Applying Proactive Market Risk Management

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There is an expectation on the part of shareholders that financial institutions assume, intermediate and advise on financial and other risks. Organizations appropriately expect that line managers possess the risk management skills, either intuitively or by incorporating formal risk analyses, necessary for their risk taking business activities. Consequently, organizations have traditionally spent the greater part of their analytical and technology budgets on expertise and tools to help these managers make money rather than to minimize losses or comply with regulatory requirements. Risk management systems were too often viewed by these organizations as a costly control function mandated by regulatory authorities with little or no benefit to the bottom line. In fact, an appropriately implemented and utilized risk management function can help organizations better align their expected returns for the risks and costs undertaken in order to increase the bottom line and ultimately enhance shareholder value.

While risk management has traditionally been viewed as a methodology for preventing large losses and appeasing regulators (capital preservation), it is also a continuous process of balancing risk taking and capital. Presented below are some high level observations on proactive market risk management and asset-liability management (ALM) at capital markets entities, banks, and insurance companies

Overview: RAROC & ROVaR

An example of proactive risk management is the risk-adjusted return on capital (RAROC) methodology developed by Bankers Trust two decades ago. RAROC balances return with risk measurements, such as Value at Risk (VaR), simulation, deterministic/scenario risk forecasting, and other risk measurement tools. The ultimate goal of RAROC methodologies is to provide a uniform measure of performance that management can use to compare the correlated economic as opposed to the uncorrelated accounting profitability of businesses. RAROC calculations include other sources of risk besides market -- credit, country, and specific/business risk -- but this paper is limited to a discussion of market risk.

Another example is the Return on VaR (ROVaR) market risk measure which utilizes estimates of future returns and volatility. The ROVaR ratio (expected return/risk contribution to portfolio) is based on ex-post performance measurement ratios developed by William Sharpe. ROVaR allows a financial institution to allocate firm capital only to those businesses and transactions whose estimated ROVaR exceeds the firm mandated hurdle ROVaR on an ex-ante basis. For example, Business A may provide an expected return of 30% on capital versus Business B's 12%. But the former's contribution to risk is 35% of capital (0.86 ROVaR) versus the latter's 10% (1.20 ROVaR). Consequently, Business B may be a more attractive business viewed purely on a risk-adjusted basis.

The expected return side of ROVaR and RAROC measures should be adjusted for funding, credit, operational costs and associated expenses. If transfer pricing is structured appropriately, such costs could vary greatly between businesses and thus significantly impact comparative ROVaR calculations. For example, a bank's consumer loan portfolio may return higher margins than commercial and mortgage loans, but the associated costs of servicing such loans may reduce their relative appeal.

RAROC and the related ROVaR measure integrate risk-taking and capital preservation functions, which usually work independently in most organizations, into the overall corporate objective of optimizing total risk-adjusted performance.

Proactive Market Risk Management For Capital Markets Activities

Risk Management Units Many entities with capital markets activities have independent risk management units (RMUs) that measure and monitor risk. RMU staff are often highly quantitative and generally possess appropriate skills to monitor traders and ensure that limits and approved trading strategies are adhered to. But a closer look reveals that not all RMUs are alike or necessarily analyze transactions on a risk-adjusted basis. Once RMU procedures and modeling methodologies have been established, most of the work involves daily transaction monitoring and participation in new product development. For these independent RMUs, true independence means there is no cross fertilization of staff between trading and risk management and that compensation is absolutely independent of trading profits.

Decomposing Risk & Proactive Reporting A proactive reporting and risk analytic infrastructure allows managers and traders to easily view the marginal impact to the firm's risk of potential transactions. For example, if a trader knows that a particular transaction will reduce the firm's or desk's total correlated risk, the trader may be more willing to proceed than if the trade will increase total risk. Of course, performance measurement and compensation should encourage this risk/return tradeoff. Otherwise, such reports may serve as strictly a management information piece and risk not being utilized by traders. Clarifying the sources of risk in the portfolio and what trades will provide effective ways to reduce risk can provide help in making appropriate trading decisions. In essence, risk management requires more than a single VaR calculation representing the potential loss amount under a certain confidence level. Risk management requires a decomposition of risk, an ability to find potential hedges, and an ability to find key drivers of portfolio profit and loss on a correlated basis.

The sources of a desk's or firm's largest correlated risks determine the composition of the most efficient hedges. For example, a hypothetical money market desk may estimate that the key driver in its European money market portfolio is the $/Mark FX rate. Though the desk has no position in the FX markets, the link between money markets and FX may drive its P&L. Consequently, the desk may be most concerned with the $/Mark rate's direction. Further, the desk might decide that trading in the FX market to either increase or decrease (hedge) its money market portfolio is more efficient than trading in disparate money market instruments.

Proactive Limit Setting The limit setting process must support the firm's risk appetite and mission yet remain flexible enough to permit capture of short-lived return opportunities. A profitable trade opportunity may require reallocating risk limits. For example, an arbitrage deal in Market A may demand exceeding risk limits by as much as 50%. But because the deal is quite lucrative and may enhance a customer relationship, the deal may be consummated cautiously by reducing risk in products or markets highly correlated to Market A.

Regulatory Pressure Regulators have influenced much of banksŐ trading risk management practices. For market risk in the trading portfolio, banks must allocate capital according to a combination of Bank for International Settlement (BIS) and US bank regulatory rules. Currently, the Basle Capital Accord of July 1988 requires that banks allocate capital strictly for credit risks. Effective end-1997, the "BIS Amendment to the Capital Accord to Incorporate Market Risks" requires additional capital for market risks in trading portfolios. In September 1996, the US bank regulators issued a joint rule, "Risk-Based Capital Standards: Market Risk" also effective end-1997, requiring banks with significant exposure to market risk to measure that risk using their own internal VaR model and to hold a commensurate amount of capital.

Business Strategy Capital markets entities are beginning to base compensation and business strategy on RAROC. In these cases, the risk/return relationship drives business strategy. For instance, if expected profitability in Business A is disproportionate to potential risk, management may downsize Business A. Fee-based businesses, many of which do not involve any direct use of capital at all, may have significant risks. For example, fee generating businesses, like corporate financial advisory and asset management, have risks which may be difficult to quantify. Advisory is often difficult to leverage since the work can be labor intensive and competitive pressures can force executive compensation to high levels. On the other hand, asset management can be heavily leveraged as raising additional money requires decreasing marginal expenditures. Yet, in general, acquired money management businesses fetch tremendous premiums, while start-ups require an acceptable three to five year track record to begin acquiring significant mandates.

Proactive ALM at Banks

Proactive ALM requires an accurate depiction of risk and the communication of such risk to product managers. Often, the major challenge for bank management is addressing the natural tension between loan and deposit product managers and ALM managers. While product managers may be constantly meeting customer demand by innovating more sophisticated product, ALM managers carefully update their models to measure and control these new risks. RAROC methodologies encourage product managers to price competing products with these risks in mind so as to maximize profits for a given level of risk.

ALM managers measure and monitor interest rate risk for all on- and off- balance sheet instruments from two perspectives: earnings and market value (see diagram). The earnings perspective focuses on the impact of interest rate changes on a bank's near-term earnings; while the market value perspective focuses on a bank's underlying value. The interest rate sensitivity of financial instruments depends on many factors, including duration, yield curve, basis, repricing characteristics, and embedded options affecting the timing of cash flows.

Earnings Risk

Earnings models focus on the impact of changes in interest rates on accrual or reported earnings. Gap models and repricing schedules analyze earnings risk in terms of the gap or mismatch between assets and liabilities over duration or maturity buckets. Gap models usually make simplifying assumptions about interest rate and cash flow behavior. For example, they often do not take account of mortgage prepayments or potential

disintermediation from rising interest rates. Further, gap models generally assume perfect correlations between products.

