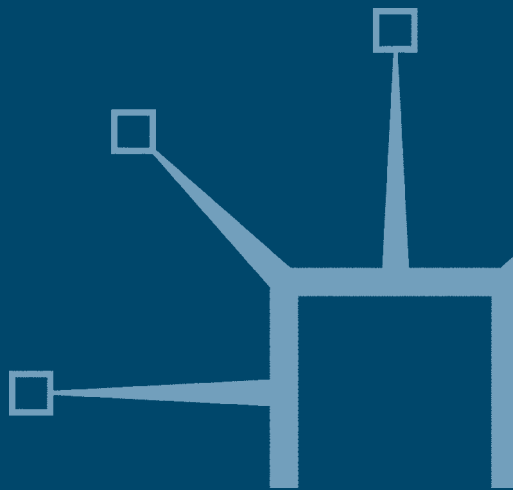


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# Economic Capital and Financial Risk Management for Financial Services Firms and Conglomerates

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Bruce T. Porteous and  
Pradip Tapadar





# **Economic Capital**

and Financial Risk Management  
for Financial Services Firms  
and Conglomerates



BRUCE T. PORTEOUS  
AND  
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# Preface

When Palgrave Macmillan first approached us about the possibility of writing a book, neither of us had any plans to write a book on any topic whatsoever, never mind one on economic capital and financial risk management! We do share a common belief, however, in the very significant value that can be added to the successful management of a financial services business by the development and use of robust financial risk management tools.

In particular, we believe that these tools can be used to assist managers in assessing and understanding the risks that their businesses are running. Without this understanding, the board and the senior managers of the business cannot, we would argue, effectively lead the business.

In practice, and as many financial services practitioners will have experienced, certain firms and financial services sectors may not always manage their risks and run their businesses with the aid of such a disciplined “scientific” approach. Little, or no, investment is made into either the development of financial statistical models, nor into attracting and developing the intellectual capital needed to support the disciplined “scientific” approach.

On the contrary, the business may be run using instinct and “gut feel,” based on the many years of experience racked up by the firm’s most senior managers. For example, arrogance, in combination with a deterministic approach, may allow executives to believe that they can value even the most complex of financial guarantees after only a few minutes thought. The rigorous model based approach is believed to be unconnected to the commercial realities of running a financial services business.

Unfortunately for the owners and the customers of those financial services firms that are run on instinct, the end result tends always to be the same. When the unexpected, or unusual, event occurs, the firm collapses into the sand onto which it has been built. Only those firms

that have been built on foundations that have been designed and tested to withstand severe, and often unforeseen, shocks will survive and prosper.

The genesis of this book can be found in two articles that appeared in Risk Magazine, Porteous (2002) and Porteous, McCulloch and Tapadar (2003), together with the authors' collective experiences of financial services businesses, particularly in life insurance and retail banking over many years. Key questions that those articles consider are

- How much capital is required to back a specific collection of financial risks?
- How should that capital vary by the type of balance sheet on which it is written and on the structure of the corporate group within which it is written?
- How does that capital compare to regulatory capital requirements?

In this book we take these questions, and the initial ideas discussed in those articles, and give them both fuller and broader treatments. We also consider other natural follow on questions such as:

- How should the performance of a financial services firm be measured after allowing for the risks that it is running?
- How should financial services conglomerates allocate capital to the business units, or corporate entities, within their groups bearing in mind their relative financial performances and risks?

Obviously, there is already a large body of work and thought available that considers many of these questions and problems. What we hope this book adds is

- An approach and viewpoint that is relevant and applicable across the range of financial services firms, rather than just one specific type of firm.
- A recognition that the same financial risks can be written by very different types of firm.
- The development of ideas and solutions that are pertinent to the risk based capital environment that will prevail for financial services firms in future.

- The development of approaches that are both rigorous and which can be implemented in practice.

We believe that the ideas and tools discussed and developed in this book will assist managers, if they so choose, to build the very strong foundations on which we believe they should build their businesses.

Bruce T. Porteous  
Pradip Tapadar



# Acknowledgments



We are extremely grateful to our families and friends who have supported and encouraged us throughout the preparation of this book. We would also like to thank Vaishnavi Srinivasan for reading the early drafts and for providing us with very constructive comments.

Bruce T. Porteous  
Pradip Tapadar



# Disclaimer



The results reported in this book are based on private research and do not necessarily reflect the views of either our current, or previous employers.

Bruce T. Porteous  
Pradip Tapadar

# List of Abbreviations

AMA	Advanced Management Approach
AGF	Additional Guarantee Sub Fund
AIRB	Advanced Internal Ratings Based
BIA	Basic Indicator Approach
CAD	Capital Adequacy Directive
CAPM	Capital Asset Pricing Model
CECO	Chief Economic Capital Officer
CRO	Chief Risk Officer
CDO	Collateralized Debt Obligation
DWP	Department for Work and Pensions
ERC	Early Redemption Charges
EVAR	Economic Value at Risk
ECR	Enhanced Regulatory Requirement
FGD	Financial Groups Directive
FSA	Financial Services Authority
FIRB	Foundation Internal Ratings Based
GF	Guarantee Sub Fund
GAO	Guaranteed Annuity Options
HPI	House Price Inflation
ICA	Individual Capital Assessment
ICG	Individual Capital Guidance
ICR	Individual Capital Ratio
IRB	Internal Ratings Based
IASB	International Accounting Standards Board
IFRS	International Financial Reporting Standards
LTV	Loan to Value
LTC	Long Term Care
LTICR	Long Term Insurance Capital Requirement
MCR	Minimum Regulatory Capital Requirement

NNEG	No Negative Equity Guarantee
CAD3	New Capital Adequacy Directive
NPLTBF	Non Profit Long Term Business Fund
OTC	Over the Counter
PPFM	Principles and Practices of Financial Management
PVIF	Present value of in force business profits
QIS	Quantitative Impact Studies
RMBS	Residential Mortgage Backed Security
RPI	Retail Price Inflation
RSA	Revised Standardized Approach
RAPM	Risk Adjusted Performance Measurement
RCM	Risk Capital Margin
RBS	Royal Bank of Scotland
SWPBR	Smoothed With Profits Benefit Reserve
SF	Smoothing Sub Fund
SPV	Special Purpose Vehicle
TOR	Terms of Reference
TSA	The Standardized Approach
VAR	Value at Risk
WPBR	With Profits Benefit Reserve
WPICC	With Profits Insurance Capital Component
WPLTBF	With Profits Long Term Business Fund

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# Introduction

### 1.1 OUR APPROACH TO RISK

Our strong conviction is that mathematical statistics is at the very heart of understanding and measuring risk. In other words, to really get a handle on how a risk might behave in future, and the consequences of this, a stochastic approach that acknowledges the range of possible future values that the risk may take is a prerequisite. In particular, this is the case for the risk's extreme values, and the probabilities of occurrence of these values. The book by Bernstein (1998) gives an excellent introduction to risk.

Deterministic centralist approaches, which focus on one central value, or a very limited range of values, of a risk, cannot tell us much about how a financial system, which is dependent on the risk, will behave in future. In particular, deterministic approaches cannot tell us much about how stable the system is to the more "extreme" values of the risk, relative to the risk's probability distribution. This is of crucial importance when considering the capital requirements of a financial services firm because these should be determined as the amount of capital that the firm needs to survive, with a specified probability, the "extremes" of the risks it is writing.

A good non financial example of the pitfalls of a deterministic approach, in the face of an uncertain or stochastic risk, is the Tay rail bridge disaster of 1879.

The first Tay rail bridge, only 19 months old at the time, collapsed on the evening of 28 December 1879 during a storm where wind pressures reached levels that had not been anticipated in the design of the bridge. A train was crossing the bridge at the time and all 75 people on the train lost their lives. The remains of the first bridge can still be seen alongside the current rail bridge as a reminder of the consequences of ignoring the extreme values of an uncertain risk, in this case wind pressure. Although the consequences for a financial services firm of not being able to

withstand an extreme value of a risk are hopefully less grim than for the first Tay rail bridge, future collapse is nevertheless also inevitable. It is only a matter of time.

Wherever possible, therefore, we prefer to model risk using mathematical statistical models that acknowledge the range of values, and their respective probabilities, that a risk may take. We include deterministic stress testing techniques within our definition of mathematical statistical modeling. This is provided that extreme stresses, well away from the central risk values, are considered.

## **1.2 OUR APPROACH TO CAPITAL**

The approach that we take to capital and finance is what might be called a “realistic actuarial” approach. It is realistic in the sense that we always try to model financial risks as realistically as possible. For example, we try to avoid approaches where artificial assets, liabilities and cashflows are generated purely as a result of their accounting treatment. Our realistic approach might also be called a market, or economic, value approach.

When modeling the capital required to back a risk, we will make inferences about the risk throughout its entire lifetime, rather than over a one year, or limited year, outlook. This is the approach that actuaries typically tend to follow in their financial modeling of insurance firms and pension funds.

Investment bankers and financial analysts, on the other hand, may often base their analyses on a one to five year look. For example, when we estimate the amount of capital that is needed to cover a risk, and the rate of return earned on that capital, we will perform our calculation over the expected lifetime of the risk. Our “actuarial” approach might therefore be called long term, rather than short term.

Whilst recognizing the value of qualitative approaches with risks that may be difficult to measure and control, for example certain types of operational risk, our approach is quantitative. In order to assess capital requirements and financial performance, we use mathematical models, both simple and complex, that are capable of replicating, to a good first order of approximation, the main features of the financial risk systems we are attempting to understand.

## **1.3 OUR APPROACH TO INFRASTRUCTURE**

By “infrastructure,” we will mean the business infrastructure that is required for risk and capital to meet. Therefore, for example, the

infrastructure will comprise firms, customers, investors, supervisors, regulations and so on.

A traditional infrastructure approach is that only certain firms should collect only certain types of risk. Life insurance firms and pension funds collect mortality risk, whereas banks do not. As firms have broadened their businesses, however, with products also crossing over into non traditional business segments, and as regulation itself has also become more harmonized, traditional infrastructure approaches have become less relevant. For example, certain products are offered by both banks and life insurance firms and certain regulators are desirous of developing common regulations that cover both insurance and banking.

The approach that we take to infrastructure is that it should depend only on the types of risk and capital that it is connecting. The risk and capital management of credit risk, for example, should be independent of the type of firm that has collected the risk.

Unfortunately, perhaps as a consequence of the traditional view, the approach that we advocate in this book has not prevailed. For example, the regulation of different types of financial services firms, or industry segments, has not only evolved in ad hoc and arbitrary deterministic ways, but also supervisors appear to have developed their regulations in isolation from each other. Therefore, for example, the way that life insurance firm credit risk has been supervised has been very different from the supervision of banking firm credit risk. Although this outcome may perhaps be understandable, it is clearly not desirable and may have encouraged regulatory arbitrage activities.

## 1.4 STRUCTURE OF THE BOOK

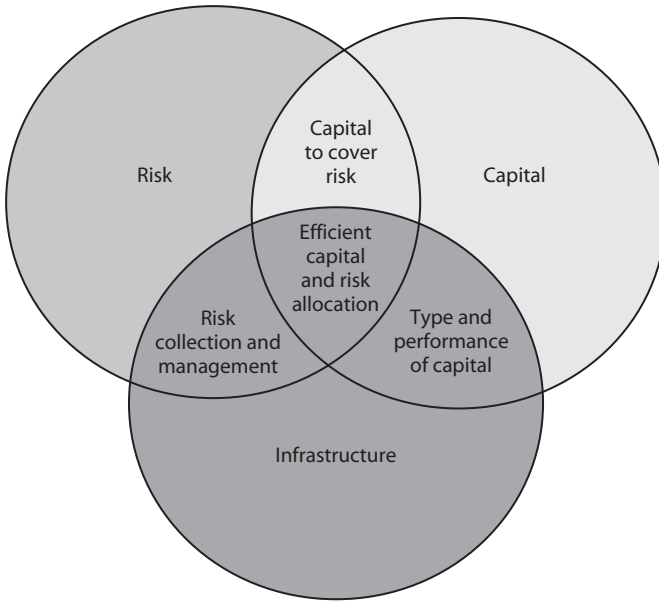
Figure 1.1 gives a diagrammatic representation of the model that we have followed in developing and structuring the book. Figure 1.1 shows the three risk, capital and infrastructure components as intersecting sets.

### *Risk/capital intersection*

In this intersection, we identify how much capital is required to cover risk. To do this, we must distinguish different types of risk (Chapter 2), measure risk (Chapters 4 and 7) and finally connect risk to capital (Chapter 5).

### *Risk/infrastructure intersection*

In this intersection we consider the infrastructure in place to collect risk and manage it. To do this, we must consider governance (Chapter 3),



**Figure 1.1** Risk, capital and infrastructure model

regulation (Chapter 14) and the types of firms that collect and manage risk (Chapters 8, 9, 10, 11 and 12).

### *Capital/infrastructure intersection*

In this intersection, we consider the types of capital the infrastructure can raise and the financial performance of this capital. To do this, we will consider different types of capital (Chapter 6) and the financial returns that can be earned on this capital for its owners (Chapters 8, 9, 10, 11 and 12).

### *Risk/capital/infrastructure intersection*

Finally, in the full three way intersection, which brings together all three components, we consider how risk can be managed and capital allocated across the infrastructure in effective and efficient ways. To do this, we consider financial services firm conglomerates (Chapter 12) and the allocation of capital and risk across the infrastructure in an attempt to optimize risk consistent financial performance (Chapter 13).

# Risk Types, Collection and Mitigation

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## 2.1 INTRODUCTION

It can be argued that the main rationale for the existence of financial services firms is to collect and manage risk, in its widest possible sense. In doing this, they usually aim to both make a profit for their shareholders and to provide value adding services for their customers, specifically managing financial risks on behalf of their customers.

Therefore, for example, a retail mortgage bank may provide a range of fixed rate mortgages for their customers at a time in the economic cycle when it is perceived that interest rates are likely to increase over the short to medium term. Customers are therefore able to lock their mortgages into current interest rates before interest rates rise.

Similarly, a defined benefit pension fund will aim to provide guaranteed pension benefits, as a proportion of final salary, to those members that stay the full course and retire at their normal retirement age. Pension scheme members are therefore able, at least in principle, to plan their post-retirement finances with a reasonable level of certainty.

In both of these examples, there is a transfer of risk from individual customers to financial services firms who collect and manage these risks for a fee. The fee may, however, very often be implicit, rather than explicit, and the customer may often be unaware of the price that they are paying for the service provided.

Financial services firms usually price their services by requiring that they earn a threshold target rate of return on the capital required to back the risk. This calculation is far from simple and involves a very large range of assumptions on the specific risk itself, associated second-order risks, customer behaviors, expenses, taxation and so on. The capital used

in this calculation is often regulatory capital, reflecting the commercial reality of the amount of capital that the regulators say is required to back the risk.

Economic capital, as defined in Chapter 5 of this book, and which will very often diverge from regulatory capital, is used by firms for the crucial purpose of managing and allocating capital across their businesses. Increasingly, however, firms are also pricing using economic capital as their base measure of capital.

## 2.2 TYPES OF RISKS COLLECTED

Examples of the types of risks that financial services firms collect through their product offerings and distribution channels, together with typical types of collectors, are listed in Table 2.1.

So, for example, when life insurance firms offered guaranteed annuity options (GAO) in association with their personal pension contracts in the 1970s, they were collecting both interest rate risk (the risk that interest rates may fall below the implicit level priced into their GAO rates) and mortality longevity risk (the risk that mortality rates would improve faster than the improvement factors implicitly priced into their GAO rates). As is well known, the alleged mismanagement of these risks played a very large role in the ultimate fall from grace of Equitable Life, the world's oldest and, until this downfall, a highly respected and successful UK life insurance firm. The so called Penrose Report, which investigated the problems that caused Equitable Life's fall, is available on the HM Treasury website at [www.hm-treasury.gov.uk](http://www.hm-treasury.gov.uk).

Similarly, investment banks packaged the debt of apparently successful firms such as Enron for sale to investors in the form of highly rated collateralized debt obligations (CDO). The investors therefore collected a complex mix of credit and operational risks associated with those firms. Assessing these risks is obviously very complex which is why the investors delegated responsibility for this to ratings agencies. Many of these structures imploded in the early 2000s causing substantial loss and embarrassment to many of the parties affected.

From Table 2.1, it can be seen that financial services firms will collect very few risks in isolation. It will be far more typical for firms to collect a large number of the risks in aggregate through their product offerings and distribution channels. Therefore, understanding the way in which these risks interact with each other is of crucial importance in managing the risks.

**Table 2.1\*** Types of risks and collectors

<i>Type of risk</i>	<i>Collector</i>
Mortality/morbidity	Life insurance, health insurance, pension funds, lifetime mortgage/reversion companies.
Claims experience risk.	General insurance, health insurance companies.
Business retention (persistence)	All
Expense	All
Market risk (e.g. equity investment)	Life insurance, asset management, pension funds, investment banks
House, or property, price inflation (HPI)	Life insurance, retail banks, lifetime mortgage/reversion companies
Credit	Life insurance, asset management, pension funds, retail/wholesale/investment banks
Interest rate	Life insurance, retail/wholesale/investment banks
Currency	Life insurance, pension funds, wholesale/investment banks
Retail price or earnings inflation (RPI)	Life insurance, pension funds
Liquidity	All
Operational	All

\* This table has been reproduced from Porteous (2002).

So, for example, when short term interest rates are on the rise, we may expect the persistence behavior of long term fixed rate mortgage customers to improve i.e. fixed rate mortgage customers will have a financial incentive to keep their fixed rate mortgages going for longer in a rising interest rate market. In statistical terminology, a multivariate, rather than a univariate analysis, is required to both understand and manage the risks under consideration.

Another observation that we can make from Table 2.1 is that many of the risks associated with financial services firms' products can be written on a range of balance sheets. For example, guaranteed equity bond products, which tend to increase in popularity following stock market falls, are

written by life insurance firms, banks and building societies. Their regulatory treatment can be quite different across these balance sheets, though the same risks are being written and the management of these risks ought to be independent of the balance sheet on which the risk is written.

A further example is the use of insurance, as provided for by non life insurers, and financial guarantees, as provided for by investment banks, to hedge identical risks. The same risk is being hedged but the regulatory treatment will usually be different. Porteous (2002) provides more examples of risks that can be written on different balance sheets with different amounts of regulatory capital consequently being required to back these risks.

These regulatory anomalies will tend to give financial services conglomerates possessing large numbers of balance sheets in their group, a competitive advantage over firms that have a narrower business focus. In other words, we might expect firms to write risks on those balance sheets where it is most “efficient” to do so. A similar point can be made in respect of jurisdictional regulatory anomalies. However, in this book we are mainly concerned with anomalies across business lines. We will return to this topic in Section 13.8.

