

# Capital Regulation for Position Risk in Banks, Securities Firms and Insurance Companies<sup>1</sup>

Richard Herring	Til Schuermann <sup>2</sup>
Wharton School, University of Pennsylvania	Federal Reserve Bank of New York
2300 Steinberg / Dietrich Hall	33 Liberty St.
Philadelphia, PA 19104	New York, NY 10045
herring@wharton.upenn.edu	til.schuermann@ny.frb.org

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**Abstract:** We examine why these regulatory differences exist and what they imply for differences in minimum capital requirements for position risk. We consider differences in the definition and measurement of regulatory capital and we quantify differences in the capital charges for position risk by reference to a model portfolio that contains a variety of financial instruments including equity, fixed income instruments, swaps, foreign exchange positions, and options – instruments that may appear in the portfolios of securities firms, banks or insurance companies. For most leading firms in the financial services industry, however, market forces, not minimum regulatory capital requirements, appear to play the dominant role in firms' capital decisions. Thus we conclude by considering measures to enhance market discipline.

**Keywords:** Risk management, Value-at-Risk, Capital Regulation, Market Risk

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## **1 Introduction**

Currently banks, securities firms and insurance companies conduct trading businesses involving many of the same financial instruments and several of the same counterparties, but subject to very different capital regulations. In this chapter we examine why these regulatory differences exist and what they imply for differences in minimum capital requirements for position risk, one of the key risks confronting financial institutions.

We will consider differences in the definition and measurement of regulatory capital and we will quantify differences in the capital charges for position risk by reference to a model portfolio that contains a variety of financial instruments including equity, fixed income instruments, swaps, foreign exchange positions, and options-instruments that may appear in the portfolios of securities firms, banks or insurance companies. For most leading firms in the financial services industry, however, market forces, not minimum regulatory capital requirements, appear to play the dominant role in firms' capital decisions. Thus we conclude by considering measures to enhance market discipline.

### **1.1 Position Risk in Securities Firms, Banks, and Insurance Companies**

“Market risk” is the “the risk of losses in on- and off-balance-sheet positions arising from movements in market prices.”<sup>3</sup> “Asset liquidity risk” is generally combined with market risk and represents “the risk that an entity will be unable to unwind a position in a particular financial instrument at or near its market value because of a lack of depth or disruption in the market for

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<sup>3</sup> Basel Committee on Banking Supervision (1996) p. 1.

that instrument.”<sup>4</sup> In what follows, we will use the term “position risk” to refer to the combination of market risk and asset liquidity risk.

Position risk that is large relative to an institution’s capacity to bear loss can seriously injure or even destroy a financial institution. Over the past thirty years the list of financial institutions that have been severely harmed by excessive position risks includes Franklin National Bank, Bankhaus Herstatt, Barings Bank, Piper Jaffray, Banesto, Credit Lyonnais, Daiwa Bank, Long Term Capital Management, and Allied Irish Bank.<sup>5</sup> A much longer list of firms, including many of the most active international financial institutions, has incurred trading losses that have exceeded at least one quarter’s earnings.

Position risk is the most important category of risk facing securities firms because proprietary positions in a wide range of financial instruments are closely allied with the core activities of underwriting, trading, and dealing in securities. Consequently, position risk has been the principal focus of capital regulation among securities regulators. Although the International Organization of Securities Commissions (IOSCO) has tried to harmonize capital requirements for securities firms internationally,<sup>6</sup> substantial differences remain among even the Group of Ten (G-10) countries that comprise the Basel Committee on Banking Supervision (Basel Committee or BCBS). The members of the European Union (E.U.) have harmonized the regulation of position risk in securities firms (as well as banks) with the adoption of the Capital Adequacy Directive (CAD) in 1993,<sup>7</sup> but securities regulators in Canada, Japan, the United States and other non-E.U. countries rely on a different framework that requires securities firms to maintain

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<sup>4</sup> Joint Forum (2001) p. 17.

<sup>5</sup> See, *inter alia*, Crouhy, Galai, and Mark (2001) and Jorion (2001).

<sup>6</sup> See Dimson and Marsh (1995, pp. 831-33) for a discussion of the abortive attempts to reach international agreement on capital requirements for securities firms. There were extensive negotiations to harmonize the capital regulation of position risk not only for securities firms, but also for internationally active banks.

minimum levels of highly liquid assets to meet promptly all obligations to customers and other market participants. In the quantitative analysis that follows, we will focus on the E.U. CAD approach and the U.S. SEC (Securities and Exchange Commission) net capital approach (NCA) because the securities firms that conduct the largest volume of cross-border activities are headquartered in these countries.

Credit risk is the most important category of risk for most banks and so the main focus of bank capital regulation has been credit risk.<sup>8</sup> Indeed, capital regulation for credit risk was the subject of the first internationally coordinated attempt to harmonize capital regulation in the financial services industry, the Basel Capital Accord.<sup>9</sup>

Large internationally active banks have always been active participants in some financial markets, particularly foreign exchange markets, to serve the needs of their clients and to conduct their own proprietary trading operations.<sup>10</sup> But as many of the banks' most creditworthy clients began to substitute capital market instruments for bank loans, banks began to serve these clients more actively in their trading rooms than on their balance sheets. Position risk became an increasingly important factor at these banks and so the regulatory authorities responded with an Amendment to the Capital Accord to encompass position risk in capital regulation (BCBS1996a). The amendment provided internationally active banks with a choice between a standardized approach (similar in spirit, but significantly different in detail from the NCA) and

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<sup>7</sup> Capital Adequacy Directive (93/6/EEC) and its amendments are virtually identical with the Basel Committee Amendment on Market Risk (BCBS 1996a) and applies to both banks and securities firms in the European Union.

<sup>8</sup> Kuritzkes, Schuermann, and Weiner (2003) report the results of a benchmarking study conducted by Oliver, Wyman & Company that surveyed the internal economic capital allocations of nine leading international banks in Europe and North America, as well as summarizing other practitioner studies. In each case the amount of economic capital allocated for credit risk far exceeded allocations to market/asset/liability management risk or operational risk.

<sup>9</sup> Basel Committee (1988).

<sup>10</sup> The ten financial institutions with the largest share of foreign-exchange market activity in 2001, which together accounted for 53.4% of total activity, included four U.S. banks, two U.S. securities firms, three European universal banks and a British bank (Wilke 2002).

the supervised use of the banks' own internal models for setting capital charges for position risk. In the quantitative analysis we will focus on the standardized approach and three different kinds of internal models used in internationally active banks. These Basel approaches to setting capital charges for position risk provide the framework within which internationally active banks and European securities firms operate.

In contrast to banks and securities firms, the main risk to insurance companies springs from the liability side of the balance sheet rather than the asset side. The fundamental risk facing insurance companies is "underwriting risk," the risk that they will be unable to pay their contractual obligations to policyholders. This may occur because estimates of future payouts under the terms of insurance contracts are too low relative to the premiums charged so that technical provisions are inadequate to meet the claims of policyholders.<sup>11</sup> Capital regulation in the insurance industry has focused mainly on establishing a buffer to make sure that insurance obligations can be met even if technical provisions prove insufficient.<sup>12</sup> But the adequacy of technical provisions depends not only on estimates of payouts under insurance contracts and costs of dealing with claims, but also on the returns on invested premiums and so insurance companies are also subject to position risk (although the term is not generally used in the insurance industry). Insurance companies tend to characterize this as asset or investment risk.<sup>13</sup>

Insurance regulation has not generally focused on position risk per se, even though in most G-10 countries insurance companies hold larger amounts of financial securities than banks (IMF 2002, p. 33). E.U. rules do not make an explicit charge for position risk, although

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<sup>11</sup> Technical provisions must take account not only of the expected payout, but also future premiums and investment income. For an excellent discussion of technical provisions see Annex 3 in Joint Forum (2001), pp. 85-90.

<sup>12</sup> As pointed out in Joint Forum (2001), p. 29, capital plays a smaller role in absorbing volatility for insurance companies than for banks due to the importance of these technical provisions.

<sup>13</sup> Joint Forum (2001), p. 17

presumably it is implicitly taken into account in judging the adequacy of technical provisions.<sup>14</sup> Instead, countries in the European Union rely primarily on strict rules regarding permissible investments and limits on concentrations of investment. Nonetheless, many of the largest insurance companies in Europe have sustained heavy losses during 2002 because of declining prices on world equity markets (Economist 2003). In the United States, however, the National Association of Insurance Commissioners (NAIC) has developed a risk-based capital framework (RBC) that sets an explicit capital charge for investment risk as the weighted sum of assets where the weights implicitly reflect not only market risk, but also credit risk and operational risk. Since this approach is more comparable to the regulation of position risk in banks and securities firms than the E.U. approach, we will focus on the NAIC approach for insurance firms in the quantitative analysis.

## **2 The Rationale for and Scope of Capital Requirements for Position Risk**

The literature on the general rationale for capital regulation in financial institutions is extensive and has been the subject of several recent surveys (Ball and Stoll 1998; Benston 1999; Berger, Herring, and Szegö 1995; Dimson and Marsh 1995). Rather than review this literature, we will highlight similarities and differences in the rationale for and consequent differences in the scope of capital regulation in the three sectors of the financial services industry--banks, securities firms, and insurance companies.

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<sup>14</sup> This may be subject to change. A recent report to the European Commission (KPMG 2002, p. 17) recommended that a new risk based system should include market risk as well as underwriting risk and credit risk.

## 2.1 Consumer Protection

One common objective of capital regulation in each of the three sectors is the protection of consumers from exploitation by opaque and better informed financial institutions. In the banking sphere the objective is depositor protection. In securities regulation, the objective is investor protection. And in insurance regulation, the objective is policyholder protection.<sup>15</sup> Capital regulation is not, of course, the only regulatory tool deployed to protect consumers, nor is it the most efficient regulatory tool for this purpose.<sup>16</sup> But consumer protection is one of the principal explicit reasons used to justify capital requirements for financial institutions in each of the three sectors.

Consumers of financial services--particularly unsophisticated consumers and investors--find it difficult to evaluate the quality of financial information, products, and services provided to them. In part this is because payment for most financial products and services must be made in the current period in exchange for benefits that are promised far into the future. But even after the decision is made and financial results are realized, it is often difficult to determine whether an unfavorable outcome was the result of bad luck, incompetence, or dishonesty. Customers face a problem of asymmetric information in evaluating financial services. Consequently they are vulnerable to *adverse selection*, the possibility that they will choose an incompetent or dishonest firm. They are also vulnerable to *moral hazard*, the possibility that firms or its agents will

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<sup>15</sup> Because the customers of reinsurers are other insurers, not unsophisticated retail clients, reinsurers are not subject to capital regulation in many countries (IMF 2002, p. 49).

<sup>16</sup> Other regulatory tools include fit and proper tests, enforcement of conduct of business and conflict of interest rules, and customer suitability requirements. Insurance that would indemnify customers in the event that the firm cannot honor its obligations also serves this function. Examples would include deposit insurance, pension benefit guarantee insurance, and insurance for customers of brokers and dealers. In the United States, the Securities Investor Protection Corporation insures customers of brokers and dealers against fraud.

subordinate their interests to those of the firm itself or another customer or even engage in fraud.<sup>17</sup>

Capital requirements are intended to mitigate the risks of adverse selection by ensuring that the financial firm has at least some minimal level of resources to honor its commitments to its customers. Capital requirements are intended to mitigate moral hazard by ensuring that the owners of a financial institution have a stake in ensuring that the firm does not engage in fraud and conforms to conduct of business rules, if only to avoid fines or loss of equity value. To be effective in this role, capital requirements must be sensitive to the risks to which an institution is exposed. It follows that if position risk is a significant factor, capital requirements should be sensitive to the position risks taken by a financial institution.

## **2.2 Systemic Risk**

### **2.2.1 Systemic Risk and Banks**

Although regulators in all three sectors emphasize consumer/investor protection, they differ with regard to the emphasis they place on preventing systemic risk. Bank regulators have long regarded the prevention of systemic risk as the fundamental rationale for imposing capital requirements on banks. Systemic risk may be defined as the risk of a sudden, unanticipated shock that would damage the financial system to such an extent that economic activity in the wider economy would suffer. The assumption is that shareholders will not take account of the social costs of systemic risk in their capital decisions and so will tend to hold less capital than if these spillover costs were considered.

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<sup>17</sup> Benston (2000) rejects the consumer protection rationale for regulating financial services arguing that in comparison with other consumer products financial products are less difficult to understand, less difficult to identify

Banks are often thought to be a source of systemic risk because of their central role in the payments system and in the allocation of financial resources combined with the fragility of their financial structure.<sup>18 19</sup> Their financial structure is highly vulnerable to a loss in confidence because of the first-come, first-served nature of their short-term deposit liabilities, the illiquid nature of their loan portfolios and the high degree of leverage they customarily maintain. Diamond and Dybvig (1983) have shown that bank runs can be self-fulfilling prophecies. If no one believes a bank run is about to occur, only those with immediate needs for liquidity will withdraw their funds and, assuming that banks have sufficient liquid assets to meet these normal liquidity demands, there will be no panic. But this is a fragile equilibrium. If, instead, everyone believes a bank run is about to occur, depositors will race to be first in line in order to liquidate their deposits before the losses due to the shock and the consequent rushed sale of illiquid assets exhaust their banks' capital positions. In the Diamond and Dybvig model, the shock may be essentially random (one well-known extension of the model characterizes the shocks as "sunspots") or the shock may be information about a deterioration in business conditions that is expected to erode the bank's capital position.<sup>20</sup>

A shock from one bank may be contagiously transmitted to other banks. This may occur because other banks are exposed (or are thought to be exposed) to similar risks or because of *actual*, direct exposures to the damaged bank in interbank markets and/or the clearing and settlement process that underlies the payments system. More insidiously, this may also happen

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as defective, and, apart from life insurance, shorter in period of service. Moreover, he argues that consumers of financial services have readier access to redress against products that turn out to be "lemons."

<sup>18</sup> Not all observers agree that the prevention of systemic risk should be an important objective of bank capital regulation. See, for example, Benston and Kaufman (1995).

<sup>19</sup> In many countries, banks control 70% or more of the assets in the financial system. In the United States, however, the bank share of total assets has fallen to little more than 20 percent (BIS 1996, p. 126).

because of *suspected* exposures to the damaged bank. In the absence of clear and convincing evidence to the contrary, market participants are likely to assume that the institutions least able to withstand the shock have been damaged by it. They will attempt to protect themselves by liquidating their claims on the suspected, weaker institutions and reallocating their portfolios in favor of claims on institutions perceived to be stronger. The result is a flight to quality.

The real cost associated with a banking crisis is the spillover effect on the real economy. If banks are liquidated, the aggregate capabilities associated with the banks' teams of employees, who are able to distinguish successfully between good assets and bad, may be destroyed. In this case total lending may be cut back a by a large amount and a severe recession may ensue. Although in recent financial crises, such as those in Scandinavia in the early nineties or in the United States in the eighties, governments have prevented the widespread collapse of the financial system by extensive intervention, historically this was not the case. Often banks were allowed to fail in large numbers. In such cases the recessions associated with banking crises were often severe. Recovery depended not only on rebuilding equity capital and reserves, but also on rebuilding new teams of employees that could distinguish between good and bad assets.

The role of risk-sensitive capital regulation in guarding against systemic risk is two-fold. First, capital is a buffer against loss and so the larger an institution's capital relative to its risk exposure, the smaller the probability that it will be fatally damaged by a shock. Second, the larger an institution's capital relative to its risk exposure, the smaller the incentive for shareholders to take risks and therefore the smaller the probability that it will be fatally damaged by a shock (Herring and Vankudre 1987).

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<sup>20</sup> Allen and Gale (1998) develop a model in this spirit based on the empirical work of Gorton (1988) and Calomiris and Gorton (1991) showing that 19<sup>th</sup>-century banking panics were preceded by a downturn in leading economic indicators.

Bank regulators have demanded that capital requirements be applied on a consolidated basis. One of the first papers issued by the Basel Committee (BCBS 1979, p. 1) emphasized the importance of achieving consolidated supervision arguing the supervisors must be “in a position to examine the totality of each bank’s business worldwide.” The principle is further refined in the recent proposed revision to the Basel Accord (BCBS 2001a, p. 11) which details procedures for consolidated corporate parents and siblings of banks.<sup>21</sup>

This emphasis on consolidation stems partly from a concern that banking groups should be constrained from double or multiple gearing by borrowing through one entity to increase the measured equity in a regulated entity. But it also stems from a concern about reputation risk and the assumption that banks are even more vulnerable to contagious transmission of shocks within a banking group than across banking groups. Thus bank regulators insist on monitoring exposures to risk and capital adequacy on a groupwide basis not just an entity-by-entity (or solo) basis. This concern about taking a groupwide view in crisis prevention also extends to crisis management. Bank regulators believe that they need to have a consolidated view of the banking group in order to minimize the systemic consequences of a shock to the banking group since an insolvency in one part of the group is expected to jeopardize the solvency of the banking entities in the group.

### **2.2.2 Systemic Risk and Securities Firms**

In the United States, regulators of securities firms have not been given a mandate to guard against systemic risk. Since investor protection is the main regulatory objective, capital

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<sup>21</sup> In contrast, the Shadow Financial Regulatory Committee has argued that regulation should focus on the insured depository institution and need not be concerned with other entities in the group so long as their liabilities vis-à-vis the bank are strictly limited (Shadow Financial Regulatory Committee 2000).

regulation for position risk extends only to the broker-dealer, the entity that deals with unsophisticated investors, not the consolidated securities firm, which may contain several other entities.

The rationale for this sharp difference in the objectives for and scope of securities regulation flows from four key structural differences between banks and securities firms. First, securities firms segregate customer funds from the firms' own funds. Thus bad news about the firms' own assets need not cause concern about the assets of the firms' clients.<sup>22</sup> Moreover, if a securities firm should fail, it is relatively easy to transfer the assets of that firm to another firm with minimal disruption in services to the client.

Second, liabilities of the securities firm are not deposit obligations payable on a first-come, first-served basis. Instead, they are generally dated, debt instruments such as commercial paper, collateralized loans, or claims that have a pay-off contingent on the performance of the firm. This liability structure protects securities firms from runs motivated by "sun spots" or other disturbances that become self-fulfilling prophecies.

Third, securities firms generally hold liquid, tradable assets that are marked to market daily. This relatively transparent balance sheet reduces the vulnerability of the typical securities firm to the asymmetric information problems that arise from the opacity of a typical bank balance sheet. Moreover, in the event that a securities firm is subject to a loss in confidence and a consequent inability to borrow, it can reduce the size of its balance sheet relatively easily, without incurring fire sale losses on the liquidation of assets.

Fourth, securities firms do not have direct access to large value payment systems. Although securities firms generate very substantial payments in the course of conducting

business for their clients and for their own, proprietary accounts, they rely on commercial banks to clear and settle such payments. Thus the collapse of a securities firm would impact the payments system only to the extent that it caused the collapse of the bank that clears and settles payments on its behalf.

The upshot of these structural differences is that securities firms should be less vulnerable to shocks than banks. Moreover, in the event that a shock, nonetheless, causes a securities firm to become insolvent, the collapse of a securities firm is less likely to spread contagiously to the rest of the financial system and become a source of systemic risk.

In the United States, the most important test of these hypotheses to date is the collapse of the Drexel Burnham Lambert Group (DBLG). When DBLG filed for protection under Chapter 11 of the bankruptcy laws,<sup>16</sup> the authorities limited their role to facilitating an orderly unwinding of the affairs of DBLG and its regulated subsidiaries (Committee on Payments and Settlement Systems 1996, p. 6).<sup>23 24</sup> Client accounts at the regulated broker/dealer were transferred to other firms with minimal disruption of services. The anticipated flight to quality in the government securities market was slight and quickly reversed. Moreover, the Dow Jones average actually finished the day above the previous close.

Can one infer from the absence of systemic disturbances accompanying the collapse of DBLG that securities firms do not pose a systemic threat to the financial system? Four trends in

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<sup>22</sup> In the United States the Securities Investor Protection Corporation protects the assets of clients in case the separation of client funds from the firm's own funds has been compromised through incompetence or fraud.

<sup>23</sup> The solvent, regulated subsidiaries were not included in the filing. Indeed broker/dealers are prohibited from entering reorganization proceedings.

<sup>24</sup> Because of concern over settlement risks, some difficulties were experienced in winding down DBLG's positions in markets that did not clear and settle through simultaneous delivery of instruments against payment. To allay fears that the settlement process might be aborted after delivery of payment to the trustee for DBLG, but before delivery of the securities to the counterparty, the Bank of England intervened to assure market participants that transactions with the trustee of DBLG would be completed.

the international financial system over the decade since the collapse of DBLG suggest that such a conclusion may not be warranted.