Consequently, many ALM managers are rapidly replacing traditional gap models with earnings simulation models. Simulation models allow the manager to make choices about the behavioral relationships mentioned above. If the assumptions are robust, such models can be significantly more accurate than gap models. Therefore, product managers can utilize better data for assessing the risk in new transactions. Dynamic simulation models, such as Earnings at Risk (EAR), warn of potential earnings shortfalls over a range of maturity buckets over longer periods of time and manage option-like returns.

Earnings risk originates from the interest rate gap between loans and bonds (assets) and deposits and other funding (liabilities). Off-balance sheet exposures, such as mortgage servicing and transaction processing fees can also be an important source of earnings risk. Traditionally, commercial banks are asset sensitive; their floating rate loans (assets) have shorter durations or reprice more frequently than their core deposits (liabilities). Thrifts and savings banks, on the other hand, tend to be liability sensitive with their deposits (liabilities) repricing more frequently than their longer duration mortgage loans (assets). To the extent that commercial banks have increased their mortgage loan holdings and long duration bond portfolios, they, too, have become more liability sensitive and are naturally exposed to rising interest rates.

Many banks proactively manage the gap in their interest rate exposures with a variety of derivatives, primarily customized OTC swaps and options and exchange traded futures. Additionally, banks can manage the basis risk between Prime-based loans and Libor-based deposits with basis swaps and spread options. Finally, bankers can manage embedded written options in their loans and deposits with both caps and floors. These derivatives are associated with either assets or liabilities and determine the aggregate interest rate gap.

Market Risk Market value models consider the potential impact of interest rate changes on the present value of all future cash flows. Because market value models provide a more comprehensive view of the potential long-term effects of changes in interest rates vis-ŕ-vis the earnings perspective, its risk numbers are often used in the calculation of RAROC and ROVaR measures to help product managers balance risk for reward.

ALM managers measure market risk with duration-gap models and/or market value simulation models. Similar to the distinction between earnings gap and simulation models, market value simulation models rely more heavily upon assumptions than do duration-gap models. Different from earnings simulation models, market value simulation cash flows are not static, e.g. cash flows are dynamically simulated over the entire expected lives of the bank's holdings.

A major hurdle for banks is incorporating correlations into the market risk analysis of their balance sheets. Once correlations are identified, scenarios of increasing correlations can be studied. Variance/covariance risk measures, which explicitly estimate volatilities and correlations, are suitable for predominately linear trading portfolios. But these linear models are less appropriate for managing correlations between loans and deposits embedding options, the major bank balance sheet items.

Increasingly, many ALM managers are relying upon more sophisticated option-adjusted simulation methods, such as Monte Carlo simulation, to account for correlations and non-linear return profiles. Banks that choose not to implement such models, at the very least,

should model user-defined interest rate and volatility scenarios. Such market value stress tests should include horizon repricing under various scenarios to capture the effects of variable relationships among key markets, changes in the shape and slope of the yield curve, and changes in liquidity and optionality characteristics.

For both simulation and stress tests, sensitivity tests should be performed on the possible breakdown of key business assumptions and parameters, such as loan and deposit growth and runoff, deposit repricing speeds, spread changes, optionality, yield curve twists, and other exogenous factors resulting in unstable correlations. Management should put in place appropriate contingency plans and periodically review both the design and results of stress tests.

Limit Setting The goal of risk management is to maintain a bank's exposures (net income, net interest income, and market) within self-imposed limits over a range of possible market movements. Limit setting should conform to the size, complexity, and capital adequacy of the bank. Further, a well-designed limit system should enable management to control risk exposures, initiate discussions about opportunities and risks, and monitor actual risk taking against predetermined risk tolerances.

Regulatory Pressure For ALM purposes, banks must adhere to a combination of Bank for International Settlement (BIS) and central bank regulatory rules. For instance, in January 1997, the BIS made a consultative proposal, "Principles for the Management of Interest Rate Risk," whose objective is to outline a number of the principles for use by supervisory authorities when evaluating banks' interest rate risk management. The proposal states that "sound interest rate risk management involves the application of four basic elements in the management of assets, liabilities, and off-balance sheet instruments:

Appropriate board and senior management oversight; Adequate risk management policies and procedures Appropriate risk measurement and monitoring systems; and Comprehensive internal controls and independent external audits"

In December 1991, the US Congress passed the Federal Depository Insurance Corporation Improvement Act (FDICIA), which requires all Federal banks and thrift regulators to incorporate an interest rate risk component into their risk-based capital requirements. Rather than imposing a "minimum capital standard" for interest rate risk, US bank regulators, on 6/26/96, issued a joint-policy, "Supervision and Regulation Letter 96-13," to allow banks to rely on their own risk measures. "Nonetheless, the agencies will continue to place significant emphasis on the level of a bank's interest rate exposure and the quality of its risk management process when evaluating a bank's capital adequacy," as the policy states. The joint-policy features the four primary elements of a sound risk management system as outlined in the BIS proposal above.

Under these and other guidelines, bankers have a road map for allocating capital between businesses. Other entities have to either live with regulators less knowledgeable about risk management or fend for themselves without regulatory guidance.

Business Strategy Risk-adjusted return methodologies permit banks to measure the marginal impact of new transactions to portfolio risk. Similarly, banks may allocate risk capital among whole businesses with the highest RAROC measures. To the extent that the RAROC measure is higher than the cost of equity, then the business is judged to be creating value for shareholders. Fee-based businesses, many of which do not involve any direct use of capital at all, may have significant risks. For example, securities trading may require

little capital to adequately support credit risk but should require a lot for market risk. Further, mortgage servicing, although a fee generating business, can be the source of significant interest rate and volatility risk. RAROC models should include the mortgage servicing portfolio's extreme sensitivity to falling rates into the ROVaR equation, although BIS requirements do not.

Proactive ALM at Insurance Companies

Exposure Management The actuarial value and risk of insurance liabilities, which are primarily written insurance policies and investment products (GICs and SPDAs), should largely determine the optimal investment benchmark allocation. Generally, life companies have longer duration assets to match their long term liabilities; while property and casualty (P&C) companies have shorter duration fixed income assets for their shorter term liabilities. Like pension funds, insurance companies generally prefer fixed income to equities to help match asset risk to liability risk. But more similar to a bank, the typical blend is often close to 95/5 versus pension funds' larger equity allocations.

The complexity of an insurance company balance sheet is also quite similar to that of a commercial bank -- many insurance companies have significant negative convexity (exposure to interest rate volatility) in both their liabilities and assets. On the liability side, they receive premiums for which they bear downside exposure in excess of upside profit potential. Further, they often write options in products such as guaranteed rates in interest sensitive products, fixed policy loan rates, cash surrender options, and flexible premium products. On the asset side, many insurance companies invest in callable bonds and mortgage backed securities, which also have negative convexity.

Cash Flow Versus Market Risk An insurance company generally looks at risk from three different perspectives: economic, accounting, and regulatory. Minimizing risk under one model may exacerbate the other two, so management must optimize risk-adjusted returns from all three perspectives. For example, fixed rate debt minimizes cash flow volatility yet maximizes market risk. Therefore, management is obliged to minimize one risk and place constraints on the other. FASB's proposal "Accounting for Derivative and Similar Financial Instruments and for Hedging Activities" is compelling insurance company treasurers to prioritize market risk over cash flow risk more so than previously.

The NAIC Standard Valuation Law of 1993 requires that a qualified actuary forecast cash flow risk according to the guidelines of the Actuarial Standards Board. The NAIC law requires insurers to consider at least seven interest rate scenarios over a ten year period. Similarly, a recent Moody's Investor Service report, "Evaluating Interest Rate Risk of US Life Insurers," indicates the US credit rating agency's usage of cash flow testing in evaluating the credit of insurance companies.