We now give brief descriptions of the risks shown in Table 2.1, where these risks are clustered together into similar risk types.

### **2.2.1 Mortality/morbidity/claims experience**

These risks would normally be collected by insurance firms. For example, with a life insurance term insurance product that pays out a guaranteed sum assured on the death of the customer, the mortality risk to the life insurance firm would be that its mortality experience is heavier than has been priced for, resulting in more claims than expected.

### **2.2.2 Persistency**

When financial services firms price their retail products, mortgages or credit cards, for example, they will make certain assumptions about the persistency experience of their customers. If customers are less persistent than has been priced for, then firms may lose money on these customers. This is because customers need to stay with the firm for a minimum period of time in order that the firm can recoup the costs of acquiring the business, in addition to earning its required profit margin. This risk may be difficult to manage with products that can be exited by the customer with little or no penalty.

### 2.2.3 Expense

When firms price their products, they will make certain assumptions about the acquisition, administration and closure unit expenses that they incur in acquiring and maintaining the business. Typically these assumptions will be based on unit expenses, per unit of product, and based on either the firm's expected, or target, expenses. If the firm's actual unit costs are in excess of those priced for and cannot be managed down to the priced level, then the firm will make expense losses as a consequence.

### 2.2.4 Market risk, house price inflation (HPI), interest rate, currency

One very simple example of interest rate risk is where retail banks use floating rate funding to back their fixed interest assets, such as fixed interest mortgages. The bank is then exposed to the risk that the cost of its floating rate funding increases, thereby reducing its interest rate margin, which is the difference between what it earns on its assets less the cost of its liabilities. The reduction in this margin then results in losses for the bank.

Similarly, a with profits life insurance firm that provides investment guarantees to its customers, whilst investing their premiums in volatile assets, such as equities, is collecting large amounts of market risk. If the returns earned by these volatile assets fall below the guaranteed return, then the firm will incur losses.

### 2.2.5 Credit

An example of credit risk is when a firm enters into a derivative contract with an investment bank to hedge a risk on its balance sheet. The firm is exposing itself to the credit risk that the investment bank, when called upon to do so, will not be able to honor the contract.

### 2.2.6 Retail price inflation (RPI)

A life insurance firm may offer an RPI linked annuity, which is an annuity, paid for life and for which the payments increase in line with an RPI index. If RPI rises faster than the life insurance firm has priced into its product, the firm will pay out more income than has been priced for, so resulting in potential losses to the firm.

We now briefly describe our approach to the last two types of risk, namely liquidity risk and operational risk, as set out in Table 2.1. We treat these risks slightly differently to the other types of risk, as described in Section 2.2.7.

### 2.2.7 Liquidity risk

The UK regulator, the Financial Services Authority (FSA), defines liquidity risk as: “the risk that a firm, although solvent, either does not have available sufficient financial resources to enable it to meet its obligations as they fall due, or can secure such resources only at excessive cost.” In other words, risks associated with those times when firms suffer from negative cashflows.

The view that we take in this book is that capital is not an appropriate risk mitigant for this risk. Management actions, such as improving the matching the firm’s asset and liability cashflows, are more appropriate mitigants.

As it may not be practical for many firms to closely cashflow match their assets and liabilities, for example banks that raise their funding “short” and lend “long”, alternative management actions will usually need to be taken, or will be required by regulators. For example, the calculating and setting up of additional liquidity reserves, or sterling reserves in unit linked life insurance firm terminology, is fairly common practice. These additional reserves are typically backed by liquid assets that can be released to fund the expected negative cashflows, as they arise.

These reserves, which we will hereafter call liquidity reserves, are calculated using firms’ best estimates of their expected future cashflows, and so cover expected liquidity risks. Other, unexpected, liquidity related risks that may arise, for example, the credit risks associated with liquidity assets held by the firm should, on the other hand, be mitigated by capital. These risks are essentially unexpected credit risks for which capital is an appropriate risk mitigant.

The approach that we take in this book, therefore, is that liquidity risk should not be mitigated by capital, but by actions taken by the firm’s management, including the setting up of liquidity reserves. The techniques and examples that we develop in the later chapters of the book will, therefore, not include any allowances for liquidity risk. But note however that, if firms consider that capital is an appropriate risk mitigant to liquidity risk, the techniques developed in this book still apply.

### 2.2.8 Operational risk

A definition of operational risk, taken from the Bank for International Settlements Basel 2 Capital Accord, which we hereafter refer to as Basel 2, is as follows:

the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. This definition includes legal risk, but excludes strategic and reputational risk.

In fact, this definition, the Basel 2 definition, has more or less become the financial services industry standard.

### **2.2.8.1 *Inadequate or failed internal processes, people and systems***

The view that we take in this book is that capital is not an appropriate risk mitigant to protect firms from losses arising from inadequate or failed internal processes, people or systems. Management actions such as improving internal processes, managing staff more effectively and developing better systems and controls are more appropriate risk mitigants for these types of operational risk losses.

Mistakes, nevertheless, will always be made no matter how well a firm is managed. That is normal and natural. In our view, however, insurance is the appropriate risk mitigant that protects the firm from those unexpected losses arising from internal process, people or systems failures that may jeopardize the solvency of the firm.

The techniques and examples that we develop in the later chapters of the book will, therefore, not include any explicit allowances for the amount of operational risk economic capital that is required to cover process, people or system operational risk losses. Note however that, if firms consider that capital is an appropriate risk mitigant for these types of losses, the techniques developed in this book still apply.

Corresponding expected operational risk losses from inadequate or failed internal processes, people and systems are simply the costs of doing business and will be covered, at least implicitly, through firms' business as usual expense analyses. This is also the case for expected external event operational risk losses.

In other words, a part of a firm's actual unit expenses will be due to these so called expected operational risk losses. As these unit expenses are used by firms to price their products and, at least for life insurance firms, set reserves, these expected business as usual operational risk losses are handled implicitly by firms through their business as usual management processes.

### **2.2.8.2 *External events***

That leaves us with operational risk losses resulting from external events. To the extent that such losses are not within the control of the firm, and are difficult or expensive to insure against, capital is an appropriate risk mitigant. These events will tend to occur independently, in the statistical sense, from the other risk events that firms are exposed to. For example, we would not normally expect the event that a firm's head

office is blown up by terrorists, or that its staff are targeted by organized criminals, to be dependent or correlated, in any way, with the market risks that the firm is running.

It therefore seems reasonable that operational risk external events should be modeled and treated independently of the other risks collected by firms. Once operational risk external event economic capital has been separately identified, it can then be combined with the economic capital amount that is required to cover the other risks collected by the firm.

The two main approaches that firms are using to determine operational risk external event economic capital are now described briefly.

### *Qualitative scorecard approaches*

Firms require business teams and units to carry out regular operational risk self assessment exercises. A key output of these exercises is that all material operational risks being run by the teams and units will have been identified and scored. Scoring will usually be according to Likelihood and Impact factors, for each risk, with scoring typically being carried out both gross, and net, of the controls that are in place to help mitigate the risk.

Firms will, therefore, have scores for all material external event expected operational risk losses. These can then be used as the foundation for a scenario based approach to estimating unexpected, or worst case losses, that may result from these events. In practice, this is achieved by asking the business teams and units to develop worst case scores and losses that could result for each of the risks that they own. These unexpected losses are then aggregated to provide an estimate of the amount of capital that is required by the firm to cover its operational risk external event losses. In performing the aggregation, judgmental estimates of the correlations between the risk events may be needed to reflect the diversification benefits present amongst the risk events.

### *Quantitative insurance approaches*

The quantitative approach, which borrows heavily from techniques developed in the non life insurance sector, is as follows:

- A statistical distribution for the occurrence of an operational risk external event is developed which, at least in theory, will involve fitting a statistical distribution to the firm's external event occurrence data.
- Similarly, a statistical distribution for the gross loss that the firm incurs, conditional on the external event having occurred, is developed. Again,

where possible, this should involve using the firm's own loss data to fit a distribution to the data.

Once these two statistical distributions have been developed, the firm can then estimate any feature of the associated operational risk event losses that it requires. In particular, it can estimate the amount of capital that is required to cover extreme, or low probability, external event losses, both gross and net of controls.

Our general insurance example, which is discussed in Section 9.4, is developed using an insurance approach similar to that described above.

### *Qualitative versus quantitative approaches*

As far as we are aware, the vast majority of firms are using qualitative type approaches, with some of the very major firms, who have larger amounts of data and resource, adopting quantitative type approaches. Although quantitative approaches are arguably superior, most firms are hampered by a lack of data, poor data quality and consistency issues. To get around these problems, some firms use data from external databases to augment their own loss data.

## **2.3 RISK COLLECTION**

### **2.3.1 Who?**

As is shown in Table 2.1, firms tend to collect the types of risk that are appropriate for the financial services license they hold. For example, mortality risks tend to be collected by life insurance firms. This is because the benefits paid out by those firms usually depend on either the survival, or death, of their clients. A bank would not normally be a collector of mortality risk, as it will not usually be licensed to carry out life insurance business.

Similarly, as life insurance firms tend not to be licensed to write mortgage business, life insurance firms are usually not direct collectors of the retail credit risks associated with mortgages.

However, there can be grey areas. For example, it can be argued that the lifetime mortgages<sup>1</sup> discussed in Section 8.3.1 contain embedded life insurance risks. Many banks and building societies offer this product, and take all of its associated risks onto their balance sheets, without feeling the need to hold a life insurance license!

<sup>1</sup> See Section 8.3.1 for a description of a lifetime mortgage product.

However, at least traditionally, specific types of risk have tended to be collected by only certain types of firm.

### 2.3.2 Where?

Once the risks described above have been collected, financial services firms have essentially three choices of what to do with the risks as follows:

1. Keep the risk on one of their own balance sheets, without fully hedging the risk (e.g. life insurance with profits funds investing in equities, retail banks selling mortgages).
2. Keep the risk on one of their own balance sheets, but hedge the risk internally (e.g. life insurance unit linked funds investing in equities and passing the market risk onto their unit linked policyholders, general insurer/wholesale bank groups offering catastrophe bonds and passing the general insurance claims experience risk onto bond investors).
3. Remove the risk from their balance sheets, at least in part, by hedging the risk externally (e.g. reinsurance of life insurance annuity longevity risk, full cash asset securitizations of retail bank residential mortgages).

As financial services firms continue to evolve into financial services conglomerates, Option 2 will become increasingly important, as firms will have more choice over where in the group to write a risk. Moreover, risks collected by one component of a conglomerate may “sit better”, or be better matched, on the balance sheet of a different component balance sheet within the group. For example, it may be more appropriate for the mortality/morbidity risks collected by a lifetime mortgage firm to be held by a life insurance firm. Moreover, a risk collected by one component firm within the group may form a “natural hedge” for a risk on another component firm’s balance sheet. One example of a natural hedge is given below.

Reversion<sup>2</sup> firms, banks and building societies are very large collectors of house price inflation (HPI) risk through their equity release reversion mortgage products. These firms may, however, be reluctant to keep this risk on their own balance sheets, but may find it difficult to hedge the risk externally in sufficient volume at the right price. Possible natural

<sup>2</sup> See Section 11.3.1 for a description of a reversion mortgage product.

hedges might be

- A life insurance firm that is a part of the same group may be able to use the HPI risk to back HPI linked product offerings.
- As HPI is normally highly correlated with average earnings, the HPI risk may be of use to pension funds, with the residual risk hedged.

It may therefore be possible for firms to hedge the HPI risks present in their reversion assets with those present in liabilities held elsewhere in the group. The capital required to back the risk will, as a result, be reduced. Firms obviously still have the option of hedging risks via arrangements with third parties, but if a natural hedge exists

- Firms will be able to avoid the cost of the third-party hedge.
- Less capital will be needed across the entire financial services system, so increasing the capital efficiency of the financial services markets.

We now move on to discuss the factors that financial services firms consider when they are deciding whether or not to keep a particular risk on their balance sheets.

### **2.3.2.1 *The firm's risk appetite for that risk***

If a firm will breach its own internal risk limits by taking the risk, then it has no choice but to write the risk off balance sheet, or lose the business. An example is when AIDS was discovered in the 1980s and was not very well understood, many life insurance firms had little or no risk appetite for term insurance business and would only write it if they could pass on very high proportions of the associated mortality risk to reinsurers.

### **2.3.2.2 *Availability of capital***

A firm may not have enough capital to write a risk on its own balance sheet and may have to pass at least a part of the risk on to another firm that has excess capital available. A firm may also, in this way, be able to increase its rate of return on capital by writing more business with the same amount of capital via a judicious use of on and off balance sheet business. See Section 13.4 where this topic is discussed in full detail.

### **2.3.2.3 *The economics of on balance sheet versus off***

It may be economically advantageous for a firm to write a risk off balance sheet. For example, under the Basel 1 banking rules, full cash securitizations of retail mortgages generally require less capital than is required to write these mortgages on balance sheet. As we shall see in Chapter 8, Basel 1 regulatory capital requirements are well in excess of the amount of capital that is needed to back mortgage asset risks.

Banks may therefore be able to increase their financial performance by writing retail mortgages off balance sheet, all else being equal. Similarly, reinsurance companies are generally more knowledgeable about risks such as morbidity risk in developing countries than life insurers and can consequently price health insurance products more competitively. It therefore makes sense for life insurers to reinsure such morbidity risks to the reinsurers. Again, see Section 13.4 for a full discussion of this and related topics.

### **2.3.2.4 *Availability of financing***

A firm may not have enough financing, or funding, available to write a risk on its own balance sheet and may pass the risk to another entity that is able to access alternative, possibly cheaper, sources of funding.

## **2.4 RISK MITIGANTS**

We now give some examples of the types of risk mitigants that are available to firms to control and manage the risks they collect.

Table 2.2 gives examples of the main types of instruments, or management actions, that firms can enter into, or carry out, to transfer risk off their balance sheets, or to help control the risks they retain on their balance sheets. On the assumption that such instruments, or management actions, do genuinely mitigate risk, it is then appropriate for this to be reflected in reduced capital requirements for the firm.

Most of the risk mitigants mentioned in Table 2.2 are used quite commonly and are well understood. However, to illustrate how these risk mitigation techniques are used in practice, we give brief discussions of some of the newer techniques.

### **2.4.1 *Property derivatives***

The property derivatives market is currently very small and immature, but is expected to grow and develop very rapidly over the next 5 to 10 years.

**Table 2.2** Types of risks and mitigants

<i>Type of risk</i>	<i>Mitigant</i>
Mortality/morbidity	Effective underwriting and claims management, longevity bonds, reinsurance
Claims experience risk	Effective underwriting and claims management processes, catastrophe bonds, reinsurance, product design, effective claims data management information systems (MIS)
Business retention (persistence)	Product design, customer retention activities
Expense	Effective expense controls and management, effective expense MIS
Market risk (e.g. equity investment)	Equity derivatives, dynamic hedging
House, or property, price inflation (HPI)	Property derivatives, securitization, insurance, reinsurance
Credit	Effective underwriting, credit default swaps, collateralization, securitization
Interest rate	Interest rate swaps
Currency	Foreign exchange derivatives
Retail price or earnings inflation (RPI)	Index linked government securities, inflation swaps, earnings swaps
Liquidity	Liquidity reserves, contingency funding plans, financial reinsurance, product design
Operational	Effective internal systems and controls, insurance, effective loss data MIS

The first property derivative transaction, which was entered into very recently, involved the UK life insurance firm, Prudential, which wanted to reduce its exposure to property by £40 million and the property firm, British Land, which wanted to increase its exposure by the same amount.

The two firms entered into a three year swap agreement whereby, if the returns from the UK property market, as measured by a specified property index, outperform a Libor related rate of interest, Prudential pays British Land the difference. Conversely, if property returns lag Libor, British Land pays Prudential the difference.

No physical transfer of assets takes place, so avoiding the delays involved in acquiring/selling property, and the associated buying/selling

costs, typically around 7%–8% of the property value. Therefore, Prudential was able to successfully transfer HPI risk off its balance sheet for three years, in exchange for Libor risk.

### 2.4.2 Credit default swaps

There is now a huge market in these instruments, which are used to transfer credit risk off a firm's balance sheet. In exchange for a premium to be paid by the firm to the writer of the credit default swap, usually an investment bank, the writer will assume the credit losses incurred by the firm in respect of designated assets on the firm's balance sheet.

As the designated assets remain on the balance sheet of the firm, credit default swaps are often called synthetic securitizations. This is because they achieve some of the regulatory capital relief associated with a full cash securitization, but do not provide any funding. The swap may be subject to a first loss arrangement whereby the firm meets the initial credit losses on the designated assets up to a pre-agreed level. Thereafter, the writer of the credit default swap meets the credit losses on the designated assets in full. The investment bank writer of the swap will usually pass on the credit risk to another party, usually a reinsurance firm or an insurance firm specializing in this type of business.

Both Basel 1, the current regulatory capital regime for banks, and Basel 2 allow reduced regulatory capital requirements for designated assets that are protected from credit losses by credit default swaps, subject to certain qualifying requirements. In other words, regulators consider that, because there is less credit risk associated with the designated assets, less credit risk regulatory capital is required to back the assets.

### 2.4.3 Longevity bonds

At the time of writing, the world's first longevity bond has been launched recently, although it is expected that the market will remain quite small and restricted in the short term.

The income paid by the bond is determined using the published mortality experience of a reference population, defined as the number of individuals in England and Wales reaching age 65 in the calendar year of the bond launch. If 90% of the reference population survives to the end of the first year of the bond launch, the bond will pay 90% of a fixed income amount. On the other hand, if 99% survive, it will pay 99% of the fixed income amount, so generating higher returns for investors when mortality experience is lighter.

The bond is, therefore, a very good asset match for pension funds, and life insurance firm annuity business, as the liabilities of these funds and firms increase as their mortality experience lightens. Availability of the bonds is, however, quite limited with, at the time of writing, only one bond worth 550 million euros having been issued.

#### **2.4.4 Product design**

Product design can be used to mitigate, or control, customer behavioral type risks such as persistency risk. For example, retail mortgage firms usually design their mortgage products with early redemption charges (ERC) that apply if the customer wishes to leave during the early months of the mortgage. The ERCs act both as a deterrent to stop customers leaving and they also allow mortgage firms to recoup at least some of the expenses that they have incurred in acquiring the business.

Consider now a discounted rate mortgage that offers customers a discounted rate for the first 12 months of the product, and the full rate thereafter. If the ERCs apply for the first 12 months of the mortgage, in line with the discount, customers' monthly mortgage repayment increases at the same time as the ERCs cease. In practice, firms therefore see very large numbers of customers leaving in the three months following the simultaneous ending of the discount and ERCs.