First, leading securities firms have become increasingly international. Not only do they participate in securities markets around-the-clock, around the globe, but also they operate through a complex structure of affiliates in many different countries with differing bankruptcy regimes, and so it may be much more difficult to unwind the affairs of a leading securities firm without disrupting markets.

Second, securities firms have increasingly affiliated with commercial banks and/or insurance companies to form financial conglomerates. Universal banking countries have long integrated the securities business with traditional commercial banking, but over the last decade financial liberalization has enabled firms in the United States and Japan, which formerly required strict separation of commercial banking from the securities business, to combine the two activities. When the securities business is integrated with banking, then systemic concerns about banking may extend to the securities business as well.

Third, securities firms have consolidated to form larger and larger entities. Partly this is because the formation of financial conglomerates has often involved mergers and acquisitions, but the pace of consolidation has been even faster among firms in the same segment of the financial services industry. Although it is possible that larger financial firms will be less likely to fail, the occurrence of failure is more likely to be associated with systemic risk since the spillover effects on the rest of the financial system are bound to be greater.

Fourth, the largest firms are becoming increasingly involved in global trading activities, particularly over-the-counter (OTC) derivatives. From 1992 to 1999, OTC derivatives markets quadrupled in notional value (Group of Ten 2001). Moreover, the concentration of activity

among the largest firms increased over the decade with the top 3 firms accounting for 27.2% and the top 10 accounting for 54.7% of the total OTC derivatives activities in the largest centers.<sup>25</sup>

There is also a corresponding increasing concentration of risk in the clearing and settlement systems for payments and securities transactions.<sup>26</sup>

Regulators outside the United States have taken a different view of the likelihood that securities firms may be a source of systemic risk. Indeed, the IOSCO (1998, p. 4) report on the use of internal models to establish position risk requirements lists “the reduction of systemic risk” as the second rationale for minimum capital requirements.<sup>27</sup>

The narrow focus of U.S. capital regulation on the broker-dealer in U.S. securities firms also contrasts sharply with the tradition in Europe. Continental European supervisors have customarily applied consolidated supervision and capital regulation to the securities activities of the universal banks in their domain, just as if they were any other traditional banking activity. Indeed the E.U. Capital Adequacy Directive requires consolidated supervision for institutions headquartered in the European Union and applies equally to banks and securities firms.

With the recent Directive on the Prudential Supervision of Financial Conglomerates, the European Union has gained potential leverage to subject U.S. securities firms to consolidated regulation and supervision. The directive may force securities firms that are not subject to consolidated supervision by a “competent” home country authority to form an E.U. holding

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<sup>25</sup> Based on data provided by the national authorities in France, Germany, Italy, Japan, Switzerland, the United Kingdom and the United States reported in Table I.6 of Group of Ten (2001). Unfortunately, data are not available for the entire decade, but concentration increased markedly between December 1998 and December 1999.

<sup>26</sup> A recent Group of Thirty (1997, p. 7) study on systemic risk includes large securities as “core institutions” that may be a source of systemic risk. Core institutions include “large, internationally-active commercial banks, which are major participants in large-value payments systems, along with the largest investment banks which are key participants in the clearing and settlement systems for globally-traded securities.”

<sup>27</sup> The IOSCO (1989) paper on Capital Adequacy for Securities Firms elaborates on this point asserting that capital adequacy standards should be designed “to achieve an environment in which a securities firm could wind down its

company that will be subject to consolidated supervision in Europe or face substantially higher capital requirements on their European operations.<sup>28</sup>

The U.S. response is evolving. At the request of the Securities and Exchange Commission, the six U.S. securities firms most active in OTC securities markets formed the Derivatives Policy Group (DPG) and agreed to report to the SEC voluntarily on the activities of the unregulated affiliates of regulated broker/dealers in OTC derivatives markets.<sup>29</sup> In addition, the Gramm-Leach-Bliley Financial Modernization Act has given the SEC the authority to authorize an Investment Bank Holding Company that might, in principle, provide some sort of consolidated supervision and regulation of securities companies. The SEC, however, has not disclosed how or, indeed, whether it will implement this part of the legislation. The European Union has made clear that the DPG initiative is not sufficient to meet their concerns, and, while the formation of a Financial Services Holding Company under the supervision of the Federal Reserve Board by a securities firm would meet the criteria of competent consolidated supervision, none of the major, internationally active securities firms that is not affiliated with a bank has chosen to form a financial services holding company.<sup>30</sup>

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business without loss to its customers or the customers of other broker-dealers and without disruption to the orderly functioning of financial markets.”

<sup>28</sup> Section 3, Article 14 (Commission of the European Communities, 2001, p. 24) states “Competent authorities may in particular require the establishment of a mixed financial holding company that has its head office in the Community, and apply to the regulated entities in the financial conglomerate headed by the holding the provisions of this Directive.”

<sup>29</sup> These firms include Credit Suisse First Boston (CSFB), Goldman Sachs, Lehman Brothers, Merrill Lynch, Morgan Stanley, and Salomon Brothers (Derivatives Policy Group 1995).

<sup>30</sup> To date only two large nonbanks have formed Financial Services Holding Companies--Charles Schwab and MetLife. Of the DPG both CSFB and Salomon Brothers are affiliated with banks and are therefore subject to consolidated supervision.

### 2.2.3 Systemic Risk and Insurance Companies

Systemic risk has not been a major preoccupation of insurance regulators, and there has been no evidence of the failure of an insurance company being a significant source of systemic risk.<sup>31 32</sup> Although failures of insurance companies can impose heavy private costs and can disrupt insurance markets they do not appear to generate significant spillover impacts on other institutions and markets.<sup>33</sup> Nor does there appear to be significant contagion across members of a corporate family of insurance companies. For example, ING cut loose a failing insurance subsidiary in London without substantial repercussions for its ability to do business (Ladbury 1995).<sup>34</sup> Since policyholder protection is the primary regulatory objective, capital regulation has tended to be focused on individual insurance companies, on a solo basis, rather than on a consolidated basis.

The main reason for this difference from banks resides in the liability structure of insurance companies. Insurance companies are not reliant on first-come, first-served demand

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<sup>31</sup> Nor does it play a prominent role in academic analysis. Cummins, Harrington, and Niehaus (1993), for example, make no mention of systemic risk in their analysis of the objectives of solvency regulation.

<sup>32</sup> The Group of Thirty (1997, p. 7) study on systemic risk concluded that the insurance companies were not among the core institutions that could be the source of systemic risk: “Core institutions do not include large insurance companies or large finance companies, even those that are very active in international markets. Although these institutions are important by virtue of their size, they present substantially less risk to the system than failure of the core institutions of which they are customers.”

<sup>33</sup> A possible exception to this generalization is provided by the failure of HIH, an Australian insurance company with operations in Europe, Asia, North and South America and a large number of creditors that included several globally active banks. This was the largest failure in Australian history with losses totaling between \$3.6 and \$5.3 billion. Nonetheless, the event did not cause significant volatility in Australian or global capital markets (IMF 2002, p. 54). It did, however, cause substantial dislocations in the construction market although this appears to have been attributable more to its monopoly position in this market than its status as an insurance company. The commission charged with investigating the collapse of HIH (HIH Royal Commission 2003, Chapter 8.2.1) concluded, in its analysis of the rationale for prudential regulation, that “Contagion is less relevant in the insurance industry. The failure of HIH did, however, impose significant costs on other sectors, For example, the building industry was seriously affected when HIH collapsed as builders found it difficult to find warranty insurance cover to projects in some states. This was at least partly the result of the dominance of parts of the builders warranty market by HIH. A market with a larger number of providers may be better able to cope with the failure of one provider than a market dominated by one company.”

<sup>34</sup> Since ING is a financial conglomerate that contains a bank as well as insurance companies, the incident also raises a question about the extent of contagion from a nonbank affiliate to the bank within the group.

liabilities and so they are not vulnerable to a loss of confidence and subsequent pressures to liquidate assets rapidly in order to meet the demands of creditors. Life insurance claims tend to be highly predictable and property-casualty claims can often be paid off slowly (Kuritzkes and Scott 2002).<sup>35</sup> Indeed, property and casualty insurers may delay payments through investigative procedures and litigation. Thus insurance companies are unlikely to find it necessary to incur fire-sale losses on the liquidation of their assets and exacerbate market dislocations by selling assets in markets with falling prices.<sup>36</sup>

In summary, capital regulation in each of the three sectors is motivated by a concern for protecting consumers of financial services. Banking regulation is distinctive, however, in its additional emphasis on capital regulation to safeguard against systemic risk. This concern leads banking regulators to insist on applying capital regulation on a consolidated basis. The differences in scope of capital regulation between securities regulators in the European Union and the United States reflect differences in history, with a tradition of universal banking in continental Europe and a more segmented approach in the United States and the United Kingdom. The European Union applies the same capital regulation for market risk to banks and securities firms on a consolidated basis. The SEC, which lacks a mandate to safeguard the financial system against systemic risk, applies capital regulation to the registered broker-dealer only, not the consolidated positions of the securities firm. Similarly, insurance regulators tend to

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<sup>35</sup> Of course, an insurance company can adopt a liability structure that makes it vulnerable to a liquidity crisis. For example, General America Life issued \$6.8 billion in short-term debt containing an option that permitted investors to redeem their claims with only seven days notice. After a downgrade by Moody's, investors tried to redeem more than \$4 billion, forcing the regulator to intervene (Swiss Re 2000).

<sup>36</sup> A recent IMF report (2002, p. 55) concludes that "many observers--including many involved with the insurance industry in some meaningful ways--have reached a comfort level with the judgment that the international systemic risks associated with the financial market activities of insurance companies are relatively limited. . . ." The report cautions, however, that the collapse of an insurance company could affect financial stability by inflicting losses on counterparties that do play a central role in the payment and securities settlement systems. But this concern applies equally to any large counterparty of a core financial institution.

apply capital regulation on a solo basis, to individual insurance companies rather than to the consolidated position of insurance groups. The upshot is that most insurance groups and U.S. securities firms can take position risks that are not subject to regulatory capital charges.

### **3 Definition of Capital and the Regulatory Disposition of Failing Firms**

Although position risk is subject to capital regulation in all three financial sectors both the capital charges and the definition of capital eligible to meet these capital charges differs from sector to sector. In this section we will examine the rationale for differences in the definitions of eligible capital among the Basel Committee, the SEC, and the NAIC. In the next section we will consider differences in the capital charge for position risk.

Some of the differences in the definitions of regulatory capital stem from fundamental differences in the underlying business and implicit assumptions about how long it would take to detect and merge or unwind a failing institution. Securities firms hold mainly marketable securities that can be valued daily--or even more frequently--and so they can be monitored at frequent intervals at relatively low cost. Moreover, because the positions of a securities firm are mainly marketable instruments, the authorities would expect to be able to achieve a prompt and orderly liquidation in which customer accounts could be transferred to another firm in the event of financial distress, if a merger with a stronger firm was not possible. Since the primary objective of capital regulation is the protection of customers of the securities firm, the regulatory authorities are willing to count as regulatory capital a wide range of instruments that are subordinate to the claims of customers. Subordinated debt, moreover, enables firms to adjust their capital flexibly at relatively low cost as their position risks fluctuate because issuance costs are lower for debt than equity.

Although banks also hold substantial amounts of marketable securities, most bank assets do not trade in broad, deep secondary markets. Thus it is relatively costly to monitor a bank daily and so it is likely that a longer lag will occur before regulators can detect deterioration in a bank's condition. Moreover, because bank regulators are concerned with systemic risk as well as depositor protection, they place a stronger emphasis on remediating a failing firm or finding a merger partner, with the option of liquidating the bank considered only as a last resort. For that reason, bank regulators place heavy emphasis on forms of "patient" capital that can permit the bank to continue operation while absorbing losses and without adding to debt servicing pressures in times of stress. By this logic, debt instruments are considered inferior forms of capital, if they qualify for regulatory capital at all. Even though suitably subordinated debt may protect depositors against loss, it imposes an additional debt-servicing burden on a bank and reduces the time regulators have to identify and attempt to remediate a faltering bank. Moreover, subordinated debt is available to absorb loss only after the bank is declared insolvent.<sup>37</sup>

Although insurance companies also hold substantial amounts of marketable instruments, their contractual obligations are much longer term than those of securities firms or banks. This gives insurance regulators a longer time than their counterparts in the other two sectors to detect and deal with financial distress. Rather than facing immediate pressure to deal with a faltering firm because of deposit runs or margin or collateral calls, insurance regulators face pressure mainly from the slower paced decisions of policyholders to let their insurance contracts lapse or, in the case of some life insurance contracts, from policyholders exercising options to withdraw

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<sup>37</sup> The Basel Committee (BCBS 1988, p. 20) justified limitations on the use of subordinated term debt by noting that such instruments are "not normally available to participate in the losses of a bank which continues trading." Nonetheless, the authorities in several countries have the authority to permit a bank to continue trading under supervisory control after its capital is depleted. For example, in the United States the FDIC is authorized to create a

funds. Since their primary objective is to protect policyholders, insurance regulators will typically ring-fence the assets and liabilities of a faltering insurance company, effectively closing it to new business until its policy obligations can be transferred to another insurance company (Joint Forum 2001, p. 33). Insurance regulators place heavier emphasis on reserves than on capital to protect policyholders from loss (Joint Forum (2001), p. 12).

### 3.1 Net Worth

Each of the three definitions of capital has one element in common--net worth. But, even this element of regulatory capital is not directly comparable across the three sectors because net worth is an accounting residual that depends on the accounting conventions used for the various elements of the balance sheet, and, reflecting historical differences in the underlying business, accounting conventions differ across the three sectors. In what follows we will focus on differences across the three sectors in the United States with only passing reference to differences within sectors across countries.<sup>38</sup>

Figure 1.1 displays pro-forma balance sheets for a securities firm, bank, and insurance company.<sup>39</sup> Securities firms are required to employ mark-to-market accounting practices because most of the assets and liabilities of securities firms are marketable securities. Positions are recorded at market or fair value with unrealized gains and losses reflected in the income statement. Values are based on listed prices where possible; but when listed prices are not available or when the firm believes that liquidating its position could affect market prices, fair

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bridge bank that would enable it to impose losses on holders of subordinated debt even though the bank continued operation.

<sup>38</sup> Nonetheless, as Scott and Iwahara (1994) have shown in their careful comparison of the implementation of the Basel Accord in Japan and the United States, cross-country differences are also highly significant.

<sup>39</sup> For a more detailed comparison of balance sheets, see Joint Forum (2001, Annex 2).

values are used. Fair values are based on internal pricing models. They should reflect management's best judgment about the value of a financial instrument, and for that reason they are much more difficult to verify objectively than listed prices. As investigations of Enron's accounting practices have shown, the managerial discretion inherent in fair value procedures can be subject to abuse.<sup>40</sup>

Under the assumption that market prices are efficient, they are as likely to rise as fall and so there is no rationale for a revaluation reserve for expected losses in a balance sheet that is drawn up according to fair value conventions. Consequently U.S. securities firms are not permitted to maintain reserves except for probable losses due to pending litigation (Joint Forum 2001, p. 30).

Bank trading accounts are also subject to fair value accounting standards, but the banking book is subject to accrual accounting standards. Thus the same financial instrument may be valued in two different ways depending on whether the bank has classified it as available for sale or in the trading book, or in the banking book as an investment asset to be held to maturity. (Bank supervisory authorities attempt to curb abuses of this discretion by monitoring shifts between the trading book and the banking book.)

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<sup>40</sup> Brick (2002), p. 1, asserts that traders made optimistic estimates of long-run energy prices and booked the resulting (unrealized) capital gains in current income.

Figure 1.1

## Stylized Pro-Forma Balance Sheets

Source: Authors' compilation

<i>Generic Bank (cost, accrual, and fair value)</i>	
<i>Assets</i>	<i>Liabilities</i>
Cash reserves	Deposits
Trading account assets	Borrowings
Investment account securities	Trading liabilities
Fed funds sold and securities purchased under agreements to resell	Subordinated Debt
Gross loans and leases	<u>Net Worth</u>
(less Allowance for loan and lease losses)	Common Stock
Other assets	Noncumulative perpetual preferred stock
	Other preferred stock
	Retained earnings
<i>Generic Securities Firm (fair value)</i>	
<i>Assets</i>	<i>Liabilities</i>
Cash & cash equivalents	Commercial paper & short-term debt
Securities & other financial instruments owned	Securities sold, but not yet repurchased
Securities purchased under agreements to resell	Securities sold under agreements to repurchase
Receivables & accrued interest	Senior notes
Other assets	Subordinated debt
	<u>Net Worth</u>
	Common stock
	Preferred stock
	Retained earnings
<i>Generic Insurance Company (statutory accounting principles)</i>	
<i>Assets</i>	<i>Liabilities</i>
Cash and cash equivalents	Technical reserves (policy obligations)
Investments	Asset valuation reserves
Other assets	Other liabilities
	<u>Surplus</u>
	Common stock
	Borrowed surplus
	Unassigned surplus

Financial instruments in the banking book are recorded at cost so that capital gains are not recognized unless they are realized. This affords bank managers some degree of discretion over the recognition of capital gains that can be used to manage earnings (Carey 1993). Loans

are reported at the principal amount outstanding, net of unearned income. The main rationale for using accrual accounting rather than fair value accounting is that many bank assets, particularly loans, are not traded in secondary markets, and it is assumed that they will be held to maturity. Although valuing individual loans is often difficult, the bank knows that, on average, some loans will not be fully repaid. This is reflected in an allowance for losses on loans and leases, which is a valuation allowance for probable losses inherent in the portfolio as of the balance sheet date. To some extent, the allowance for losses may be regarded as an attempt to mark the portfolio of loans and leases to market, but it is intended to reflect only the loss in the event of default, not changes in market value due to changes in the credit quality of the borrower (transition risk) or a change in the market price of credit risk (spread risk).<sup>41</sup> Similarly, reserves appear as a liability account to cover potential off-balance sheet credit losses (Everett et al., 2002, p. 8).

These differences in accounting conventions mean that net worth in a securities firm is not directly comparable to net worth in a bank. The value of securities in the banking book will not reflect unrealized capital gains or losses and the allowance for loss may be a very imprecise way of marking loans to market. Furthermore, bank regulators place additional restrictions on the components of net worth that may be counted as regulatory capital. Reflecting their emphasis on “patient money,” bank regulators restrict the kind of preferred stock that may be counted as core capital to noncumulative perpetual preferred. Other, cumulative, fixed-charge preferred shares count only as supplementary capital (BCBS 1988, p. 6).

The NAIC capital requirements are based on statutory accounting principles (SAP) not generally accepted accounting principles. “Policyholders’ Surplus” is the statutory accounting

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<sup>41</sup> Reserving practices vary markedly across countries for tax, regulatory, and accounting reasons. Scott and Iwahara (1994) highlight differences between practices in Japan and the United States. See Carey (2001, Appendix A) for a discussion of accounting conventions with regard to credit losses.

term that corresponds to net worth or owners' equity, although it differs in fundamental respects from the net worth concepts used by the SEC and the bank regulatory authorities. Statutory accounting principles are intended to have a decidedly conservative bias. For the most part, SAP requires the lowest of several possible values for assets and the highest of several possible values for liabilities. Indeed, under SAP, some assets are omitted from the balance sheet altogether if they cannot be converted to cash at or near a known amount. But, in addition to making a conservative statement of the *level* of net worth, the rules of SAP are designed to prevent sharp *fluctuations* in net worth. This can lead to a decided departure from conservative valuation principles. Assets reported on the balance sheet--"admitted assets"--are valued according to NAIC rules. Equity claims are shown at their "association values," which usually correspond to year-end market values. On several occasions the NAIC has authorized insurance companies to use association values that have been significantly above year-end closing prices in order to prevent "technical insolvencies caused by temporarily depressed market prices" (Troxel and Bouchie 1995, p. 8). Some European insurance regulators have exercised similar forbearance recently. For example, German insurers had to book equity losses in the year they occurred, but in the wake of the decline in equity markets after September 11, insurers were allowed (Hulverscheidt and Fromme 2003) "to create 'hidden losses' by postponing write-downs if the market value of their investments fell below the purchase value."

Another exception to the generally conservative bias of SAP is the valuation of bonds, which appear on the balance sheet at amortized cost under the (possibly optimistic) assumption that an insurance company is a going concern that will not have to liquidate bonds at depressed prices before they mature. This approach ignores, of course, any increase in interest rates or

widening of credit spreads that would adversely affect the fair value of the bond before maturity.<sup>42</sup>

Insurance companies establish reserves to cover both policyholder claims and declines in asset value. These appear on the balance sheet as a liability and are known as underwriting reserves, or technical provisions, or reserves. In general underwriting reserves do reflect the intended, conservative bias of SAP and are subject to statutory minimums that may exceed the company's own estimates. In contrast to "reserves" under GAAP, insurance reserves are a true liability.