CMT-Based Hedging In general, insurance company balance sheets are similar to a short straddle option position. They are exposed to increasing volatility on both the asset and liability side with few natural hedges. When rates rise, they have a liquidity shortage as customers surrender policies to pursue more attractive investments; so the firm may not invest in the higher prevailing rates. Conversely, when rates decline, cash receipts accelerate so that the insurance company is forced to reinvest at the lower prevailing rates. To proactively address such option-like exposure, many insurance companies are heavy purchasers of OTC Constant Maturity Treasury (CMT) caps and floors, swaptions, and swaps to either hedge this exposure linearly or asymmetrically. CMT indices are often used

to match the longer term nature of the underlying bond portfolios. To complicate matters, many insurers face significant basis risk between their declared crediting rates, which are usually tied to a 5-7 year CMT rate, and portfolio yields. Often, the CMT rate does not match the risk of the underlying bond portfolio's return. Again, CMT caps, floors and swaps may be the appropriate hedge alternative. Lastly, insurance companies often use basis swaps and spread options to hedge the difference between the spreads over their asset and liability indices.

Business Strategy As with other financial institutions, large insurance companies are generally decentralized so that different operating units make investment and product decisions that result in overall risk exposures that are suboptimal or even unacceptable from a firmwide view. Costly inefficiencies emanate from different operating units developing redundant capabilities and transactions. There is often no centralized reporting system to identify the firm's overall exposures so that management can avoid transaction duplicity. Conversely, decentralization allows operating unit managers to leverage their knowledge of local capital markets and local regulatory, accounting, and tax structures. Risk management allows the beneficial aspect of decentralization to coexist with the advantages of RAROC methodologies -- centralized asset allocation and controls, ex-ante risk measurement, and efficient capital utilization.

Conclusion

As Peter Bernstein stated in his popular Against the Gods: the Remarkable Story of Risk, the basis for risk management and ALM concepts have been around for centuries -- Pascal's probability theory, Bernoulli's utility theory, an older Bernoulli's Law of Large Numbers, De Moivre's standard deviation, Gauss's normal distribution, Galton's regression to the mean, and Quetelet's bell curve, to name a few. Yet, it is only in the last several years that a large part of the global financial community developed robust risk modeling methodologies and technologies to reduce the likelihood of catastrophic losses. This is primarily in response to the tremendous expansion of the financial marketplace with the increased volatility of financial and commodity products. In addition, the advent of a liquid derivative market now provides financial managers with an abundance of risk management tools. Utilization of these tools in conjunction with a sophisticated ALM process can enhance shareholder value by reducing the likelihood of losses and by providing the basis for risk-adjusted measures for optimally allocating capital between businesses and products.

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Calculated Risk: How banks make sure they stay off the Barings path

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This article represents the personal views of the writer and does not necessarily reflect the views of the Reserve Bank of Australia.

The finance industry has increased its awareness of risk management practices as a result of high profile failures abroad, advances in technology and developments in the regulatory process. There has been an increased emphasis on the quality of internal management systems as a key defence against large trading losses such as those experienced at Barings, Daiwa, Sumitomo and National Westminster. Advances in technology have enabled institutions to develop more sophisticated systems for monitoring and controlling risk. Regulatory developments have contributed by recognising the more rigorous risk management methodology contained in banks' internal models for the purpose of setting market risk capital standards.

With the shift in focus to risk management, there has been ever increasing attention devoted to the quantitative "rocket scientist" elements underlying trading products and risk management methodologies. This paper however, steps away from the mathematics and looks at the qualitative framework surrounding the quantitative analysis. It analyses at a practical level the issues involved in risk management across an organisation. It highlights the increasing emphasis on risk management systems, methodologies and practices by institutions and regulators. The paper looks at the significance of the control function in the risk management framework and outlines a number of trends including the growing importance of the risk control unit. It briefly touches on the major issues underlying asset and liability management and examines the contentious issue of defining the trading and banking book. Finally it outlines some market trends including the move away from proprietary trading towards customer generated business.

1. **Systems and Technology**

In a typical dealing room there are a range of different systems across the various markets/products (for example, foreign exchange, interest rates, commodities, equities and options). Traders have access to front end dealing systems with the focus on pricing, position keeping and risk management. The back office and risk management functions have systems to generate confirmations and settlement, produce independent profit and loss and risk exposure reports and monitor limits. The final link in the chain is the accounting function which is responsible for the general ledger system.

One of the problems with disparate systems is aggregating data across the various desks in a meaningful and timely fashion. Consolidated profit and loss and risk management reports are generally produced on an end of day (or by early morning the following day) basis. There is a move however, towards further integrating systems with the ultimate goal of intraday risk monitoring.

Another problem arising from disparate systems is the process of reconciliation between front and back office systems. The process of reconciliation is vital as it helps identify differences in exposures and profit and loss between front and back office systems. This is a key step in fraud protection but is generally a time consuming and manually intensive process.

It is becoming increasingly apparent that it is near impossible to design a "super" system to cover all products across the different markets. The overall aim has shifted towards interfacing systems and ensuring that front and back office systems speak the same language. The transition towards systems that involve straight through processing is becoming more achievable across dealing rooms, especially where products are relatively standardised, such as foreign exchange. The end result is an increase in efficiency as the process largely eliminates manual intervention and the potential for human error. Banks are also moving towards downloading relevant information from various systems to a data "warehouse" which is then used to generate market and credit risk, capital and other management reporting.

With advances in technology and the increasing emphasis on risk management, there is a move towards developing more sophisticated systems. The proliferation of market risk software packages has meant that even the smaller institutions now have access to relatively sophisticated market risk management systems. One of the real constants in the industry is the continual upgrading of systems as markets and conditions change. An example of this is the use of technology such as object oriented software that can be easily adapted to incorporate new products and risks.

Institutions often run into practical problems when implementing new systems across Treasury operations. Implementation of a new system often takes significantly longer than expected because of unanticipated delays in testing, debugging, training and implementation. In some instances, the system might simply fail to live up to expectations and may have to be modified or scaled down to suit the trading environment. In an attempt to address system implementation problems, there has been a move towards having a dedicated project team to monitor and co-ordinate changes and ensure a smooth transition.

It is critical that systems development does not lag product development. Problems occur in situations where systems are not capable of processing unusual, more structured transactions conducted by front office staff. In many instances, manual adjustments are required or the current system has to be manipulated in order for the transaction to be processed increasing the probability of fraudulent behaviour and the potential for incorrect processing of transactions.

As well as the systems issues associated with new products, it is essential that staff across the entire institution understand the various risks associated with the introduction of a new product. This is where the new product approval process has an integral part to play. The process generally involves detailed documentation outlining the characteristics and risks associated with a new product and how these risks will be managed. Before the product can be traded, sign-off is generally required by the various areas across the bank including the front office, back office, accounting, financial control, risk control, internal audit and senior management.

2.**Control Functions**

Front office trading roles have traditionally been regarded as more prestigious and highly remunerated than corresponding back office functions. Similarly, the capabilities of front office technology has often outstripped that of the back office. There has been an increased focus however, on back office processes, systems and personnel especially after the fallout surrounding the recent trading disasters including Barings, Daiwa and Sumitomo. These cases demonstrate that it is often operational risk and a breakdown of basic internal controls rather than mispecified risk management methodologies and systems that pose the greatest risk.

Having truly independent back office staff who can understand and analyse the risks associated with more complex transactions, such as derivatives, is just as important as having competent dealers who can trade these instruments. The quality of back office staff has steadily improved in terms of educational requirements, experience and remuneration. However, it still remains the fact that the back office lags behind the front office.

There has been a shift towards re-structuring of control functions and the development of an independent risk control unit. The primary function of this unit is to provide an objective review of the trading activities conducted by the front office. Under the market risk capital guidelines, banks that use internal models must have an independent risk control unit that is responsible for the design and implementation of the bank's risk management system.

At a practical level, risk control units vary in the scope of functions performed and in their level of integrity and independence. The risk control unit's responsibilities range from treasury support functions to comprehensive units dedicated to monitoring the risk management process. An important requirement for a strong risk control unit is qualified personnel who can understand the risk management information being produced. Accordingly, there is a move towards employing ex-traders to head up the risk control functions.

