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## **Book Review of Risk Management**

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**Risk Management**  
by **Michel Crouhy, Dan Galai and Robert Mark**  
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*Risk Management* offers comprehensive coverage of the design and operation of a risk management system: its technical modelling and its interplay with the external regulations by which such a system is governed. More specifically, it provides a framework for viewing the policies, methodologies, data collection, and technical infrastructure used to support risk management. Investment, hedging, and management strategies are discussed. Attention is given to the measurement of market, credit, and operational risks as integrated in a multi-period market model as well as to liquidity risk and other long-term, horizon-risk management policies. The book looks at the role of the risk manager, often a key member of the senior executive team in any firm where risk is a key factor affecting corporate value, such as in banks and other financial and non-financial organizations. In this book, the authors provide the product of their academic researches and their practical work in the field.

The first four chapters present an introduction to the purpose and role of risk management: the place it holds in the institution; how the system itself is managed, particularly with regard to its regulation and its extensive internal role in guiding and meeting the requirements of the institution's external overseers. Chapter 1 treats the need for risk-management systems in financial institutions, while chapter 2 covers the current international regulations governing banks. In Chapter 1, the authors point out that banks are now increasingly engaged in what might be called "risk shifting" activities. These activities keep raising the ante for expertise and know-how in controlling and pricing the assets that banks manage in the marketplace (page. 2). As derivatives are the essential instrument of risk shifting, banks now practice not only capital intermediation but also risk intermediation. Chapter 1 also presents an interesting historical review of the evolution of various derivative products in different markets since their introduction in 1972.

Chapter 2 offers a good description of the foundation and historical evolution of the regulatory environment in which banks currently operate, stressing in particular the links with deposit insurance. The current regulation for market risk is analysed in detail in Chapter 4. Finally, Chapter 1 reviews the basis of portfolio management, seeing that this concept will be revisited in many chapters of the book. The authors are particularly strong advocates of the need to develop a portfolio-management approach to credit risk, in order to obtain an accurate diversification of this risk and help the different institutions develop adequate overall credit-risk strategies for setting optimal capital requirements. The last part of Chapter 2 provides a critical review of the current regulatory environment and analyses the different proposals for the next Bank of International Settlements (BIS) accord, now scheduled for 2005.

Chapter 3 is concerned with a framework for best practices in risk management, whereas Chapter 4 reviews, in detail, the current Bank of International Settlements capital requirement for market-risk management and compares standardized models to the internal models that banks can use for reporting regulatory capital. Institutions often fail to structure and supervise risk management even though this is fundamental to obtaining the desired results. The fact that two of its authors have experience in banking is a plus for the book. They give a detailed account of the way risk management is organized in a financial institution, with special emphasis on those authorized to control risk in the organization. According to the authors, everyone in the firm must understand the roles and responsibilities related to risk management, including its links with senior management, trading-room management, and operations. Two elements crucial to an efficient risk-management system are the process for delegating authority and the structure for monitoring risk. The audit's currently popular role is also analysed. Finally the authors show how to establish risk limits and how to manage liquidity risk, another popular subject since the LTCM "default" in 1998.

Chapter 4 compares a bank's internal risk-management system to the standardized approach of the Basle regulation. Since 1998, banks have been free to choose either of these two approaches to market-risk management, though they are still obliged to follow the Basle regulation for credit risk. The message of the chapter is that well diversified banks have a strong advantage in using internal models which let them set their capital requirements in direct relationship with the optimal economic capital corresponding to their true portfolio risk. In point of fact, the standardized approach yields a much higher capital charge for general market risk than the internal VaR model when the portfolio is well diversified.

Chapters 5 and 6 analyse the measurement of market risk in detail, with particular emphasis on the VaR approach. Stress testing and scenario analyses are also covered. Variants of the standard market-risk VaR related to the Normal distribution assumption—such as incremental-VaR, delta-VaR, dynamic VaR, and E-VaR—are analysed along with examples. Space is also devoted to errors in measurement and the back-testing of the models. Equity-price risk, interest-rate risk, foreign-exchange risk, and commodity-price risk are studied in detail in portfolios containing linear and non linear derivatives. The Greek risk measurements for portfolios containing options are reviewed as well as their weaknesses. Parametric and non-parametric VaRs are compared for different time horizons and Monte Carlo simulations for estimating VaR are discussed. Chapter 6 overviews the different extensions of the standard VaR approach and covers the testing of the different models.