If the ERCs apply beyond the discount period, say for 18 months, then when customers' monthly mortgage repayments increase after 12 months, they would incur an ERC if they left. Because of this, many of those customers that otherwise would have left, stay. By the time that the customers are free of ERCs, after 18 months, many of the customers have become accustomed to paying the higher mortgage repayments and do not leave, even though they are free to do so without incurring an ERC. This behavioral effect has been observed by firms to continue for many months after the end of the ERC period, resulting in much superior persistency experience as compared to mortgages without such, so called "overhanging," ERCs.

Overhanging ERCs are extremely effective in controlling, or mitigating, customer persistency risk. On the downside, however, mortgages with overhanging ERCs are much harder to sell than mortgages without overhangs.

## **2.5 SUMMARY**

In this chapter we have discussed the various types of risks that financial services firms collect, which firms collect the risks, where they are

written and how the risks can be mitigated. The most important risk mitigant that is available to firms in controlling the risks they collect is their own internal risk governance structures and processes. We now move on to discuss these governance structures and processes in detail in the next chapter.

# Risk Governance

### 3.1 INTRODUCTION

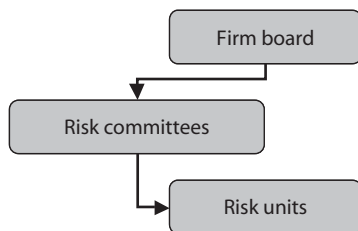
Before we move on to consider the hard quantitative risk management aspects of financial services firms, we first set out the softer, more qualitative, governance aspects of risk management that firms must follow as a matter of best risk management practice.

The responsibilities of a bank's board, as described in Basel 2, are taken as our key guide to these governance aspects for all types of financial services firms. Note that, although the approach of this chapter is driven by Basel 2 requirements for banks, exactly the same principles apply to all other types of financial services firms.

The most important risk responsibilities of a bank's board under Basel 2 are as follows:

1. Identifying the material risks collected by the firm
2. Putting in place the infrastructure and processes required to manage these risks
3. Measuring risk, specifying risk appetite and putting in place limits and controls to ensure that the firm stays within its articulated risk appetite
4. Assessing the amount of capital that the firm needs to cover the risks that it has collected and intends to collect
5. Putting in place effective internal reporting processes and compliant external reporting processes
6. Putting in place independent reviews of the firm's internal controls.

We will discuss each of these responsibilities in more detail.



**Figure 3.1** Risk management delegation

We first note that, although a firm’s board is responsible for the risks run by the firm, and their management, the board will in practice delegate the “doing of risk management” to the firm’s risk committees. The firm’s risk committees will therefore usually have a direct reporting line to the firm’s board.

Figure 3.1 illustrates this. The risk units shown in Figure 3.1 support the risk committees in their delegated tasks of the doing of risk management.

As is described later, risk reporting will usually flow through the firm’s Enterprise Wide Risk unit, which is responsible for taking a holistic view of risk across the firm.

## 3.2 RISK IDENTIFICATION

Identifying the material risks that a firm collects ought to be straightforward and, for many firms, it will be. However, firms may collect, or run, risks that can sometimes be difficult to recognize. To illustrate these points, we will consider the Basel 2 categorization of risks into Pillar 1 and Pillar 2 risks.

First, the Pillar 1 risks are those risks for which Basel 2 specifies a prescribed minimum regulatory capital requirement. Pillar 2 risks are not covered by Pillar 1 and there is no prescribed minimum regulatory capital requirement. Instead, firms are required to self assess the amount of regulatory capital that is needed to cover these risks and must satisfy their own local regulator that the approach that they have taken is reasonable and sound.

There are also other more qualitative type risks that do not fall naturally into either the Pillar 1 or Pillar 2 categories. We illustrate these points by considering specific Pillar 1, Pillar 2 and other risks as described below. As we will see, some of the Pillar 2 risks that we identify below are business type risks that do not naturally fit into our Table 2.1 in Chapter 2, which lists the specific types of risk, that financial services firms collect.

### 3.2.1 Pillar 1

The risks for which Basel 2 requires a bank to hold a prescribed minimum regulatory capital requirement are

- Credit risk
- Market risk in the trading book, but not in the banking book
- Operational risk

Banks therefore recognize these risks, by default, through their requirement to hold a prescribed minimum regulatory capital requirement for the risks.

### 3.2.2 Pillar 2

The risks that Basel 2 requires banks to self assess include

#### *Credit concentration risk*

If a bank has, for example, a large exposure to one corporate counterparty, or to one segment of the retail market, this risk may not be captured by a bank's Pillar 1 regulatory capital requirement and banks are required to self assess the additional capital that should be held to cover this risk.

#### *Banking book market risk*

This was introduced in Section 2.2.4.

#### *Business cycle risk*

If the bank feels that the business, or economic, cycle may turn down and that it may need additional capital to maintain its position through the cycle, it is required to self assess the amount of capital that it needs to cover this risk.

#### *Liquidity risk*

As discussed in Section 2.2.7, this risk would normally be mitigated by the holding of additional liquid assets. However, if a bank considers that it should have additional capital to cover this risk, it should self assess the amount of capital needed.

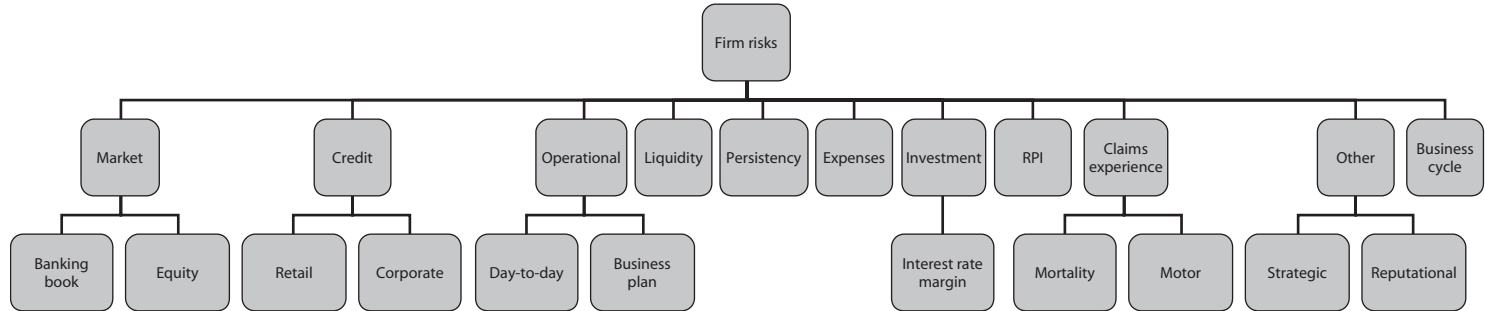
Less obvious Pillar 2 type risks that banks may be running include

#### *Persistency risk*

As described in Section 2.2.2.

#### *Expense risk*

As described in Section 2.2.3.



**Figure 3.2** Risk hierarchy

### *Margin risk*

When banks, or firms, price their products, they will price using an assumed interest rate margin for the product. This is the interest rate they expect to earn on the invested assets less the associated costs of funding, or financing, the product. If the bank does not earn the interest rate margin assumed in its pricing, perhaps because its cost of funding has increased as a result of a ratings downgrade, the bank will make a margin loss. It may therefore be appropriate for banks to self assess the amount of capital that is required to back interest rate margin risk for those product segments where this is a genuine risk.

These risk examples illustrate that, sometimes, material risks run by a bank may not always be straightforward to identify. Moreover, such risks will be highly bank specific and will require banks to invest time and effort in identifying and understanding the risks that they are running.

### **3.2.3 Other**

Other risks that do not fall naturally into either the Pillar 1 or Pillar 2 categories include strategic and reputational risks.

An example of a strategic risk is the risk associated with a firm being overly, or wholly, dependent on a single channel of distribution for its products. An example of a reputational risk is the brand damage that could result as a consequence of a firm receiving a large regulatory fine.

These risks are qualitative in nature and, as a consequence, are more difficult to get a handle on and understand than quantitative type risks. Nevertheless, firms should still try and identify such risks, usually as a part of their strategic and business planning cycle. Scenario analysis can then be used by the firms to help them understand the consequences of such risks and to develop appropriate mitigants, which will usually be management actions or improving systems and controls, rather than capital.

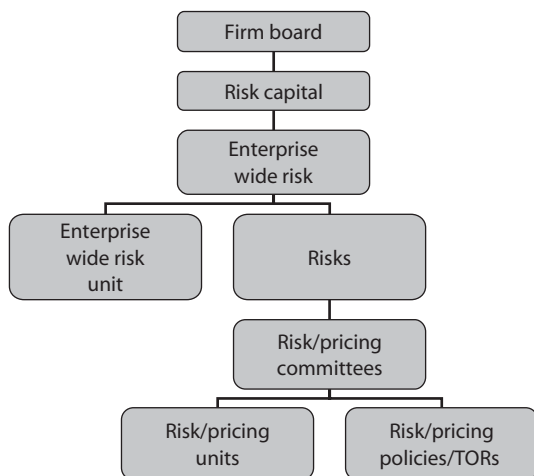
Figure 3.2 shows a possible risk hierarchy for a financial services firm.

It can be seen that the risks range from, on the left hand side of the figure, the hard quantitative risks to the softer, more qualitative risk types, on the right hand side of the figure.

## **3.3 RISK MANAGEMENT INFRASTRUCTURE AND PROCESSES**

Having identified the risks that are being run, or collected, by the firm, the board must put in place the infrastructure and processes to manage these risks.

An initial question for firms to consider is whether a standalone risk function should be set up with a risk director representing that function on the firm's board. Small firms may not be able to afford the additional



**Figure 3.3** Risk infrastructure and processes

cost of a standalone function, whereas large firms will be so complex that a standalone function will be an absolute necessity.

In our view, a separate risk function is always preferable as it reduces or eliminates segregation of duties issues and certain task ownership issues. For example, it is inevitable that some of the risks being run by the firm will be Finance type risks, such as pricing risks. If the Risk function reports into Finance, for example, then Finance will have a potential conflict of interest in the reporting of its own risks. The perception of this potential conflict to third parties outside of the firm, such as the regulator, will always be negative.

Figure 3.3 shows a potential risk management hierarchy for a firm. We discuss each level in this risk hierarchy as follows:

#### *Firm board*

Ideally there should be one owner, the Chief Risk Officer (CRO), for all risks collected, or run, by the firm. However, many small firms may prefer to have one, or more, risk owning executive directors in place. Each will have executive management responsibility for the risks that they own.

#### *Risk capital*

This is the level at which the firm self assesses the amount of capital that it requires to cover the risks that it is running. This is described in Section 3.5.

### *Enterprise wide risk*

This is the unit, or area, that takes a holistic view of risk across the firm. At this level, risk reports will be gathered from their respective risk and finance silos and aggregated for reporting up to the board. In particular, Pillar 2 risks such as business cycle risks, which cut across risk committees, will tend to be managed at this level.

### *Risk committees*

Each material risk will typically be managed by a risk committee. Each risk committee will manage its risks in line with a board approved risk policy and the committee itself will be formally constituted with a proper terms of reference and an appropriate membership. Most risk committees will “do” risk management whereas some, like an operational risk committee, may perform an “oversight” role only. In other words, in some firms, the operational risk committee will delegate the “doing” of operational risk management to the business areas where the risks are being run and the committee, itself, will perform an oversight role on how these risks are being managed.

### *Risk units*

Each risk committee will be supported by a risk unit that develops and maintains the technical infrastructure and processes that are used to measure and control the risks of the committee. For example, the credit committee will typically have a dedicated credit risk analysis unit in place to assist it in managing the credit risks of the firm.

For firms that are a part of a large group, or conglomerate, the infrastructure and processes set up by the firm will need to be consistent with the larger group approach to risk management. Typically, group risk management at the centre of the group, or conglomerate, will set out the standards and requirements that must be adhered to throughout the group.

## **3.4 RISK MEASURES, APPETITE AND LIMITS**

### **3.4.1 Measures**

Perhaps the key role of a risk committee is to develop measures that capture the amount of risk that the firm is collecting, or running. For example, Value at Risk (VAR) measures the potential loss that a bank may incur from taking on market risk over a given time period, at a specified confidence level, and generally uses Monte Carlo techniques.

VAR techniques are also increasingly being used to measure corporate, or non retail, credit risk, but less so for retail credit risk. We would

consider VAR to be a genuine risk measure as it is a well defined quantitative measure of the potential loss that a firm may incur as a result of accepting a specific type of risk.

In practice however, many firms may not actually measure the risks that they are taking on. For example, the retail credit risk that is taken on with a mortgage is often controlled using portfolio limits. Therefore, for example, firms might put a limit on the proportion of high loan to value (LTV) business that they are prepared to accept. Although this undoubtedly allows the firm to control, or limit, credit concentration risk, it does not measure, or quantify, the amount of risk that is being taken on.

Similarly, mortgage retail banks may measure and monitor arrears rates by customer segment, for example, the proportion of mortgages that are three or more payments in arrears, and track these over time. We would again argue that, although such arrears rates do give an indication of the amount of relative risk that the firm is running, such measures do not identify how much absolute risk the firm is running. For example, arrears rates cannot tell the firm how much money it may lose over the next 12 months, with a prescribed probability, from the credit risks associated with mortgages.

Similar points can be made across all risk types.

Generally speaking, for the purposes of this book, we consider that for a risk measure to be meaningful, it must be capable of quantifying the potential loss that may result to the firm, over a prescribed time period and with a prescribed confidence level, or probability, from taking that risk. Economic capital, described later in this book, is a prime candidate for such a risk measure as it is capable of handling most, if not all, risks.

### 3.4.2 Risk appetite

Once a firm has developed a meaningful risk measure for the risks it is collecting, it is then in a position to specify or articulate its risk appetite, relative to the risk measure. If a firm does not measure risk in a meaningful way, it is not likely that it will be able to articulate an appetite.

That does not mean to say that it cannot limit or control risk. It can still set risk limits which will, indeed, control risk, but the firm will not be able to say anything meaningful about the potential losses that it may incur as a result of accepting risk.

Note that firm appetite can be set, first, for each risk individually and, second, for all risks in aggregate. The aggregate appetite may allow for the potential interactions, or more loosely the potential correlations, between the risks and may, as a consequence, be less than the sum of the individual risk appetites. For example, credit risk may tend to be “low” when market risk is “high”, and so on.

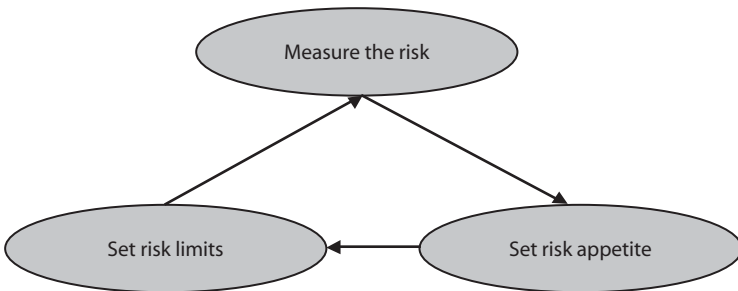
### 3.4.3 Risk limits

Once a firm has articulated its risk appetite, it is then in a position to set the risk limits that will control risk and keep the collected risks within the firm's articulated appetites. For example, the firm might set a trigger limit at 95% of its articulated appetite to identify when the firm is getting close to its appetite. As mentioned above, firms may often jump straight to the limit setting stage, before they have developed meaningful risk measures and have articulated their risk appetite.

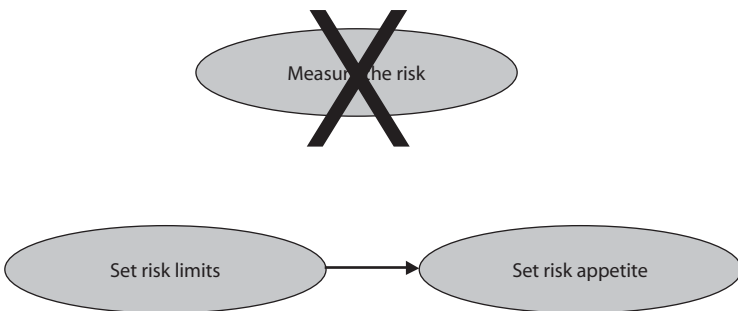
The risk limit should be stated by reference to the underlying risk measure and will be designed to ensure that the firm stays within its articulated appetite. For example, if market risk is being measured using VAR, the limit may be specified by putting an upper limit on a business unit's daily VAR, which keeps the firm within its appetite.

Figure 3.4 illustrates this process using our risk control cycle management tool.

The firm begins by measuring the amount of risk it is taking. It then articulates its appetite relative to the measured amount of risk and, finally, sets limits, also relative to its risk measure, to ensure that it stays



**Figure 3.4** Risk control cycle



**Figure 3.5** Risk limit control cycle

within its articulated appetite. Risk will be measured on a regular and ongoing basis with risk appetites and risk limits refreshed by the firm, usually on an annual basis.

Figure 3.5 illustrates the alternative process that some firms may, however, follow. They start with risk limits and then use those to articulate their appetite without ever having measured the underlying risk in the first place.

### 3.5 RELATE CAPITAL TO RISK

Under Basel 2, for banks, and new regulations for UK insurers, see Chapter 14, financial services firms are required to self assess the amount of capital that they believe is needed to cover the risks they are running. The level of prescription around how firms should carry out such a self assessment is, in practice, and by regulatory design, limited.

However, within the financial services industry, the generally accepted approach to carrying out this risk capital self assessment is by using economic capital models of the firm's business. Economic capital is the main theme of this book and is discussed in full detail in Chapter 5.

Once a firm has developed the infrastructure and tools required to determine its self assessed risk capital, firms will be expected and required to use this risk capital to manage their businesses as follows:

- To ensure that the firm has enough current available capital to cover the risks it is running, as measured by its current level of risk capital.
- To ensure that the firm will have enough future available capital to cover the risks that it is planning to run, as measured by its projected future risk capital levels. Moreover, the firm should allow for planned changes in the firm's risk profile going forward in projecting risk capital.
- To articulate its risk capital goals explicitly in its strategic and business plans.

We believe that risk capital is the key risk management tool that all firms should be using to manage their businesses from a risk perspective. For example, as mentioned earlier, risk capital could be the fundamental risk measure used in a firm's risk control cycle.