### **3.2 Reserves, Subordinated Debt, and Other Forms of Regulatory Capital**

As noted, broker-dealers in the United States are prohibited from maintaining valuation reserves because their mark-to-market accounting discipline should make them unnecessary. Securities firms are permitted to supplement net worth with subordinated debt to meet capital requirements.<sup>43</sup> Qualifying subordinated debt must have a minimum maturity of one year and provide that the broker-dealer's obligation to repay be suspended if repayment would cause the broker-dealer to violate its minimum capital requirement. Broker-dealers generally rely heavily on subordinated debt to meet their capital requirements.

Under the original Basel Capital Accord, banks are permitted to issue subordinated debt as supplementary (Tier 2) capital up to a limit of 50% of core (Tier 1) capital. Qualifying subordinated debt must have an original maturity of over five years and is subject to a

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<sup>42</sup> This treatment applies only to bonds "in good standing." A bond is considered "in good standing" if (Troxel and Bouchie 1995, p. 9) "it is not in default, has a maturity date, is amply secured, and is among the classes of bonds approved by the NAIC. Other bonds are shown at market value unless there is a reason to believe a lower value would be realized for their sale."

cumulative 20% discount for each of its last five years of maturity (BCBS 1988, p. 20). With the Amendment to the Capital Accord for Market Risk, the BCBS expanded the role for subordinated debt by recognizing an additional kind of capital (Tier 3) for the purpose of meeting the capital requirement for market risk. Tier 3 capital is subordinated debt with an original maturity of at least two years. Like the SEC, the bank regulators require that such debt include a lock-in clause precluding payment of either interest or principal if the payment would cause the issuing bank's risk-based capital ratio to fall below the minimum. Although broker-dealers make extensive use of short-term subordinated debt, banks do not.<sup>44</sup> At yearend 2001, none of the U.S. banks subject to the capital requirement for market risk had Tier 3 capital outstanding.

In addition to subordinated debt, banks in the United States, under Basel I, are permitted to include, as Tier 2 capital, the allowance for loan loss reserves up to a maximum of 1.25% of risk-weighted assets (USGAO 1998, p. 119). The Basel Accord also permits the inclusion of a number of other items in Tier 2 capital at the discretion of the national authorities such as undisclosed reserves, revaluation reserves, and a variety of hybrid capital instruments (BCBS 1988, pp. 18-19).

The NAIC permits the use of debt (borrowed reserves) and valuation reserves in the computation of total adjusted capital (Joint Forum, 2001, p. 50). In practice, subordinated debt is often issued by the parent and down-streamed as equity in the regulated insurance company

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<sup>43</sup> Appendix D to the U.S. Net Capital Rule, 15c3-1 (SEC 1997a), sets out the conditions for satisfactory subordination agreements.

<sup>44</sup> National regulators are free to decide whether to allow banks to employ Tier 3 capital at all. Several have chosen not to authorize Tier 3 capital. Linnel, Andrews, and Moss (2000, p. 4) conclude that banks have been deterred from issuing Tier 3 capital because the lock-in clause gives it a higher risk profile compared to Tier 2 subordinated debt, so that "spreads on such instruments must exceed the spread of lower Tier 2 to compensate investors for the additional risk. As a result, not only is Tier 2 term subordinated debt cheaper, but it is a more flexible capital instrument as it can be used against both trading and banking book exposure. . . ."

In summary, definitions of eligible regulatory capital differ across the three sectors. Even those components of eligible regulatory capital that appear to be the same, such as net worth, are in fact quite different because of fundamental accounting differences. These accounting differences in turn reflect differences in the basic business of each sector and implicit assumptions about how to deal with a failing firm. Consequently it is difficult to make meaningful comparisons about the quantity of regulatory capital across banks, securities firms, and insurance companies. We can only concur with the Joint Forum's (2001, p. 5) conclusion that "comparisons of individual elements of the different capital frameworks are potentially inappropriate and misleading."

In the following section, we provide an overview of the different approaches to setting capital charges for position risk across the three sectors. After contrasting the Basel Committee approach for internationally active banks with the net capital approach of the SEC and risk-based capital approach of the NAIC, we will attempt to quantify some of the differences, in the following section, by reference to a model portfolio.

## **4 Regulatory Approaches to Capital**

### **4.1 Rules vs. Internal Models**

Perhaps the most important difference in regulatory approaches is between reliance on rules versus internal models to set capital charges. Rule-based systems rely on regulators to specify the capital charge for each position. For example, under the SEC's NCA, equity positions must have 15% capital set aside if they are considered liquid or 40% if they are considered illiquid (SEC rule 15c3-1). Rules do not take into account diversification benefits achieved through less than perfect correlation (the so-called portfolio effect). While they are relatively

simple to understand and implement, rules have the disadvantage of being inflexible. They have difficulty dealing with product innovation, whether that innovation is designed to benefit clients or simply to circumvent the rules themselves.

Internal models are designed to take diversification effects into account. Moreover, regulators hope that by encouraging financial institutions to build their own comprehensive, portfolio-based models to measure risk, risk management will be strengthened, and the incentives of regulators and firms will be more closely aligned. Hendricks and Hirtle (1997, p. 3) highlight this point: “By substituting banks’ internal risk measurement models for broad, uniform regulatory measures of risk exposure, this approach should lead to capital charges that more accurately reflect individual banks’ true risk exposures. And by including qualitative standards, the approach is consistent with the shift in supervisory interest from a focus on risk measurement to a more comprehensive evaluation of banks’ overall risk management.” Only the Basel Committee approach and the almost identical CAD of the European Union allow for an internal models approach for capital assessment.

## **4.2 Banking**

The market risk amendment to the Basel Accord (BCBS 1996a) establishes a capital charge for market risk in a bank’s trading book and for exposure to foreign exchange and commodity price risk in the banking book as well.<sup>45</sup> It assigns a capital charge for general and specific risk, although this distinction is not made for all types of risk factors. The separation between general and specific risk is similar to the distinction between systematic and

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<sup>45</sup> By applying market risk capital to interest rate instruments in the trading book only, it may discourage the taking of positions in the trading book to hedge interest rate risk exposure in the banking book.

idiosyncratic risk, although specific risk includes some notion of default likelihood as well.<sup>46</sup> Specific risk may also be incorporated in the internal models approach, subject to supervisory approval, through increasing the number of risk factors, stress testing, or scenario analysis. But it is usually subject to an add-on instead.

Banks with a *significant* market risk exposure are required to calculate a risk-based capital ratio that takes into account market risk in addition to credit risk. U.S. regulators deem market risk exposure to be significant if the gross sum of trading assets and liabilities on the bank's balance sheet exceeds 10% of total assets or \$1 billion (USGAO 1998, p. 121). At the end of 1996, 17 banks met this criterion, while at the end of 2001 it was well above 40.<sup>47</sup>

#### **4.2.1 Banking: Basic/Standardized Approach**

The standardized approach (SA) to market risk measurement was proposed by the Basel Committee in April 1993 and updated in January 1996. The European Commission in its Capital Adequacy Directive (CAD) adopted something very similar known as the building block (BB) approach.<sup>48</sup> The main difference between the Basel Committee's SA approach and the European Union's BB approach is in the weights for specific risk. The capital charge is 8% (SA) or 4% (BB) for equities, reduced to 4% (SA) or 2% (BB) for well diversified portfolios. The designation "well diversified" seems to be at the discretion of the regulator. (See also Scott and Wellons 1999.) While some netting is allowed, diversification benefits achieved by holding less than perfectly correlated assets do not reduce capital charges. The overall capital charge for

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<sup>46</sup> "Specific risk means the changes in the market value of specific positions due to factors other than broad market movements, including idiosyncratic variations as well as event and default risk." (USGAO 1998, p. 125).

<sup>47</sup> Hendricks and Hirtle (1997) point out that "[t]he actual number of institutions that are ultimately subject to the market risk capital requirements may differ from these figures for two reasons: supervisors can, at their own

market risk is simply the sum of capital charges for each of the exposures. A full description of the rules is contained in BCBS (1996a), but we will highlight in the next subsections some of the capital charges that are important for computing the capital requirement for our model portfolio.

#### 4.2.1.1 Interest Rate Risk

Specific risk charges for debt instruments are differentiated by counterparty. There are three broad groups with five risk charges, as summarized in Table 1.1. The “qualifying” category is broadly any issuer who is rated investment grade, plus government sponsored enterprises and multilateral development banks.

Table 1.1  
Specific Risk Charge, Interest Rate Risk, BIS Standardized Approach

<i>Issuer</i>	<i>% Capital Charge</i>
Government	0
Qualifying	0.25 (< 6 months)
	1.00 (between 6 and 25 months)
	1.60 (> 24 months)
Other	8

Source: Authors' compilation based on BCBS (1996a)

The defining feature of general market risk is the broad allowance for full netting subject to so-called vertical (within maturity band) and horizontal (across maturity bands) disallowances, which reduce the netting offsets. Broadly there are two approaches for calculating risk exposure: the maturity and the duration method. The former is more formulaic while the latter is designed to better reflect risk as function of yield curve volatility. In our model portfolio below, we employ the simpler maturity approach for calculating required market risk capital. All interest

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discretion, include or exclude particular institutions, and institutions have the option to become subject to the capital requirements with supervisory approval.”

<sup>48</sup> EU (93/6/EEC).

rate derivatives and off-balance sheet instruments in the trading book need to be included in the risk calculation. Options are treated separately.

#### **4.2.1.2 Equity Position Risk**

All equity positions in the trading book are subject to the market risk capital calculation. Netting is allowed for positions in the same issue only. Specific risk is defined as the banks *gross* equity position while general risk applies only to *net* positions. The charge for specific risk is 4% if the portfolio is considered both liquid and well diversified; otherwise the charge is 8%. The general market risk charge is 8%. Thus the total market risk charge can be as much as 16%. As with interest rate instruments, equity derivatives and off-balance sheet positions held in the trading book should be included in the market risk calculation. Options are treated separately.

#### **4.2.1.3 Foreign Exchange Risk**

For foreign exchange (FX) and commodities, no distinction between general and specific risk is made. The FX calculation involves netting exposures in the same currency exposure and taking the maximum of the sum of the net short or long position across currencies. Gold is included in the FX risk calculation rather than in commodities. The capital charge is then 8% for the overall position.

#### **4.2.1.4 Treatment of Options**

Options are required to be marked to market at the end of the trading day using market prices and, importantly, implied volatilities for valuation. The BCBS laid out several alternative approaches to calculating market risk capital charges for options. The simplified approach, available to banks that use only purchased options, are functions of the market value of the option (money-ness) and the market value of the underlying security. For banks that also write options, several intermediate approaches are available. These approaches involve the calculation

of delta, gamma, and vega of the options (the delta-plus approach) or the somewhat more advanced scenario approach based on matrix values of the underlying position. (For additional discussion of the valuation of options, see Appendix I.) Both are approximations to the full Monte Carlo approach allowed (and advocated) under the internal models approach. In our model portfolio, we employ the intermediate, delta-plus approach to establish the capital charge for the options position. No credit is given to hedging an option position since each instrument is treated separately.

#### **4.2.2 Banking: Internal Models Approach**

The 1996 amendment to the Capital Accord provided for the supervised use of internal models to establish capital charges, a revolutionary change in capital regulation. It was an implicit recognition of the complexity and fast pace of innovation in financial instruments and institutions where any rule written to set capital charges for a given set of instruments may spur innovations to reduce or avoid the charge. Only an internal models approach is likely to be able to address the portfolio of risks comprehensively and dynamically.

The internal models approach is designed to fully capture portfolio diversification effects that occur when assets that are less than perfectly correlated are combined in a portfolio. The goal is to more closely align the regulatory assessment of risk capital with the risks actually faced by the bank.<sup>49</sup> The approach starts from the presumption that similar risks should face similar capital charges.

General market risk is a direct function of the output from the internal value-at-risk (VaR) model initially developed by and for banks. It is used to answer the question: “Given the

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<sup>49</sup> See Hendricks and Hirtle (1997) for an excellent overview.

size of our positions, what is the most we should expect to lose over the next day due to market fluctuations?” Based on a probability distribution of returns for the positions, this question can be answered for a specified level of confidence. (See Appendix I for a survey of VaR modeling techniques.) The capital requirement is based on a ten-day 99% VaR, which is often based practically on a one-day 99% VaR, scaled up to reflect a 10-day holding period using a scaling factor,

$$99\% \text{ VaR} \times \sqrt{10} \times \kappa \quad (1.1)$$

where  $\sqrt{10}$  is the liquidity factor to move from a 1-day to a 10-day holding period and  $\kappa$  is the supervisory add-on (3-4, depending on backtesting results). Market-risk equivalent assets are then  $\frac{1}{.08} = 12.5$  times the aggregated risk exposure (standardized) or charge (internal models).

Which banks are eligible to use the internal markets approach? This is left to the discretion of each country’s supervisor, based on a number of qualitative and quantitative criteria (BCBS 1996a). As of the fourth quarter of 2001, 18 of the largest 50 bank holding companies (by total assets) in the United States were reporting market risk equivalent assets from their internal models.

The resulting capital charge from the internal model,  $C^{FED}$ , is the maximum of yesterday’s 99% 10-day adjusted ( $\sqrt{10}$ ) daily VaR or the average of the daily VaR over the preceding 60 trading days multiplied by the regulatory capital multiplier  $\kappa \in [3,4]$ .<sup>50</sup>

$$C^{FED} = \max \left[ VaR_{t-1}, \kappa \times \frac{1}{60} \sum_{i=1}^{60} VaR_{t-i} \right] \quad (1.2)$$

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<sup>50</sup> Stahl (1997) shows that there is probabilistic rationale for the range of the multiplier, albeit post hoc. VaR estimates are just that—estimates—and hence suffer from noise. Stahl shows that the relevant scaling factor should be between 2.5 and 4, making the choice of 3 quite reasonable.

The calculations are to be based on data from at least one year (about 250 trading days).

#### **4.2.2.1 Backtesting**

How can a supervisor know whether the internal model of a bank accurately reflects the risk exposures of its portfolio? In stark contrast to the situation with credit risk models, regulators have the luxury of rich and plentiful data to test market risk models. It is relatively straightforward to compare model outputs (forecasts) with actual outcomes (realizations). The BCBS requires banks to perform backtesting on a quarterly basis using one year (about 250 trading days) of data. This process simply counts the actual number of times in the past year that the loss on the profit and loss account (P&L) exceeded VaR. Over the course of a 250 trading-day year, we should expect 2.5 exceptions for 99% VaR, but the regulators allow four. Just because a bank has experienced four exceptions, however, does not mean the model is necessarily wrong. In fact, there is a 10.8% chance that the model will experience more than four exceptions even if VaR was calculated correctly. (The second column of Table 1.2 shows the probability of observing the number of exceptions specified in the first column (Pr[exceptions]) over 250 days, if the VaR model is accurate. The BCBS has established color zones--shown in the third column--to indicate whether the bank will be subject to a penalty in the form of a higher multiplier--see column 4--because the number of exceptions is too high.)

Table 1.2  
Backtesting VaR Models, Regulatory Color, and Capital Multipliers

<i># of exceptions in 250 Days</i>	<i>Pr(exceptions) if true 99% VaR<sup>a</sup></i>	<i>BCBS Zones</i>	<i>Multiplier</i>
0	8.1%	Green	3.0
1	20.5%		3.0
2	25.7%		3.0
3	21.5%		3.0
4	13.4%		3.0
5	6.7%	Yellow	3.4
6	2.7%		3.5
7	1.0%		3.65
8	0.3%		3.75
9	0.08%		3.85
10 or more	0.01%	Red	4.0

Source: BCBS (1996b)

<sup>a</sup>The percentages in the second column indicate the odds of observing the number of exceptions specified in first column under the assumption that the VaR model is correct.

The validity of backtesting rests on two questionable assumptions regarding the nature of portfolio changes and the associated profit and loss (P&L) account. First, VaR is usually an end-of-day measurement that is attributed to the P&L result of either the preceding day or the following day. In either case, the risk taken during the day may vary considerably from the end-of-day risk. The variation can be systematic, as would be the case if proprietary trading positions were taken intraday and then closed out by the end of the day. It can also be random, as would be the case if positions were taken temporarily and closed out frequently to facilitate customer orders. Significant differences between end-of-day VaR and intraday VaR can lead to systematic over- or underestimation of risk. This will result in a much weaker relationship between VaR and measured P&L volatility. Put another way, different intraday trading behaviors and strategies will appear identical to an end-of-day VaR system.

Second, the P&L result is assumed to be solely the result of movements in market prices. But, in addition to position-taking gains and losses, the P&L often contains fees, commissions, mark-ups, market making spreads and the results of intraday trading that are invisible to the

standard batch VaR run once a night; all of these have a significant positive impact on P&L and add a modest amount of volatility to P&L which is unrelated to VaR. If the positive impact outweighs the increase in volatility, backtesting by means of exception counting may be undermined by fee, commission, or spread income that cloaks position-taking losses.

### **4.3 Securities Firms**

The European Union applies the same capital rules to securities firms as to banks. These are virtually identical to the standardized and internal models approach of the BCBS. U.S. securities firms, however, are subject to an entirely different capital regulation regime that we will analyze in this subsection. (Japanese securities firms face a similar regime.)

#### **4.3.1 The U.S. Net Capital Rule (Rule 15c3-1)**

The Net Capital Rule and calculation is designed to ensure that if the business were forced to close its doors today, it would be able to return all customer-owned assets and complete customer transactions. Hence liquidity is given primary importance in determining net capital. Let  $L^{sec}$  be the liabilities of the securities firm other than subordinated liabilities, and let  $R^{sec}$  be customer related receivables. The Net Capital Rule in turn has two standards: the basic method, which requires net capital to exceed 6 $\frac{2}{3}$ % of aggregate indebtedness, and the alternative method, used by most of the large broker/dealers (and any with significant proprietary position taking), which requires net capital to exceed 2% of customer debit items. Because it applies to the most important U.S. securities firms, we will focus on the alternative method in this section and apply it to the model portfolio in the following section.

- The capital requirement under the basic method is  $C_{reg,1}^{SEC} \geq \frac{L^{sec}}{15}$  subject to certain exclusions such as fully collateralized obligations.<sup>51</sup>
- The capital requirement under the alternative method is

$$C_{reg,2}^{SEC} \geq \max \left[ \frac{R^{sec}}{50}, \$250,000 \right]$$

Assets on the trading book are subject to haircuts--an industry term for valuating securities below market prices; they reflect the liquidity of the instrument and credit quality of the counterparty as follows: the lower the liquidity and the lower the credit quality, the larger the haircut. In that sense the SEC haircuts combine credit and liquidity risk with market risk. Final net (regulatory) capital for the firm is the sum of assets, adjusted for haircuts, less the liabilities:

$$C^{SEC} = A(1 - h) - L$$

where  $h = \frac{\sum A_i h_i}{A}$ , a weighted average of the haircuts,  $h_i$ , for asset categories,  $A_i$ . A summary of haircuts is given in Ball and Stoll (1998).

Rule 15c3-1 applies a punitive haircut of 100% to swaps and OTC derivatives. For that reason U.S. securities firms conduct most of their OTC derivatives operations in unregistered affiliates in the United States or in overseas offices, often in Europe, where they are subject to the European Union's CAD, not in the registered broker-dealer.<sup>52</sup>

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<sup>51</sup> I.e.  $6\frac{2}{3}\%$  of  $L^{sec}$ .

<sup>52</sup> Often the major U.S. securities firms maintain two unregistered affiliates to deal in OTC derivatives: one that is AAA-rated and bankruptcy remote for ultra credit sensitive counterparties and an unrated affiliate.

Recently the SEC has experimented with Basel-style internal models regulation for affiliates that deal in OTC derivatives. So far, only three firms have chosen to become regulated OTC dealers under this “SEC lite” regime.<sup>53</sup>

#### **4.3.1.1 Capital Charges for Debt**

For U.S. government and agency instruments, the haircuts are the most modest. They range from 0% for very short-term (0-3 months) to 6% for long-term (> 25 years) debt. Haircuts are applied to net positions, Investment grade municipal bonds are treated similarly, though the top end is 7% for maturities of 20 years or longer. But the treatment of municipal bonds differs with respect to netting: the haircuts are applied to the maximum of long or short positions, not the net position.

For investment grade nondomestic government and agency instruments as well as for corporate debt, haircuts are applied to the maximum of long or short positions, not the net position, and can climb as high as 9% for maturities of 25 years or more. Noninvestment grade debt receives a haircut of 30% under the basic method and 15% under the alternative approach.

#### **4.3.1.2 Capital Charge for Equities**

Under the basic approach, the haircut for liquid equities is 30% but only 15% under the alternative approach. A stock is considered liquid for net capital purposes if it traded on an exchange or has more than two market makers. For illiquid stocks the haircut is 40%. If the position involves a combination of longs and shorts, it becomes a bit more complicated. Taking a liquid stock position as an example, a broker-dealer's haircut for equity securities is equal to 15% of the market value of the greater of the long or short equity position plus 15% of the market

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<sup>53</sup> SEC 1998 (Release No. 34-40594, OTC Derivatives Dealers).

value of the lesser position, but only to the extent this position exceeds 25% of the greater position (SEC 1997a).