A large part of the book ( the six chapters from 7 to 12) is devoted to credit-risk management. The authors present in detail and evaluate the major competing models for measuring and valuing credit risk. They cover credit-risk rating and migration, credit-risk measurement, and portfolio credit-risk management. The regulation of credit risk is still elementary and quite arbitrary. As a result, the capital-risk requirement regulated may often differ from banks' optimal economic capital risk. This may be one of the factors that prompted banks to move into securitization activities designed to maintain the capital they require by selling low-risk assets and holding high-risk ones in order to increase their profits. It should be mentioned that, under current regulations, banks are obliged to maintain much higher capital reserves for many good-

risk private corporations than those required for many government bonds. Moreover, the same percentage must be used for all private firms whatever their rating. These rules were supposed to be revised in 2002 but the revision was postponed for lack of agreement among the different parties, including the major banks. This lack of agreement may be partially explained by the operational risk discussed in Chapter 13. We must also mention that these chapters on credit risk are backed up by numerous appendices covering many technical developments not found in similar books. For example, two appendices to Chapter 8 present the Elements of Merton's model as well as the Default Prediction- Econometric Model, whereas two appendices to Chapter 9 discuss the Integrating Yield Spread with Options and Risk Neutral Valuation Using "Risk Neutral" EDFs. Many of the book's other chapters also contain very useful appendices.

Chapter 7 is devoted to the description of credit-risk systems. Internal and external risk-rating methods (those of agencies such as Moodys' and Standard and Poor's) are described in detail, including those used to rate debt and the migration of credit risk. Chapter 8 describes the CreditMetrics model. It shows how to calculate the credit VaR and the corresponding capital requirement for a portfolio of bonds, taking into account the credit-risk correlations between the different bonds in the portfolio. The authors also discuss the usefulness of having conditional default probabilities and conditional transition probabilities that would take different macroeconomic factors into account. This part of the research is not well developed in the literature because the actual data sets do not cover enough years to take the different credit cycles into account. The recovery rates in case of default are not very well documented in this literature. CreditMetrics, for example, uses the maturity of the debt as a basic model, but this seems insufficient, particularly when the macroeconomic cycles are again considered. Recovery rates should at least be a function of interest rates.

Chapter 9 covers a competing approach in the market: the contingent claim approach. The major difference between the two approaches is related to the data used to estimate the ratings for transition probabilities. In the CreditMetrics approach the information comes from the historical frequencies of default and credit migration. Two crucial assumptions are made in this approach: (1) all firms in a given credit class have the same probabilities of default and transition, and (2) the actual default rate is equal to the average historical default rate without any weight for the more recent record. KMV has developed an alternative to the credit-migration approach. It is based on the structural model developed by Merton, where the economic value of default is presented as a put option on the value of the firm's assets. Each firm can thus be analysed separately when the data are available. The authors develop the model and show how to estimate the credit risk of a firm by using its equity value to approximate its assets. Correlations between the returns on assets are useful for estimating the correlations between default probabilities and for computing the credit VaR of an entire portfolio.

Chapter 10 is devoted to two other models used in the market: the Actuarial ( or Credit+) Model and the Reduced Form Model. Chapter 11 compares the different models with real data. The authors obtain that, when the parameters are correctly harmonized, few differences are observed in the results. But they also show that "the differences between the models become more important, in relative terms, at higher (percentage) loss levels" ( page 430). Finally they

recommend that banks should rely on their internal rating system for their middle-market portfolio, since small private firms cannot be directly compared to large public firms.

Chapter 12 looks at the hedging of credit risk, which is, of course, another form of protection and a way of reducing capital requirement as well as of collateralizing debt or netting positions. Emphasis is put on credit swaps. Chapter 13 introduces operational risk and Chapter 14 focuses on capital allocation among the different activities or departments. The authors explain how to develop operational risk control and measurement and how to implement the RAROC model to measure performance and allocate economic capital. Chapter 15 is concerned with model risk.