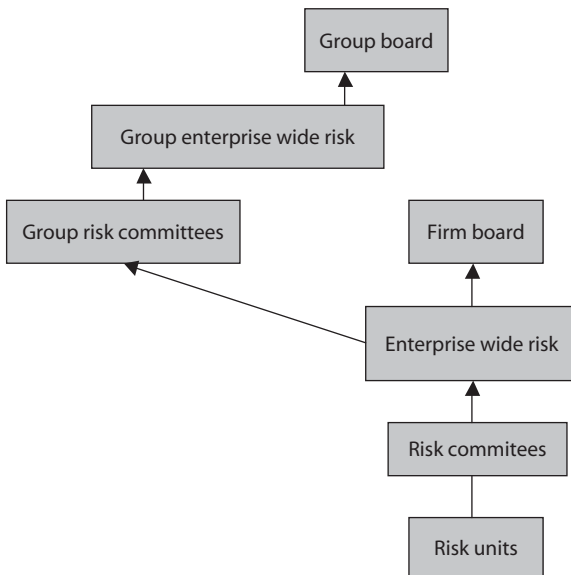
## 3.6 REPORTING PROCESSES

### 3.6.1 Internal reporting

Basel 2 requires that the board of the bank should receive regular reports on the firm's risk profile and its risk capital needs. This is mainly to assess and check that

- Emerging trends in the material risks collected by the firm are being monitored.
- The assumptions underlying the risk capital calculation are still appropriate.
- Available capital is sufficient to cover the risks currently being run by the firm.
- Projected available capital is adequate to cover the risks projected to be run by the firm.
- The firm's articulated risk capital goals are still appropriate.

Firms will need to consider how frequently their board should receive such reports, how detailed the reports should be and in what form they should be presented. This will tend to be firm specific, driven mainly by the requirements of the firm's board and senior managers.



**Figure 3.6** Internal risk reporting process

The Pillar 2 type risks and the risk capital calculation tend to cut across all risk committees and some areas of Finance, such as product pricing. Firms will therefore need to be very clear in defining the roles and responsibilities of the various parties involved in preparing the firm's internal risk reports.

Consistency with group reporting will also need to be considered as well as whether the firm's enterprise wide risk profile, or individual risk profiles, should be reported to the group centre. The group's requirements will be the main driver of this, however.

Figure 3.6 sets out a potential reporting process for a firm that is a part of a larger financial services group.

In this potential reporting process, the firm's enterprise wide risk profile is reported into the group.

### **3.6.2 External reporting**

For external reporting, firms will usually be most concerned to ensure that they are compliant with the disclosure regulations, that their approach is consistent with their peers and that it satisfies the needs of all of stakeholders, including investors.

Usually, a board approved disclosure policy will be required by the regulators. This should cover how the specific disclosures were decided upon, internal controls over the disclosure process and the process for assessing and monitoring the ongoing appropriateness of the disclosures.

Regulators would also tend to require that disclosures are consistent with the way that the firm assesses and manages risk. Notwithstanding all of these points, a firm's external reporting will, of course, be driven to a very large extent by its accounting requirements.

## **3.7 INDEPENDENT REVIEWS OF INTERNAL CONTROLS**

At least under the Basel 2 banking rules, a firm's board is responsible for

- The establishment of a process to monitor compliance with internal policies.
- Verifying that the firm's internal controls are adequate.
- Periodically reviewing risk management processes.

In practice, firms are likely to handle these requirements by

- Using external consultants to carry out periodic one off reviews to identify process and control weaknesses.

- Relying on the firm's Audit Committee and both internal and external auditors to monitor compliance thereafter.

Particular issues that firms may face include:

- There is a limited supply of experienced consultants available in the market to carry out the one off reviews. Fees therefore tend to be high and the same advice may sometimes end up being passed around the industry.
- Many of the consultants are ex-regulators, sometimes with limited business experience. Firms may therefore receive advice that helps them comply with the letter of the regulations, but which may not add much value from a practical risk management perspective.
- Internal audit staff may not be appropriately skilled, nor have the business experience, to handle the increasingly complex and challenging risk management requirements that they are being asked to audit.

### **3.8 SUMMARY**

In this chapter, we have discussed the formal governance structures that firms are required to put in place to manage the risks they collect. Even if a firm has put in place its hard, quantitative risk management tools, without the softer, more qualitative risk management tools described in this chapter, a firm would not be following best risk management practice.

We now move on to consider the fundamentally important topic of risk measurement in the next chapter.

# Stress Testing to Measure Risk

## 4.1 INTRODUCTION

As described in Chapter 3, firms are required to self assess the amount of capital that they believe is needed to cover the risks they are running. There are many ways in which this self assessment may be carried out and it will certainly vary across firms.

In this book, we will achieve the self assessment by subjecting the realistic balance sheet of a firm's businesses to deterministic stresses or stochastic stresses. The amount of capital that is required for this realistic balance sheet to remain solvent, following a range of stresses, then represents the firm's self assessed risk capital amount. This is described in more detail in Chapter 5, which deals with economic capital.

Note that, throughout this book, we use this self assessed risk capital amount as our key measure of risk.

In this chapter, we now define and discuss both deterministic and stochastic stress testing and compare their relative merits. We first describe what we mean by a deterministic stress.

## 4.2 DETERMINISTIC STRESSES

Under a deterministic stress of a firm's realistic balance sheet, the behavior of the balance sheet is examined when one, or more, of the firm's risk variables are assigned specific extreme values. Although a probability is sometimes assigned to a deterministic stress, giving a half way house between deterministic and stochastic stress testing, this tends to be the exception rather than the norm.

Take a retail mortgage bank, for example. The risk capital of the bank's mortgage book depends on the future interest rate margin that the bank may earn on its mortgages. This is the rate of interest earned by the firm on its mortgages, less the cost of funding these mortgages. The bank may believe that its average interest rate margin over the lifetime of its existing in force business is 0.012 p.a.

If everything goes by plan, the bank should earn a margin close to 0.012. If not, it will earn a margin less than 0.012 and capital will be required to absorb this loss. If the bank does better than planned, its margin will exceed 0.012 and capital will be released.

The extent to which the margin might be either more, or less, than 0.012 will depend on the specific circumstances of the bank, for example its funding mix and how stable this is likely to be going forward. The cost of the bank's funding will not be known with certainty and will vary according to both internal influences, for example the bank's credit rating, and external influences, for example the credit cycle.

Substantial judgment will, therefore, be required in choosing the deterministic stresses to be used. Stresses plus, or minus, 25 basis points, or 0.0025, may be appropriate for one bank, but may be too extreme for another bank's management.

Once a full range of deterministic stresses has been designed and agreed, the realistic balance sheet of the bank's business is subjected to each stress and the amount of capital that is required to back the risks that define each of the deterministic stresses can be calculated.

### 4.3 STOCHASTIC STRESSES

Most, although not all, of the risks that firms collect can be modeled as random variables, in the formal mathematical statistical sense. Some examples are given below.

#### *Retail mortgage bank example*

As we discussed in Section 4.2, a bank's margin will usually not be known with absolute certainty. Modeling this future margin as a stochastic process allows this uncertainty to be quantified, so assisting the firm in controlling and managing it. For example, treating the margin as a stochastic process allows us to quantify how extreme the margin can be in the tails of its distribution.

Examining the percentiles of the firm's observed monthly interest rate margin over a specified period of time will allow the firm to understand

how low its margin can fall to, at each percentile level. Stochastic models can be designed to replicate this tail behavior and can then be used by the firm to self assess the amount of risk capital it needs to cover this type of risk event.

### *Life insurance annuity example*

The capital management of a life insurance firm's annuity portfolio depends on the future mortality experience of the firm's annuitants. For example, the lighter that its mortality experience is, the greater its reserves should be to cover liabilities. Most firms' annuity portfolios are large enough for current annuitant mortality, across the entire portfolio, to be stable and estimable with a high degree of accuracy. The biggest uncertainty, however, is the rate at which mortality will improve in the future.

Actuaries have consistently underestimated mortality improvement rates and ongoing advances in medical sciences and genetics may mean that this improvement rate may even accelerate in future. Estimating the effect and timing of medical advances on future mortality is obviously impossible. Nevertheless, it is still feasible to build simple and credible stochastic models of mortality improvement rates, based to some extent on what has happened in the past, and these are useful in quantifying the risks associated with improving future mortality.

### *With profits life insurance example*

The capital management of regular premium life insurance products depends on the investment returns that future premiums will earn. For savings products, this will usually mean the future returns that can be earned on investment in a mixture of equities and fixed interest assets. These future returns are obviously not known with certainty.

One approach to handling this uncertainty is to model the returns as realizations of a specific stochastic process, for example, a multivariate time series model. Once a credible stochastic model has been developed and built, future asset returns can be repeatedly simulated using the model. These returns can then be used to help understand the behavior of the firm under the stochastic variability, or volatility, captured by the model. For example, light can be shed on how much risk capital is required to back the investment guarantees implicit in life insurance with profits funds. Practical examples illustrating this approach are given in Chapter 11.

### *Pension fund example*

The amount of funding needed by an occupational pension scheme fund to meet its liabilities depends on the future fixed unit expenses of the fund, its ongoing annual maintenance expenses, for example. Future unit expenses are unknown and, moreover, they depend on numerous factors that cannot realistically be modeled.

For example, the effectiveness of the fund trustees and the managers in controlling costs and the absolute size of the fund itself will affect the fund's unit expenses. So, it will usually not be practicable, or realistic, to model the future unit expenses, per se, using a stochastic process. An alternative approach is to model the rate of increase of unit expenses from one year to the next.

Over the longer term, this rate of increase will usually be highly correlated with RPI. For example, if the unit costs are mainly attributable to fixed staff expenses, based on past experience, the rate of increase of the unit expenses over the longer term is likely to be well modeled by assuming that it equals RPI plus an additional 1 or 2% p.a. Most financial services firms have fairly well developed stochastic models of future RPI.

The examples described above form a very small selection of the type of risk variables that are amenable to stochastic modeling.

## **4.4 MULTIVARIATE NATURE OF THE RISK VARIABLES**

As discussed in Chapter 2, the range of risks that financial services firms collect is very extensive. For example, even a relatively simple building society is subject to persistency, expense, HPI, credit, interest rate, liquidity and operational risks.

It is relatively straightforward to quantify risks individually. However, in reality risks occur simultaneously, and according to the likelihood of their mutual occurrences. For example, one might expect poor credit experience and high interest rates to be dependent, or positively correlated. Likewise, high levels of credit defaults and low, or even negative HPI, tend to occur when interest rates are high.

For stochastic stresses, therefore, the stochastic process that models the mutual behaviors of the risk variables that quantify risk will be a multivariate process. In other words, the model should be capable of describing risk variable dependencies, as well as the marginal behaviors of the risk variables themselves. With mortgages, for example, persistency and interest rates may tend to be negatively correlated as customers

may churn their mortgages more in a high interest rate environment. The stochastic process chosen will therefore need to be able to model this type of dependency.

For deterministic stresses, the values that particular risk variables take under the individual stresses will need to be chosen quite judiciously. For example, in the mortgage example above, the high interest rate stresses should only contain “low” values for the persistency risk variable.

Given the very large number of risk variables that a financial services firm is affected by, the dimensionality of the stochastic process used for stochastic stress testing, and also of the deterministic stresses, will often be very high. The dimension reduction techniques that are available for stochastic processes, and their deterministic stress equivalents, will therefore be of great assistance. In Chapter 7, we develop a high dimensional stochastic model that is built up from relatively low dimensional building blocks.

#### **4.5 CAUSAL NATURE OF THE MULTIVARIATE DEPENDENCIES**

As well as being multivariate in nature, usually in very high dimensions, financial services firms’ risk variables may also exhibit directional dependencies, or causal relationships. For example, high interest rates may cause poor credit experience. On the other hand, it is not likely that poor credit experience will cause high interest rates.

So, credit experience and interest rates are dependent and the direction of the dependence is clear. In statistical parlance, we call credit experience a response variable and interest rate an explanatory variable. In building a stochastic process to model these two risk variables, we would normally work with the distribution of the response variable, conditional on the explanatory variable, and with the marginal distribution of the explanatory variable itself.

Likewise, we expect government bond yields and equity dividend yields to be dependent. These yields tend to take on high values together, for example. However, there is no obvious causal relationship between these variables. In statistical parlance both of these risk variables are therefore response variables and we would therefore work with the full bivariate distribution of these response variables in building a stochastic process for these risk variables.

Deterministic stress testing should also acknowledge any directional dependencies, or casual relationships, that may be present amongst the risk variables. This can be achieved by developing conditional stress tests for response variables, conditional on the values of the stressed

explanatory variables. The full deterministic stresses are then constructed by first stressing the explanatory variables, then followed by the conditional response variable stresses.

## 4.6 MATHEMATICAL TRACTABILITY

For very simple financial services firms, with either stochastic or deterministic stresses, it may be possible to quantify risk in terms of closed form mathematical expressions. Although this is elegant and satisfying, it will almost never be achievable in practice for “real” financial services firms.

Our approach in this book is to focus on financial services firm models and risk variable stochastic process models that, to a first order of approximation, represent very good descriptions of the real world they are modeling. Most features of these real world systems can then be estimated using stochastic, or Monte Carlo, simulation techniques. This approach allows us to tackle a very wide range of practical problems.

## 4.7 STRESS CONFIDENCE LEVEL

When using stochastic stresses to quantify risk, we do this with reference to a prescribed probability or confidence level, over a prescribed time horizon or confidence period. Typically, a probability level of 0.995 and a one year confidence period is used. However, instead of using one prescribed probability level, for example 0.995, our preferred approach is to quantify risk for the prescribed confidence period for a range of estimated probability levels, typically 0.95, 0.99 and 0.995. Results are then presented for all of these probability levels.

When doing this, one has to remember that the underlying stochastic process used to quantify risk at these probability levels is, at best, an approximation, or model, of reality. Probability levels of 0.995, say, should therefore be taken with a “pinch of salt” and used mainly as indicators of relative likelihood, rather than as genuine probability statements in their own right.

When assessing risk using deterministic stresses, it is more difficult and it may not be feasible to assign probability statements to these assessments. Firms may feel confident that they can assign probabilities to each of the deterministic stresses used to assess risk but, ultimately, very substantial amounts of judgment will be required to achieve this.

In practice, the best that is likely to be achievable is a qualitative categorization along the lines of “medium likelihood,” “low likelihood” or “very low likelihood.”

## 4.8 RELATIVE PROS AND CONS

The main advantages of stochastic stress testing are

1. A stochastic approach allows probability statements to be made for risk capital.
2. Correlations, or multivariate dependencies, between the risk variables can be modeled formally rather than by simply assuming, as with deterministic stress testing, that the variables are 100% correlated and always occur together.

The main difficulties with the stochastic approach are as follows:

1. Implementation involves estimating the multivariate stochastic process of the risk variables under consideration. This is likely to be challenging due to data paucity and the very large number of risk variables that will usually be required.
2. It can be difficult to identify which risk variables are responses and which are explanatory. In other words, identifying causal relationships between risk variables, and also the direction of these relationships, may not be straightforward. For example, for a life insurance firm offering long term savings products with significant investment guarantees and which are backed by equities, lapse or surrender rates may increase when equity markets perform poorly. Lapses may increase because customers take a short term view of their savings policy and select against the life insurance firm when they perceive that their investment guarantees are “in the money.” The life insurance firm will need to try and understand the reason for increased lapse experience and then model it.
3. The stochastic models that drive stochastic stress testing can be technically difficult to develop and implement.
4. The stochastic approach is much more challenging to communicate, for example, to the firm’s board or regulator.

## 4.9 SUMMARY

In this chapter we have described both deterministic and stochastic stress testing. For the reasons described in the chapter, we always prefer, and advocate, stochastic approaches in preference to deterministic approaches. Stochastic uncertainty is at the heart of what risk is, and the mathematical statistical theory that has been developed to model and understand that uncertainty is, in our view, a key tool that should be used to manage risk, in its widest sense.

We now move on to define and discuss economic capital in Chapter 5.

# Economic Capital

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## 5.1 DEFINING ECONOMIC CAPITAL

Economic capital is a key, perhaps the key, quantitative risk measure for financial services firms. In this chapter we define economic capital and set out its potential uses.

The term “economic capital” has been around for many years and is referred to in the risk and finance literature frequently. But what does it actually mean in practice?

Basel 2 says that it is the amount of capital that is required to cover the risks that the financial services firm is running, as self-assessed by the firm. This definition is somewhat unhelpful and obviously gives firms a great deal of discretion in determining their economic capital amounts.

Our first objective in this chapter is to provide a more helpful definition of economic capital. A good starting point may be to consider what “economic” and “capital” mean separately.

### *Capital*

The purpose of capital in a financial services firm is to absorb the losses associated with the risks the firm is taking on, to ensure that it remains solvent and is thus able to honor the commitments it has made to its customers.

### *Economic*

Capital may be called *economic* because it measures the firm’s risk in economic, or market value, terms.

Putting these two terms together, “economic capital” involves quantifying the amount of capital that is required, on an economic or market value basis, to support the risks the firm is running. Economic capital therefore connects the risks that a firm is running to the capital that is required to back these risks.

We define economic capital as follows:

### *Definition 5.1*

*Economic capital for the business of a firm is the amount of capital, or excess assets, that this business requires to ensure that its realistic, or market value, balance sheet remains solvent, over a specified time horizon, with a prescribed probability or confidence level, following events that are unexpected, yet not so unlikely that they might never occur in practice.*

The “unexpected” events will usually be described by a set of specified deterministic stresses, or by the tails, or extremes, of a stochastic process that generates the stochastic stresses.

We also define economic value at risk (EVAR) as follows:

### *Definition 5.2*

*EVAR for the business of a firm is the amount of value, on a realistic, or market value, basis that is destroyed over a specified time horizon, with a prescribed probability or confidence level, by events that are unexpected, yet not so unlikely that they might never occur in practice.*

It can be seen that economic capital and EVAR are very closely related.

For firms that have high value businesses, where the realistic, or market, values of their assets are well in excess of their realistic liabilities, economic capital calculated according to Definition 5.1 may equal zero, even under very extreme deterministic or stochastic stresses. This is because the value inherent in these businesses may be more than adequate to ensure that the realistic balance sheet of the business remains solvent, even after a very extreme stress. In these situations, it may be helpful to also consider EVAR, as EVAR shows how much value is destroyed by the unexpected events, even if all of the firm’s business value is not destroyed.

However, for the purposes of this book we will choose to work mainly with Definition 5.1.

## **5.2 TIME HORIZON FOR DETERMINING ECONOMIC CAPITAL**

Definitions 5.1 and 5.2 beg the question of what is an appropriate time horizon over which to determine economic capital? The time horizon that is most typically chosen, somewhat arbitrarily, is one year. This

may be convenient when considering the financial performance of the firm over the year ahead.

In this book, however, we advocate taking a longer term view. For example, the important risks that a firm is facing may not materialize within the next year and having sufficient capital to cope with a one year time horizon tells the firm nothing about how much capital is required beyond this first year when the firm may be at most risk.

For these reasons, we argue that it is more appropriate to define economic capital by reference to the time horizon determined by the expected outstanding life of the firm's in-force business. That way, economic capital will be adequate to enable the firm to survive specified deterministic or stochastic stresses throughout the remaining lifetime of its current in force business.

In some of the practical examples given in later chapters, we describe how economic capital varies by the particular time horizon chosen.

### **5.3 EXCLUSION OF THE CAPITAL ASSETS BACKING A FIRM'S BUSINESS**

In applying Definition 5.1 and Definition 5.2, we exclude all of the firm's available equity and debt capital that is backing the firm's business from our calculations.