#### **4.3.1.3 Capital Charge for Foreign Currency**

Haircuts are given to open, that is, unhedged, currency positions. In the spirit of assigning larger haircuts to less liquid asset types, currencies are grouped into major and other currencies, the former containing (as of 2001) the Euro, the Japanese Yen, the British Pound, the Swiss Franc, and the Canadian Dollar. These positions receive a 6% haircut, while all other positions are subjected to a 20% haircut.<sup>54</sup>

#### **4.3.1.4 Treatment of Options**

Options receive treatment similar to the BCBS standardized approach under the SEC. They are required to be marked to market at the end of the trading day using market prices and implied volatilities for valuation. The SEC has two approaches: (1) the capital charge is based on the market value of the underlying asset, or (2) the capital charge is based on the market value of the option. The SEC amended the Net Capital Rule in February 1997 and made significant revisions to the treatment of options. For the first time something akin to an internal models approach was allowed.<sup>55</sup> The amendment<sup>56</sup> requires that the options model calculate theoretical prices at 10 equidistant valuation points within a range consisting of an increase or a decrease of the following percentages of the daily market price of the underlying instrument for each kind of option: (1) 15% for equity securities with a ready market, narrow-based indexes, and nonhigh-capitalization diversified indexes; (2) 6% for major market currencies;<sup>57</sup> (3) 10% for high-

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<sup>54</sup> Section (c)(2)(vi) of Rule 15c3-1.

<sup>55</sup> See the Dec. 1997 Commentary SEC Release No. 34-39456; File No. S7-32-97, especially pp. 9-10.

<sup>56</sup> SEC 1998 (Release No. 34-38248; File No. S7-7-94, pp. 9-11).

<sup>57</sup> The major market currencies are: Deutschemark, British pound, Swiss franc, French franc, Canadian dollar, Japanese yen, and European currency unit.

capitalization diversified indexes; and (4) 20% for currencies other than major market currencies. The applicable haircut is the greatest loss at any one valuation point. We applied this option valuation approach to our model portfolio in the next section.

Like the BCBS standardized approach, this partial portfolio approach ignores hedging strategies designed to mitigate the risk. Typically an option position is at least hedged with respect to a change in price of the underlying position or delta hedged. But this is considered a separate position to which a haircut is applied. This increases the total required capital and thus actually discourages a firm from using a basic risk mitigation technique.

#### **4.3.2 The Capital Adequacy Directive (CAD) of the European Union**

The CAD (93/6/EEC--see Joint Forum 2001) applies to *both* banks and securities firms in the European Union. Market risks are defined to include all risks listed in the Market Risks Amendment to the Basel Accord (i.e., interest rate risk, equity position risk, foreign exchange risk, and commodity price risk) plus settlement risk. Two methods are proposed: (1) a building block approach that applies specified capital charges to the current market value of open positions (including derivatives) in fixed income and equities and the total currency and commodities positions and (2) an internal-models-based (VaR) approach. The resulting capital charge from the internal model is almost the same as the BIS charge.

#### **4.4 Insurance**

In contrast to the regulatory capital frameworks used by bank and securities regulators, insurance regulators make capital charges for both asset and liability risk (Webb and Lilly 1994; Kupiec and Nickerson 2001; Joint Forum 2001). In fact, a major source of market risk is the

interest rate risk that results from the asset-liability mismatch (ALM). We will focus on the risk-based capital (RBC) model for life insurance. The RBC model for property and casualty (P&C) insurance is based on the life model and is very similar.<sup>58</sup>

The RBC approach recognizes four classes of risk: (1) C1 or asset risk, analogous to credit risk in the Basel framework; (2) C2 or insurance risk or underwriting risk resulting from underpricing of insured risks; (3) C3 or interest rate risk due to the ALM problem; (4) C4 or business risk, analogous to operational risk in the Basel framework.<sup>59</sup>

RBC attempts to take account of concentration (or diversification) for each class of risk. For example, for C1 (asset risk), the risk factor for the 10 largest asset exposures is doubled, providing a strong incentive for diversifying the investment portfolio. C1 risk makes up the bulk of insurance risk-based capital in the United States, as Table 1.3 makes clear.

Table 1.3  
Distribution of RBC Amounts by Risk Category  
All U.S. Insurers, 1991

<i>Risk Type</i>	<i>% Contribution</i>
C1: Asset	70.5
C2: Insurance/underwriting	16.1
C3: Interest rate <sup>a</sup>	10.1
C3: Operational	3.3

Source: Webb and Lilly (1994, p. 48)

<sup>a</sup> Only reflected in the life RBC formula.

The final RBC, adjusted for covariance, is

$$C_{reg}^{ins} = RBC = \sqrt{(C1 + C2)^2 + C2^2} + C4^{60} \quad (1.3)$$

<sup>58</sup> For more detail on the P&C RBC formulation, see Feldblum (1996). For a comparison between life, health and P&C, see AAA (2002).

<sup>59</sup> Capital for business risk is typically assessed in the United States by the state insurance guaranty fund.

<sup>60</sup> In 1991 the average diversification benefit via this formula was 11.4% for U.S. insurers.

This RBC is then compared to total adjusted capital (TAC), where TAC includes capital and policyholder surplus (reserves) as determined, in the United States, by each state's statutory accounting requirements. The ratio of TAC to RBC determines when regulatory action may be taken. For values of this ratio exceeding two, no regulatory action is taken.<sup>61</sup> If the ratio falls below 0.7, the regulator must take control of the insurance company. In between are different levels of regulatory intervention less severe than outright placement under regulatory control (e.g., rehabilitation, liquidation).

#### **4.4.1 Market Risk under NAIC's RBC**

As noted earlier, the NAIC does not use terms such as "position" or "market" risk. Indeed, even the minor part of the investment book that is marked to market (equity positions) is done so only at the same frequency as the reporting cycle, which is at most quarterly, and often only at yearend. But both C1 (asset risk) and especially C3 (interest rate risk) contain elements of what would be regarded as position risk by regulators in the other two sectors of the financial services industry.<sup>62</sup> In spirit C1 is closer to the Basel risk-adjusted assets for credit risk. For example, risk weights for C1 are 30 basis points (bp) for cash (for the possibility of bank failure)<sup>63</sup> and 0% for U.S. government bonds (effectively immune from credit risk but not from market risk factors such as interest rate fluctuation and inflation), 0.3% for AAA to A rated bonds, then increasing further for lower rated bonds (there are six risk bands in total), 0.5% for

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<sup>61</sup> Actually, if the ratio is between 2 and 2.5 and declining, the insurer may drop into the first category ("Company Action Level") at the discretion of the supervisor (Webb and Lilly (1994, p. 4).

<sup>62</sup> Interest rate risk appears only in the life, not the P&CRBC formula.

<sup>63</sup> A 30bp probability of failure over a one-year horizon corresponds roughly to a BBB rating, about the average for the U.S banking system, Interestingly, the average annual default rate of U.S. banks from 1934-2000 has been 26 bp.

residential mortgages, 3% for commercial mortgages, and 30% for common stock (see Table 1.4).<sup>64</sup>

Table 1.4  
NAIC Asset Risk (C1) Weights (%)

<i>Assets</i>	<i>LIFE</i>	<i>P&amp;C</i>
U.S. govt. bonds	0	0
Cash	0.3	0.3
NAIC 1: AAA to A rated bonds, including GSE debt and most collateralized debt obligations	0.3	0.3
NAIC 2: BBB rated bonds	1.0	1.0
NAIC 3: BB rated bonds	4.0	2.0
NAIC 4: B rated bonds	9.0	4.5
NAIC 5: CCC rated bonds	20.0	10.0
NAIC 6: Bonds “near default”	30.0	30.0
Whole residential mortgages	0.5	5.0
Commercial mortgages	3.0	5.0
Common stock	30.0	15.0
Preferred stock (+)	2.0	2.0

Source: Kupiec and Nickerson (2001); Saunders (2000)

Risk weights for interest rate risk (C3) are based on analysis of U.S. treasury spot rates from 1977 to 1990. Over that period the 95% confidence interval for interest rate volatility was reported to be 3.5%-4%. (Webb and Lilly 1994, p. 40). The risk applies to the asset liability mismatch (ALM) and hence depends crucially on accurate estimates of liability exposures and outflows. For example, annuity reserves are divided into three risk categories (low, medium, and high) depending on callability of the contract. The capital charge for C3 risk is reduced by one-third if regulators judge that the insurance company is running a well-balanced ALM portfolio. Insurance companies are also permitted to net out most reinsurance.

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<sup>64</sup> Webb and Lilly (1994) contains full detail, including adjustments for differing loss given default (LGD) assumptions.

#### 4.4.1.1 Treatment of Derivatives and Options

Broadly speaking, derivative instruments are treated the same as bonds by the NAIC for life insurers and receive a flat 5% RBC weight for health and P&C companies (AAA 2002). No “credit” is given for hedging a position. Rather the hedge is added as a separate exposure. Risk mitigation through reinsurance, which could be thought of as a credit derivative, is credited with capital reduction.

#### 4.4.2 VaR in Insurance

VaR has not yet become a standard risk measurement tool in the insurance industry. In a survey for the Society of Actuaries, Britt et al. (2000) report that only about one-third of survey responders (8 of 24 large U.S. insurers) use value-at-risk (VaR). Of those who use VaR, 50% stated that reports are generated only quarterly, 25% at a frequency of monthly (or more often). This longer horizon is also reflected in liquidity reporting.<sup>65</sup> Of the survey respondents, 42% filed liquidity reports at quarterly frequency. Only 33% generated such reports once a month (or more frequently). This study, consistent with the Joint Forum (2001) report, indicates that insurance companies are much less subject to sudden liquidity needs than either banks or securities firms might be. Both banks and securities firms are much more transaction intensive, and of course the average duration of both the assets and liabilities are considerably longer for life insurance companies. Moreover, the liabilities of an insurer are typically not tradable financial assets, in contrast to the other two sectors and, as such, can be very difficult to value.

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<sup>65</sup> Examples of liquidity reports include lists of highly liquid securities that can be sold without triggering a capital loss, maximum cash that can be raised in 30 days, ratio of liquid assets to projected surrender under 3 scenarios (base, stressed, and panic), etc.

## 5 The Trading Experiment--A Model Portfolio

In order to quantify some of the differences in regulatory framework across the three sectors, we have constructed a model portfolio to compute the capital charges under each framework. The portfolio is broadly representative of the financial instruments that may be traded by an internationally active financial institution. The portfolio has been constructed to emphasize two of the most important challenges facing any attempt to model position risk: fat-tailed distributions of returns where extreme returns occur more frequently than one would expect under the normal distribution (leptokurtosis) and nonlinear returns such as those from options. (See Appendix II for an extensive discussion of key issues in modeling volatility.)

Table 1.5 displays the model portfolio (along with the associated risk factors). Leptokurtosis is introduced by including risk factors from an emerging market (Mexico) and nonlinearity through a series of simple combinations of European equity options. Straightforward hedging techniques are employed; for instance, option positions are delta hedged, exposures to foreign equities are hedged by foreign exchange (FX), and so forth.

This section may be viewed as an extension of the work of Dimson and Marsh (1995) who used an actual portfolio of equities to contrast the capital charges under an earlier version of the SEC Net Capital Rule, the E.U. Building Block approach, and a portfolio approach used by regulators in the U.K. Our portfolio contains a much broader range of financial instruments, and we use the current SEC Net Capital Rule, the BCBS internal models approach--which was introduced after the Dimson and Marsh (1995) paper was written--and the RBC framework of the NAIC.

Table 1.5  
Positions in the Portfolio (Columns) and Exposure to Risk Factors (Rows)

<i>Instruments</i>	<i>Long 5-yr, short 1-yr (US yield curve slope exposure)</i>	<i>Long UK 5-yr yield curve + FX exposure)</i>	<i>Flat</i>	<i>FX swap (USD/GBP)</i>	<i>Long £, short peso, long MX 6M</i>	<i>Long Mexican IPC, short S&amp;P, FX hedged</i>	<i>Calendar spread on S&amp;P500 (<math>\Delta</math> &amp; rho hedged)</i>	<i>FTSE 100 protection put per SEC 5.4</i>	<i>Straddle on S&amp;P500 (<math>\Delta</math> hedged)</i>	<i>Total portfolio</i>
US\$ cash			10,000	(14,556)		120,000		(765,075)		(649,631)
1-yr U.S. treasury	(50,000)		50,000 & (50,000)	14,556			10,313			(25,131)
5-yr U.S. treasury	100,000						(431)			99,569
S&P 500 index						(100)	(3)	(2)		(105)
GBP cash				10,000	100,000					32,075
1-yr U.K. treasury		(77,925)		(10,000)						(10,000)
5-yr U.K. treasury		100,000								100,000
FTSE 100 index								100		100
MXP cash 6-month					(1,429,868)	(114,701)				(1,544,569)
CETES					100,000					100,000
IPC (Bolsa) index						18				18
S&P 500 put <sup>a</sup>									1	1
S&P 500 call							1 and (1)		1	2 and (1)
FTSE put								1		1

Source: Authors' compilation

<sup>a</sup> Options are denominated in 100 contracts. All options are European.

## 5.1 Risk Factors

We cover the range of typical risk factors: FX, interest rates, equity, and for options, the implied volatilities, as summarized in Table 1.6 and Table 1.7. For fixed income we chose treasuries representing two points on the yield curve, 1-year and 5-year, except for Mexico where the yield curve beyond two years can be quite unreliable, which is characteristic of emerging markets. There we stick with the shorter end of the yield curve: 6-month and 1-year Mexican treasuries (Cetes). The sample range is January 1, 1997 to December 31, 2001 for a total of 1,304 trading days.

Table 1.6  
Risk Factors and Financial Instruments

<i>Geography</i>	<i>FX/Cash</i>	<i>Fixed income</i>	<i>Equity</i>	<i>Options</i>
U.S.	USD cash	1-yr treasury 5-yr treasury	S&P 500	S&P 500 implied volatilities (put/call)
U.K.	GBP cash (USD /GBP exposure)	1-yr treasury 5-yr treasury	FTSE 100	FTSE 100 implied volatilities (put/call)
EM (Mexico)	MPX cash (MXP/US\$ exposure)	6-m treasury 1-yr treasury	IPC (bolsa)	

Source: Authors' compilation

Table 1.7  
Risk Factor Data Sources

<i>Risk factor</i>	<i>Data source and comments</i>
U.S. 1-yr	1-yr constant maturity <sup>a</sup>
U.S. 5-yr	5-yr benchmark
S&P 500 implied volatility	Put and call implied volatilities
U.K. 1-yr	1-yr interbank middle rate
U.K. 5-yr	5-yr U.K. govt. bond
FTSE 100 implied volatility	Put and call implied volatilities
MX 6-m	Mexico cetes 182-day note (secondary market prices)
MX 1-yr	Mexico cetes 364-day note (secondary market prices)

Source: Data source for implied volatilities is Bloomberg; all others, Datastream

<sup>a</sup> 1-yr constant maturity was chosen because the 1-yr Benchmark was discontinued on August 29, 2001.

## 5.2 Trading Positions

The portfolio features a range of positions that an internationally active financial institution might trade. Our aim in constructing the portfolio is to explore a broad set of risk factors across geography and asset type. Naturally such an exploration cannot be exhaustive. Nor is it engineered to maximize differences in regulatory capital. Indeed, as will become clear, the overall differences in capital charges are sometimes surprisingly small.

## 5.3 Option Positions

The simplest option is the European call (put) equity option. This instrument gives the buyer the right, but not the obligation to buy (sell) the underlying stock at some predetermined strike price at a fixed date in the future.<sup>66</sup> To gain a bit more richness in our simple portfolio, we combined a set of plain vanilla European calls and puts to form a set of well known complex options (see Hull 1993, chapter 8). We have the following option positions in our portfolio, all expiring within one month:

- *Straddle*: Buy call and put with same strike price and expiration date. The trader is betting on large move but does not want to commit to a particular direction. Ostensibly, the trader is long volatility. This is a natural strategy for the stock of a company subject to a takeover bid.
- *Protective put*: Buy a put on stock and the stock itself. The put insures against downside movement.

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<sup>66</sup> The Black-Scholes pricing formula applies strictly only to these simple options. Even the simple extension to the American option, which can be exercised at any time between the purchase and expiry date, cannot be accurately priced using the Black-Scholes formula.

- *Calendar spread*: Sell one call with a certain strike and buy a call with same strike but a later expiration date. The investor is betting on small movements; the loss is small if the movements are large. If the strike is close to the current price, it is called a neutral calendar spread. If the strike is above (below) the current spread, it is a bullish (bearish) calendar spread. Ours is relatively neutral.

#### 5.4 Simulation Results

We collected data on eleven risk factors on a daily basis from the beginning of 1997 to the end of 2001. Given a set of positions laid out in Table 1.5 we then asked the question: what is the risk assessment on December 31, 2001, using the different approaches to establishing capital charges for position risk? Specifically, we compute the capital charges under the following: (1) the three variants of VaR--the parametric, historical,<sup>67</sup> and Monte Carlo simulations,<sup>68</sup> for parametric VaR we follow the RiskMetrics approach; (2) the Basel Committee Standardized Approach; (3) the SEC Net Capital Rule; and (4) the NAIC RBC rules for a life insurance company. This exercise highlights some (but, certainly not all) of the differences among the different regulatory capital regimes.

Any comparative discussion of these capital charges, be it at the position or portfolio level, is easier if one has a benchmark against which to base any number. Certainly the internal models approach is the most sophisticated and comprehensive of the available methods, and of the three variants available, historical simulation is arguably best able to capture many of the

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<sup>67</sup> The historical simulation approach requires repricing the position at time  $t$  for  $t = 1, \dots, T$  total trading days (we have 1,304 days) at the prevailing price. For options positions this requires using the prevailing implied volatility to reprice the option at that date. Our simplified approach ignores smile features of the implied volatility.

<sup>68</sup> For additional discussion of these approaches to modeling VaR, see Appendix I.

salient features of market risk--volatility clustering, fat-tailed returns, and nonlinearity in options.<sup>69</sup>

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<sup>69</sup> See Appendix II for a more detailed discussion of modeling the volatility of asset returns. See also Hendricks (1996).



Table 1.8  
Comparing Capital Charges (\$)

<i>Risk measurement approaches</i>	<i>Long 5-yr, short 1-yr (US yield curve slope exposure)</i>	<i>Long UK 5-yr (UK yield curve + FX exposure)</i>	<i>Flat</i>	<i>FX Swap (USD/GBP)</i>	<i>Long £, short peso, long MX 6M</i>	<i>Long Mexican IPC, short S&amp;P, FX hedged</i>	<i>Calendar spread on S&amp;P500 (<math>\Delta</math> &amp; rho hedged)</i>	<i>FTSE 100 protection put per text</i>	<i>Straddle on S&amp;P500 (<math>\Delta</math> hedged)</i>	<i>Total portfolio</i>
Net value	31,940	(0.07)	10,000	309	8	5,192	8,889	0.15	3,043	59,382
Contributory VaR <sup>a</sup> (parametric)	(87)	(158)	0	(0.46)	777	(703)	4	13,009	(1)	12,841
Basel capital (parametric VaR)	7,061	7,420	0	271	20,503	21,030	103	127,924	14	121,818
Basel capital (Monte Carlo VaR)	6,384	7,633	0	258	18,887	20,623	2,144	121,640	7	113,624
Basel capital (historical simulation VaR)	5,128	6,987	0	167	26,345	33,212	3,573	150,705	11,726	152,638
Basel standardized approach	3,250	4,412	0	1,362	1,098	11,481	31,225	263,332	17,885	334,044
SEC rule	2,500	8,734	0	29,112	2,348	17,221	1,716	119,391	509	181,531
15c3-1 haircut	0	437	30	44	109	37,516	1,163	228,120	956	268,374

Source: Authors' compilation

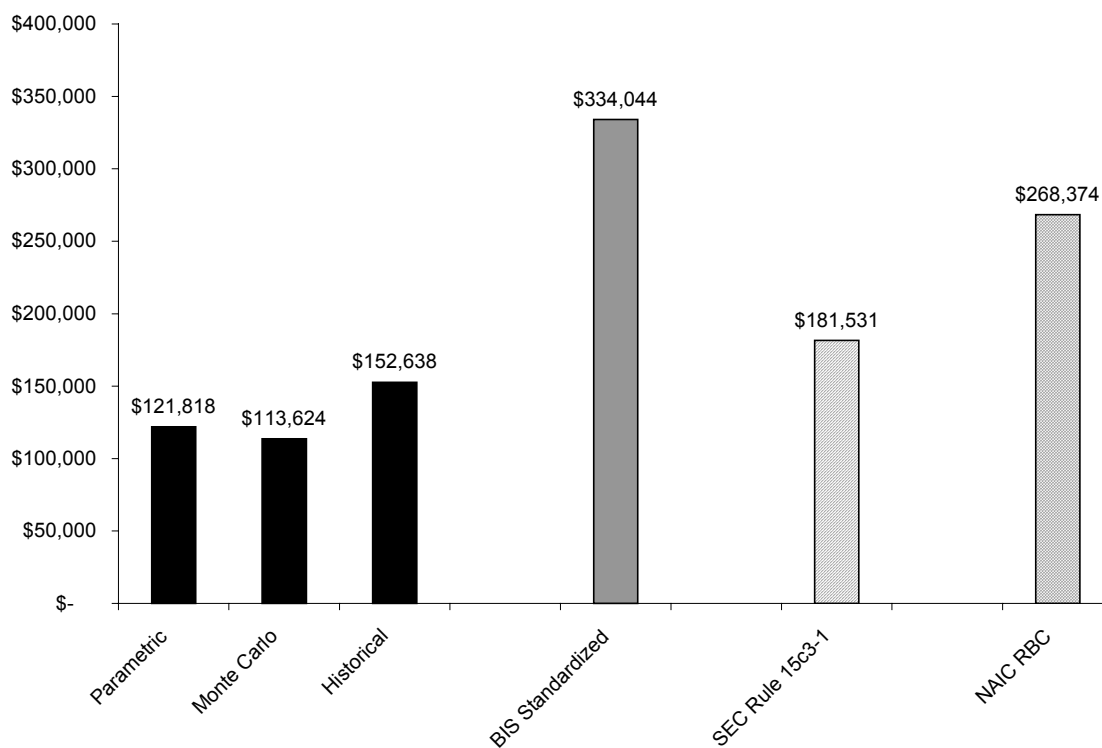
<sup>a</sup> Contributory VaR takes into account diversification benefits contributed by this position to the overall portfolio.