Though it may represent a significant share of a bank's total risk, operational risk is a quite new subject for the Basle Committee. According to the authors, total risk can be divided into three main categories: 70% for credit risk, 10% for market risk, and 20% for operational risk. Moreover, since market and credit risks will be more diversified in the short run, operational risk may become more significant in relative terms. The major problem with operational risk is that its definition is quite vague in the financial literature and even in the Basle documents. So, it is difficult to impose a rule or a method that will fix the capital requirement for regulation.

Chapter 13 is a very good introduction to operational risk even though the technical models to measure it are not presented. This stands in sharp contrast to the chapters on market and credit risks. In fact the authors present the framework developed at CIBC to control this risk. Operational risk is related to the risk of operating a business. It includes the risk of computer breakdown, a bug in the software, errors of judgement, fraud,... It is interesting to observe here that unlike market and credit risk, operational risk is more subject to moral hazard. So if a bank covers this risk it must also introduce the appropriate incentives to reduce this potential behavioural problem to a minimum. The same comment applies if the institution chooses to transfer this risk to outside risk-takers such as insurers.

The authors separate the operational risk into two major components: risk of operational failure (internal to the firm) and strategic operational risk ( external to the firm). The first is related to any failure in the course of operating the business, whereas the second arises from environmental factors beyond the firm's control, such as a change in regulation or competition, an earthquake or even a new political regime. The authors limit their analysis to the operational failure component and divide the severity of this risk into two categories: one that is expected and another that is unexpected. As for the management of other types of risk, they insist that success in controlling them will depend on how well the firm coordinates its business infrastructure with internal auditing and risk management. They present a long section of the chapter to show how this coordination can be developed. The main objective is to develop ways of measuring this risk, this would involve: computing an operational-risk VaR for optimal capital requirement; implementing stress testing procedures; and allocating capital according to the results.

One major problem with operational risk is the lack of accurate data, particularly for large losses. One possibility discussed in the literature is to transfer the catastrophic portion to external risk-takers such as insurers and reinsurers. But, as mentioned before, this risk is subject to moral hazard and it is not clear that the insurance market will take it over at a low price without clear

incentive schemes and strong transparency in management and auditing. Since all the data needed are not available in the short run, the authors suggest that a meaningful part of the exercise should be devoted to setting qualitative measurements for some of these risks. The authors are confident that the banking industry will develop internal models for managing operational risk comparable to those now used for market and credit risks and that the BIS will be more willing to take these models into account when setting the regulated required capital.

Capital allocation is very important for banks, as it is for any other financial institution. The authors focus their attention on the risk-adjusted return on capital (RAROC) methodology and present it as “a critical component of the integrated risk management framework.” The RAROC analysis can in fact be used to determine how much capital is required in each business line. It is also a good instrument for managers who need to make a fair trade-off between risk and return. The definition of capital is important for the application of the RAROC methodology.

Once again the authors take the time to distinguish economic capital from regulated capital. Economic capital is designed to “absorb unexpected losses, up to a certain level of confidence” which is usually between 95% and 99% because it would be too costly to operate at a 100% level. Regulatory capital is derived from a set of rules issued by a regulatory agency or, in the case of banks, by the BIS. The two definitions may not coincide because the rules may not take account of the different parameters required to obtain the optimal level of capital needed in a given institution, parameters such as the correlations between the different risks in the portfolio or the average empirical credit risk of a group of public or private institutions.

It is, of course, the economic definition that matters for financial institutions, provided their internal models are adequate or free of significant model risks, a subject to which we shall return when examining Chapter 15. We know that, since 1998, banks have been allowed to use their internal model for computing their level of regulatory capital for market risk, and this is a first step in reducing the gap between the two definitions. However, this internal use is subject to the regulated conditions already discussed for Chapter 4.

The authors next show how to apply the RAROC methodology to the three major risks— market, credit, and operational—and propose an integrated capital management process. A prerequisite for the use of such management tools is, of course, obtaining the collaboration of all decision levels in developing an efficient risk-management information system. The remainder of the chapter shows how to implement a RAROC model and how to measure risk-adjusted performance by applying what they call a second-generation RAROC model that takes into account regulatory constraints.