If capital were to be included, it would absorb, as it is designed to, some of the value losses that occur when the realistic balance sheet of the firm's business is subjected to deterministic or stochastic stresses. As a consequence, the economic capital amount for that business is reduced. As we are interested in estimating the amount of capital that is required to support the risks that the firm is running in the carrying out its business, it is therefore appropriate to exclude the firm's available capital from the economic capital calculation.

Note also that, if available capital were to be included, the resultant economic capital for the firm's business would also include an amount of economic capital that is required to support the capital assets themselves. For example, if the capital is invested in assets, which carry credit risk, the firm's business economic capital would also include a component of capital that is required to cover the credit risks associated with the capital assets. This is clearly not appropriate.

As a general principle, the approach that we adopt in this book is that the economic capital requirement of a firm's business should be independent of the firm's equity and debt capital structure. Excluding the firm's capital from the economic capital computation achieves this and also allows a meaningful comparison between economic capital and the regulatory capital requirements of a firm's business to be made.

## 5.4 EXPECTED LOSSES VERSUS UNEXPECTED LOSSES

As we have seen earlier, economic capital is defined as the capital buffer that is required to absorb the impact of unexpected losses in the realistic balance sheet of the firm's business, over a prescribed time horizon. These losses are different from the expected losses that a firm provisions, or reserves, for in the normal course of its business. Provisions, or reserves, are set up to cover expected losses, although sometimes conservatism in their calculation can result in them also covering unexpected losses. Economic capital is concerned with unexpected losses, rather than expected losses.

The approach that we take in this book is as follows:

- Expected losses should be covered by provisions, or reserves.
- Unexpected losses should be covered by economic capital.

By “expected” we mean losses that correspond to the statistical mean, or “centre,” of a stochastic process, or to the base case scenario in a set of deterministic stress tests. By “unexpected” we mean losses that correspond to the low/high percentiles, or extremes, of a stochastic process, or to the extreme stresses in a set of deterministic stresses.

## 5.5 USES OF ECONOMIC CAPITAL

Having defined economic capital, we now consider how a firm might use economic capital in the running of its business.

### 5.5.1 Capital adequacy

A firm may want to check that the overall amount of capital it holds is in line with its own internal assessment of the level of risks that it is running.

- If a firm has much more capital than economic capital, then this could result in inefficiencies as the excess capital might be used better elsewhere.
- On the other hand, if a firm has less capital than economic capital, then it is probably taking on too much risk and the firm should consider either de-risking its balance sheet or raising fresh capital.

### 5.5.2 Validation of regulatory capital

Economic capital can be used to validate a firm's regulatory capital requirement against its own assessment of the risks it is running. For

example, if a business unit within the firm has a regulatory capital requirement that is well in excess of its economic capital amount, the firm may give this unit lower capital priority over units where regulatory capital and economic capital are better aligned.

When a firm is discussing and negotiating its Pillar 2 regulatory capital requirement with its regulator, the firm will need to know its economic capital requirement. If a firm can demonstrate that its Pillar 2 regulatory capital requirement is excessive relative to its economic capital, then the regulator may be more amenable to reducing this regulatory capital requirement.

### 5.5.3 Risk measurement, appetite and limits

As discussed in Chapter 3, firms will usually define their risk appetite, for each particular risk that they collect, in the risk policies approved by the firm's board each year. Some appetites will be defined in economic capital type terms, for example by defining market risk in terms of VAR, whereas other appetite definitions may bear little or no relation to economic capital.

One example might be where credit risk appetite is defined using limits placed on the nominal amounts that can be invested with approved counterparties, with these limits typically varying by the credit rating of the counterparty. This type of risk appetite definition is clearly sensible, but it says little, or nothing, about the quantity of risk that a firm is taking on.

One obvious use of economic capital, therefore, is to measure risk and to then specify the amount of risk that a firm is willing to accept. For example, risk appetite could be specified in terms of an upper limit on the amount of economic capital that a firm is prepared to commit to the risk taking. The firm may, for example, be prepared to take on risk up to the point where risk economic capital reaches £1,000 million, but not beyond that point.

Specifying risk appetite in this way connects the firm's risk appetite, and its risk limits, with the amount of capital that is required to back the risk and this has considerable appeal.

### 5.5.4 Business planning

As a firm develops and grows, it is important that it monitors and forecasts its economic capital requirements. These requirements will evolve with the firm as it moves into new lines of business, or as its existing business changes and responds to the economic cycle and new business environments.

If the firm enters a more risky line of business, or a less benign business environment, for example, both will require increased amounts of economic capital and the firm will need to plan for this. This allows firms to quantify the amount of future risk that they will accept and assists them in planning how they intend to manage it.

### 5.5.5 Performance measurement

In order to assess firm, or business unit, performance, shareholders and the management of the firm will usually focus on the actual rate of return that is being earned on the equity capital employed in the firm or business unit. This earned return is then compared with the cost of the capital employed to check if the firm, or business unit, is adding value, in other words, to see if the actual earned rate of return on equity capital is in excess of the cost of capital.

This analysis should recognize and take into account the relative riskiness of the firm, or business unit, in order that comparisons across firms or business units are fair and meaningful. For example, a firm may be achieving a high rate of return on capital employed simply as a result of operating in a high risk business.

The riskiness of a firm's business will, according to the well known Capital Asset Pricing Model (CAPM), be reflected in a firm's cost of capital. In other words, the cost of capital for "high risk" firms will be in excess of that for "low risk" firms. As a result, the value addition threshold for "high risk" firms will be above that for "low risk" firms, as should be the case.

As the amount of a firm, or business unit's, equity capital is determined, to a large extent, by its regulatory capital requirements, which may not be well aligned with the risks that the firm, or business unit, is running, the approach described above may produce distorted results.

For example, Firm A may have a higher regulatory capital requirement than Firm B, although the risks they are running are equal. This may result in Firm A having more equity capital than Firm B. Unless this "over capitalization" is reflected in Firm A having a lower cost of capital than Firm B, because Firm A's over capitalization means it is less risky, Firm A will be penalized, relative to Firm B, by an artificially deflated actual earned rate of return on capital figure.

An alternative approach, which we discuss in more detail in Chapter 13, is to base derived actual earned rates of return on capital on economic capital, rather than equity capital. Provided that firms' economic capital amounts accurately reflect the risks they are running in their businesses, these derived actual rates of return on capital can then be compared on a risk consistent basis across firms, business units and products. This is

because the risks that are being run are automatically taken account of on a consistent basis by the economic capital calculation.

As the derived actual rates of return on economic capital have been adjusted for risk, at the confidence level used to determine economic capital, it is appropriate that actual earned rates of return on economic capital should be compared to corresponding capital costs, at the same confidence level. Chapter 13 discusses this topic in much more detail.

## 5.6 ECONOMIC CAPITAL CALCULATION IN PRACTICE

As we shall see in later chapters, calculating economic capital does not involve the use of any prescribed formulae or set of rules. In fact, substantial judgment is required.

Before a firm can calculate its economic capital, there are a number of questions that it must be able to answer, for example:

- What is the time period over which the firm wishes to consider its risks?
- Which risks is the firm exposed to over this time period?
- What is the probability, or likelihood, that these risks will materialize?
- Is a stochastic, or a deterministic, approach appropriate?
- How do these risks interact with each other and how can we model these dependencies?

In order to address these issues, a firm must

- Identify the material risks that it is exposed to over the time period of interest.
- Collect data on the risks that it is exposed to. For some types of risk, credit risk for example, both industry and company specific data are likely to be abundant whereas, for other types of risk, operational risk for example, data may be sparse.
- Design a range of stochastic, or deterministic, stresses that cover the full range of possible material risk outcomes. Modeling the dependencies amongst the individual risks will be especially challenging.
- A comprehensive financial/statistical model will need to be developed to quantify the impact of the risk stresses.

Since economic capital quantifies the impact of unexpected losses, it follows that economic capital will be driven by the tails, including

the tail dependencies, of the distribution of the particular risks under consideration.

A combination of reliable data, robust modeling, judgment and experience will be required to determine credible economic capital amounts. Moreover, the calculation will be dynamic and will evolve as experience emerges and as the business and economic environment changes.

Calculating economic capital for a group containing a number of firms, or business units, involves further complexity. Unless all of the firms or business units within the group are perfectly positively correlated, adding up the economic capital amounts for each firm or business unit will result in an overstatement of the group's economic capital.

Normally, we would expect at least some of the firms, or business units, within a group to be less than perfectly correlated with each other. For example, high real rates of interest will usually be bad news for lenders, but good news for pension funds or life insurance firms. Calculating economic capital for a group therefore also involves assessing and modeling the dependencies between the firms, or business units, within the group.

This will be discussed in detail later in Chapter 12.

## **5.7 RELATIONSHIP OF ECONOMIC CAPITAL WITH REGULATORY CAPITAL REQUIREMENTS**

The parties most interested in comparing economic capital and regulatory capital requirements, together with their reasons for this interest, are discussed below.

### **5.7.1 Financial services firms**

Capital management and allocation is a key business planning activity for all firms. Enough capital must be allocated to allow the firm, and its business units, to cover their regulatory capital requirements, whilst optimizing the return on the firm's total available capital.

Firms will, therefore, have in mind both the external, and the internal, view in carrying out their regular capital management and allocation exercise. The external view will focus on regulatory capital requirements and published financial strength. The internal view will focus on the actual capital that is required to cover the risks that each business unit is running, and the return that can be earned on this capital, bearing in mind the constraints that the external view puts on the unit and firm.

In an ideal world, where economic capital and regulatory capital requirements are well aligned, firms would be able to allocate capital to business units according to their economic capital needs. Those units could then price their products and manage their businesses on a purely economic capital basis.

The beauty of this approach is that the performances of the firm's business units are then directly comparable as they are all using an equivalent amount of capital given the risks that they are running. The firm would then be able to understand, for example, if a high margin, high capital business unit is outperforming a low margin, low capital business unit.

In practice, however, economic capital and regulatory capital requirements are generally not well aligned. Firms may therefore wish to adjust the above comparative analysis to allow for the costs, or subsidies, that result because business units are capitalized according to their regulatory capital requirements.

This is discussed in full detail in Chapter 13.

## 5.7.2 Regulators

Over recent years, financial services firm regulations have not kept pace with the rapid developments and innovations that have occurred in the financial markets. The prescriptive rules used by regulators may now be well out of date and are also relatively risk insensitive. As a result and, as discussed in Chapter 14, a very large amount of regulatory change is now expected to occur over the next 5–10 years.

In particular, economic capital will become a key regulatory tool for both quantifying the amount of risk that a firm is running and to assist regulators in setting a regulatory capital requirement that is based on, at least some scientific, rather than on arbitrary rules.

## 5.7.3 Shareholders

All else being equal, the firms that make the most effective use of capital will be the firms that generate the most value and will therefore represent the most attractive investment opportunities. For example, firms that focus on products where economic capital and regulatory capital requirements are well aligned may find it easier to generate value than a firm that offers products where the regulatory capital requirement is in excess of economic capital although, obviously, competition will still be a key determinant of value creation.

## 5.8 SUMMARY

In this chapter we have defined economic capital and have described its various uses. As mentioned at the start of this chapter, we are of the view that economic capital is the key quantitative risk tool that is available to firms in the management of the risks they collect.

We now move on to consider the various types of capital that can be used to back firms' regulatory capital requirements.

# Types of Capital

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## 6.1 INTRODUCTION

In this chapter we describe the role of capital and also discuss the different types of capital that are available to financial services firms to cover their regulatory capital requirements. The discussion is based on a banking model as, at least in the UK, this is the model that has recently been adopted by other types of financial services firms.

This chapter should be considered as an introduction to the topic, which in practice can be extremely complex and opaque, especially in regard to the very detailed and, often subjective, rules that define the different types of capital.

For the purposes of this book, we are most interested in what we might call “true risk” capital. In other words, capital which is of the highest quality that is genuinely on risk and which can be lost in its entirety during times of financial stress.

## 6.2 THE ROLE OF CAPITAL

Capital, in its broadest sense, acts as a buffer to absorb the losses of a financial services firm, usually in times of financial stress, and so protecting the interests of customers’ owed money by the firm, for example, the policyholders of a life insurance firm, or the depositors of a bank.

Three fairly self evident key properties that capital must possess are

- It must be able to absorb losses.
- It must be available permanently.
- It must be fully paid up so that the firm has full possession of the capital funds.

## 6.3 CATEGORIZATION OF CAPITAL QUALITY

Capital, in order of decreasing quality, is categorized by regulators into the following main types:

1. Core Tier 1
2. Innovative Tier 1
3. Upper Tier 2
4. Lower Tier 2

Each of these is described in more detail below, together with Tier 3 capital, which is used specifically to back the risks run by bank's trading book.

As is described below, Core Tier 1 capital, and probably Innovative Tier 1 capital also, are most clearly types of "true risk" capital, whereas some of the other types of capital discussed below are essentially debt capital and are on risk only in the event of firm insolvency, when the higher quality capital is destroyed completely.

Note that the costs of Innovative Tier 1 and Tier 2 capital are usually tax deductible, whereas those of Core Tier 1 are not. Consequently, Innovative Tier 1 and Tier 2 capital are usually cheaper than Core Tier 1, although they are valued less highly by regulators in terms of quality.

### 6.3.1 Tier 1

Tier 1 capital is the highest quality of capital and must generally satisfy the following three characteristics:

1. *Subordination.* In the event of severe financial stress, Tier 1 capital is repaid last after all other creditors and capital providers.
2. *Perpetual maturity.* Tier 1 capital should be perpetual, subject to at most an issuer call after a number of years, usually five. Features which date the instrument, for example an issuer call in conjunction with an increase in the coupon rate, compromise the permanence of the capital and disqualify it from Core Tier 1, although it may still count as Innovative Tier 1.
3. *Ability to defer costs.* The financial services firm should have the ability to waive dividends, or interest, in times of financial stress. Instruments with cumulative dividends or interest do not qualify as Tier 1 capital.

### **6.3.1.1 Core Tier 1**

Core Tier 1 capital typically comprises

1. Permanent share capital, including both fully paid up ordinary share capital and perpetual, non cumulative preference shares
2. Reserves deriving from retained earnings, share premia and other surpluses
3. Retained profits arising from the current year, provided they have been verified by the firm's external auditors
4. Minority interests arising from consolidation in permanent shareholders' equity.

### **6.3.1.2 Innovative Tier 1**

Where a Tier 1 instrument involves a step up in dividends, it is regarded as Innovative under Basel guidelines. To be eligible to count towards a firm's regulatory capital requirement, Innovative Tier 1 capital is limited to at most 15% of total (i.e. Core Tier 1 plus Innovative Tier 1) Tier 1 capital.

This is because Innovative Tier 1 capital is considered to be of inferior quality to Core Tier 1. In this instance, the implicit maturity implied by the step up compromises the perpetual requirement of Tier 1 capital.

At least in the UK, Tier 1 capital that is issued indirectly, such as capital issued via a Special Purpose Vehicle (SPV), also counts as Innovative. The additional operational risks associated with such capital, for example the associated legal and cross-jurisdictional risks, usually disqualify indirect Tier 1 capital from counting as Core Tier 1.

### **6.3.2 Tier 2**

Tier 2 capital usually comprises

1. Reserves arising from the revaluation of fixed assets and fixed asset investments
2. General provisions
3. Perpetual cumulative preferred shares, including those that are redeemable at the option of the issuer, such shares being convertible into ordinary shares

4. Perpetual subordinated debt satisfying certain qualifying conditions
5. Subordinated term debt including dated preferred shares, convertible subordinated bonds and short term subordinated loan capital with a minimum original term to maturity of five years and 1 day and subject to straight line amortization over the last five years of its life (the amortization is to avoid a sudden diminution in the capital available to the firm on expiry of the capital).

### *Upper versus Lower Tier 2*

Issued Upper Tier 2 capital is perpetual and is cumulative. In other words, its interest or dividend payments may be deferred but, unlike Tier 1 capital, cannot be cancelled.

Issued Lower Tier 2 capital is usually dated and its interest or dividends should be paid as they fall due. Lower Tier 2 capital is therefore considered as a lower form of capital than Upper Tier 2 as it gives less funding flexibility because the deferral of an interest payment can trigger a default event.

### **6.3.3 Tier 3**

Tier 3 capital is used only to support the trading activities of banks and usually comprises short term qualifying subordinated debt that has a minimum original maturity of two years and for which the repayment of debt is suspended if the bank's capital falls below a specified level.

## **6.4 CAPITAL DEDUCTIONS AND LIMITS**

A host of very detailed deductions and limits apply to all capital types. For example, banks, spurred on by imaginative investment bankers, continually test the boundary between Tier 1 and Tier 2 capital and regulators respond with ever more deductions and limits. Some of these are described below.

### **6.4.1 Deductions**

When calculating a firm's capital base, deductions that are usually made from Tier 1 capital include

1. Holdings of own shares

2. Intangible assets and goodwill
3. The current year's net losses, if any.

This is because, intangible assets for example, are deemed to be low quality and not eligible to be counted towards a firm's regulatory capital requirement. Certain deductions must often be made from the sum of Tier 1 and Tier 2 capital, usually 50% from Tier 1 and 50% from Tier 2. These include

1. Investments in unconsolidated subsidiaries and associates
2. Connected lending and guarantees of a capital nature
3. Capital instrument holdings issued by credit and financial institutions
4. Qualifying holdings in non financial companies.

### **6.4.2 Limits**

Limits on the amounts of capital that are eligible for regulatory capital purposes tend to vary by the type of financial services firm being considered. For example limits vary between banks with and without trading books. Some examples of the types of limit that are applied by regulators are as follows:

1. Tier 1 capital should be made up of at least 50% ordinary shares, associated reserves and retained earnings
2. Innovative Tier 1 capital can comprise at most 15% of total Tier 1 capital
3. Tier 2 capital should not exceed Tier 1 capital
4. Tier 2 subordinated term debt should not exceed 50% of Tier 1 capital
5. Tier 3 capital may be used to cover trading book requirements, except counterparty risk or settlement risk capital requirements in the trading book.

## **6.5 SUMMARY**

In this chapter we have given a description of the different types of capital that are available to financial services firms to cover their regulatory capital requirements. As was described, a key feature of this capital is the

way that it is tiered according to its perceived quality. The constraints on the amount of capital that is eligible to count towards a firm's regulatory capital requirement were also described. The topic is complex, but is obviously of crucial importance to the firms themselves, regulators and the providers of the capital.

We now move on to consider the more technical Chapter 7, which describes our stochastic model, which is the engine that generates the stochastic stresses used to determine economic capital.