Capital charges for individual positions are given in Table 1.8 and portfolio-level results are given in the last column of Table 1.8 (and Figure 1.2). The differences are sometimes dramatic, although to be sure, this result may just be an artifact of this particular portfolio. Leaving aside the most dominant position, the protection put on the FTSE100, for the moment, consider first a comparison of the three variants of VaR (parametric, Monte Carlo and historical simulation). At the individual position level, we see the expected result: historical VaR often yields a higher capital charge than parametric VaR, especially for emerging markets exposure. A good example is the long Pound, short Peso and Mexican 6M position, where historical VaR (\$26,345) is about 30% higher than parametric VaR (\$20,503). For some of the options positions this is even more dramatic. Both the calendar spread and straddle on the S&P500 have risk levels implied by historical simulation that far exceed parametric VaR. We will discuss the option positions in greater detail below.

Figure 1.2

## Regulatory Capital Compared

Source: Authors' compilation



Historical VaR tends to be the most conservative of the three VaR variants in common use precisely because it takes into account the fat tails, whether returns are linear or nonlinear, and are particularly prevalent in emerging markets.<sup>70</sup>

Moving on to the rule-based approaches, for the simple bond positions, capital charges differ only modestly, the outlier being the NAIC RBC capital that gives very favorable treatment to government bonds. Note also that some of the interest rate risk, captured by the other

approaches, may be captured separately by the NAIC rules under C3 interest rate risk. However, C3 calculations of RBC must be done in the context of a particular liability exposure, which is beyond the scope of our experiment.

The NAIC RBC approach is the only approach that assigned a capital charge to our long \$10,000 (Flat) position. (Recall that the NAIC RBC assigns a 30bp charge against cash (see Table 1.4), resulting in a \$30 charge here.) The other case in which the NAIC capital charge is substantially higher than either the SEC or various Basel capital charges is for the Long Mexican IPC, short S&P, FX hedged position. This is largely driven by the high capital charge the NAIC has assigned to equities (30%) without allowing for netting.

The swap position receives a much higher capital charge under the SEC Net Capital Rule, 15c3-1 (\$29,112) than under any other approach. As a basis for comparison, Basel capital under historical simulation VaR would be \$167. The SEC haircuts are extremely unfavorable to swaps on the accounts of the broker/dealer. Indeed, leaving out the dominant protection put, nearly half of the total remaining SEC capital charge comes from the FX swap position.<sup>71</sup>

The Basel Standardized Approach was designed to be generally more conservative than the internal models approach, precisely to act as a motivation for banks to invest in the necessary infrastructure to be able to adopt the latter. At the portfolio level this is obviously the case: under this approach, the portfolio receives the highest capital charge of any of the approaches. There are exceptions, however, even on some simple positions. For example, the first two positions (long U.S. 5-year; short U.S. 1-year treasury; long U.K. 5-year treasury) receive a lower capital charge than under any of the internal models approaches. This is likely due to higher than anticipated

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<sup>70</sup> Pritsker (2001) reminds us that historical VaR is not a panacea by showing that even this method misses significant tail events.

<sup>71</sup> Consequently, broker/dealers book most swap activity in affiliates.

(under the standardized approach) risk factor volatilities. Fat tailed returns are obviously not driving the results, as in both cases, historical VaR-based capital is lower than the other two internal models approaches imply, suggesting that the risk factor volatilities are the likely cause.

A picture of the risk contribution of individual positions under the VaR approach can be obtained by looking at contributory VaR in Table 1.9.<sup>72</sup> Contributory VaR may be negative, as is the case for the long-short equity position (long Mexican IPC, short S&P500), if it provides diversification benefits at the portfolio level. This may be due to natural off-sets--elsewhere in the portfolio we are long the S&P500--or it may be due to negative correlations of the underlying risk factors. We can get a glimpse of this by looking at the correlations of the risk factors (except implied volatilities) at the end of the sample period in Table 1.9. The exchange rate returns seem to be weakly negatively correlated with equity returns. Looking down (or across) the USD/MX Peso column, we see negative correlations with the S&P500, the FTSE100, the IPC itself, as well as with U.S. and U.K. treasury rates, all of which appear elsewhere in the portfolio.

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<sup>72</sup> For computational convenience, we calculate contributory VaR for the linear approach only, which does not take account of the nonlinearities in returns introduced by the option positions.



Table 1.9  
EWMA Correlation Matrix of Risk Factor Changes  
(absolute level changes), at sample end (12/21/2001);  $\text{Lambda} = 0.94$

<i>Holding</i>	<i>S&amp;P</i> <i>500</i>	<i>FTSE</i> <i>100</i>	<i>IPC</i> <i>(Bolsa)</i>	<i>US\$/GBP</i>	<i>US\$/Peso</i>	<i>US 1-</i> <i>year</i>	<i>US 5-</i> <i>year</i>	<i>UK 1-</i> <i>year</i>	<i>UK 5-</i> <i>year</i>	<i>6-month</i> <i>cetes</i>	<i>1-year</i> <i>cetes</i>
S&P 500	1.00	0.65	0.61	-0.25	-0.09	0.28	0.08	-0.02	0.17	0.05	-0.12
FTSE 100	0.65	1.00	0.54	-0.30	-0.14	0.32	0.18	0.18	0.32	-0.19	-0.18
IPC (Bolsa)	0.61	0.54	1.00	-0.08	-0.18	0.24	0.32	0.19	0.44	-0.08	-0.20
US\$/GBP	-0.25	-0.30	-0.08	1.00	0.24	-0.17	-0.02	-0.20	-0.01	0.30	0.25
US\$/Peso	-0.09	-0.14	-0.18	0.24	1.00	-0.19	-0.23	-0.18	0.18	-0.04	0.23
US 1-year	0.28	0.32	0.24	-0.17	-0.19	1.00	0.80	0.12	0.14	-0.14	-0.13
US 5-year	0.08	0.18	0.32	-0.02	-0.23	0.80	1.00	0.21	0.35	-0.12	-0.14
UK 1-year	-0.02	0.18	0.19	-0.20	-0.18	0.12	0.21	1.00	0.54	0.06	0.01
UK 5-year	0.17	0.32	0.44	-0.01	0.18	0.14	0.35	0.54	1.00	0.01	0.03
6-month cetes	0.05	-0.19	-0.08	0.30	-0.04	-0.14	-0.12	0.06	0.01	1.00	0.48
1-year cetes	-0.12	-0.18	-0.20	0.25	0.23	-0.13	-0.14	0.01	0.03	0.48	1.00

Source: Authors' compilation

Finally, it is worth dissecting the options positions. Note that for the options positions, implied instead of parametric volatilities were computed. The protection put on the FTSE100 (long the FTSE100, the underlying position, and long a put, essentially insurance against downward movements in the FTSE100) is a large position. It cost \$765,075 (which appears as a negative entry for US\$ cash in Table 1.9) and has a capital charge of \$150,705 under the historical simulation VaR internal models approach. This is larger than either of the other VaR approaches, indicating that there are fat tails in the FTSE100 as well as the USD/GBP exchange rate.<sup>73</sup> The SEC Net Capital Rule assigns a capital charge that is closest to the internal models approach. This is likely due to the recent (February 1997) changes for the capital calculation for options positions, which are significantly more nuanced than the previous simple haircuts. The NAIC RBC approach falls between the internal models and BIS Standardized approach, the latter topping out at \$263,332, a good example of appropriately providing banks an incentive to move to the more complex internal models approach.

An excellent example of capital charge differences is the Calendar Spread on the S&P500, delta and rho (interest rate risk) hedged. The parametric VaR approach severely underestimates the risk of nonlinearity (\$103 vs. \$2,144 for the Monte Carlo approach), while incorporating fat tails and implied (instead of parametric) volatilities, as done in the historical simulation VaR approach, provides a better picture of the risk in this position: \$3,573.

Hedging is given only partial credit in the rules-based approaches. A major distinguishing feature of the internal models approach is that it is a portfolio approach by design. Hedges are meaningful only in the context of another position, the one that is being hedged, a feature that

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<sup>73</sup> Recall that this portfolio is valued from the perspective of a \$-denominated institution.

may not be captured in rules that focus on individual positions. In Table 1.10, we explore the impact of hedging for the calendar spread on the S&P 500. First we add a delta hedge to provide protection against changes in the underlying price and then a rho hedge to protect against interest rate risk and show the resulting capital charges for the three variants of VaR and the SEC Net Capital Rule. For all approaches, the delta hedge is the most significant risk mitigant, but there is large disagreement between the methods around the amount of risk mitigation. Parametric VaR indicates a 77% reduction, from \$829 to \$187, while historical VaR suggests that the reduction is more like 3%, from \$3,711 to \$3,602. Adding a rho hedge results in a further drop of 45%, according to parametric VaR, but only a 1% drop according to historical simulation VaR. Rather than reducing capital charges as hedges are added, the Basel standardized approach calls for increased capital because each hedge is treated as an additional position. The SEC Net Capital Rule gives credit for the delta hedge (a short on the underlying **position**) but not for the rho hedge, which is a net long position (a combination of long 1Y and short 5Y on the U.S. treasury).

Table 1.10  
Impact of Hedging for Calendar Spread on S&P500 (\$)

<i>Risk measurement approaches</i>	<i>Naked</i>	<i>Delta hedged</i>	<i>Delta and rho hedged</i>
Parametric VaR	829	187	103
Monte Carlo VaR	2,828	2,148	2,144
Historical simulation VaR	3,711	3,602	3,573
Basel Standardized Approach	30,809	31,153	31,225
SEC Net Capital Rule	2,142	1,625	1,716

Source: Authors' compilation

Finally, consider the ninth position in our portfolio, a straddle on the S&P500, which is delta hedged. For the internal models approaches, capital difference are surprisingly large: \$14 for parametric VaR against \$11,726 for historical simulation VaR. A straddle is a bet on large moves in the underlying position; a move in either direction results in a large value change of the

option. These large moves can be driven by high volatilities or fat-tailed returns. The S&P500 is only moderately fat-tailed (a kurtosis of around 5.5, where 3 is considered normal), but the parametric volatility, used by both the parametric and Monte Carlo VaR methods, was 14.6% (annualized) at the end of the sample period (i.e., on the day this hypothetical risk exercise is undertaken), compared with 20.3% (call) or 20.1% (put) for the implied volatility. In combination, the slightly fatter tails and higher volatility of the historical simulation lead to a much larger capital charge than implied by the other two internal models approaches. The BCBS standardized approach is again the most conservative (\$17,885) while the other two rules-based approaches are both under \$1,000.

## **6 Pitfalls in the Use of VaR**

Regulatory approaches for setting capital charges for market risk seem to be converging across the three financial sectors to an internal models approach--some variant of VaR, supplemented by stress testing and scenario analysis. This approach is already widespread among internationally active banks and European securities houses. The SEC has experimented with an internal models approach for derivatives dealers, and a recent report to the European Commission has recommended adaptation of the Basel approach for insurance companies (KPMG 2002). But is VaR the optimal approach to risk measurement?

### **6.1 Evaluating VaR**

Does VaR accurately measure market risk? We will consider this question at a theoretical level below. At an empirical level, Kupiec (1995) and Jorion (1995) point out that VaR is itself an estimate of a true but unknown distribution quantile, and thus suffers from estimation error

just like any other parameter, an error that increases with the confidence level (99% VaR suffers greater error than 95% VaR). Kupiec (1995) shows that this error can be quite large.<sup>74</sup>

Several papers have examined the accuracy and information content of VaR model estimates with subsequent bank performance. Berkowitz and O'Brien (2002) compare daily VaR forecasts with next day trading results using a sample of large U.S. banks containing confidential supervisory data. While the VaR models provide a conservative estimate of the 99% tail on average, there is substantial variation across institutions. Moreover, they demonstrate that a simple Generalized Autoregressive Conditional Heteroskedasticity (GARCH) volatility model based on daily trading P&L outperforms the VaR models in forecasting next day trading results. Jorion (2002) and Hirtle (2003) examine the information content of VaR reporting. Both studies suggest that such disclosures are indeed informative? Jorion (2002) finds that VaR disclosures predict variability in trading revenues. Similarly Hirtle (2003) reports that reported market risk capital is useful for predicting changes in market risk exposure over time for individual banks; however, such disclosures provide little information about differences in market risk exposure across banks. In sum, VaR seems far from the last word in market risk measurement.

### **6.1.1 Horizons, Time Scaling, Liquidity, Extreme Events**

What is the appropriate horizon over which to measure market risk? If volatility is measured at high frequency, how should it be scaled to a lower frequency? What is the impact of illiquidity on the market risk measure? Finally, since the risk manager is really interested in extreme events, why not model those directly?

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<sup>74</sup> Lopez (1999) compares alternative methods for evaluating VaR models and develops his own superior method based on proper scoring rules of probability forecasts.

The issues of horizon, time scaling, and liquidity are intimately related.<sup>75</sup> For very liquid instruments, a shorter horizon is certainly appropriate, while an instrument or position that is known to be relatively illiquid should be modeled with a longer horizon. The BCBS and CAD rules require that the market risk capital charge be sufficient to cover a 10-day holding period. For practical purposes, banks measure market risk, using VaR, for example, at a daily frequency, and the conversion from daily to 10-day (time scaling) is done using the root- $t$  (or root- $h$ ) rule: multiply the daily standard deviation by the square root of the horizon. Thus for a 10-day horizon, the daily VaR estimates are increased by  $\sqrt{10} \approx 3.16$ . Diebold et al. (1998) show that such scaling is inappropriate. They show it is only strictly appropriate for independently and identically distributed data and that it overestimates volatility at longer horizons.

Naturally the horizon over which market risk is measured should also reflect the frequency of trading (Joint Forum 2001). This tends to be shortest for securities firms and longest for insurers. For example, the NAIC Life RBC for equities explicitly assumes a two-year holding period (AAA 2002), a horizon over which credit risk issues tend to dominate market risk. SEC haircuts are calibrated largely along lines of perceived liquidity, rendering U.S. treasuries the most liquid and nonlisted stocks as relatively illiquid.

The purpose of the 10-day holding period in the BCBS and CAD regulations for banks is to build in an illiquidity premium. Jorion (2001) discusses various other approaches to dealing with liquidity risk including the incorporation of information from the bid-ask spread and specific trading strategies. Bangia et al. (1999) distinguish between endogenous and exogenous liquidity risk depending on whether the position is sufficiently large to influence the market price

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<sup>75</sup> See Christofferson, Diebold, and Schuermann (1998).

upon liquidation (endogenous) or the particular market is just inherently less liquid such as emerging markets equities (exogenous).

Finally, the direct modeling of extreme events using recent advances in the area of extreme value theory (EVT) has generated some new approaches to dealing with long-tail events. Originally developed for insurance questions (e.g., how high should the dykes be to prevent the one-in-500-year flood?), the toolkit of EVT is succinctly described for a broader technical audience in Embrechts, Klüppelberg, and Mikosch (1997). EVT holds the promise of providing a means of assessing probabilities of extreme events outside the range of historical experience. What, for example, is the probability of a 35% one-day drop in the S&P 500, and the consequent expected loss in a portfolio? Several papers are collected in a volume edited by Embrechts (2000) that includes an excellent introduction to the area for risk managers (McNeil), applications to value-at-risk (Danielsson and DeVries), multivariate EVT (Embrechts, de Haan, and Huang), and correlations (Embrechts, McNeil, and Straumann).<sup>76</sup> A more sobering assessment of EVT and its potential for risk management is provided in a contribution by Diebold, Schuermann, and Stroughair (1998) to *Advances in Computational Finance* edited by A.N. Burgess and J.D. Moody (1998).

### **6.1.2 Stress Testing and Scenario Analysis**

It is industry best practice and a supervisory requirement in several countries to conduct stress testing and scenario analysis of one's portfolio. Stress testing serves two main objectives: Capital adequacy/regulatory compliance, since it is required by the regulators; and the market risk goal of control by informing management of potential losses/gains under extreme market

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<sup>76</sup> See also Neftci (2000).

conditions. They should be performed regularly (quarterly-monthly firm-wide, weekly-daily business-level) and business lines should respond to stress testing results. While it is supplemental to VaR for most firms, for some it has at least equal footing in their risk management process. Jorion (2000) points out that modest stress testing of one important correlation parameter would have exposed some significant risks to Long Term Capital Management in their portfolio.

The extent to which supervisors should specify stress tests remains an open question, Supervisors in some countries resist specifying stress tests because they are concerned about an implicit implication that official support would be forthcoming in the event of shocks that exceed the levels specified in stress tests and because they believe that a supervisory requirement might subvert what should be a valuable management tool by making it a routine compliance task. Supervisors in other countries believe that they can gain valuable information about the vulnerability of the financial system to systemic risk by reviewing the results of some standard stress tests for all regulated market participants. Even supervisors who hold this view, however, believe that firms should be encouraged to design their own stress tests as well.

#### **6.1.2.1 Stressing the Risk Factors**

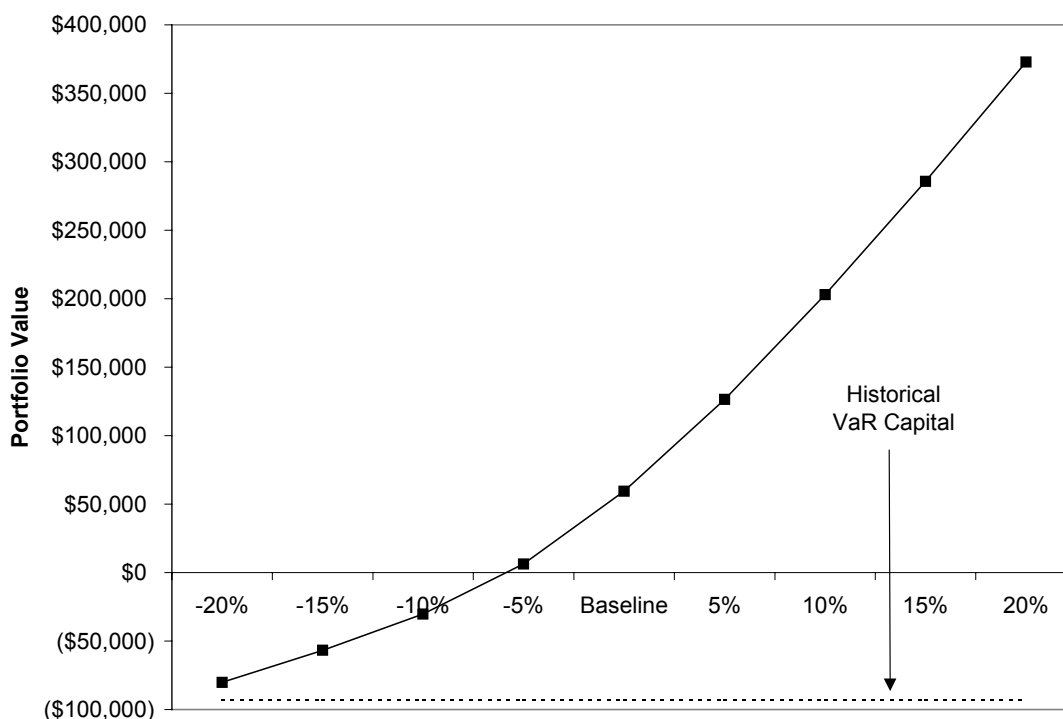
We conducted two sets of stress tests. The first simply increased (decreased) each risk factor by 0 to 20% in steps of 5%. The results are presented in Figure 1.3, with the capital levels implied by the historical simulation VaR indicated by a dotted line. Because the portfolio has a combination of long and short positions as well as options, the relationship between risk factor changes is not linear (i.e., directly proportional to the changes in risk factors). A drop of a little more than 5% in all of the risk factors is enough to render the portfolio to negative value. But the option positions, designed largely to protect against adverse movements, result in a less than

proportion decline in portfolio values as the risk factors drop by more and more. Even a drop of 20% in all the risk factors does not cross the capital barrier implied by historical simulation VaR.