Model risk is a very important chapter for institutions that plan to use internal models. Many institutions lose money because their internal models have not been adequately implemented, particularly as concerns settings for different complex financial products. Some classic examples are discussed in Chapter 15 and their sources of errors are well documented. The different theoretical sources of model risk are also well documented.

In Chapter 16 the authors turn their attention to the risk management of non-banking corporations. The authors review the determinants for risk management and the procedure for risk management, related in most part to accounting issues, a subject that seems to have been neglected by the different regulatory authorities over recent years.

Finally the book ends with a look at the future of risk management, affording the authors the opportunity to return to their favourite topic: the integration of risk management.

## **Conclusion**

We very much enjoyed reading this book. It covers with great competence all the aspects of risk management with which banks must deal. Many of the chapters are also very useful for other financial institutions. The book reflects the strong academic and practical competence of its team of authors. The detailed treatment of both credit and operational risk is still relevant and the emphasis placed on risk control and auditing is timely in the light of recent events.

Some expansions would be welcome for the third printing. There should be more detailed analyses of the empirical issues involved in the risk-management needs of non-banking firms. It was the regulation of capital that motivated the development of strong risk-management teams in banks. One factor of this motivation was that arbitrary rules for setting regulated capital forced banks into the costly practice of holding large and inadequately justified reserves. These issues are still on the table for credit risk and operational risk and (at least for the latter) it seems unlikely they will be resolved before 2005. These issues are a less intense concern for non-banking institutions and it would be interesting to have a longer discussion on what distinguishes other financial firms or funds from banks.

Empirical analyses of the reasons motivating non-financial firms to implement risk management systems are now available in academic journals and they would be a welcome complement to Chapter 16.

Another topic not covered is the securitization activity of the banks and its role on risk management. It would be interesting to know the links between optimal capital, the intensity of the securitization activity and the bank overall risk.

The first two printings of the book contain many typos and errors in the tables. We report a list in the Appendix. The authors should see that they are corrected in the third printing.

We recommend the book to all academics and professionals and also encourage its use in graduate courses in risk management. But please wait for the third printing which should be available soon.

## Appendix

### Chapter I

- P. 17, Table 1.4 : total amounts for all **504** banks with derivatives.
- P. 26, Line 7 : at \$13.27 instead of \$13.
- P. 26, Line 16 : should be \$3.75 instead of \$3.90.
- P. 30, Table 1.6 : Fuji Bank : 34 instead of 39.
- P. 41, Line 7 : April 1998 instead of April 1999.

### Chapter II

- P. 57, Figure 2.1 :  $\times$  instead of  $-$ , at two places.
- P. 75, Line 4 from below :  $B^-$  instead of  $B^+$ .

### Chapter III

No comment.

### Chapter IV

- P. 148, Line 16 : Table 4.6 instead of 4.8.
- P. 157, Line 14 :  $\sigma_m^2$  instead of  $\sigma_m$ .
- P. 157, Line 22 :  $\sigma_{u_i}$  instead of  $\sigma_u$ .
- P. 157, Line 26 : both summations are to  $n$ .
- P. 158, Line 1 : summation to  $n$ .
- P. 158, Line 7 : the equation should be  $SR_p = P \sum_{i=1}^n x_i \sigma_{u_i}$ .
- P. 168, Table 4.13 : The calculated VaR values do not correspond to the formula  $2.33 \sigma |\Delta V_0|$  as suggested. For example, 20,588 should be replaced by 20,569 and 862,879 by 862,510. However, these differences do not affect the conclusions in the chapter.

### Chapter V

- P. 199, last equation from below: A + sign instead of a  $-$  one after  $\ln$  (1).
- P. 203, Table 5.4 : first line + 1 instead of  $-1$ .
- P. 203, first equation under the Table 5.4,  $-430.63$  dy instead of  $+430.63$  dy.
- P. 204, first equation :  $+2\rho \frac{D}{1+y}$  instead of  $-2\rho \frac{D}{1+y}$ .
- P. 204, third equation : there is a + sign instead of a  $-$  one after  $10^{-4}$  and the number  $-0.0726$  has to be in parentheses.
- P. 209, Table 5.7 : Line 1, column 2 :  $-\$0.05$  instead of  $-\$0.11$  and  
Line 3, column 2,  $-\$0.11$  instead of  $-\$0.05$ .
- P. 210, Table 5.9 :  $+\$0.09$  instead of  $-\$0.09$  and  $+\$0.06$  instead of  $-\$0.06$ .