A well resourced and effective internal audit unit is an important control function in the risk management framework. A strong internal audit process provides management with a degree of comfort in the sense that there is a monitoring of activities by a unit independent of the trading function. In this context, while a negative finding in an internal audit report clearly signals problems, provided there are adequate follow-up procedures (to quickly resolve significant weaknesses), the fact that the internal audit function is able to highlight areas of concern is a positive sign.

The size, focus and quality of the internal audit function varies dramatically. Audit approaches range from mechanistic ticking off of lists of questions to a more risk based focus. In the risk-based approach the timing of audits is linked to the perceived riskiness of the particular business environment. Areas identified as high risk, such as Treasury, are subject to more frequent audits. The strength and effectiveness of an internal audit team is a function of the resources devoted to the area and how internal audit is perceived within the organisation by senior executives, traders and risk management staff.

3.**Segregation of Duties**

The clear segregation of duties is a fundamental principle of internal control that has long been recognised as the first line of protection against the risk of fraudulent or unauthorised activities. It is important that there are clearly defined, independent reporting lines for both the front office and the back office/risk control functions. The lack of a well defined reporting structure creates a potential conflict of interest and the risk that some trading could be concealed, or incorrectly reported.

4. **Risk Management Methodologies**

Risk measurement methodologies are becoming increasingly sophisticated and some form of Value at Risk (VAR) model is generally used to analyse and monitor market risks. VAR models aim to measure the potential loss on a portfolio that would result if relatively large adverse price movements were to occur. VAR is used predominantly as a high level management tool with structural limits, such as basis point values and net open positions, used to influence trader behaviour. VAR is, however, starting to be driven down to the dealer level as traders become more sophisticated and measures such as risk adjusted performance (based on VAR) shape behaviour and move capital to its most efficient use.

A comprehensive stress testing program is an essential supplement to a VAR model. Stress testing involves subjecting trading portfolios to unexpected but possible shocks in market or political conditions. This enables an institution to evaluate its capacity to absorb potentially large losses and to identify steps that it can take to reduce its risk and conserve capital. The move moving towards more regular stress testing is in part being driven by the market risk capital requirements whereby banks using internal models will be required to submit the results of their stress testing scenarios to the Reserve Bank on a quarterly basis.

5.**Asset and Liability Management**

For a number of institutions with large balance sheets the interest rate risk lying within the banking book is substantially greater than the market risk sitting within the trading book. Therefore, it is essential that a comprehensive risk management framework is developed, that effectively identifies, measures, monitors and controls interest rate risk exposures. In general, increasing resources and attention is being devoted to balance sheet risk management. Systems used are becoming more sophisticated as institutions move away from traditional gap analysis to simulation of net interest income and market value of equity. State of the art techniques including simulation and option type analysis are being used to analyse the risks underlying the balance

sheet in greater detail. The aim is not only to manage these risks but to add value to the entire process.
The integrity and timeliness of data on current positions is a key component of the risk measurement process. One of the biggest hurdles is obtaining accurate, timely data across the entire operation from retail banking to Treasury. The problem arises because of the large number of disparate systems that are used. This data aggregation problem implies that detailed analysis of interest rate risk is usually only conducted on a monthly basis. In the interim, however, major movements in the balance sheet are monitored. At smaller institutions, the problem of aggregating data over a number of systems is substantially reduced and this enables the management of interest rate risk on a more frequent basis, often using simpler techniques.
The complexity involved in modelling interest rate risk has meant that even Basle Committee on Banking Supervision has deferred the development of a capital standard. The complexity arises from the fact that as well as technical assumptions and economic forecasts one needs to take into account customer behavioural patterns, such as break-outs and prepayment behaviour, which is hard to model accurately. In addition, the difficulties associated with determining objective mark to market values for assets and liabilities (for example, loans) introduces another level of subjectivity to the process. Despite these complexities, the magnitude of potential interest rate risk on the balance sheet implies that banks as well as supervisors will devote more attention to this area over the next few years.

6.**Accrual versus Market Value Accounting**

The question of whether transactions should be classified as trading or investment is a widely debated issue. The fundamental problem is that there are no clear rules that define the boundary between investment and trading positions. The implementation of the market risk guidelines will partly address this issue as each bank will be required to agree a trading book policy statement with the Reserve Bank. The statement will establish which activities constitute the trading book and the arrangements in place to prevent inappropriate switching of transactions between the trading and banking books. The difficult issue of defining a trading book within the context of the broad structure of a bank will be addressed in terms of looking at the “substance” behind the words of a trading book policy statement.

7.**Market Trends**

A well acknowledged trend is the maturing of many of the traditional trading markets. As competition has increased and with products becoming more commoditised, margins have declined and this has lead to a fall in profitability. There has also been a decline in proprietary trading in many banks as a result of lower margins and generally lower levels of market volatility. To counter this, there has been a push to increase income by expanding and generating more value from the customer franchise. The rationale is that customer generated business is more sustainable and significantly less volatile than proprietary trading.
The general move is towards selectively targeting markets where institutions have a comparative advantage and attempting to build niches. An example of this is the search for new, more profitable markets, such as commodities and equity related trading. Increasingly, institutions are also attempting to capitalise on natural niches in local and international market and are focusing attention on products and markets where they have a global edge.
Treasuries are moving away from being perceived as a simply another profit centre to playing an important role in the overall banking/customer relationship. For example, banks are taking an active role in educating customers about the risks involved with various products, especially in

relation to exotic instruments. Banks visit corporate clients and make presentations to senior management about the nature of the products and the risks involved. A similar process of education is occurring internally as banks make Board members more aware of the risks underlying both the Treasury and asset and liability management functions.

Conclusion

Four forces are driving increased awareness of risk management practices: high profile trading disasters; regulatory developments; advances in technology; and the trend away from proprietary trading towards customer generated business. The large losses at financial institutions demonstrated that it is often operational risk and a breakdown of basic internal controls that pose the greatest threat. This has driven an increased focus on back office processes, systems and personnel. Regulatory developments, such as market risk capital requirements and guidelines, have also played their part in accelerating the adoption of increasingly sophisticated methodologies to analyse and monitor market risks. Technological advances have greatly aided the adoption of these more sophisticated systems. The move away from proprietary trading and towards customer generated business has increased the emphasis on educating clients about the risks involved in various products. This process of education has extended internally within financial institutions. Increased awareness of risk management practices should reduce the likelihood of future large trading losses.

Appendix I: Trading Disasters

Barings made losses totalling $1.89billion due to the unauthorised trading activities of Nick Leeson. These activities went undetected as a consequence of a failure of management and other internal controls of the most basic kind.

At Sumitomo Corporation, the company's chief copper trader lost an estimated $1.8billion on futures contracts. Sumitomo did not separate its front office trading activities from its back office processing and control unit. The trader also reportedly declined to take a holiday in his ten years at Sumitomo, thus making it more difficult for auditors to discover his wrongdoing.

At Daiwa bank, Toshihide Iguchi accumulated $1.1billion of losses over 11 years of bond trading in New York. There were a number of internal control weaknesses at the bank including the fact that Iguchi was responsible for both securities trading and custody operations and some related back office functions.

The NatWest Group recently announced a £ 77million charge against pre-tax profits as a result of losses incurred in the London interest rate options business.

Interest Rate Risk Management: The Risk Point Method

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Summary

Interest rate risk management is a major component of any comprehensive risk management program ***Duration*** **is a popular tool employed by sophisticated users for interest rate risk measurement. By effectively using it, an institution can all but eliminate basic market risk which is no longer a major concern. Among the other types of interest rate risk, we focus on** ***yield curve risk*** **which has attained importance recently. To model yield curve risk, we use a form of price sensitivity relative to a specific hedge instrument. This number, called the** ***risk point*** **helps us use a variety of hedge instruments to better handle yield curve risk.**

It is appropriate to look at the risk point concept as a more complete description of risk than just as a way to handle yield curve risk. This view is supported by the fact that the risk point method is useful in several situations. It can accurately highlight yield curve risk in an asset/liability context. In portfolio management, it can help us evaluate bond swap opportunities more precisely. In structured investment, it can help replicate portfolios in indexing applications and in developing efficient benchmarks. It can provide a superior selection of bonds in dedicated portfolios. It can help create more robust immunization strategies. It leads to more accurate hedge design in trading. Finally, it also provides more insight into the current crop of exotic investments.