Figure 1.3

### Impact of Stress Tests on Portfolio Value

Source: Authors' compilation



#### 6.1.2.2 Scenario Tests

The second stress test was a series of three specific scenarios shown in Table 1.11: (1) an E.U. crisis characterized by a flight from equities to fixed income; (2) a Mexico crisis combining a drop in the peso exchange rate with a dramatic increase in Mexican interest rates and flight to U.S. treasuries; and (3) a terrorism scenario mimicking broadly the market reactions following the September 11 attacks in New York and Washington DC. The percentage changes are

judgmental and are designed to be a bit extreme for the purposes of the stress scenarios. The specific risk factor impacts are described in Table 1.12.

Table 1.11  
Stress Scenarios

<i>Risk Factor</i>	<i>Scenarios: % Change of Risk Factor</i>		
	<i>EU Crisis %</i>	<i>Mexican Crisis %</i>	<i>Terrorism %</i>
S&P 500	-10	-2	-10
FTSE 100	-20	-1	-10
Mexico IPC (Bolsa)	-10	-25	-10
US\$/UK£	-15	0	0
US\$/MX Peso	+10	-40	-5
US Treas. 1y	+10	+10	-5
US Treas. 5y	+10	+20	0
UK Interbank 1-yr	+40	+10	-5
UK Treas. 5-yr	+30	+20	0
Mex. Treas. 6-m	+10	+100	+5
Mex. Treas. 1-yr	+10	+100	0

Source: Authors' compilation

Table 1.12  
Impact of the Stress Test Scenarios (\$)

<i>Approaches</i>	<i>Long 5-yr, short 1-yr (U.S. yield curve slope exposure)</i>	<i>Long U.K. 5-yr (U.K. yield curve + FX exposure)</i>	<i>Flat</i>	<i>FX swap (USD/GBP)</i>	<i>Long £, short peso, long MX 6M</i>	<i>Long Mexican IPC, short S&amp;P, FX hedged</i>	<i>Calendar spread on S&amp;P500 (<math>\Delta</math> &amp; rho hedged)</i>	<i>Protection Put (FTSE)</i>	<i>Siraddle on S&amp;P500 (<math>\Delta</math> hedged)</i>	<i>Total portfolio</i>
Net value	31,940	(0,07)	10,000	309	8	5,192	8,889	0.15	3,043	59,382
Basel capital (parametric VaR)	7,061	7,420	0	271	20,503	21,030	103	127,924	14	121,818
Basel capital (Monte Carlo VaR)	6,384	7,633	0	258	18,887	20,623	2,144	121,640	7	113,624
Basel capital (historical simulation VaR)	5,128	6,987	0	167	26,345	33,212	3,573	150,705	11,726	152,638
Basel standardized approach	3,250	4,412	0	1,362	1,098	11,481	31,225	263,332	17,885	334,044
SEC Rule 15c3-1 haircut	2,500	8,734	0	29,112	2,348	17,221	1,716	119,391	509	81,531
NAIC RBC: C1	0	437	30	44	109	37,516	1,163	228,120	956	268,374
EU crisis (net value)	30,384	(6,740)	10,000	384	(36,430)	15,296	7,080	(149,551)	9,607	(119,969)
Mexico crisis (net value)	28,765	(5,362)	10,000	338	57,983	5,611	8,687	(5,848)	3,356	103,530
Terrorism (net value)	31,888	0	10,000	295	7,265	15,484	7,099	(36,131)	9,634	45,534

Source: Authors' compilation

The results are contained in Table 1.12, with the last column summarizing the impact at the portfolio level. At the portfolio level it makes sense to ask the question: does the scenario generate losses that exceed the required capital levels implied by the different capital regimes? Asking this question at the position level is not meaningful unless firms base their position limits on required capital. Still, it is interesting to track the impact of specific scenarios on individual position values. Only the E.U. crisis position results in a loss exceeding the internal models capital levels, although it does not exceed any of the rules-based capital levels. Interestingly, the scenario we call “Mexico Crisis” results in a value gain of \$44,148, from an initial value of \$59,382 to \$103,430.

Taking each crisis in turn for some position level outcomes, the E.U. crisis scenario has a significant adverse effect on the long U.K. bond, the long pound/short peso position and the FTSE100 protection put positions. It is worth dissecting the effect on the protection put which, recall, is a long position in the FTSE100 itself, protected with a put (strike just below the current FTSE100 level), but valued in US\$. The decline of 20% in the FTSE results in a large loss on the underlying position, partially offset by the put getting into the money. Once one factors in the change in the dollar/pound exchange rate, the net loss is about \$150K. Some positions gain in value, namely the long IPC, short S&P500, FX hedged position, largely due to U.S. and Mexican asset prices reacting positively in this scenario, as well as the straddle on the S&P500. The Mexico crisis generates a gain in the long pound/short peso position of nearly \$58K, more than making up for losses in some of the other positions. Finally, the terrorism scenario yielded large losses only on the protection put on the FTSE100 (about \$36K) while several of the other

positions gain in value: long pound, short peso (up from \$8 to \$7,265), long IPC, short S&P (up from \$5,192 to \$15,484), and the straddle on the S&P500 (up from \$3,043 to \$9,634).

## 6.2 Coherent Risk Measures and the Regulatory Framework

If regulators are to achieve their stated goal of making capital charges sensitive to the actual positions risks taken by regulated firms, how should their regulatory frameworks be designed? Christoffersen and Diebold (2000) and Berkowitz (2001) argue that rather than focus on just one number such as VaR, risk managers and, implicitly, regulators should focus on the whole density function of returns, perhaps using techniques such as those laid out in Diebold, Gunther, and Tay (1998) and Berkowitz (2001). Nonetheless, interest in a simpler, summary measure continues. What standards should such a summary measure meet and how do the regulatory approaches currently in use measure up to these standards?

Artzner et al. (1997, 1999) lay out a set of criteria necessary for what they call a “coherent” measure of risk. Following roughly their notation, let  $X$  and  $Y$  be the returns  $k$ -periods from now for two subportfolios,<sup>77</sup> and let  $v$  be any real number,  $\lambda \geq 0$ , and  $r$  the risk-free interest rate. Then a coherent risk measure  $\rho$  must satisfy the following four conditions:<sup>78</sup>

- |     |                                      |                              |
|-----|--------------------------------------|------------------------------|
| (1) | $\rho(X+Y) \leq \rho(X) + \rho(Y)$   | [subadditivity]              |
| (2) | $\rho(\lambda X) = \lambda \rho(X)$  | [homogeneity]                |
| (3) | $\rho(X) \geq \rho(Y)$ if $X \leq Y$ | [monotonicity] <sup>79</sup> |
| (4) | $\rho(X + r \cdot v) = \rho(X) - v$  | [risk-free condition]        |

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<sup>77</sup> We suppress subscripts  $k$  (periods into the future) and  $\alpha$  (confidence level or critical value) here.

<sup>78</sup> Ugur Koyluoglu’s comments were very helpful in this section.

Condition (1) is crucial in that it reflects basic portfolio effects: the risk of the sum cannot be greater than the sum of the risks. Condition (2), reflecting position scaling, raises the specter of large position sizes since it states that breaking up the position/portfolio into  $\lambda$  pieces should be the same as  $\lambda$  times the risk of each piece. Indeed, a rather large position, especially if many market participants hold that same position, could be more than proportionately riskier than a small one due to impacts on prices upon liquidation. Ideally the liquidation impact should be reflected in the forecast of  $X$  (i.e.,  $X_{t+k}$ ). Conditions (1) and (2) together imply convexity of the risk measure corresponding to risk aversion by the regulator and/or the risk manager. Condition (3) simply means that if the value  $X$  (portfolio value  $k$ -periods ahead) is always less than (or equal to)  $Y$ ,  $X$  must be riskier than  $Y$ . The last property (4) reflects risk treatments of risk-free investments: if an initial quantity  $v$ , invested at the risk-free rate  $r$ , is added to the portfolio of future value  $X$ , the firm enjoys capital relief of  $v$ .<sup>80</sup> If the entire portfolio is invested in the risk-free asset, it should be riskless.

VaR satisfies all conditions except the first, sub-additivity--that the risk of the sum is never greater than the sum of the risks.<sup>81</sup> Unfortunately, the subadditivity condition has important implications for the measurement and management of position risk. Specifically, it allows for decentralized measurement of risks, say for each position or product (an FX swap), to be added up to higher levels of aggregation--say to a desk (swaps), then to a group (trading) and a business unit (capital markets) in a coherent fashion. Financial institutions actually do manage their business in this drill-down/build-up fashion, so that violation of the subadditivity condition

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<sup>79</sup> There is some confusion about the inequalities in this expression. In their more technical paper--Arztner et. al. (1999)--the inequality is reversed because of a slight difference in definition of  $X$  and  $Y$ . Their 1997 paper as well as Jorion's (2001) treatment of coherent risk measures reflects our notation.

<sup>80</sup> Arztner et al. (1999) call this condition "translation invariance" with the implication that for each  $X$ ,  $\rho(X + \rho(X) \cdot r) = 0$ .

is a concern. One consequence is that VaR could be influenced by reorganizing the trading floor without changing the overall portfolio. Moreover, a firm could concentrate all of its tail risks in one desk in such a way that the risk borne by that desk appears just beyond the overall portfolio VaR threshold.<sup>82</sup>

How might this happen? If the portfolio contains a position that might generate a loss only in extreme market conditions, effectively generating a bump or set of bumps in the tail of the portfolio return distribution. As an illustration, consider the following return distributions for two portfolios shown in Figure 1.4). They have identical means and variances. Portfolio A is a Gaussian ( $\mu = -0.5$ ,  $\sigma = 2.6$ ) and portfolio B is a Gaussian mixture--95%  $N(0,1)$ , 5%  $N(-10,25)$ . Thus portfolio B has some loss results that are large, albeit unlikely. The two portfolios may have identical VaRs at about the 5% level, but B is clearly more risky (which would show up at the 1% level in this case).

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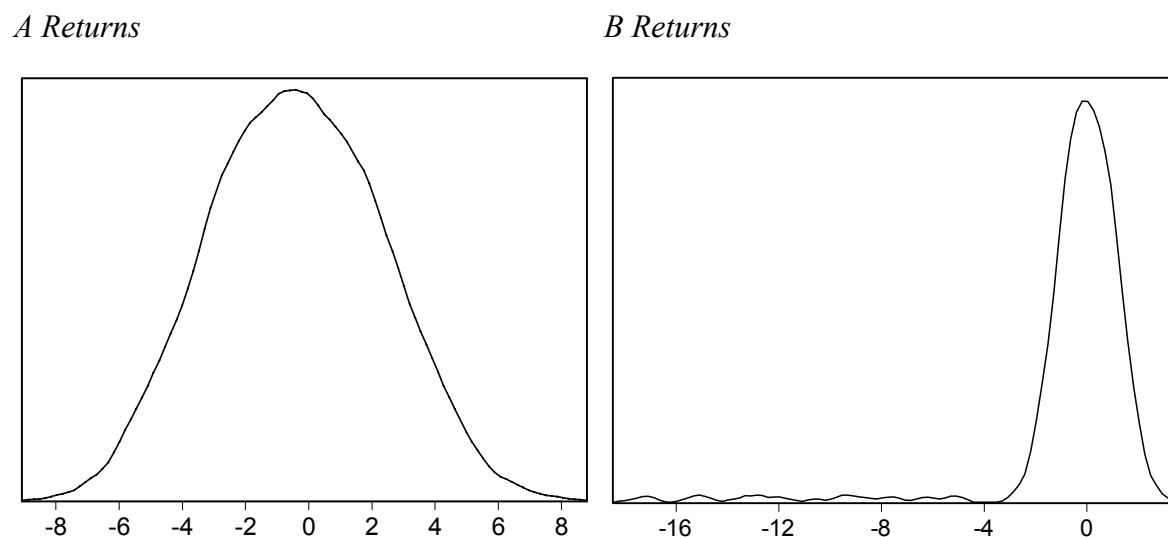
<sup>81</sup> Note that if the underlying distributions of all the risk factors are normal, then subadditivity is not violated.

<sup>82</sup> For a fascinating discussion about the difficulty of risk capital attribution, see Koyluoglu and Stoker (2002).

Figure 1.4

## Two Portfolios: Bumps in the Tails

Source: Authors' compilation



Crouhy, Galai, and Mark (2001, p. 253) point out that this situation is common in credit risk with concentrated portfolios that have large single exposures.<sup>83</sup> However, those same conditions may also occur in position risk, especially in the presence of options.

The other regulatory measures of position risk fare much worse. In addition to violating the subadditivity condition, they violate two more of the conditions for a coherent risk measure as well. While it is beyond the scope of this chapter to provide a formal evaluation of the coherency of each regulatory approach, we can make some simple observations. All of the regulatory approaches fail to satisfy the subadditivity condition because they fail to detect bumps in the tails (or “holes” on the way to the tails) in the portfolio return or value distribution.

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<sup>83</sup> One need not have a large position to violate subadditivity, Consider the example of two uncorrelated \$1 loans that each have a probability of default equal to 0.9%. Their individual 99% VaRs would both be zero. However,

Artzner et al. (1999) point out that the SEC net capital rule also falls short of a coherent risk measure because it fails at least two additional conditions--(2) monotonicity and (3) homogeneity. The monotonicity condition is also violated by both the Basel Committee Standardized Approach and the NAIC RBC approach. A simple example is a calendar option with and without rho-hedging (interest rate hedging). The hedge reduces risk while increasing required capital under both regulatory regimes. Similarly, the NAIC RBC approach violates the homogeneity condition because it penalizes concentrations of risk (i.e., position scaling). Specifically, the NAIC RBC provide a “concentration adjustment,” or additional capital charge for lack of diversification (Webb and Lilly 1994, p. 139), to the ten largest single-name exposures, since the baseline methodology does not sufficiently address concentration risk. To be sure, the ex post adjustment is appropriate in the context of the NAIC approach; but a coherent risk measure would not need such an ex post adjustment.

### 6.3.1 Expected Shortfall, Exceedence, Tail VaR

How could VaR be strengthened to meet the subadditivity condition? One potential solution is to include the expected shortfall or exceedence. It answers the simple question: how bad is bad? Borrowing from the insurance literature, authors such as Embrechts, Klüppelberg, and Mikosch (1997), Artzner et al. (1997, 1999), Neftci (2000) and Basak and Shapiro (2001), among others, suggest looking at the beyond-VaR region. Recall that we denoted  $\text{VaR}(k, \alpha)$  as the VaR estimate at time  $t$  for a  $k$ -period ahead return. It is the critical value of the return distribution  $f_{t+k}(\cdot)$  that corresponds to its lower  $\alpha$  percent tail. More specifically,  $\text{VaR}(k, \alpha)$  is the solution to

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their combined VaR will be \$1 because the probability that one of the loans would default in this two-loan portfolio

$$\alpha = \int_{\text{VaR}(k, \alpha)}^{\infty} f_{t+k}(x) dx \quad (1.4)$$

The BIS requirement for  $\alpha$  and  $k$  are  $\alpha = 1\%$  and  $k = 10$  days. In the previous section we saw that distributions with bumps in the tails are troublesome for standard VaR. One way to capture this tail effect is through the tail conditional expectation (called “Tail VaR” by Artzner et al. (1999) or EVaR by Crouhy, Galai, and Mark (2001)). Very simply, it is the expected value of returns of the beyond-VaR( $k, \alpha$ ) threshold:

$$E(x_t | x_t \leq \text{VaR}(k, \alpha)) = \int_{-\infty}^{\text{VaR}(k, \alpha)} x \cdot f_{t+k}(x) dx \quad (1.5)$$

This measure describes the expected loss given that VaR( $k, \alpha$ ) has been exceeded. Taking the mean is a very simple summary statistic of the beyond-VaR tail. However, the risk manager (and regulator) might care differently about the probability mass being piled up near the VaR threshold or further away (i.e., deeper into the tail), prompting one to consider estimating higher moments of the tail region (standard deviation, skewness, and so on). It becomes clear again that the information loss from attempting to summarize the portfolio risk in a single number from the whole density can be substantial.

Several researchers have already made use of this measure. Neftci (2000) applies the metric in combination with EVT to the tails of the distribution only. His portfolio contains fixed income and FX positions, and he finds that it performs surprisingly well in measuring the mean excess beyond some threshold (e.g., 1%), both in and out of sample. Basak and Shapiro (2001) show that risk managers who maximize their expected utility subject to a VaR constraint will optimally choose riskier portfolios than agents without the VaR constraint. While they insure that

their probability of loss is fixed (at  $\alpha$ , their VaR constraint), as a consequence they suffer larger losses when a large loss does occur. Finally, Berkowitz (2001) provides a method for evaluating these tail-based metrics.

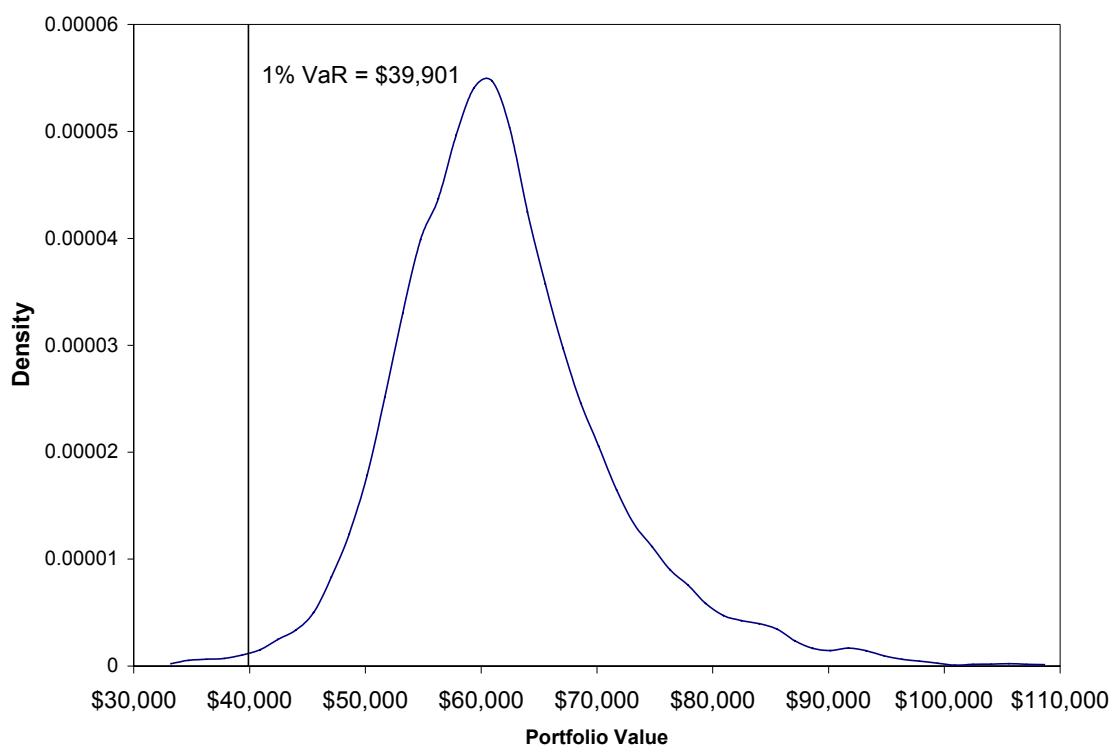
We can compute a tail-VaR for our portfolio in the following fashion. The historical simulation VaR generates a distribution of portfolio returns for the current (12/31/2001) portfolio using all observed return values in the 1,300-day sample (see Figure 1.5).

Figure 1.5

Portfolio Return Density--Historical Simulation

Note: The distribution of values on the X axis is based on historical VaR.

Source: Authors' compilation.