P. 213, Equation 29 :  $\sqrt{\Delta t}$  instead of  $\Delta t$  in  $\sigma\sqrt{\Delta t}Z$ .

## Chapter VI

No comment.

## Chapter VII

4 numbers must be changed in Table 7.11 (p. 288) in order to be in accordance with the text.

Line 1 :	AA	BB
	11.06	2.27

Line 1 of the second group :	AA	BB
	9.67	2.09

P. 291, Notes, Table 7.12 : 100.563 instead of 109.124 to both places.

## Chapter VIII

Table 8.1 : The horizontal sum for the BBB is 101%!

Table 8.5 : Always 2% as difference: 109.35; 109.17 and so on. For example, in Box 8.1, the true number is 107.53.

Table 8.7 : Should be 1.47 (0.18 + 0.12 + 1.17) with the B and not the CCC for 99 percent confidence level, as suggested on page 329. (So, the  $\Delta V$  must be -9.45 instead of -23.91.)

## Chapter IX

P. 363, Table 9.2, last column : 2.7 instead of 2.5; 9.6 instead of 8.4; 14.6 instead of 12.5; 20.7 instead of 17.3.

For the .20 column : 1.7 instead of 1.5; 4.6 instead of 4.1; 9.5 instead of 8.3.

For the .10 column : 0.9 instead of 0.8; 4.6 instead of 3.1.

For the .05 column : 0.0 instead of 0.1; 2.2 instead of 2.1.

P. 365, in the formula for  $d_2^1$  : T should be outside the parentheses. In fact, if the exact values from the Normal Table were used, the cost of default would have been 3.37 instead of 3.39. The exact ratio for the expected recovery value is  $0.135/0.241 \times 100 = 56.016$ .

P. 366 : There is no minus sign before  $\frac{1}{T} \ln \left( \frac{F}{F - EL_T} \right)$ .

P. 382 : Three lines from below, we should read :  $-d_2 - (\mu - r) \frac{\sqrt{T}}{\sigma}$ .

P. 384 : Combining (19) and (21) instead of (15) and (17), below (21).

P. 386 : In the cov ( $r_i, r_j$ ) expression, we should have  $\beta_{1i} \beta_{1j} \text{ var}(I_1)$  instead of  $\beta_{1i} \beta_{2j} \text{ var}(I_1)$ .

P. 394 : In the table, 52.42 is the total of  $PV_1$  and 46.65 is the total of  $PV_2$ .

## Chapter X

P. 414 : Figure 10.4, last column :  $\lambda = 0.94$  and  $1 - \lambda = 0.06$ .

P. 417, Table 10.4 :

Cumulative Default Probabilities : $P_t$ (%)	Conditional Default Probabilities : $p_t$ (%)
0.48	0,48
0.96	0.87
1.83	1.28
3.11	2.09
5.20	2.18
7.38	2.59
9.97	2.97

## Chapter XI

OK

## Chapter XII

P. 460, Figure 12.9 : The arrow at the top should be in the other direction.

## Chapter XIII

No comment.

## Chapter XIV

P. 559, Figure 14.19 : \$14.4 ( $3\% \times \$480$ ) instead of \$14.4 ( $3\% \times \$400$ ).

P. 571, 572 and 575 : We have some difficulties with the numbers on page 575 because it is not clear to us whether  $(A_2)$  (p. 571) and  $(A_3)$  (p. 572) are adequate. Our evaluation suggests that in  $(A_2)$  we should have  $\sigma_z^2$  instead of  $\sigma_z$  and in  $(A_3)$ ,  $-0.5\sigma_y^2$  instead of  $-5\sigma_y^2$ .

## Chapter XV

P. 605, Line 12 :  $\$44 \times 2.33 \sqrt{10} = 324$  million instead of 993 million.

## Chapter XVI

P. 649, Table 16.2 : 2,942.2 instead of 2.914.2.

## **Chapter XVII**

No comment.