I. Introduction

Institutions, i.e., investors as lenders and corporations as borrowers, assume various types of financial risk. These include liquidity risk, credit risk, currency and interest rate risk and option or convexity risk. In this chapter we will focus on interest rate risk. In addition, we will show how the concepts developed apply to many other types of risks as well. It is important to view interest rate risk as an integral part of a comprehensive risk management program. Risk management can be defined as a systematic approach that attempts to provide a degree of protection to the institution from risk and makes such risk acceptable. Any complete interest rate risk management program, therefore, should provide the necessary framework for the implementation of the *4M*'s of risk management: measurement, monitoring, modification and management.

Measurement - defines exactly what types of risks will be managed under the program. For each risk, the appropriate risk measures and acceptable procedures for measurement are defined as well.

Monitoring - sets forth the mechanics of locating which parts of the institution are sources of different forms and quantities of risk and the frequency with which these risks will be measured and reviewed. It puts in place the necessary systems and procedures to ensure that the information can be and is obtained when desired.

Modification - provides the risk manager with the tools necessary to modify any particular risk to desired levels. For example, here is where we determine whether futures or swaps are appropriate instruments for the institution and the limits on quantities and purposes for which these will be used. In actual use, optimization by the risk manager, i.e., selection of tools and quantity, is also done here.

Management - is the collection of policies and procedures for the exercise of the other three M's. Here we define the upper and lowerbounds for each risk category as well as the conditions under which an action will be required to initiate the modification step. In addition to routine policy, this part of risk management includes some emergency powers for the risk manager and guidelines as to how and when these powers can be used. As an example, the emergency powers could include relaxation of the limits on the tools or amounts that can be employed.

In a way, we can compare risk management to a form of insurance. It can shield the institution from risk where its assumption is necessary. For example, in the absence of automobile insurance, we would probably find the risks of driving a car unacceptable. It is insurance that makes it possible for us to drive. The main function of risk management is similar: it is to enable the institution to be in business, that is, to assume the necessary risks. For example, it facilitates a bank to make long term loans that are in demand regardless of whether long term funding for the loan is available, by providing acceptable techniques to hedge the resultant interest rate risk. It enables a multi-national corporation to engage in business overseas, shielding the firm from changes in exchange rates. In general, the more leveraged an institution, the more critical risk management is to that institution. This is because its net worth then is a small fraction of the size of its assets and even modest market moves can result in wide swings in the net worth. Risk management is therefore simply the process of preservation of net worth.

The function of risk management is not just protection from risk. The safety achieved through it also opens up opportunities for enhancing the net worth. An effective risk management program can make it possible for an institution to take on positions that would have been considered too large or too risky in the absence of the protection offered by risk management. Such a program can also enable an institution to enter into new business areas as the demands of the marketplace change and grow. In many cases these businesses would have been beyond the reach of the institution without the comfort of the insurance provided by risk management.

Every manager has two fundamental priorities. The first priority is to protect and preserve the existing business or investment and provide damage control.The second priority is to enhance the returns, strengthen the business and enrich the institution. Risk management, as discussed above, can be a vital ally to the manager in fulfilling these two needs.

There are several types of financial risk. These include interest rate risk, currency risk, credit risk, liquidity risk and option or convexity risk. Among these, some risks, e.g., interest rate risk and option risk, fall neatly within the risk management framework mainly because it is possible to quantify the risks easily and appropriate hedging vehicles are available. Any acceptable risk management policy will also help measure and monitor liquidity risk and provide suitable strategies for its management. Other risks are more complex to manage. Consider credit risk. It is difficult to manage it in the traditional sense. It is best controlled by limiting it before it is assumed.

The focus of our attention in this chapter will be the quantifiable risks, interest rate risk in particular. As a consequence, we will be dealing mainly with risks associated with fixed income assets and liabilities.

II. Measures of Interest Rate Risk

As a first step in developing a framework for risk management, we have to define interest rate risk and determine an acceptable way to measure it. Let us briefly review the basic definitions.

Interest Rate Risk - We measure interest rate risk by considering *price sensitivity*, that is, the change in the value of an asset or liability cash flow in response to a change in interest rates. More precisely, price sensitivity is expressed as the dollar change (or, some times, a percentage change) in value for a unit change in interest rates. This unit is most often one basis point or 100 basis points.

Different fixed income instruments have different levels of interest rate risk. Various risk measures are available, each with its own advantages and problems.

Maturity - The term to maturity is an indicator of interest rate risk. Longer maturity bonds usually move more in price than shorter maturity bonds. However, this ordering does not always hold. Maturity takes into account only the timing of the final principal flow in a fixed rate bond, and ignores other important information such as the size and timing of other cash flows. The actual interest rate sensitivity depends upon these factors and therefore, maturity, though sometimes useful, is only an approximate indicator of risk. Maturity is also not a cardinal measure, that is, it does not *quantify* risk.

Duration - It is possible to blend information contained in the size and timing of all cash flows into one number, called *duration*, that can be a more useful measure of risk. Duration is the weighted average time of all of the cash flows, the weights being the present values of the cash flows. For bonds with only one cash flow, e.g., zero coupon bonds and money market instruments, duration is equal to maturity. For others, duration will be shorter than maturity.

It turns out that by slightly adjusting duration by dividing by a factor (1+Y) where Y is the annual yield to maturity of the bond in decimal form, we get *modified duration* which is exactly equal to the price sensitivity of the bond as we have defined above. Since the adjustment factor is very close to one, duration and modified duration can be used interchangeably in most situations. This is also justified because duration is an approximate measure anyway. By this reasoning, we diligently avoid the common temptation to dwell on the (inconsequential) difference between the two durations.

We can also think of duration of a security as the maturity of a zero coupon bond of equal price sensitivity. This definition is a more general one in that it can be used with more complex securities such as options and with leveraged positions. For example, if the duration of an option is 150, it simply means that the price sensitivity of the option is equal to that of a zero coupon bond of maturity equal to 150 years. Some instruments (e.g., options) can have negative duration which can be represented by short positions in zero coupon bonds.

Dollar Duration Duration represents the *percentage* change in value in response to a change in rates. By weighting duration by the value of a holding, that is, by multiplying the market value of a holding by its duration (expressed as a decimal percentage), we get dollar-weighted duration. Known as *dollar duration*, this number represents the actual dollar change in the market value of a holding in a bond in response to a 100 basis point change in rates. When expressed as a dollar change per one basis point move in rates, dollar duration is sometimes called the *price value of a basis point*, or, *PVBP*. Other than the factor of 100, there is little difference between dollar duration and PVBP.

The major advantage of using dollar duration is that it is additive. The concept, therefore, extends easily from individual securities to portfolios. The dollar duration of a portfolio is simply the (algebraic) sum of the dollar durations of the individual holdings.

Convexity Duration (or dollar duration) is not a constant. It changes as a result of changes in market rates and because of passage of time. For simple fixed coupon bonds, the dollar duration increases when the rates fall. That is, as the market rallies (i.e., as rates fall), for each successive basis point move down, the bond price increases at an increasing rate. Similarly, if rates increase and the market declines, the rate of decline slows down as the rates rise. This property is called *convexity*. It is a desirable property in an asset since the price sensitivity changes in a way beneficial to the holder of the asset.

There are certain securities with option-like features such as callable corporate bonds and

mortgage backed securities that show a contrary behavior: their duration can fall in rallying markets and increase in falling markets. This property, called *negative convexity*, is not a desirable property in an asset, unless suitably compensated, as the price sensitivity moves in a way not beneficial to the holder.

In most situations, convexity is a second order effect, that is, its influence on the price behavior of a bond is small compared to that of duration. However, for large moves in market rates, for highly leveraged positions, and where option-like features are involved, convexity can be important.