The tail VaR at  $\alpha = 1\%$  is the mean of all portfolio returns beyond the 1% tail. That value is \$39,901, which exceeds the capital levels of all methods. That the tails are somewhat fat is confirmed by the portfolio kurtosis, 4.8, but it so happens that in our portfolio return distribution, the bumps are in the “good” tail.<sup>84</sup>

## 7 Regulatory Versus Market Capital Requirements: Concluding Comment

Leading firms in all three sectors customarily maintain levels of eligible regulatory capital far in excess of the regulatory minimums. The recent Joint Forum survey (2001, p. 53) found that banks typically operate with capital levels between 1.3 and 1.8 times required capital, securities firms from 1.2 to 1.3 times the warning level,<sup>85</sup> and insurance companies more than 5 times required capital. In part this is due to regulatory inducements. In the United States, for example, banks must have a Tier 1 risk-based capital ratio of 6% or more (rather than the minimum of 4%) and a Tier 1 to total asset (leverage) capital ratio of 5% or more (rather than the 4% minimum) to be considered “well capitalized” (USGAO 1998, p. 129). Well capitalized banks have lower risk-based deposit insurance premiums and are more likely to receive regulatory permission for expansion of activities.

In addition, some regulatory sanctions cut in before the regulatory minimum. For example, broker-dealers undergo “heightened supervision” if their net capital falls below a warning level of 5% of their aggregate debit items relative to the regulatory minimum ratio of 2% (Joint Forum 2001, p. 95). Similarly, if an insurance company has total adjusted capital less than 200% of the regulatory minimum under which the supervisor may place the insurer under

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<sup>84</sup> These and other approaches are discussed in a special issue of the *Journal of Banking & Finance* 26(7) July 2002, devoted to the topic of VaR and beyond VaR.

<sup>85</sup> Defined below as 5% of aggregate debit items.

regulatory control, the insurance company is required to submit a plan to the supervisor for raising total adjusted capital above 200% (Joint Forum 2001, p. 98). But even allowing for a margin of safety to avoid regulatory sanctions, it appears that firms have significantly more capital than the regulators require. While some of the excess may represent an effort to stockpile capital to provide flexibility for strategic acquisitions, it appears that the binding constraint is not regulatory requirements, but the market requirement.

Leading firms appear to target ratings for their long-term debt that exceed the degree of protection from insolvency that the regulators require. This decision is presumably driven by calculations of the debt rating and leverage ratio that will maximize shareholder returns. And so market discipline, not regulatory discipline, is the main constraint for most firms.

The rating agencies and financial analysts, who serve as delegated monitors for many investors, inform market assessments of position risk and capital adequacy for position risk. Their evaluations are based on qualitative and quantitative analysis of publicly available information, augmented sometimes in the case of rating agencies by private disclosures of information.<sup>86</sup> They are asked by investors and debtors to make the comparative judgments across the three sectors--a challenge that the Joint Forum (2001, p. 5) concluded could not be met with confidence on the basis of regulatory data because "the frameworks and underlying accounting are different in so many respects. . . ." In response to market demands and regulatory pressure, the publicly available data for making such assessments is steadily improving.

Financial institutions are particularly opaque, however, making assessments by rating agencies and equity analysts more difficult. Morgan (2002) measures this opacity by showing

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<sup>86</sup> The SEC's recent Fair Disclosure regulation (Regulation FD) requires that material disclosures to security analysts be made available at the same time to the public at large.

that bond raters disagree more about banks and insurance companies than about any other kind of firm.

In the wake of a string of corporate losses from derivatives activity and in recognition of the increasing relevance of market risk in the assessment of corporate performance, the SEC (1997b) established disclosure standards for quantitative and qualitative information about market risk that took effect in June 1998. Virtually all publicly traded corporations in the United States must report quantitative information about their exposure to market risk in one of three formats: (1) a table of contract terms, including fair value of market risk sensitive instruments, and expected cash flows for each over the next five years and in the aggregate thereafter; (2) a sensitivity analysis of the potential loss in earnings due to possible near term change in interest rates, foreign exchange rates, commodity prices and other market prices; or (3) VaR disclosures for market risk sensitive instruments that might arise from market movements of a given likelihood over a specified interval.<sup>87</sup> The SEC's (1998) early evaluation of the new disclosures indicated that market participants find them useful and the direct costs of disclosure have been relatively low.

In a study of oil and gas firms, Rajgopal (1999) found that the tabular and sensitivity analyses were, indeed, related to their exposure to energy prices. Trading portfolios at major financial institutions, however, are subject to a much broader range of risk factors in which VaR measures would appear to be a more informative form of disclosure. Jorion (2002) has shown VaR disclosures by eight U.S. banks do indeed predict realized market risk.<sup>88</sup> It was not possible, however, to make meaningful direct comparisons of VaR disclosures across institutions. The

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<sup>87</sup> Linsmeier and Pearson (1997) describe the rationale for the SEC's approach.

sophisticated transformations that Jorion performed to extract useful comparative information indicate some of the limitations in current disclosure practices. VaR data were reported for different intervals--as period averages or end-of-period levels or as graphs of daily levels--and with different underlying assumptions about the holding period and confidence level. Berkowitz and O'Brien (2002) compare daily VaR forecasts with next day trading results using a sample of large U.S. banks containing confidential supervisory data. While the VaR models provide a conservative estimate of the 99% tail on average, there is substantial variation across institutions.

The recent BCBS (2002, p. 12) survey of public disclosures by 48 banks from 13 countries indicates that the challenge of making meaningful *international* comparisons across banks is even more difficult. Although almost all of the surveyed banks use VaR to assess their market risk, the details they disclosed about their VaR estimates varied considerably. While 96% of the banks disclosed the confidence level used for VaR estimates, only 89% disclosed the holding period assumption and 74% disclosed the observation period on which the VaR estimates were based. 47% provided a graph of daily profits and losses on trading activities combined with VaR. 51% provided summary VaR data on a weekly or monthly basis. Nonetheless, this survey indicated an increased level of transparency of position risk exposures relative to a similar survey conducted two years earlier (BCBS/IOSCO 1999b, December).<sup>89</sup> In 1998, only two-thirds of the firms reported VaR measures, and only a quarter reported VaR results on a weekly or monthly basis.

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<sup>88</sup> Hirtle (2003) finds that reported market risk capital is useful for predicting changes in market risk exposure over time for individual banks; however, such disclosures provide little information about differences in market risk exposure across banks.

<sup>89</sup> The results are not directly comparable because the sample included forty banks and investment banks from twelve different countries.

The Technical Committee of IOSCO and the BCBS have agreed to a set of recommendations for public disclosure of trading activities of banks and securities firms (BCBS/IOSCO 1999a, February) that would enhance transparency and provide a sounder basis for market discipline by customers, creditors, counterparties, and investors.<sup>90</sup> The two committees agreed that information should be: (1) provided with sufficient frequency and timeliness to give a meaningful picture of the institution's financial position and prospects; (2) comparable across institutions and countries and over time; and (3) consistent with approaches that institutions use internally to measure and manage risk, thus capturing enhancements in risk management practices over time. Their specific recommendations with regard to market risk disclosure include:

- Description of the major assumptions used to estimate VaR including the type of model, holding period, confidence level, observation period, and portfolios covered.
- Daily information on profits and losses on trading activities, combined with daily VaR.

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<sup>90</sup> One channel of market discipline has received considerable attention--subordinated debt. At least eight recent studies--Board of Governors (2000), DeYoung et al. (2001), Flannery, and Sorescu (1996), Hassan (1993), Hassan, Karels, and Peterson (1993), Jagtiani, and Lemieux (2001), Jagtiani, Kaufman, and Lemieux (2002) and Morgan, and Stiroh (1999)--have found that secondary market debt spreads consistently reflected risk differences across banking organizations. Unfortunately, several factors in addition to the probability of default affect yields and spread. Hancock and Kwast (2001) have emphasized the lack of liquidity in many secondary markets. Elton et al., (2001) found that while default risk is significant in spreads between (nonfinancial) corporate and government bonds, it accounts for a smaller proportion of the spread than the tax premium and risk premium. Similarly, Collin-Dufresne, Goldstein, and Martin, (2001) find that default risk explains only about one quarter of the variation in the changes in spreads. Although liquidity factors explain a bit more of the remaining variation, most of it is explained by a component that is unrelated to firm-specific or macroeconomic factors. Partly because variations in the price of subordinated debt are not solely related to credit risk, the Shadow Financial Regulatory Committee (2000) has suggested that regulatory sanctions be linked to a sustained rise in a bank's spread above the investment grade spread. Further the Committee suggested that if secondary markets are thin, greater emphasis be placed on regular issuance of subordinated debt at spreads no greater than the spreads on investment grade securities on the assumption that in order to place an issue of subordinated debt on reasonable terms, the bank will be obliged to make appropriate disclosures to potential investors.

- Summary VaR results on a weekly or monthly basis.
- Average and high/low VaR for the period.
- Results of scenario analysis.
- Discussion of the number of days actual portfolio loss exceeded VaR.

The Basel Committee has made a renewed commitment to strengthening market discipline in the New Basel Capital Accord, although the recent working paper on Pillar 3, (BCBS 2001b) appears not to go quite as far as the earlier set of joint principles agreed with IOSCO. Quantitative disclosures include only (September 2001, p. 13): (1) the aggregate VaR; (2) the high, median, and low VaR values over the reporting period and period end; and (3) a comparison of VaR estimates with actual outcomes, with analysis of important “outliers” in backtest results (BCBS 2001b).

In view of the more limited use of mark-to-market accounting conventions and VaR in insurance companies, it is understandable that the insurance regulators did not join the Basel Committee and IOSCO in this statement of principles. But, until insurance companies make comparable disclosures, it will be difficult to compare position risk across the three sectors. Nonetheless, market discipline holds out greater hope for consistent treatment of position risk in the three sectors than harmonization of regulatory requirements. Once market participants gain a consistent picture of position risk exposures they are likely to impose consistent capital standards in terms of economic capital, not the idiosyncratic kinds of regulatory capital recognized across the three sectors. So long as market demands, not regulatory capital requirements remain the binding constraint on the largest firms, that should be sufficient to remove concerns about inconsistencies in the regulatory treatment of position risk.

## Appendix I: Value-at-Risk

Value-at-risk has become the method of choice among financial institutions for measuring market risk and thus deserves perhaps more detailed treatment in this chapter. It is embedded in banking regulation in the form of the internal models approach implemented by the Basel Committee in 1996. Even insurance companies, the sector least focused on position risk, are beginning to make use of this approach.

### I.1 Definition of VaR

VaR is used to answer the question: “On a daily basis, what is the value which is at risk during severe market fluctuations?” It is the potential loss of market value of a given portfolio of traded securities that is only expected to be exceeded with a fixed probability (*tail probability* =  $1 - \text{confidence level}$ ) if the securities are held for a particular *holding period*. Hence VaR is a specified quantile of the forecasted portfolio return distribution over the holding period.

Suppose we have  $N$  risk factors,  $y_i$ ,  $i = 1, \dots, N$ . The return on risk factor  $y_i$  at time  $t$  is defined at  $r_{i,t} = \ln\left(\frac{y_{i,t+1}}{y_{i,t}}\right)$ . Then the portfolio return is simply  $r_{p,t} = \sum_{i=1}^N w_i r_{i,t}$  where the weights  $w_i$  sum to unity by scaling the dollar positions in each asset  $y_{i,t}$  by the portfolio total market value  $Y_t$ . We may conveniently define portfolio mean return and portfolio volatility as:

$$E(r_{p,t}) = \mu_{p,t} = \sum_{i=1}^N w_{i,t} \mu_{i,t}$$

$$V(r_{p,t}) = \sigma_{p,t}^2 = \sum_{i=1}^N w_{i,t}^2 \sigma_{i,t}^2 + \sum_{i=1}^N \sum_{j=1, j \neq i}^N w_{i,t} w_{j,t} \sigma_{ij,t} = \mathbf{w}_t^T \Sigma_t \mathbf{w}_t$$

where  $\Sigma_t$  is the portfolio covariance matrix at time  $t$ .<sup>91</sup>

Let  $Y_t$  be the portfolio value at time  $t$ , and define the  $k$ -period ahead portfolio return as  $r_{p,t+k} = \ln\left(\frac{Y_{t+k}}{Y_t}\right)$ . Conditional on the information at time  $t$ ,  $\Omega_t$ ,  $r_{p,t+k}$  is a random variable with distribution  $f_{t+k}(\cdot)$ :  $r_{p,t+k} | \Omega_t \sim f_{t+k}(\cdot)$ . We denote the VaR estimate at time  $t$  for a  $k$ -period ahead return as  $\text{VaR}(k, \alpha)$ . It is the critical value of  $f_{t+k}(\cdot)$  that corresponds to its lower  $\alpha$  percent tail. More specifically,  $\text{VaR}(k, \alpha)$  is the solution to

$$\alpha = \int_{\text{VaR}(k, \alpha)}^{\infty} f_{t+k}(x) dx \quad (1.5)$$

As an example, the BIS requirement for  $\alpha$  and  $k$  are  $\alpha = 1\%$  and  $k = 10$  days (see Figure 1.6). The resulting capital charge from the internal model is the max of yesterday's 99% 10-day adjusted ( $\sqrt{10}$ ) daily VaR or the average of the daily VaR over the preceding 60 trading days multiplied by the regulatory capital multiplier  $\kappa \in [3, 4]$ , plus an additional capital charge for specific risk:  $C_t^{BIS} = \max\left[\text{VaR}_{t-1}, \kappa \times \frac{1}{60} \sum_{i=1}^{60} \text{VaR}_{t-i}\right] + SR_t$ . The calculations are to be based on data from at least one year (about 250 trading days).

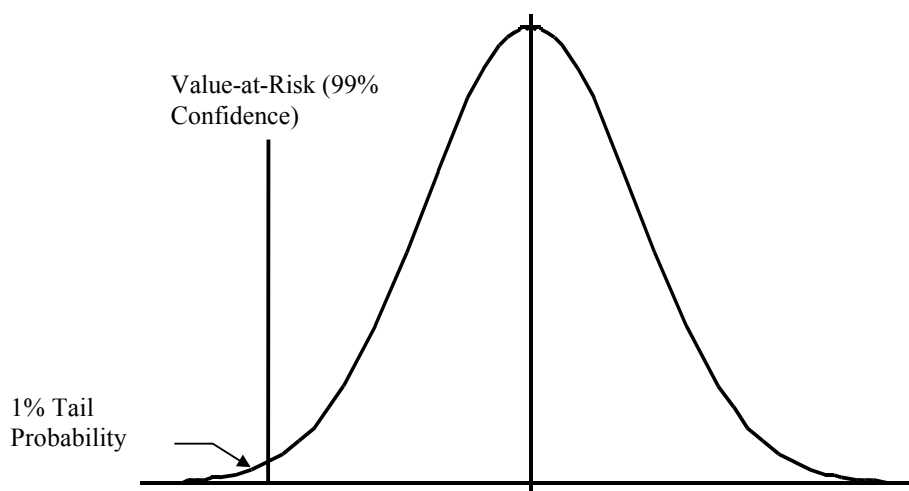
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<sup>91</sup> Since VaR is the value at risk at the end of the day  $t$  over the day  $t+1$ ,  $\Sigma_t$  is then used as a forecast for  $t+1$  and hence sometimes assumes that subscript:  $\Sigma_{t+1}$ .

Figure 1.6

## Stylized Value-at-Risk

Source: Authors' compilation

*Portfolio Gain/Loss*

Broadly there are three approaches to computing VaR: two using parametric methods that make particular assumptions about the asset return distribution--specifically that  $f_{t+k}(\cdot)$  is multivariate Gaussian--and a nonparametric method that makes much weaker assumptions about the underlying return process. The first is called *parametric VaR*, a version of which has been popularized under the RiskMetrics moniker. This method is popular because it is so easy to compute. If the portfolio contains many nonlinear instruments such as options, VaR is best computed by parametric simulation or *Monte Carlo*. The nonparametric approach, called *historical simulation*, lets the data speak more for itself by simply resampling from the available sample path of risk factor returns. There is a price one pays, however: in addition to a significant computational burden, one is literally condemned to repeating history.

## I.2 A Short Diversion: Options

As options play such a central role in risk management, it may be useful to briefly pin down their notation. The value of an option  $V = V(S, X, t, T, r, \sigma)$  where  $S$  = price of underlying position,  $X$  = strike price,  $t$  is a time indicator,  $T$  is the strike time (i.e.,  $T-t$  is the maturity),  $r$  = risk-free rate, and  $\sigma$  = volatility (annual) of the underlying position, We're interested in obtaining the change in value of the option as these factors change, This is easily obtained using a Taylor Series expansion ("the Greeks"):

$$dV = \frac{\partial V}{\partial S} dS + \frac{1}{2} \frac{\partial^2 V}{\partial S^2} dS^2 + \frac{\partial V}{\partial t} dt + \frac{\partial V}{\partial \sigma} d\sigma + \frac{\partial V}{\partial r} dr + \dots \quad (1.6)$$

where  $\frac{\partial V}{\partial S}$  is called *delta*,  $\frac{\partial^2 V}{\partial S^2}$  is called *gamma* (an option's convexity),  $\frac{\partial V}{\partial t}$  is called *theta*

(sometimes also called the time decay rate of the option),  $\frac{\partial V}{\partial \sigma}$  is called *vega* and  $\frac{\partial V}{\partial r}$  is called

*rho*. By definition these changes are local as they describe the effect of small changes of the arguments to the value of the option. Risk managers, however, are interested in more global characteristics. Hence the Greeks are often of limited usefulness for risk management, if not for short-term (dynamic) hedging.

The simplest options are European equity options, either puts or calls. These can be valued using the well known Black-Scholes pricing formulae. While these plain vanilla options remain common and are even traded, there seems to be a nearly infinite variety of so-called exotic options (see, for instance, Zhang 1998). One can already achieve a modest degree of complexity by simply combining a set of simple European puts and calls as we will in our simulation exercise.

### I.3 VaR Estimation

#### I.3.1 Parametric/Linear VaR

There are three fundamental elements in the basic approach: the first is the choice of *risk factors* to assess the risk of the portfolio, the second is the *covariance matrix*, and third is the *sensitivity vector* that encapsulates the response of the portfolio.

There are two important assumptions on which the statistical structure of VaR rests:

1. Asset or security returns are linear functions of the underlying risk factors.
2. These returns follow a normal distribution and are linearly correlated.

The covariance matrix encapsulates all of the information concerning the volatility and the correlation of the risk factors. The sensitivity of each instrument to the risk factors is captured by the sensitivity vector, which is essentially the derivative of the price of each instrument with respect to each individual risk factor (also called Delta).<sup>92</sup>

Ultimately, the final expression for the value-at-risk of a portfolio results from combining the sensitivity vector for the portfolio with the covariance matrix:

$$\text{VaR}_t = \theta \cdot \sqrt{\mathbf{w}_t' \Sigma_{t+1} \mathbf{w}_t} \quad (1.7)$$

The parameter  $\theta$  depends on the desired confidence level; if, for example, this is 99% then  $\theta$  will be 2.33 for the Gaussian distribution,

It is common practice to determine parametric VaR by augmenting linear sensitivities (deltas,  $\Delta$ ) with quadratic changes of portfolio value with accompanying changes in underlying risk factors (gamma,  $\Gamma$ ). Furthermore, BIS guidelines recommend that the parametric calculation

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<sup>92</sup> Note that we do not describe the important and nontrivial process of mapping position cash flows into risk factors. Typically a financial institution will have a very large number of positions (50,000 or more is not rare) but a smaller number of risk factors ( $N$ ). For instance, the RiskMetrics dataset comprises less than 500 risk factors. See Jorion (2001, chapter 7) and J.P. Morgan (1995, Part III).

should be supplemented by including the effect of  $\Gamma$ .<sup>93</sup> This is straightforward and any good commercial VaR system should be able to incorporate  $\Gamma$  effects.<sup>94</sup> The problem with relying on the Greeks for risk management is that these parameters are only reliable for small changes in the inputs to pricing models. They provide “local” answers and are essentially trader’s tools providing a useful guide for the continual rebalancing of the portfolio. But for risk management, the interest usually lies in the large movements of the input variables--“global” answers across broad changes of the underlying positions--and for large movements, the Greeks are a very poor guide since they themselves change rapidly.

We know that the linearity assumption is violated by having derivative products like options in one’s portfolio. However, VaR is often a reasonable approximation of a firm’s risk profile. For example, Nick Leeson’s portfolio shortly before his downfall was dominated by positions in Japanese government bond futures and Nikkei futures (Jorion 2001). Not only is this portfolio highly concentrated (there are only two instruments), but it contains derivative products (a short straddle in Nikkei futures).<sup>95</sup> Nevertheless, basic VaR would have revealed that Leeson had almost \$1 billion at risk! His final loss amounted to approximately \$1.3 billion. Given the unusually large drop in the Nikkei following the Kobe earthquake, the highly concentrated nature of the portfolio, and its high proportion of derivatives, this loss is still remarkably close to the VaR forecast.<sup>96</sup>

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<sup>93</sup> In fact, even the Basel Standardized Approach requires the use of  $\Delta$  and vega for the calculation of capital if options are both bought and sold by the bank.