# The Stochastic Model

## 7.1 INTRODUCTION

As stated in Chapters 4 and 5, our preferred approach in this book is to determine economic capital using a stochastic, rather than a deterministic, approach wherever possible. This chapter develops a stochastic model that is effectively the engine that generates our stochastic stresses.

The chapter is somewhat technical and may not be of interest to all readers. We would suggest, therefore, that those readers who have no interest in the technical details of our stochastic model read this, and the following two paragraphs, and then skip the rest of this chapter and move directly on to Chapter 8, which contains our banking applications.

The book is written in such a way that the chapters beyond this chapter can be understood without this chapter needing to be read in detail. All that the reader needs to know is that the stochastic model that is developed in this chapter is used to generate the stochastic stresses that will be used to determine the percentile economic capital for each of our later examples.

For instance, with a retail mortgage bank, the stochastic model will be used to generate response variables, such as the bank's interest rate margin, that drive economic capital. These generated response variables are then used to calculate the amount of economic capital that the bank requires to cover the mortgage risks that it is running under the stochastic stresses generated by the stochastic model. Therefore, to reiterate, the stochastic model is the engine that generates our stochastic stresses.

At this point, readers who have no interest in the technical details of the stochastic model should proceed directly to Chapter 8.

The chapter is structured as follows:

1. We describe very specific examples of the stochastic model involving only a small number of response variables. We call these models *specific low dimensional models*.
2. Motivated by the models in 1, we then generalize these specific low dimensional models to form a more general model. This general model is, in fact, a high dimensional multivariate time series model, but where the model is constructed from relatively low dimensional building blocks. We call this model the *general high dimensional model*.
3. To apply the general high dimensional model described in 2 in practice, we next develop more specific versions of this general high dimensional model. We will, in fact, apply these specific models in all of the examples that appear in the later chapters of the book and we call these models *specific high dimensional models*.

Obviously, there is a huge amount of literature on this subject, see Tsay (2002) for example. However, a novel approach that we introduce in this book is the combination of multivariate graphical models, see Lauritzen (1996), Edwards (1995) or Porteous (1985), with financial time series models. This is fully described later in this chapter.

We now give examples of our specific low dimensional stochastic models.

## 7.2 SPECIFIC LOW DIMENSIONAL STOCHASTIC MODELS

### 7.2.1 Response variables modeled

We denote the  $i$ th response variable in month  $t$  as  $Y_{it}$ . Here the  $Y_{it}$ s represent the annual value of the  $i$ th response variable, for example, the annual rate of RPI, at month  $t$ .

We propose an initial specific model where we model response variables as a first order autoregressive time series with constant volatilities. In other words, each  $Y_{it}$  is modeled as:

$$Y_{it} = \beta_i Y_{i(i-1)} + \varepsilon_{it},$$

where  $\varepsilon_{it} \sim N(0, \sigma_{it}^2)$  is the error term associated with the  $Y_{it}$  response variable.  $\beta_i$  and  $\sigma_{it}^2$  are unknown parameters to be specified. Here N denotes

the Normal, or Gaussian, distribution. The  $\varepsilon_{it}$ s are assumed to be independently distributed across response variables and time.

This means that the conditional expectation,  $E(Y_{it} | y_{i(t-1)}, y_{i(t-2)}, \dots) = \beta_i y_{i(t-1)}$ , and the conditional variance  $\text{Var}(Y_{it} | y_{i(t-1)}, y_{i(t-2)}, \dots) = \sigma_{it}^2$ .

It then follows that the unconditional expectation,  $E(Y_{it})$ , and the unconditional variance,  $\text{Var}(Y_{it})$ , of the  $i$ th response variable equal 0 and, for time constant  $\sigma_{it}^2$ ,  $\sigma_i^2/(1-\beta_i^2)$  respectively.

If the unconditional expectation,  $\mu_i$ , of the  $i$ th response variable is not zero, we model this by simply adding  $\mu_i$  to the  $Y_{it}$ s, as generated by the stochastic model, to form a new response variable  $Z_{it}$  as follows:

$$Z_{it} = \mu_i + Y_{it}.$$

From our definition of  $Z$ , it then follows that  $E(Z_{it}) = \mu_i$ .

In all that follows, it will be implicit hereafter that, if  $\mu_i$  is non zero, we will work with the  $Z_{it}$ s, rather than the  $Y_{it}$ s.

## 7.2.2 One dimensional stochastic model

In this section we give an example of a one dimensional model by modeling the UK Equity Dividend Yield response variable using a simple model. Our model is based on that described in Section 7.2.1 with parameter values as set out in Table 7.1.

In other words, we model the UK Equity Dividend Yield response variable as a first order autoregressive time series. Figure 7.1 (see colour Plate 1) shows 10 simulations, or realizations, of the model over a 25 year period for this base case model.

The relatively high value of  $\beta$  chosen ensures that there is strong autoregressive, or trending, behavior apparent in the series. It can be seen that the series fluctuates around its unconditional expected value of 0.0325, with the spread determined by its unconditional standard deviation of 0.0075.

The series appears volatile although it varies exactly as expected under the model. This demonstrates a key message of our approach, that

**Table 7.1** Response variable model and volatility model parameterizations – one dimensional model

Response variable	Unconditional	First order	Unconditional
	expectation	autoregressive	standard deviation
	$\mu_i$	parameter	$\sigma_i/(1-\beta_i^2)^{1/2}$
		$\beta_i$	
UK Equity Dividend Yield	0.0325	0.975	0.0075

human instinct and judgment are, in general inadequate or deficient, when it comes to quantifying, or understanding, stochastic variability in practice. Moreover, this inadequacy worsens very significantly when higher dimensional, or multivariate, response variables are being considered.

In Figure 7.2 (see colour Plate 2), we show 10 more realizations, or simulations, of the model, but with the  $\beta$  parameter reduced to 0.9. It can be seen that the serial dependence, or within response variable dependence within each of the 10 series, as expected, has reduced significantly.

The series look more random, with less structure, despite the fact that the modeled autoregression ensures that there is real structure, or dependencies, in the series. The human eye, and judgment, again have difficulty in discerning this structure, or the dependencies that we know are present in the series.

In Figure 7.3 (see colour Plate 3), we have re-run the 10 simulations, or realizations, having increased the assumed unconditional standard deviation to 0.01 with the  $\beta$  parameter reset to 0.975. It can be seen, as expected, that the strong serial, or within response variable, dependence returns but, as expected, the series fluctuate more widely about their unconditional expected value of 0.0325.

We now move on to consider a three dimensional extension of the one dimensional model.

### 7.2.3 Three dimensional stochastic model

This initial example involves the three response variables UK RPI, UK Equity Earnings Growth and UK Equity Dividend Yield. The construction and properties of the general high dimensional and specific high dimensional stochastic models will follow immediately from this three dimensional example.

As described in Section 7.2.1, we assume that each of the three response variables follows a first order autoregressive time series model with constant variances, or volatilities, and constant correlations, as described below.

We assume the parameter values shown in Table 7.2.

We will assume a constant correlation model where the correlation,  $\rho_{ijt}$ , between the error terms  $\varepsilon_{it}$  and  $\varepsilon_{jt}$  equals

$$\rho_{ijt} = \omega_{ij}$$

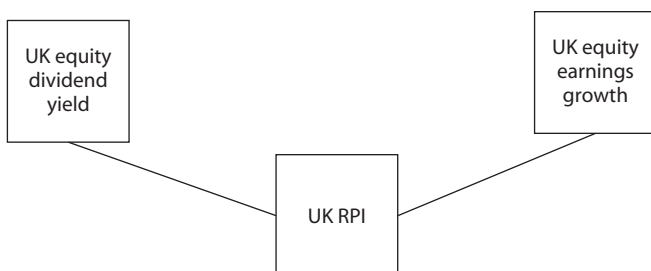
for all  $i \neq j$  and  $t$ , provided that  $\varepsilon_i$  and  $\varepsilon_j$  are connected in the graphical model that defines the multivariate dependency structure of the  $\varepsilon_i$ s.

**Table 7.2** Response variable model and volatility model parameterizations – three dimensional model

<i>Response variable</i>	<i>Unconditional expectation</i> $\mu_i$	<i>First order autoregressive parameter</i> $\beta_i$	<i>Unconditional standard deviation</i> $\sigma_i/(1-\beta_i^2)^{1/2}$
UK RPI	0.0275	0.975	0.0075
UK Equity Earnings Growth	0.0425	0.95	0.02
UK Equity Dividend Yield	0.0325	0.975	0.0075

**Table 7.3** Correlation model parameterization – three dimensional model

<i><math>\varepsilon</math> pair</i>	<i>Correlation coefficient</i> $\rho_{ij}$
UK RPI/UK Equity Earnings Growth	0.1
UK RPI/UK Dividend Yield	0.3

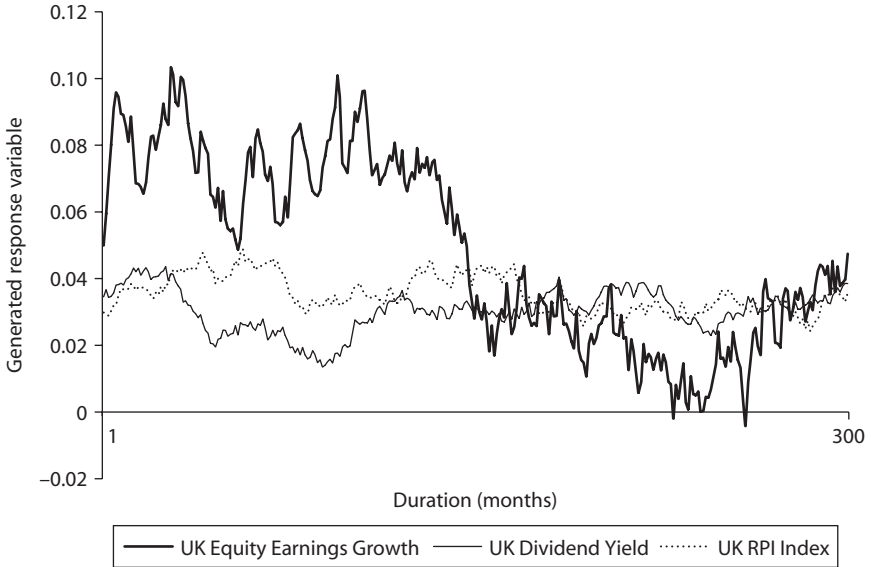
**Figure 7.4** Graphical model of between response variable dependency model

See Section 7.3.3 for a full explanation of the graphical model approach to representing the multivariate dependency structure of the  $\varepsilon$ s. As always,  $\rho_{ijt} = 1$  for  $i = j$ .

In the graphical model that defines the multivariate dependency structure of the  $\varepsilon$ s, we assume that the UK RPI  $\varepsilon$  is connected to the UK Dividend Yield and UK Equity Earnings Growth  $\varepsilon$ s, with no other connections in the graph. This means that, the UK Dividend Yield and UK Equity Earnings Growth  $\varepsilon$ s are conditionally independent at all time points  $t$ , given the UK RPI  $\varepsilon$ , and so UK RPI drives the correlation structure of the  $\varepsilon$ s.

This graphical model is illustrated in Figure 7.4.

The correlation parameter values that we have used are set out in Table 7.3.



**Figure 7.5** Three dimensional stochastic model – base case

Note also that this model is equivalent to a one factor model, where the factor is UK RPI.

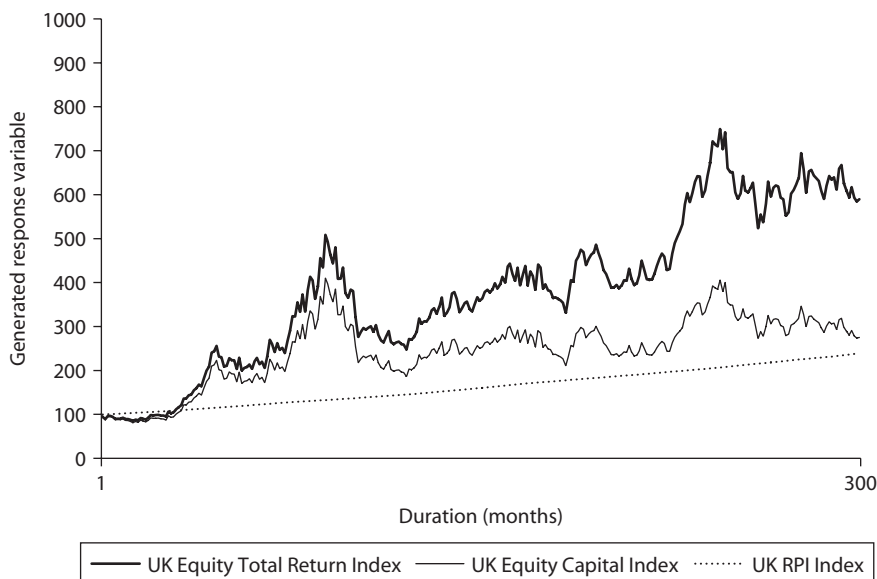
Figure 7.5 shows typical realizations of the three simulated response variables over a 25 year period assuming the parameter values set out in Tables 7.2 and 7.3.

It can be seen from Figure 7.5 that the model produces results that are qualitatively very similar to real series of investment data.

Using the three simulated response variables, we can construct derived variables such as, for example, an equity capital index. First we calculate an equity earnings growth index using the stochastically generated equity earnings growth response variables. This is then converted into an equity capital index by dividing the earnings index by the stochastically generated equity dividend yields. In doing this we assume that dividend payout ratios remain broadly constant over time. We can then rebase this equity capital index to its required starting point.

A total equity return, capital plus income, index can then be formed from the derived capital index and the stochastically generated dividend yields.

An RPI index can also be constructed similarly. Figure 7.6 graphs a typical realization of a simulated UK equity capital index, a UK equity total return index and a UK RPI index. Again, these indices are qualitatively very similar to genuine UK equity and UK RPI indices.



**Figure 7.6** Three dimensional stochastic model – specimen index output – base case

**Table 7.4** Estimated statistics computed from the stochastic model output versus historical data – base case

<i>Statistic</i>	<i>Model output Real equity total return p.a.</i>	<i>Historical data, 1900–2000* Real equity total return p.a.</i>
Mean return (arithmetic)	0.07	0.08
Standard deviation	0.20	0.20
Skewness	0.5	0.7
Kurtosis	0.8	0.8
Correlation with RPI	−0.04	

\* Dimson, Marsh and Staunton (2002). Mike Staunton, Director of the London Share Price Database provided the skewness and kurtosis data. Note that normal random variables have zero skewness and kurtosis values.

Table 7.4 compares real total equity return means, standard deviations, skewness and kurtosis coefficients, as estimated from the output of the stochastic model over 2,500 simulations, with the corresponding statistics for UK historical data. Table 7.4 also shows real total equity return correlation with RPI, as generated by the model.

The results given in this table show that the total real returns as generated by the stochastic model are plausible and are consistent with the pattern of returns that have been observed over very long periods of time in the past: see Dimson, Marsh and Staunton (2002) for more detail on the historical data.

The model generates a very small negative correlation between real total equity returns and RPI. In other words, real total equity returns tend to be slightly higher in low inflation environments. However, the correlation is so low that we can reasonably conclude that real total equity returns, as generated by the model, are not dependent on RPI.

### 7.2.4 Three dimensional stochastic model with stochastic volatilities

In this section, we extend the example given in 7.2.3 to allow for time varying variances or volatilities. In particular, we assume a first order stochastic volatility model for response variable  $i$  where, conditional on all information up to time  $(t - 1)$ ,  $\sigma_{it}^2$  is described by the expression

$$\sigma_{it}^2 = \phi_{i0} + \phi_{i1}\varepsilon_{i(t-1)}^2.$$

It then follows that the unconditional variance of the  $i$ th response variable equals

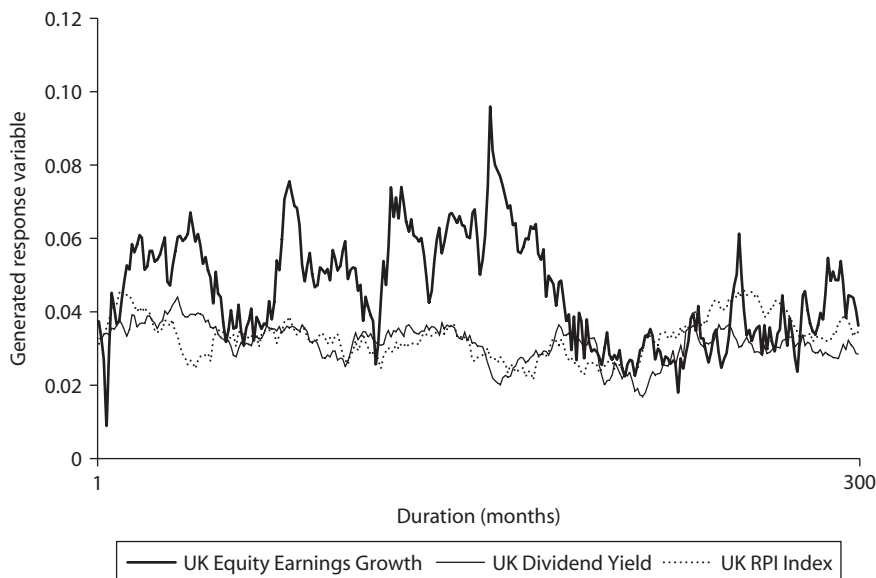
$$\frac{\phi_{i0}}{\{(1 - \phi_{i1})(1 - \beta_i^2)\}}$$

The  $\phi_{i1}$  parameter controls the amount of  $\varepsilon^2$  autoregression in the  $\sigma_{it}^2$  series. For  $0 < \phi_{i1} < 1$ ,  $\varepsilon^2$  autoregression in the series increases the volatility of the unconditional distribution of the response variables. It can also be seen that, the closer  $\phi_{i1}$ , or  $\beta_i$ , is to 1, the larger the unconditional variance of the  $i$ th response variable.

When introducing the stochastic volatility model into our stochastic model we will, therefore, usually adjust the  $\phi_{i0}$  parameter to ensure that the unconditional variance of the  $i$ th response variable remains unaltered as a result of introducing stochastic volatility. This will also help to aid comparison with the constant volatility model results.

Before illustrating the effect of the stochastic volatility model, we first provide some motivation for the type of physical behavior that the stochastic volatility model is able to describe.