III. Yield Curve Risk

Several years of use of the duration concept has imparted the ability to most financial institutions to all but eliminate market risk via prudent hedging activities. As a result of this, other residual risks have gained prominence. Some of these risks can be dominant in many situations, and, among them, the most important is *yield curve risk*, and deserves a detailed treatment. In particular, yield curve risk can be significant in portfolios containing options, some mortgage derivative and most exotic securities.

As usually stated, duration of a fixed income asset (or liability) is the price sensitivity relative to its own yield. Therefore, when we use duration for hedging purposes, we are implicitly assuming that the yield levels of the various assets and liabilities move in parallel, that is, in equal amounts. In fact, however, different credit, coupon or maturity sectors of the market move differently in terms of their yield. This difference is known as the basis risk among the sectors. *Basis risk* with respect to different maturity sectors is also known as *yield curve risk* and represents changes in the yield curve that are not parallel shifts. These include the so called reshaping shifts, e.g., twists, pivoting moves, steepening and flattening.

In general, basis risk is difficult to measure and

hedge. Most hedging vehicles address market

risk, e.g.,, changes in the Treasury rates, not basis risk. It is possible to take the view that only market risk is hedgeable and treat basis risk as a prudent business risk that an institution has to take. This is the only approach in dealing with

certain types of basis risk, e.g., credit risk.

A risk measure can be considered more complete compared to a simple measure such as duration if we can incorporate some of the important basis risks. Fortunately, it is possible to address yield curve risk in many acceptable ways. By necessity, such a broader risk measure will be more than just one number.

One method is to divide assets and liabilities into smaller maturity baskets, and analyze each basket separately. If each basket covers a sufficiently small maturity range, then we can assume that the yield curve risk is acceptably small within that range. In a hedging application, we would use hedging instruments suitable for that maturity range to match dollar durations. In an asset/liability context, if each basket or sector is matched, using appropriate hedges as required, then the assets and liabilities are matched as a whole because of the additivity property of dollar duration. To the extent that the yields of all assets and liabilities as well as the hedging instruments used within a sector move in step, this approach is satisfactory.

There is a problem, however. It turns out that an asset of a given maturity might react to changes in rates in another maturity. Consider, for example, a 10-year bond with a coupon of 10%. The cash flow from this bond occurs every six months throughout its life. Since the value of a bond is simply the sum of the present values of the individual cash flows, it stands to reason that the value of the 10-year bond could be influenced by rate changes not just in the 10-year maturity but also in all shorter maturities representing the cash flows.

In this context, it is appropriate to clarify what we mean by a `rate.' In fixed income analysis, we use two type of reference interest rates: full coupon rates and spot or zero-coupon rates. Full coupon rates are analogous to the yield to maturity on bonds trading at or close to par, e.g., the yield on an on-the-run (current coupon) Treasury. The spot rate for a given maturity, on the other hand, is the yield on a zero coupon bond with that maturity. When dealing with individual cash flows, e.g., for discounting, it is appropriate to use spot rates; when dealing with bonds trading near par, full coupon rate can be used.

Since a bond is just a collection of cash flows, its yield is a complex blend of the individual spot rates corresponding to the coupon and principal flows. Given the spot rate curve, we can easily determine the coupon yield curve. Conversely, a given spot rate is complex blend of all shorter-maturity coupon rates. Given the coupon rate curve, we can determine the spot rate curve. In summary, a given spot rate depends upon all intermediate coupon rates; a given coupon rate depends upon all intermediate spot rates.

The value of a 10-year par bond, then, responds to all intermediate spot rates, but depends only on the 10-year coupon rate. Thus, to hedge a 10-year par bond, all that we need is another 10-year bond, e.g., the current 10-year Treasury. If we wish to use zero coupon bonds for hedging, then a 10-year zero coupon bond and smaller amounts of all intermediate maturity zero coupon bonds will be required for hedging. Similarly, a single cash flow occurring in the tenth year can be efficiently hedged by a 10-year zero coupon bond. On the other hand, if we wish to use current coupon Treasuries for hedging, then, in addition to the 10-year Treasury, we will also need shorter maturity Treasuries.

If the bond we are hedging is not priced at par, then it behaves like the combination of a 10-year full coupon bond and a 10-year zero coupon bond. For example, a $100mm holding of a 9% bond selling at 90 can be viewed as the sum of $90mm of a 10% par bond and $10mm of a zero coupon

bond. Thus the sensitivity of the 10-year discount bond is the sum of that of each of its components. The hedge for a bond not near par, therefore, is a blend of the hedges for a zero and that for a full coupon

bond.

In summary, then, an asset (or a liability) of a given maturity might respond to spot or coupon rate changes in other shorter maturities. Therefore, we need to do more than simply group the assets and liabilities in maturity sectors.

One way to handle this problem is to first break down each asset and liability into its cash flow components. Then the individual cash flows can be grouped into maturity buckets. Now, the price sensitivity of each sector is more clearly defined, at least with respect to spot rates corresponding to each sector.

The cash flow approach provides very valuable insight into the relative natures of the assets and the liabilities. However, it represents risk in terms of spot rate, that is, in terms of zero coupon bonds which are rarely used for hedging. A more sophisticated approach is the *risk point method*,

discussed below.

IV. Toward a More Complete Risk Measure: The Risk Point Concept

Since risk is a measure of change in value, it stands to reason that risk management and security valuation ought to be closely related. Therefore, it is advantageous to use a model that integrates these two aspects. The risk point method attempts such integration. It also has the practical advantage that it measures risk relative to available hedging instruments.

We define the *risk point* of a security or portfolio with reference to a specific hedge instrument. For this reason, it can also be called *relative dollar*

duration. It represents the change in the value of the security or portfolio due to a one-basis point change in the yield of the hedge. If we divide the risk point by the dollar duration or PVBP of the hedge, we get the dollar amount of the hedge instrument to be used as a hedge. This hedge amount will protect the portfolio against risk from small changes in the market sector represented by the hedge

instrument.

Unlike PVBP or dollar duration which measures the *total* interest rate risk, the risk point measures only one component of the total risk. This component represents the risk due to a change in rates in a given maturity sector. Thus, to determine a complete risk or hedge, we need a full set of risk points, relative to a set of hedge instruments. From this set of risk points we can determine the portfolio of hedge instruments that will hedge a given portfolio.

The risk point method consists of three main steps:

A. We first list the hedge vehicles that we are willing to use.

A. We then apply a model that values the assets and liabilities *relative* to the prices of the hedge vehicles.

A. We change the yield or price of one of the hedge instruments by a small amount, keeping all other yields and prices the same. With the new yield, we revalue the portfolio again. The change

in its value (expressed as dollars per one-basis point change) is the risk point of the portfolio. We get the amount of the hedge instrument needed for hedging by simply equating the PVBP of the hedge to the risk point of the

portfolio.

This procedure is explained more fully in the next section.

V. An Implementation of the Risk Point Method

The essential part of the risk point method is a model that values the assets and liabilities relative to the hedge instruments chosen. In order to be able to deal with a variety of assets and liabilities, the set of hedges chosen must also be broad. An example of a practical implementation of the method follows.

Hedge Instruments. - For our example, we include all the current coupon Treasury bonds and notes in the set of hedge instruments that we consider. T-Bills are included to handle cash flows occurring in the short term.

Valuation Model. - We will use a simple, but effective, valuation model. The procedure will be to value each financial instrument as the sum of the discounted present values of the cash flows generated by the instrument. We must first determine the *discount function*, i.e., all the discount factors that will be used for this procedure. This is a two-step process.

In the first step, to obtain appropriate spreads to evaluate cash flows from corporate bonds, we include spreads from the interest rate swap market.

The composite rate, i.e., the sum of the Treasury yield and the spread, is called the *par bond yield* (See Table 1).

, It represents the yield on par bonds of the credit quality represented by the spreads used. We then use linear interpolation to generate the *par curve*, i.e., par bond yields at all maturities (See Column 3, Table 2).