<sup>94</sup> An exercise conducted by Marshall and Siegel (1997) is revealing. They gave portfolios of varying degrees of complexity to 11 different vendors and found the discrepancy in risk outputs to be distressingly wide.

<sup>95</sup> Our mock portfolio contains a straddle as well.

<sup>96</sup> Leeson’s portfolio risk is still underestimated by 25%, a large portion of which would have been captured using a simulation-based method as described in the next section. If in addition the derivative instrument has a discontinuous payoff function such as with a barrier option, the limitations of the parametric linear method become even more apparent. Only a simulation-based approach will reveal the value impact of these trigger points.

The second assumption, multivariate normality, simplifies the VaR computation dramatically. Specifically, all we need to measure and model VaR is the variance and the correlation between assets or instruments since the normal distribution is fully described by its first two moments. Then we should be able to predict well the likelihood of severe market fluctuations and their impact on loss, if not their exact timing.

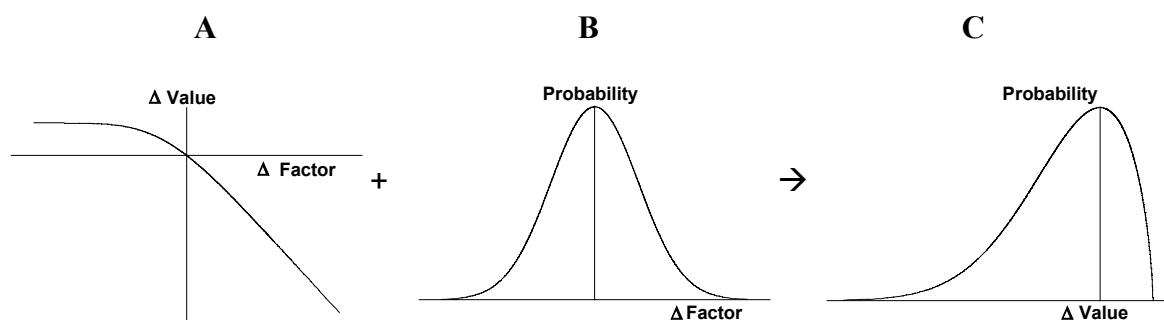
### I.3.2 VaR with Simulation: Parametric Monte Carlo and Historical

It turns out that it is easier to accommodate violations of the first assumption (nonlinearity) than of the second (fat tails). Fixes run the gamut from approximations via “the Greeks” to full valuation using extensive Monte Carlo simulation. Simulation-based approaches are the only way to adequately characterize the risk of even moderately complex options. To understand the distribution of value changes for the derivative instrument, consider the following diagram, Figure 1.7):

Figure 1.7

#### Option Payoffs and Value Distributions

Source: Authors' compilation



Panel A describes the payoff function of the option as the underlying changes; here it is nonlinear. The next panel is the familiar distribution of the risk factor or the underlying, while panel C combines the two: it describes the distribution of value changes of the derivative product. In simulation we generate artificially the data for B, recompute the value of the derivative product using A to obtain C. Note that C looks rather non-normal even though B looks quite normal. The reason is simple: the nonlinearity we see in A results in a non-normal derivative value change distribution. Only a simulation-based approach will capture this.

Finally, even the distribution of the market factors themselves, panel B, might be non-normal. One solution to this problem is to use the actual history, instead of a synthetically generated one, of the underlying risk factor to repeatedly revalue the derivative product. By doing both, parametric Monte Carlo to understand the impact of nonlinearity, and historical simulation to see the impact of non-normality, one can achieve a reasonably satisfactory approximation of the risk profile of any instrument.

An example using two options from our mock portfolio is instructive. Consider a European calendar spread option on the S&P500 index, delta and rho hedged, as well as a protection put on the FTSE100 equity index, FX hedged.<sup>97 98</sup> We compare VaR estimates obtained from a Monte Carlo simulation with similar estimates obtained from a historical simulation and the linear parametric variance-covariance approach in Table 1.13. For the calendar spread option the linear parametric approach is significantly below the other two methods. Interestingly, the nonlinearity of options does not necessarily mean that this linear approach always underestimates risk. This becomes evident in the second example, the

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<sup>97</sup> A calendar spread option is composed of two calls with the same strike but different maturity dates.

<sup>98</sup> A protection put is a put option with a strike at or below the current level and a long position in the underlying security.

protection put, where the Monte Carlo approach actually indicates a lower risk value than the linear parametric. Fat tails, however, are ubiquitous. The historical simulation method yields the highest risk value in both examples.

Table 1.13  
Comparison of VaR Techniques for Two Positions

Technique	VaR Estimates	
	S&P500 calendar spread, $\Delta$ and $\rho$ hedged \$	Protection put on FTSE100, FX hedged \$
Linear Parametric	11	13,484
Monte Carlo Simulation	226	12,822
Historical Simulation	377	15,886

Source: Authors' compilation

#### I.4 Comparison of Statistical VaR Techniques

Here we briefly summarize the strengths and weaknesses of the three VaR techniques described above.

- Parametric Delta-Plus approach:* In the parametric technique, changes in value of a position are related to changes in underlying risk factors through linear sensitivities of the position to the risk factors. Changes in portfolio value result from an aggregation of such changes corresponding to all positions in the portfolio. Furthermore, risk factor returns are assumed to be joint normally distributed. With the knowledge of the covariance matrix and linear sensitivities of the portfolio value to changes in underlying risk factors, the standard deviation of portfolio value results from a simple matrix multiplication. VaR is proportional to this standard deviation, the proportionality constant being the inverse of a standard normal distribution corresponding to a desired level of confidence.

The main advantage of the parametric approach is that does not require large amounts of data and is computationally easy. The two underlying assumptions are the joint normally distributed risk factors and the linear response to changes in risk factors.

- *Monte Carlo approach:* This approach involves generating synthetic draws from a multivariate distribution with estimated parameters from the sample path of risk factor movements. Typically that distribution is multivariate normal. The portfolio is revalued at the generated risk factor movements and VaR is determined from the resulting distribution of portfolio value changes for a given level of confidence.

The Monte Carlo approach relaxes the assumption of linear response to changes in risk factors, and therefore provides significantly better results for portfolios with a large number of options, albeit at the cost of computational intensity. This can become a binding constraint if the portfolio contains many options, and/or those options are quite complex, sometimes known as exotic options.

- *Historical simulation approach:* Historical simulation entails generating the joint variation of risk factor returns from historical time series information. The daily returns obtained from historical data are used to determine potential movements in the value of today's risk factors, and these represent historical "trials." The current portfolio is revalued for each historical trial, and resulting changes in value are used to determine the distribution of portfolio value change. VaR is defined as the distance from the mean of this empirical distribution to a point corresponding to the desired confidence level.

The historical simulation approach relaxes both assumptions of joint normality and linear response, but it is the hardest to implement: it is computationally very intensive, and requires a large amount of data to be effective.

Table 1.14  
Comparison of VaR Approaches

<i>Attribute</i>	<i>Parametric Technique</i>	<i>Monte Carlo Simulation</i>	<i>Historical Simulation</i>
<i>Risk calculation:</i>			
Ease of computation	➤➤➤➤	➤	➤➤
Ability to capture nonlinearity	➤	➤➤➤➤	➤➤➤➤
<i>Risk factor dynamics:</i>			
Ability to model non-normality	➤	➤	➤➤➤➤
Independence from historical data	➤➤	➤➤➤➤	➤
<i>Stress testing and risk decomposition:</i>			
Ability to model significant disturbance	➤	➤➤	➤➤
Ability to stress parameter assumptions	➤➤➤➤	➤➤➤➤	--
Ability to perform contributory risk analysis or to breakout risk sources	➤➤➤➤	➤➤	➤➤

Source: Authors' compilation

## Appendix II: Modeling Volatility of Asset Returns

We commonly observe asset or security prices  $P_t$ , but we are interested in modeling daily returns, which are a function of the price changes. The return is defined as the natural log of the ratio of today's price to yesterday's price:

$$r_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \quad (1.8)$$

Daily return processes are usually assumed to have a zero mean and no serial correlation. These conditions are typically met. Note, however, that simply because we find no serial correlation (i.e., dependence over time) for the returns does not necessarily mean that no temporal

dependence exists. This subtle but important distinction is a result of the first of two stylized facts about asset returns:

- They exhibit volatility clustering; low volatility periods tend to cluster together as do periods of high volatility.
- The distribution has fat tails relative to the normal; it is said to be leptokurtic (have excess kurtosis).

We illustrate these points using a time series of daily returns for the U.S. dollar price of the Mexican peso, a currency we will use in the risk illustrations later. Volatility clustering is illustrated in Figure 1.8, while leptokurtosis is illustrated in Figure 1.9.

Figure 1.8

Time Series of Daily Returns, MXP/US\$, 1/1/1997–12/31/2001

Source: Authors' compilation

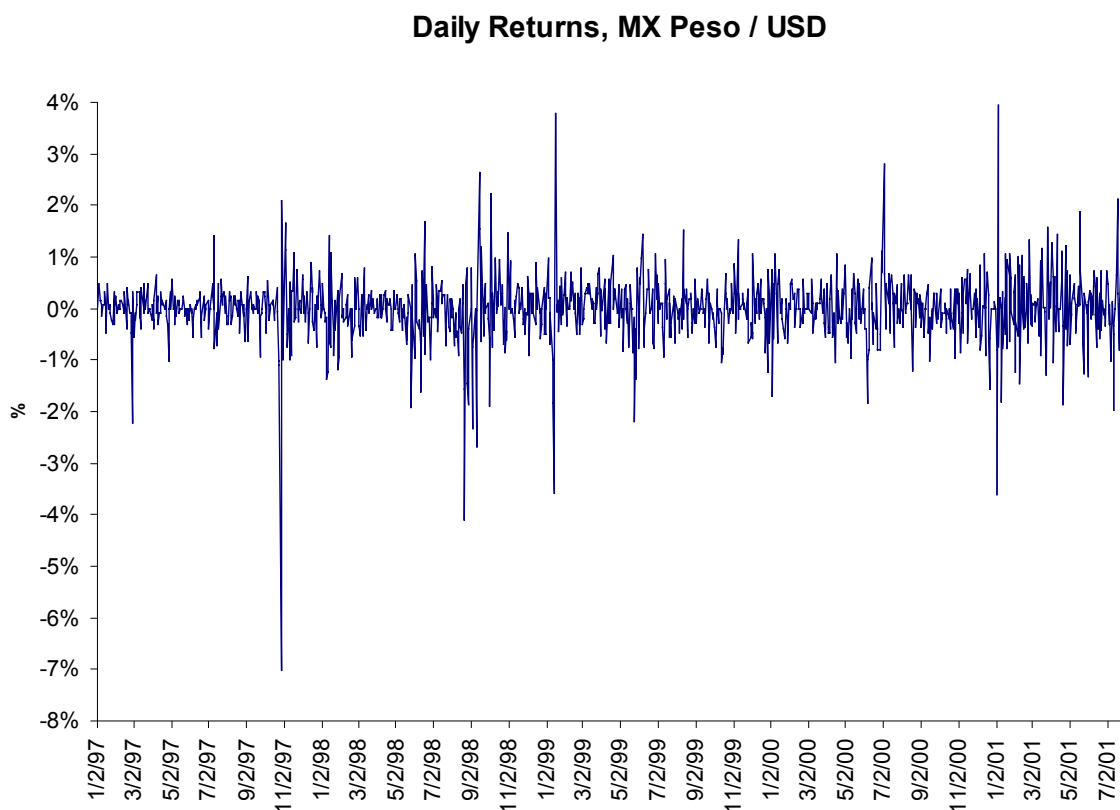
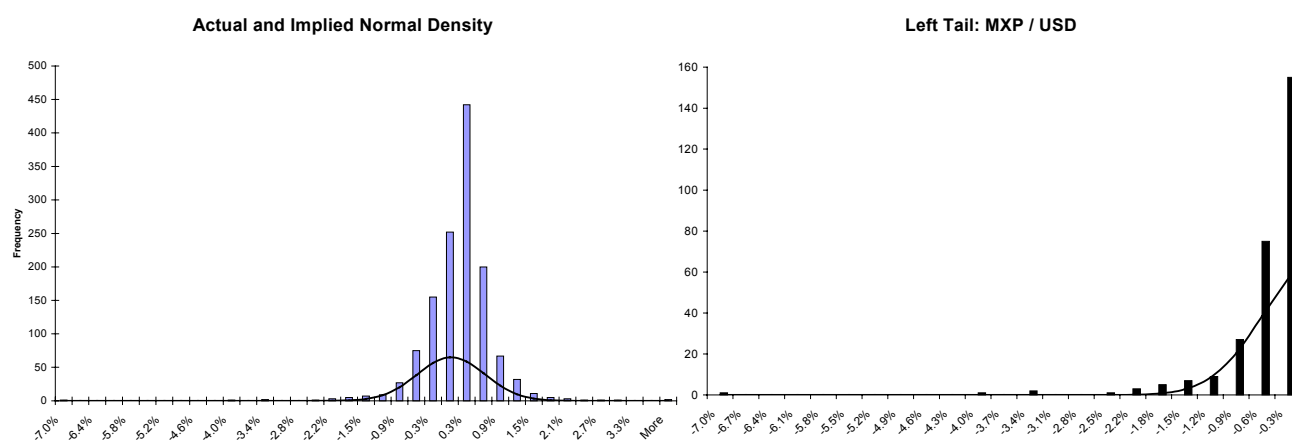


Figure 1.9

Density of Daily Returns: MXP/US\$, 1/1/1997–12/31/2001

Source: Authors' compilation



Fat tailed returns are particularly prevalent in emerging markets. For example, for the range of our sample (1/1/1997 to 12/31/2001), daily returns on the pound sterling price of the dollar has a kurtosis of 4.0 while for the U.S. dollar price of the Mexican peso, the kurtosis is 22.6, Note that the kurtosis of a normally distributed random variable is always exactly 3.

In Figure 1.9, we show in the left panel the entire density, and in the right we show only the left tail. Relative to the superimposed normal, the phenomenon of “too many large moves” becomes clear. This is a direct result of the leptokurtosis or fat tail phenomenon.

Volatility models for risk management should capture these two phenomena of volatility clustering and fat tails. In the next section we illustrate some of the approaches commonly used in industry for risk management.

## II.1 Models of Volatility

There are two approaches to obtaining an estimate of volatility: historical, based on past returns, and implied, based on options.

### II.1.1 Historical (Return-Based) Models of Volatility

Historical models of volatility involve a combination of the immediate past, usually yesterday, and the historical average. They differ in the weight they assign to these two factors. Putting too much weight on the historical average risks ignoring important recent events or structural changes. Conversely, placing too much weight on yesterday's activity produces very noisy estimates that perform quite poorly in forecasting.

At one extreme is the straight moving average (MA) model that weights the immediate past equally with all other observations. The estimate of today's variance is merely the estimate we have today of the historic average:

$$\sigma_T^2 = \frac{1}{T-1} \sum_{t=1}^T r_t^2 .$$

For banking, the BIS requires the sample length  $T$  to be at least one trading year, or about 250 days, although institutions are encouraged to use longer periods.<sup>99</sup>

The workhorse of volatility models in finance is surely the GARCH (1,1) model.<sup>100</sup> This model was first developed by Engle (1982) as ARCH and then extended by Bollerslev (1986) to G(eneralized) ARCH. Its popularity stems largely from its ability to model well univariate asset returns and capture the two important stylized facts of volatility clustering (serial correlation in

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<sup>99</sup> Sometimes the variance is normalized by  $T$  instead of  $T-1$ . Clearly for large  $T$  this makes very little difference. Technically this will still produce a consistent if biased (for finite samples) result.

<sup>100</sup> For an extensive discussion of ARCH modeling in finance, see Bollerslev, Chou, and Kroner (1992).

the squared returns) and fat tails. The GARCH forecast of the variance is a linear combination of the historical variance, the previous day's squared return, and a constant term  $\omega$ :

$$\sigma_T^2 = \omega + \alpha r_{T-1}^2 + \beta \sigma_{T-1}^2 \quad (1.10)$$

A special case of this three parameter model is the one-parameter Exponentially Weighted Moving Average (EWMA) model implemented in a popular industry risk model, RiskMetrics

$$\sigma_T^2 = (1 - \lambda)r_{T-1}^2 + \lambda\sigma_{T-1}^2 \quad (1.11)$$

where the weighting parameter  $\lambda$  is between 0 and 1. A comparison of the GARCH and EWMA model reveals that GARCH reduces to EWMA if  $\alpha + \beta = 1$  and  $\omega = 0$ .

A simple interpretation of the EWMA model is as an information updating model: new information receives weight  $(1-\lambda)$ ; thus the decay rate of information is  $\lambda^t$ . The smaller is  $\lambda$ , the more weight is placed on today's information set as described by  $r_T^2$ .<sup>101</sup> Several empirical studies have found that for modeling daily asset prices in general, values of  $\lambda = 0.93, 0.95$ , and  $0.97$  are appropriate. RiskMetrics uses  $\lambda = 0.94$  for its daily forecast.

### II.1.2 Implied Volatility

An alternative to the historical, returns-based view of estimating volatility is simply to look at the prices of options in the market. The value of an option  $V = V(S, X, t, T, r, \sigma)$  where  $S$  = price of the underlying position,  $X$  = strike price,  $t$  is a time indicator,  $T$  is the strike time (i.e.  $T-t$  is the maturity),  $r$  = risk-free rate, and  $\sigma$  = volatility (annual) of the value of the underlying position. Given a market price of an option denoted  $\tilde{V}$ , one can solve for the volatility *implied*

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<sup>101</sup> There is sometimes confusion about the subscripts in (11), specifically that the right hand side is not contemporaneous. Strictly speaking it is; (11) should be interpreted as an updating equation. Given  $\sigma_{T-1}^2$  which is known by time =  $T$ , the analyst takes the observation realized at  $T$ , squares it, and updates the volatility as in (11).

by that option price, call it  $\tilde{\sigma}$ , using the relevant options pricing formula (e.g., Black-Scholes for European options). Implied volatilities are sometimes favored since they are said to be forward looking and better able to reflect market sentiment, but they are available for only a limited set of assets.

## **II.2 Performance of Volatility Models**

### **II.2.1 Historical Models**

If GARCH fits the data well and is a general case of the other two models, why would it not necessarily be the model of choice? The dominant reason is that GARCH does not extend easily to a multivariate environment. Secondly, GARCH has in fact not lived up to its promise in out-of-sample forecasting and prediction. Hendricks (1996) compares many different models, among them several EWMA, GARCH, and MA, and finds that EWMA performs consistently as well or better than all others. His paper is important because the comparison is across a very broad class of assets and models. Diebold and Lopez (1995) point out that volatility model performance can differ greatly across asset classes and markets. One model may predict bonds in Europe very well but will do quite poorly modeling stock return volatility in Japan.

### **II.2.2 Implied Volatility Models**

Which broad class of models does better: historical returns-based or implied volatility models? Day and Lewis (1992) is one of the first papers to examine this question. Using implied volatilities from S&P100 options, they compare these to GARCH and exponential GARCH volatility forecasts and find that the implied forecasts do contain some useful information in forecasting volatility but perform no better than the historical. Canina and Figlewski (1993),

by contrast, find that implied volatility is almost always dominated by historical models. More recently, Fleming (1998) finds mixed evidence on which yields a better forecast. He finds that implied volatilities systematically overpredict future volatilities, but that the bias is not large enough to suggest trading opportunities.

### **II.2.3 What is “True” Volatility?**

Each of the model classes mentioned, historical and implied, are in no way model free. In fact, one might argue that implied volatility is doubly model dependent: one to price the option, another (perhaps the same, perhaps not) to back out the volatility from the observed market price. A model-free approach based on squared returns over the relevant horizon is, unfortunately, a very noisy indicator of volatility.

With the availability of ultra-high frequency data for markets such as FX and equities, it has become possible to approximate the (unobservable) continuous time data generating process. One such approach is outlined in Andersen, Bollerslev, Diebold, and Labys (2001) for FX and in Andersen, Bollerslev, Diebold, and Ebens (2001) for equities. Here the authors lay out a method for constructing so-called ex-post realized daily volatilities from much higher frequency (e.g., two-minutely) squared returns. These authors find impressive improvements over GARCH type models in forecasting realized volatility. By contrast, Blair, Poon, and Taylor (2001) look at intraday returns and find that nearly all relevant information is contained in the implied volatilities. Moreover, in out-of-sample forecasting, the implied volatilities are tough to beat.

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