First, remember that the  $\sigma_{it}^2$ s model the variances of the  $\varepsilon_i$ s at time  $t$ , conditional on the past prior to time  $t$ . They therefore represent what we might call “local” conditional variances, or volatilities, at time  $t$ . If the  $\varepsilon_i$  at time  $(t - 1)$  is “large”, in absolute terms, then  $\sigma_{it}^2$  will also be “large”,



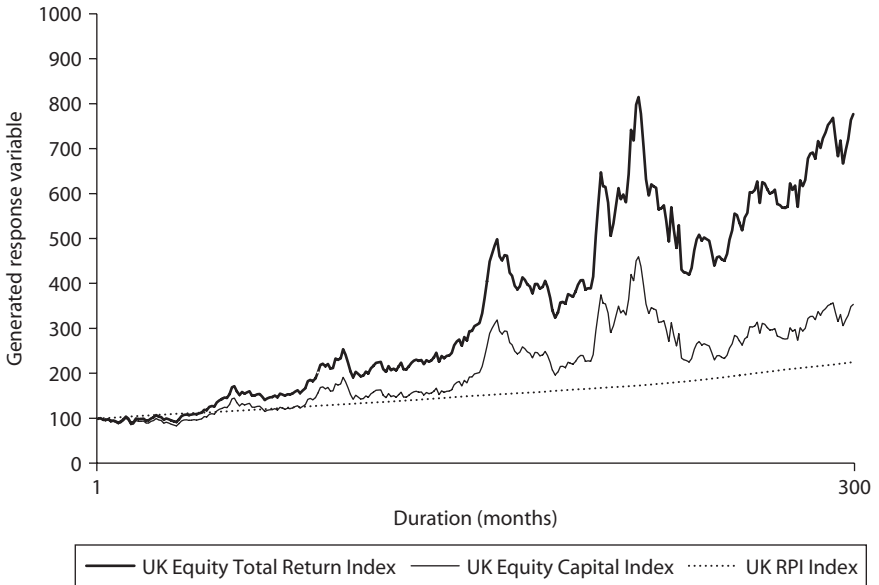
**Figure 7.7** Three dimensional stochastic model – stochastic volatilities

implying an increased level of volatility at time  $t$ . Extreme values of  $\varepsilon$ , or jumps, are then more likely than with the constant volatility model. In other words, extreme values of past  $\varepsilon$ s can cause local jumps in the underlying  $\varepsilon$ s, and so the response variables. Such patches of increased local volatility are very often observed in genuine investment time series data.

To illustrate the effect that this type of stochastic volatility has on the response variables generated by the model, we have recalculated Figure 7.5 and Figure 7.6 assuming that, for the UK Dividend Yield and UK Equity Earnings Growth  $\varepsilon$ s, the  $\phi_{it}$ s equal 0.5, with the  $\phi_{i0}$ s reset to ensure that the unconditional variances of these response variables are unaltered from those used in Section 7.2.3 above. The UK RPI volatility model is left unchanged, as we believe that UK RPI is less prone to this type of increased local volatility in practice.

Our results are shown in Figures 7.7 and 7.8 respectively.

Comparing Figure 7.7 with Figure 7.5, we can see that the stochastic volatility simulation graphs are generally smoother over most of the term of the projection, but with more extreme jumps that are locally focused. This is as we expect as the stochastic volatility term induces the steep jumps and the imposed constant unconditional variance, or volatility, assumption then forces the graphs to be smoother over the remainder of the term of the projection. Comparing Figure 7.8 with Figure 7.6 shows that these features are also carried over into the derived indices.



**Figure 7.8** Three dimensional stochastic model – specimen index output – stochastic volatilities

**Table 7.5** Estimated statistics computed from the stochastic model output versus historical data – stochastic volatilities

<i>Statistic</i>	<i>Model output Real equity total return p.a.</i>	<i>Historical data, 1900–2000 Real equity total return p.a.</i>
Mean return (arithmetic)	0.07	0.08
Standard deviation	0.22	0.20
Skewness	0.7	0.7
Kurtosis	1.8	0.8
Correlation with RPI	−0.04	

Table 7.5 compares real total equity return means, standard deviations, skewness and kurtosis coefficients, as estimated from the output of the stochastic model over 2,500 simulations, with UK historical data statistics. Table 7.5 also shows real total equity return correlation with RPI, as generated by the model.

Comparing Table 7.5 with Table 7.4 shows that the stochastic volatility term has increased real equity total return standard deviation,

skewness and kurtosis, with the mean and correlation essentially unaltered. The main conclusion, therefore, is that the stochastic volatility parameter has fattened the tails of the real equity total return distribution, which as we shall see later in our examples, can prove useful in practice.

Note also that the introduction of the stochastic volatility term destabilises the statistics reported in Table 7.5. For example, the mean return reported in Table 7.5 is much more variable, over different runs of the 2,500 simulations, than it is with the constant volatility model. This increased volatility is caused by the more extreme jumps in the underlying response variables that occur as a consequence of the stochastic volatility term.

### 7.2.5 Three dimensional stochastic model with stochastic correlations

In this section, we now move back to the constant volatility, constant correlation example shown in Section 7.2.3 and extend it to allow for stochastic correlations. We first set out the mathematical model that we have assumed for our stochastic correlations and, following this, we then describe the real world physical rationale for the model.

In particular, we assume that the correlation between the  $i$ th and  $j$ th  $\varepsilon$ s, conditional on the past up to time  $t$ ,  $\rho_{ijt}$ , is described as follows:

$$\rho_{ijt} = \begin{cases} \omega_{ij0} & \text{for } t < T \\ \omega_{ij0} & \text{for } t > T \text{ and provided that } c_{ijt} < C_{ij} \text{ for at least one of the } (i,j) \text{ pairs that are connected in the graphical model representing the multivariate dependency structure of the } \varepsilon \\ \omega_{ij1} & \text{for } t > T \text{ and provided that } c_{ijt} > C_{ij} \text{ for all } (i,j) \text{ pairs that are connected in the graphical model representing the multivariate dependency structure of the } \varepsilon \end{cases}$$

Here  $-1 < \omega_{ij0}, \omega_{ij1}, C_{ij} < 1$  and

$$c_{ijt} = \frac{\sum \varepsilon_{i(t-s)} \varepsilon_{j(t-s)}}{\{(\sum \varepsilon_{i(t-s)}^2)(\sum \varepsilon_{j(t-s)}^2)\}^{1/2}},$$

where the summations are over  $s = 1, 2, \dots, T$ . Therefore,  $c_{ijt}$  represents the rolling correlation between  $\varepsilon_i$  and  $\varepsilon_j$  over the previous  $T$  months.

The rationale for this model is as follows. For the first  $T$  months, correlations are set to a constant value of  $\omega_{ij0}$ . Once these  $T$  months are over, the conditional correlation is allowed to vary and, in fact depends on the correlation of the observed  $\varepsilon_{i,s}$  and  $\varepsilon_{j,s}$  over the previous  $T$  months.

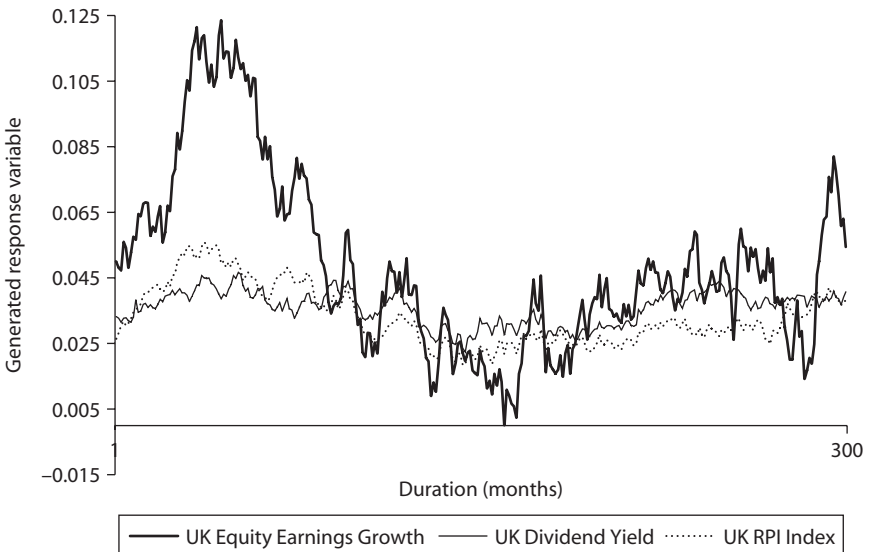
If at least one of the observed correlations for the  $(i, j)$  pairs connected in the graphical model representing the multivariate dependency structure of the  $\varepsilon$ s is lower than the threshold  $C_{ij}$ , then the conditional correlations at time  $t$  are set to  $\omega_{ij0}$  for all of these  $(i, j)$  pairs.

Alternatively, if all of the observed rolling correlations are greater than their thresholds  $C_{ij}$ , then the conditional correlations at time  $t$  are all set equal to the  $\omega_{ij1}$ s where the  $\omega_{ij1}$ s will have much larger values than the  $\omega_{ij0}$ s. In other words, once the observed rolling correlations become “large,” all conditional correlation parameters kick up to the higher levels and stay there until at least one of the observed rolling correlations falls below its threshold.

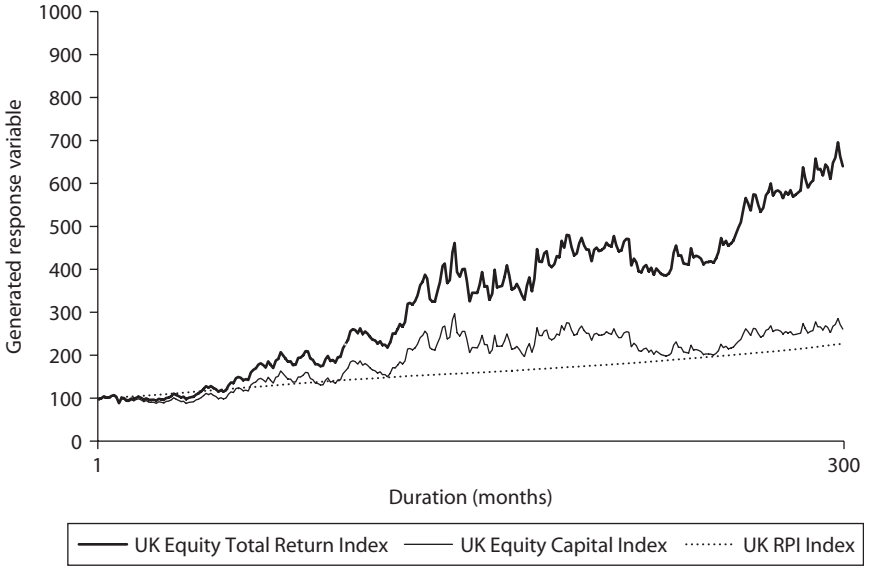
This behavior is very often seen in practice. For example, investment variables tend to become very highly correlated for relatively short periods during times of market stress.

To illustrate the effect that this type of stochastic correlation has on the response variables generated by the model, we have recalculated Figure 7.5 and Figure 7.6 assuming that, for the UK RPI/UK Equity Dividend Yield and UK RPI/UK Equity Earnings Growth correlations, the  $\omega_{ij0}$ s equal 0.3 and 0.1 respectively, as used in the previous examples, with the  $\omega_{ij1}$ s set to 0.9 and 0.7 respectively. The  $C_{ij}$ s are set to 0.625 and 0.425 respectively and a value of  $T = 12$  months is used.

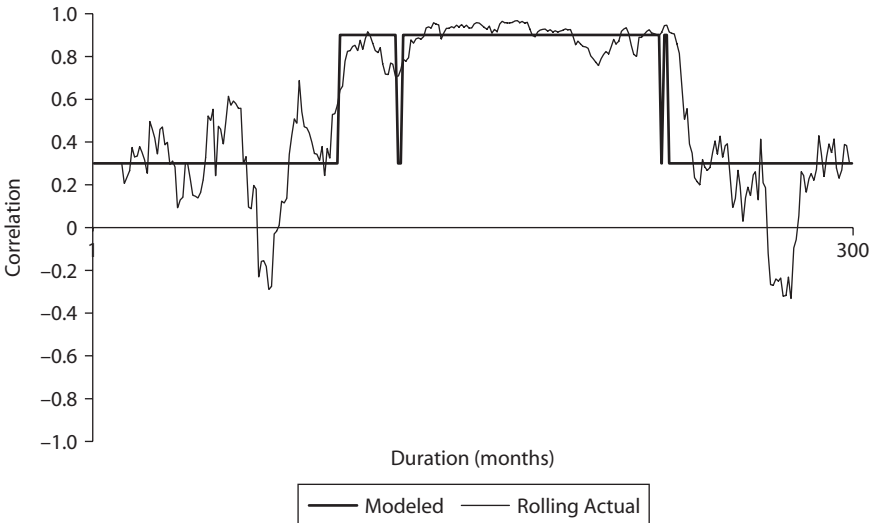
Our results are shown in Figures 7.9 and 7.10. Figures 7.11 and 7.12 also show, respectively, the corresponding UK RPI/UK Dividend Yield



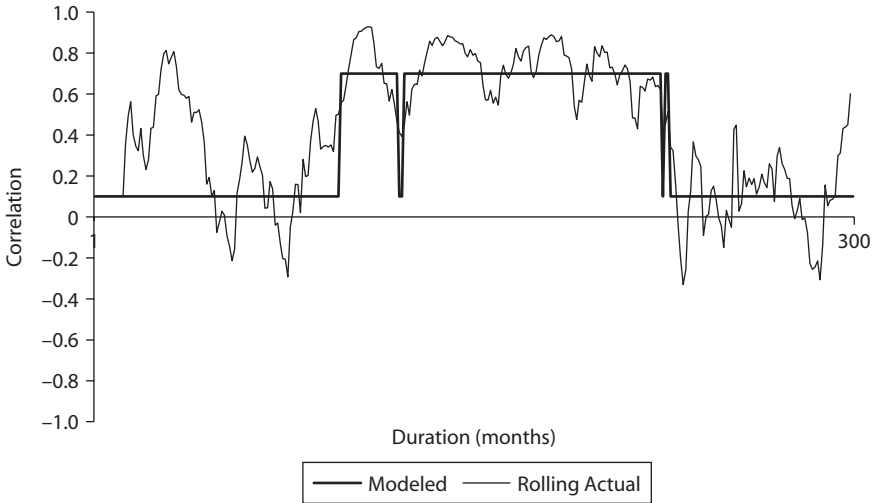
**Figure 7.9** Three dimensional stochastic model – stochastic correlations



**Figure 7.10** Three dimensional stochastic model – specimen index output – stochastic correlations



**Figure 7.11** Three dimensional stochastic model – modeled stochastic correlation versus rolling actual correlations for UK RPI and UK Equity Dividend Yield



**Figure 7.12** Three dimensional stochastic model – modeled stochastic correlation versus rolling actual correlations for UK RPI and UK Equity Earnings Growth

and UK RPI/UK Earnings Growth modeled correlation parameters and the observed rolling correlations.

Comparing Figure 7.9 with Figure 7.5, we can see that the stochastic correlation simulation graphs are much more tightly correlated in the middle section of the projection than they are in Figure 7.5. Figures 7.11 and 7.12 confirm this as they show that the observed rolling correlations and, consequently, the modeled correlation parameters kick up to the higher levels in this middle section of the projection. Comparing Figure 7.10 with Figure 7.6 shows that the stochastic correlation model, at least for this example, produces equity indices that are less locally volatile than the constant correlation model which, again, is as expected.

The reason for this is as follows: when the UK Equity Dividend Yields and UK Equity Earnings Growth response variables become more highly correlated, the effect of high/low dividend yields, which imply index capital falls/gains, tends to be dampened by associated high/low earnings growth rates. In other words, jumps in dividend yields, which cause capital value falls, are offset by earnings growth rate increases, which drive capital appreciation.

Table 7.6 compares real total equity return means, standard deviations, skewness and kurtosis coefficients, as estimated from the output of the stochastic model over 2,500 simulations, with the corresponding UK historical data statistics. Table 7.6 also shows real total equity return correlation with RPI, as generated by the model.

**Table 7.6** Estimated statistics computed from the stochastic model output versus historical data – stochastic correlations

<i>Statistic</i>	<i>Model output Real equity total return p.a.</i>	<i>Historical data, 1900–2000 Real equity total return p.a.</i>
Mean return (arithmetic)	0.07	0.08
Standard deviation	0.20	0.20
Skewness	0.5	0.7
Kurtosis	0.7	0.8
Correlation with RPI	–0.04	

If we compare Tables 7.6, 7.5 and 7.4, we can see that the stochastic correlations, unlike the stochastic volatilities, have limited effect on real equity total returns.

### 7.2.6 Three dimensional stochastic model with stochastic volatilities and stochastic correlations

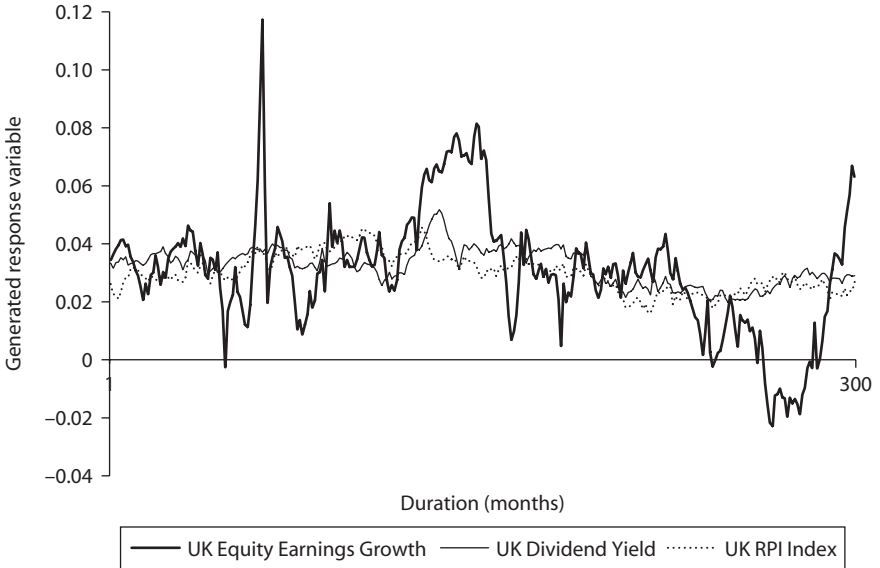
In this section, we extend the example shown in Section 7.2.3 to allow for both stochastic volatilities and stochastic correlations. In particular, we assume the stochastic volatility model assumed in Section 7.2.4 in conjunction with the stochastic correlation model assumed in Section 7.2.5.

We have recalculated Figure 7.5 and Figure 7.6 and our results are shown in Figures 7.13 and 7.14 respectively. Figures 7.15 and Figures 7.16 also show, respectively, the corresponding UK RPI/UK Equity Dividend Yield and UK RPI/UK Equity Earnings modeled correlations and the observed rolling correlations, calculated over the previous 12 months.