The second step is to determine the zero curve, or, equivalently, the discount factors, from the par curve. Discount factors can be derived sequentially from the par curve one after another. This process is called *bootstrapping*. This procedure builds the zero curve in a step-by-step or inductive manner. For each maturity, it uses the fact that the price of a bond is the sum of the present values of all the cash flows (coupon and principal) from the bond. It is best illustrated using algebraic notation.

Suppose we have already determined the first n semi-annual discount factors, f1, f2, ..., fn. Then the discount factor for the next period, f(n+1) is determined using the following relationship:

$$1 = c \times f1 + c \times f2 + ... + c \times fn + (1+c) \times f(n+1)$$

where the left-hand side, 1, represents the price of par, c is the semi-annual coupon payment (one-half of the par rate) and (1+c) represents the final payment with principal and interest for a par bond maturing at the end of the (n+1)th period. Each of the factors of the form (c x f1) represents the present value of a cash flow. The relationship simply says that the sum of the present values of all cash flows is equal to the price of the bond. The required discount factor, f(n+1), is therefore given by:

$$f(n+1) = \frac{[1 - (c \times f1 + c \times f2 + ... + c \times fn)]}{(1 + c)}$$

Or,

$$f(n+1) = \frac{[1 - c \times (f1 + f2 + ... fn)]}{(1 + c)}$$

Thus, given the par curve, if we know the first discount factor, we can compute all other discount factors sequentially. The first discount factor is easy to determine since the six-month par rate is also a six-month zero rate since a six-month (semi-annual) bond has just one cash flow.
From the discount factors, it is easy to compute the zero rates. The nth zero rate, zn, is related to the nth discount factor, fn, via the relationship:

$$fn * (1+zn/2)^n = 1,$$
$$FnX(1+(Zn/2))^n=1$$

assuming semi-annual compounding. The interpolated par curve (Column 3), the discount function (Column 4) and the zero rates (Column 6) are all shown in Table

2.
Once the discount function or the spot rate curve is known, the value of any security is simply the sum of the present values of its cash flows, discounted at the appropriate spot rate. This is shown in Table 3 for a 10-year bond with a coupon of 10%. Each present value (Column 5) is simply the product of the cash flow (Column 4) and the corresponding discount factor (Column 2). The total PV, 114.740102, is the value of the bond.
Determination of Risk Points. To determine the risk point corresponding to a given hedge, the following steps are taken: First, the yield on the hedge instrument is changed by one basis point. Then the spot rates are recomputed using this new price for the particular hedge instrument, keeping the prices (and yields) for all other hedges the same as before. The value of the asset (or liability or portfolio) is now recomputed. The change in the value of the asset due the change in the yield of the hedge gives us the risk point of the asset relative to that hedge instrument. This procedure is repeated for all hedge instruments in the set of hedges chosen. The risk point relative to a hedge can be used to determine the amount of the hedge to be bought (or sold) to hedge it against changes in the price of that hedge.
To illustrate this procedure, let us increase the yield on the 10-year Treasury from 7.466% (from Table 1) by one basis point to 7.476%. The composite rate changes from 7.876% to 7.886%. The new discount functions and zero rates are recomputed as in Table 4 (compare with Table

2). The computation of the new value of the 10% bond under study is shown in Table 5 (compare with Table 3). The value of the bond has fallen from 114.740102 to 114.667571, that is, by 0.072531. This number is the change in dollars for every $100 par holding of the bond. This is the risk point for the 10% bond relative to the 10-year Treasury.

The risk point is usually computed for a given par holding of a security. In analytical situations where the par holding is hypothetical, it is convenient to express it as dollars per $10,000 par holding. This makes the risk point number roughly comparable to duration or dollar duration. The risk points for this bond relative to all the other hedges are shown in Table Table 6 (Column 5) on this basis, i.e., for a $10,000 par holding. Also shown here are a few other results that should be of interest to risk managers. Column 6 shows the fraction (as a percentage) of the total risk represented by any given sector. For example, approximately 95.4% of the risk in this bond is in the 10-year sector. Column 6 expresses the risk point as a percentage of the total value of the bond. The numbers in this column are similar to duration. These two columns, along with the risk points themselves, form a more complete picture of the risk in the 10% bond under consideration. Exhibit 1 shows a graphical depiction of the risk points. We call the collection of risk points the *risk profile* or the *risk point profile*.

VI. Properties of Risk Points

Table 6 also shows the sum of all the risk points, called the *total risk*. This number, 7.600610, is similar the PVBP for the bond as it represents the change in the value of the bond due to a parallel move up of the yield curve by one basis point. If this is expressed as a percentage of total value of the bond (Table 6, Column 7, last row), then we get a number similar to the duration of the bond.

At first blush, it seems as though total risk will increase or decrease based upon the selection of hedge instruments. However, the risk point method is quite robust, and under most conditions handles arbitrary selection of hedge instruments well. For example, let us delete the 5-year

Treasury from the hedge instrument list, and recompute the par curve, zero curve and the risk points. Table 7 shows the new risk points and total risk. Note how the risk in the 7-year sector has been redistributed between the 3-year and the 10-year sectors.

The risk points have another interesting property. Consider again the 10% coupon, 10-year bond above. The collection of risk points actually represents a portfolio of hedging Treasuries, called the *hedge portfolio*. This portfolio has the property that its risk is the same as that of the bond. When a portfolio is designed so as to match the risk of another, then the former is called an *immunizing* or *duration-matching* portfolio. In addition, the cash flow from this portfolio is close to that of the cash flow from the bond. When a portfolio is designed so that its cash flows match that of another, the former is called a *dedicated portfolio*. The hedge portfolio is always immunizing or duration matching. The larger the number of hedge instruments, the closer the hedge portfolio comes to a fully dedicated portfolio.

There is one difference between the dedicated portfolio in this context and the one used in structured investments. In the latter, only positive holdings are considered whereas in our hedging portfolio, negative holdings, i.e., short positions, are quite common.

Finally, risk points are additive, in two ways. The risk point in any sector for a portfolio can be computed easily by simply adding the risk points in that sector of all bonds in the portfolio. In addition, we can quickly compute the risk point for a broader sector by adding the risk points for all the smaller sectors within.

Table 8 and Table 9 show the risk points for a various common fixed income investments. It is interesting to look at the risk profile for an exotic

structure. in Table 10, we show the profile for a 3-year note that pays coupons equal to the 5-year swap rate less a fixed spread. Such a note is called a CMS note or Constant Maturity Swap rate note. The coupon on the note is reset semi-annually. Simple duration analysis will treat the note essentially as a floating rate instrument, implying a small duration or risk. The risk point profile (Table 9, Column 5), however, reveals that the CMS note has negative and positive risks. In fact, the note is bullish on rates up to 3 years and bearish on rates beyond that. In particular, the note has risk in the 5- and 10-year maturities even thought it is only has a 3-year maturity.

VII. Applications of the Risk Point Method

The risk point method, being a more complete and comprehensive measure of interest rate risk, can be used wherever other simple measures such as duration are currently being used. We provide here a brief review.

Hedging. This is the most common use of duration, and therefore, of risk points. Common duration analysis not only gives us just a crude approximation for the hedge, but it also fails to provide critical information as to which hedge instruments are optimal to use. On the other hand, the risk point method correctly identifies the major risks in a portfolio and directly generates the portfolio of hedge instruments best suited for the hedging task. Since the starting point for the risk point method is the selection of hedge instruments, we have full control over which hedge instruments will be considered for hedging from the outset.

The par amount of any hedge instrument required to hedge a portfolio can be determined by

dividing the risk point of the portfolio by the PVBP

of the hedge instrument. For example, consider the 10% coupon bond again. For every $100 of the bond, we need $104.5370 (7.253094/6.938302) of the 10-year Treasury as a component of the hedge.

