaR_i \tag{11}$$

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

$$\begin{aligned} \mathrm{CI} &= \mathrm{V}_p \, \mathrm{VaR}_p \sqrt{T}\,\mathrm{M} \\ &= \sum_{i=1}^{n} V_i VaR_i \,(1-\mathrm{D}) \sqrt{T}\,\mathrm{M} \end{aligned} \tag{12}$$

where V_p : the initial portfolio value.

T: the holding period of VaR.

M: the multiplication factor of the internal model approach.

D: 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 savings arising from the internal model method relative to the standardized building block approach is the diversification effect (including the hedge effect). Not only is there a partial offset in the building block approach proposed by the Basel Committee, but we also permit a complete offset such that the hedging effects become closer between the internal model method and the standardized approach. The advantage in terms of the capital savings resulting from the internal model approach relative to the standardized approach is that this approach can thus be reduced to only the diversification effects(excluding the hedge effect). To ensure that there are capital savings from the internal model approach relative to the standardized approach, we combine equation (11) with equation (12) to set the same common markup for the risk weights of all assets as

$$m = \sqrt{T}\, M \tag{13}$$

Based on equation (13), the capital savings arising from the internal model approach relative to the standardized approach simply 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 (9) into equation (13) yields

$$\frac{W_i}{VaR_i} = \sqrt{T}\, M \tag{14}$$

Thus, the "theoretically correct VaR-based risk weights" are obtained as

$$W_i^* = VaR_i \sqrt{T}\, M \tag{15}$$

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 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 standardized 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 standardized approach and the internal model method.

6. Conclusion

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. In addition, any reasonable VaR-based model should in general provide capital savings in order to provide banks with incentives to develop their own internal models. The internal VaR-based model approach provides well-capitalized financial 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 financial 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 behavior. Such an approach may thus benefit both the regulatory authority and the equityholders.

However, under the risk weights set by the Basel Accord, our empirical findings suggest that the weights set by the Basel Accord do not reflect the financial risk properly since the riskier the asset is, the lower is the "capital charge markup." Put in another way, the risk weights used in the standardized method are more favorable to the risk assets than the riskless assets. There might thus exist significant "supervisory discrimination" among different assets under the Basel Accord. As a result, the regulators will fail to reduce the insolvency risk of the financial institutions to an acceptable level to achieve their capital regulation goal. The internal VaR-based model approach does not necessarily provide capital savings to encourage the financial institutions to develop their own internal models that can reflect the riskiness of a portfolio efficiently. Whether or not the internal model approach can provide capital savings depends on the characteristics of the portfolios of the financial institutions. In general, the capital savings will occur only in the case of low-risk financial institutions. The high-risk financial institutions will choose the standardized method as their calculation tool of capital requirements. It may cause a similar moral hazard problem and fail to provide incentive for high-risk financial institutions to develop their own internal models.

To introduce more risk sensitive capital requirements and provide financial institutions with incentives to develop their own internal models, we propose the adoption of "VaR-based risk weights" that link the solvency parameters of the internal model with those of the standardized method as well. Thus, it can resolve the moral hazard problem of "supervisory discrimination" arising from the risk weights prevailing internationally as set by the Basel Accord and ensure that capital savings result from the internal VaR-based model in order to encourage the financial institutions to develop their own internal models. 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 of the standardized approach and the multiplication factor 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 standardized approach and the internal model method.

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