Indexing. As a structured portfolio methodology, indexing is quite common. Indexing requires one to manage a portfolio in such a way that the returns from the portfolio track that from a given bond index, e.g., various Lehman Brothers indexes or the Merrill Lynch Government Bond Index. A common technique is to purchase, as far as possible, the same bonds as in the index in the same proportions. The effectiveness of this technique is limited because indexes almost always have too many bonds in them and most of these are not available at fair prices in the quantities required. An alternative is to manage the portfolio duration to match the published duration of the index as closely as possible. This technique allows the manager to pick bonds that are relatively cheap for the portfolio.

Situation. A portfolio manager is running an indexed fund tied to an index with a duration of 5 years. Given the bearish mood of the market, the manager decides to keep the duration of the fund short, at 4.5 years. Rates do climb. However, the manager finds that the fund has barely kept up with the index, and has not out-performed the index as expected. Further analysis reveals that the yield curve has steepened as the rates rose. The fund holds a relatively large amount of 10-year bonds which have suffered a loss. Thus duration matching in normal situations, and using a shorter duration in a bearish market, provide no guarantee that expected results will be obtained.

The reason is that duration is an over simplification.

A superior way to index is to first determine the full risk point profile of the index and then manage the fund against this profile as a guide. Then the manager will know what types of yield curve bets are implied in the fund's portfolio.

Immunization and Dedication. Another popular application of duration is in immunization. If we are managing a portfolio in order to meet a specific liability in the future, immunization calls for balancing the portfolio so that the duration of the portfolio equals the duration of the liability.

This procedure is a based on a parallel shift assumption for yield curve moves. Therefore, it is subject to the same types of surprises suffered by the index fund manager above.

A more robust approach is to determine the risk point profile of the liability and match this to the risk profile of the portfolio. In this sense, immunization is not much different from index fund management.

In dedicated portfolios, a common strategy is to cash-match for in the early years and use immunization in later years. Again, this strategy can be made more robust by using risk point matching rather than just duration matching in the back years.

Benchmarking. In many industrial corporations, the performance of the liability portfolio is measured against a benchmark portfolio. In many ways, this procedure resembles indexing. Again we recommend use of the risk point profile for managing the liabilities. Perhaps, the creation of the benchmark portfolio itself can benefit from this method.

Scenario Analysis. One use of duration is in scenario analysis. Under parallel shift assumptions, we can quickly determine the change in the value of a portfolio from its duration. This use of duration is limited to parallel shifts, and fails to reveal risks due to reshaping shifts of the yield curve. Using the risk point profile of the portfolio, it is easy to carry out scenario analysis including yield curve twists and other reshaping shifts. For example, in the case of the 10% coupon bond above (Table 6), if the 10-year rate moves up by 10 b.p. and the 5-year rates move up by 5 b.p. and the other rates are unchanged, then the change in the value of a $10,000 holding can be estimated to be $73.825740 (10 x $7.253094 + 5 x $0.258960).

Bond Swap Transactions. A common bond swap transaction is to swap a bond (a bullet) for a pair of bonds (the dumbbell) in such a way that the duration of the dumbbell is equal to that of the bullet. Even though it is difficult to match the risk point profiles of the bullet and the dumbbell, the profiles provide accurate clues as to where the risks and bets in the transaction might be.

VIII. Extensions

The application of the risk point method is not limited to securities with simple, known and fixed cash flows. It is in fact a general approach and can be used to hedge virtually all instruments. As long as a security can be valued relative to a set of hedge instruments, the method is applicable. For example, suppose that we are considering an option on a 10-year zero coupon bond. Then, we can easily determine the risk point for the option by first determining the change in the price of the zero relative to the current 10-year Treasury. Secondly, we determine the corresponding change in the price of the option due the change in the zero price. This directly gives us the risk point of the option relative to the current 10-year

Treasury.

The concept can also be extended to include risks other than interest rate risk. For example, suppose that we would like to hedge the option on the 10-year zero coupon bond against changes in volatility. We would choose a hedge instrument that responds to volatility, such as an option on the current 10-year Treasury. To determine the risk point, called the *volatility risk point*, which can be defined in various ways, we compute the change in the value of the hedge as well as the option on the zero per unit change in the volatility. The ratio of the two represents the risk point of the option relative to the hedge with respect to volatility. This number is the number of units of the hedge-instrument required to hedge the option on the zero to protect against changes in volatility.

In addition to volatility risk, we can similarly define risk points for stock market risk, exchange rate risk, commodity price risk, credit risk, etc. The two key factors in such extensions are the availability of appropriate hedge instruments and a valuation model.

Convexity. We can also extend the idea of duration-like risk point to convexity. Convexity basically measures the non-linear relationship between the cause (change in the reference rate) and the effect (value or price of a security). One way to measure the non-linearity is to look at the difference between a linear estimate and the actual value. In Table 11, we show the difference between the change in the value of the 10% bond for a 10 basis point change in the yield of a hedge (Column 6) and 10 times the change in value for a 1 basis point change in yield (i.e., the risk point, Column 5). The result, Column 7, can be called the convexity points.

There is another way to determine convexity, as in Table 12. We can move the entire yield

curve by a small amount (10 basis points), and re-compute the risk points. The difference between the risk points computed before (Column 5) and after (Column 6) the parallel shift. The result will represent a type of convexity

points.

It is difficult to pinpoint exactly how the convexity points ought to be used as convexity itself is a second-order effect. Nonetheless, we recommend their use, even for just monitoring purposes, by the risk manager. This is especially so when exotic securities are involved.

IX. Market Volatility and Value-at-Risk Analysis

The risk points are static numbers in the sense that they are properties of securities, not of the market. However, it is straightforward to incorporate data that describe market dynamics such as variance (or volatility) and covariance of prices and yields.

One way to include volatility is to simply multiply the risk point relative to a hedge by the standard deviation for that hedge. For example, suppose that the risk point for a portfolio is $10,000 per basis point change in the 5-year Treasury. Suppose also that the yield of the 5-year Treasury changes about 3 basis points per day on the average. Then, we can say that the value of the portfolio changes about $30,000 (3 basis points times $10,000 per basis point) per day on the average due to changes in the yield of the 5-year Treasury.

We can extend this idea further. Value-at-Risk (VAR) of a portfolio represents the amount of loss that could result with a given probability. Suppose that the probability that a portfolio can lose more than $2 million over a one-week horizon is less than 3%. Then the VAR for the portfolio is $2 million, that is, with 97% confidence, we can say that the loss in the portfolio is going to be less than $2 million over the one-week horizon. Different confidence bands and horizon periods are used in different contexts. In order to estimate the VAR of a portfolio, we not only have to estimate the price volatility of each security in the portfolio, but also the correlation for each pair of securities. In order to limit the task of data estimation to a manageable level, that is, to reduce the number of pair-correlations that need to be estimated, some type of mapping is usually applied. The RiskMetrics methodology includes one such mapping. In this context, a mapping is a representation of the portfolio in a simpler, more tractable format.

The risk point concept also leads to an efficient mapping. Recall that the vector of risk points represents a portfolio, called the equivalent portfolio, of hedge instruments with equal risk. If the hedge instruments, relative to which the risk points are computed, are carefully chosen, then the equivalent portfolio is an excellent representative portfolio or mapping for VAR computation. Since the risk point concept is driven by a valuation model, this approach ensures that the mapping is not ad hoc as in other methodologies, but is based on robust and valid analytical reasoning. In addition, VAR analysis based on the risk point concept can handle more complex securities in the portfolio including options.

X. Conclusion and Summary

In this chapter, we have presented the risk point concept as a more complete measure of interest rate risk than other commonly used measures such as duration. The concept adds value in almost all situations where duration is used, including: hedging, immunization, dedication, indexation, bond swapping and scenario analysis. The risk point concept is especially valuable in the management of portfolios including options and most of the complex modern financial instruments. We recommend that the risk point method be used as an integral part of a comprehensive risk management program. In risk management, as in most important situations, our policy is to reject the black box approach. By providing more insight into the nature of risk, the risk point method takes us one step away from the black box, one step closer to our ideal.