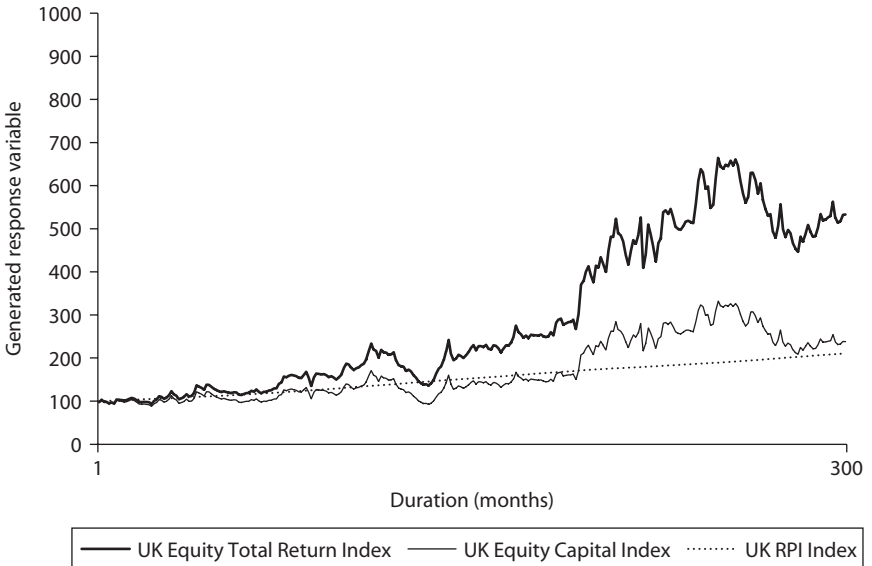
By comparing Figure 7.13 with Figure 7.5, and Figure 7.14 with Figure 7.6, and by inspecting Figures 7.15 and 7.16, a combination of the effects described in Sections 7.2.4 and 7.2.5 can be seen. In other words, a combination of extreme local jumps, caused by the stochastic volatility model, and periods of increased levels of correlation, as caused by the stochastic correlation model, can be observed.

Table 7.7 compares real total equity return means, standard deviations, skewness and kurtosis coefficients, as estimated from the output of the stochastic model over 2,500 simulations, with the corresponding UK historical data statistics. Table 7.7 also shows real total equity return correlation with RPI, as generated by the model.

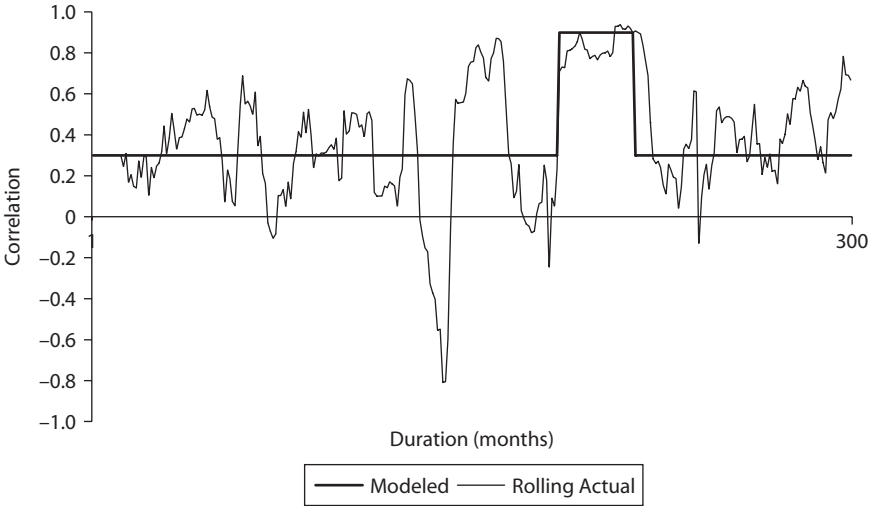
Comparing Table 7.7 with Tables 7.4, 7.5 and 7.6 shows that the combined stochastic volatility and stochastic correlation models have increased real equity total return standard deviation, skewness and



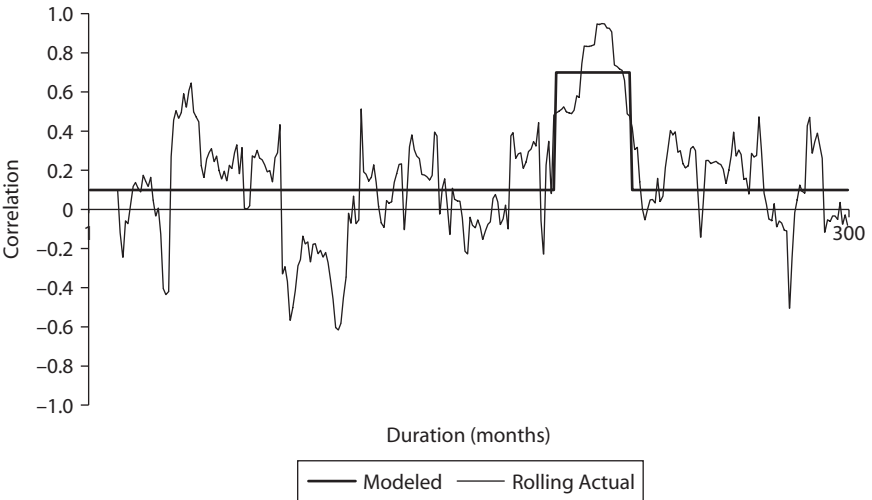
**Figure 7.13** Three dimensional stochastic model – stochastic volatilities and correlations



**Figure 7.14** Three dimensional stochastic model – specimen index output – stochastic volatilities and correlations



**Figure 7.15** Three dimensional stochastic model – modeled stochastic correlation versus rolling actual correlations for UK RPI and UK Equity Dividend Yield with stochastic volatilities



**Figure 7.16** Three dimensional stochastic model – modeled stochastic correlation versus rolling actual correlations for UK RPI and UK Equity Earnings Growth with stochastic volatilities

kurtosis, with mean and correlation essentially unaltered. Moreover, the increases are larger than those observed when using the stochastic volatility model on its own.

The main conclusion, therefore, is that the stochastic volatility and stochastic correlation models, in combination, have significantly fattened the tails of the real equity total return distribution.

**Table 7.7** Estimated statistics computed from the stochastic model output versus historical data – stochastic volatilities and correlations

<i>Statistic</i>	<i>Model output Real equity total return p.a.</i>	<i>Historical data, 1900–2000 Real equity total return p.a.</i>
Mean return (arithmetic)	0.07	0.08
Standard deviation	0.24	0.20
Skewness	0.7	0.7
Kurtosis	2.0	0.8
Correlation with RPI	−0.04	

We again observed that the introduction of stochastic volatility term to the constant volatility, stochastic correlation model increased the volatilities of the statistics reported in Table 7.7. For example, the mean return reported in Table 7.7 is much more variable, over different runs of the 2,500 simulations, than it is for the constant volatility, stochastic correlation model. This is again caused by the more extreme jumps in the underlying response variables that occur as a consequence of the stochastic volatilities.

We now move on to describe our general high dimensional stochastic model in full detail.

### 7.3 THE GENERAL HIGH DIMENSIONAL STOCHASTIC MODEL

We list in Table 7.8 the response variables that are included in our general high dimensional stochastic model.

We believe that this list is comprehensive enough to allow us to estimate stochastic economic capital for most types of financial services firms. If more response variables are required it is, however, relatively straightforward to add them into the model.

An important feature of our approach, as indicated in the examples above, is that we model within response variable and between response variable dependencies separately using distinct models. This ensures that within response variable and between response variable dependencies are kept separate and are not mixed up.

#### 7.3.1 Within response variable dependence model

By “within response variable dependence,” we mean the serial dependence that is present within almost all time series data. For example, the dividend

**Table 7.8** Modeled response variables*UK economic*

- 1 Retail Price Inflation (RPI)
- 2 Equity earnings/dividend growth
- 3 Equity dividend yield
- 4 Short term cash yield
- 5 Medium term government bond yield
- 6 Medium term corporate bond yield
- 7 Long term government bond yield
- 8 Long term corporate bond yield
- 9 Mortgage yield
- 10 Property rental growth
- 11 Property rental yield
- 12 £ appreciation against \$

*US economic*

- 13 Consumer price inflation (CPI)
- 14 Equity earnings/dividend growth
- 15 Equity dividend yield
- 16 Short term cash yield
- 17 Medium term government bond yield
- 18 Medium term corporate bond yield
- 19 Long term government bond yield
- 20 Long term corporate bond yield
- 21 Mortgage yield

*Demographic/behavioral*

- 22 Mortality improvement
- 23 Persistency

yield on an equity index in month  $t$  tends to depend on the dividend yields at month  $(t - 1)$ ,  $(t - 2)$ ,  $\dots$ .

The general form of our within response variable dependence model is that the distribution of  $Y_{it}$ , conditional on the past up to time  $t$ , is described by the formula:

$$Y_{it} = g(y_{i(t-1)}, y_{i(t-2)}, y_{i(t-3)}, y_{i(t-4)}, \dots) \\ + h(\varepsilon_{i(t-1)}, \varepsilon_{i(t-2)}, \varepsilon_{i(t-3)}, \varepsilon_{i(t-4)}, \dots) + \varepsilon_{it}$$

Here,  $g$  and  $h$  are general functions to be defined by specifying both their functional forms and the values of the parameters on which they depend.

For the moment, we assume that  $E(Y_{it})$ , the unconditional expected value of  $Y_{it}$ , equals zero. The  $\varepsilon_{it}$  term is the error associated with the  $Y_{it}$

response variable. If the unconditional expectation,  $\mu_i$  of the  $i$ th response variable is not zero, we model this by simply adding  $\mu_i$  to the  $Y_i$ s to form the  $Z_i$ s, as described in Section 7.2.1.

The function  $g$  captures the autoregressive features of the response variable  $Y_i$ . In other words  $Y_i$  depends on its own past values. Whereas, the function  $h$  captures its moving average features. In other words,  $Y_i$  depends on its own past error terms.

Usually,  $g$  and  $h$  will have very simple functional forms and will depend on a relatively small number of parameters. Our own practical experience suggests that, at least to a good first order of approximation, it is possible to model actual within response variable dependency structures using parsimonious models.

### 7.3.2 Volatility model

We specify the general high dimensional stochastic model using models similar to the generalized autoregressive conditional heteroscedastic model that Engle (1982) pioneered. In particular, we assume that

$$\varepsilon_{it} \sim N(0, \sigma_{it}^2),$$

where  $N$  denotes the Normal, or Gaussian, distribution and

$$\begin{aligned} \sigma_{it}^2 = & u_{\sigma}(\sigma_{i(t-1)}^2, \sigma_{i(t-2)}^2, \dots) + v_{\sigma}(y_{i(t-1)}, y_{i(t-2)}, \dots) \\ & + w_{\sigma}(\varepsilon_{i(t-1)}, \varepsilon_{i(t-2)}, \dots) \end{aligned}$$

Here  $u_{\sigma}$ ,  $v_{\sigma}$  and  $w_{\sigma}$  are general functions to be defined by specifying both their functional form and the values of the parameters on which they depend. Obviously, we must always ensure that  $\sigma_{it}^2 > 0$  for all  $i$  and  $t$ .

The  $u_{\sigma}$  function models autoregressive volatility behavior. In other words, the tendency for past modeled volatility, as measured by the  $\sigma^2$ s, to influence current modeled volatility. Similarly, the functions  $v_{\sigma}$  and  $w_{\sigma}$  model, respectively, the effect that past response variables and error terms have on current levels of volatility.

### 7.3.3 Between response variable dependence model

We model the between response variable dependencies via the conditional correlation matrix of the  $\varepsilon$ s using graphical models.

By “between variable dependence” we mean the non serial dependencies that are present across multi-dimensional investment data. For example, government bond yields and equity dividend yields tend to be positively correlated.

If  $d$  denotes the number of response variables that we are modeling, our basic model is as follows:

1. In standard matrix notation, let  $D_t = \text{diag}(\sigma_{1p}, \sigma_{2p}, \dots, \sigma_{(d-1)p}, \sigma_{dp})$ .
2. With  $\underline{\varepsilon}_t = (\varepsilon_{1p}, \varepsilon_{2p}, \dots, \varepsilon_{(d-1)p}, \varepsilon_{dp})^T$  let  $\text{Cov}(\underline{\varepsilon}_t) = D_t R_t D_t^T$  so that  $R_t$  represents the correlation matrix of the  $\varepsilon_t$ 's.
3. We define the structure of  $R_t$  using graphical models that drive the conditional independence properties between the  $\varepsilon_t$ 's.

Graphical models allow the conditional independence properties of the  $\varepsilon$ s to be read off their graph and the dimension reduction capability of the model chosen is also then apparent.

The graph of the model that we have chosen to use with our general and specific high dimensional models is shown in Figure 7.17. Here,  $d = 21$ , ignoring the Mortality Improvement and Persistency demographic/behavioral response variables, for the moment.

In Figure 7.17,  $\varepsilon$ s  $i$  and  $j$  are defined to be connected if the  $(i, j)$ th element of the inverse correlation matrix  $R_t^{-1}$  is non zero. As we have assumed that the  $\varepsilon$ s follow a multivariate normal distribution, setting elements of  $R_t^{-1}$  to zero, suppose  $(k, l)$  for the moment where  $k < l$  and with all other elements of  $R_t^{-1}$  non zero, standard matrix identities show that  $\varepsilon_{kt}$  and  $\varepsilon_{lt}$  are conditionally independent, given the remaining  $\varepsilon_{it}$ s ( $i = 1, \dots, k-1, k+1, \dots, l-1, l+1, \dots, d$ ).

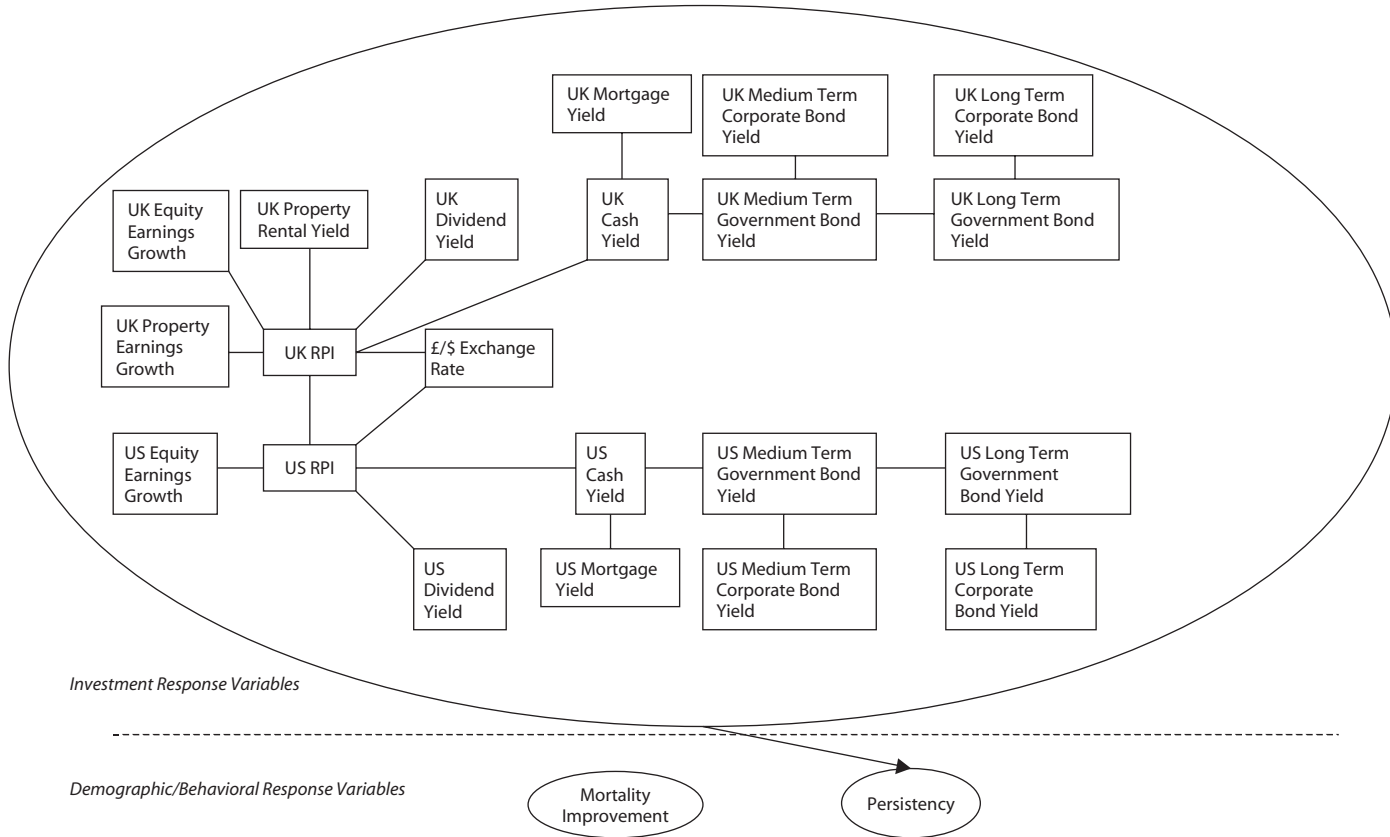
The full probability density function,  $f$ , of the  $\varepsilon$ 's can then be expressed as follows:

$$f(\varepsilon_{1p}, \varepsilon_{2p}, \dots, \varepsilon_{(d-1)p}, \varepsilon_{dp} | F_{(t-1)}) =$$

$$\frac{f^M(\varepsilon_{1p}, \dots, \varepsilon_{(k-1)p}, \varepsilon_{(k+1)p}, \dots, \varepsilon_{dp} | F_{(t-1)}) \times f^M(\varepsilon_{1p}, \dots, \varepsilon_{(l-1)p}, \varepsilon_{(l+1)p}, \dots, \varepsilon_{dp} | F_{(t-1)})}{f^M(\varepsilon_{1p}, \dots, \varepsilon_{(k-1)p}, \varepsilon_{(k+1)p}, \dots, \varepsilon_{(l-1)p}, \varepsilon_{(l+1)p}, \dots, \varepsilon_{dp} | F_{(t-1)})}$$

Here,  $M$  denotes a marginal probability density function and  $| F_{(t-1)}$  denotes conditioning on all information prior to time  $t$ .

It can be seen that setting this element of  $R_t^{-1}$  to zero allows the probability density function of the  $d$   $\varepsilon_t$ s to be expressed in terms of the probability density functions of  $(d-1)$   $\varepsilon_t$ s. In other words, the dimensionality of the  $\varepsilon$  dependency structure has been reduced from  $d$  to  $(d-1)$ . If we continue setting elements of  $R_t^{-1}$  to zero, we gradually reduce the dimensionality of the  $\varepsilon$  dependencies until, in the end,  $R_t^{-1}$  is diagonal and the  $d$   $\varepsilon_t$ s are mutually independent, conditional on  $F_{(t-1)}$ .



**Figure 7.17** Graphical model of between response variable dependency model

Porteous (1995) has shown, using formal mathematical statistical techniques that, for high dimensional investment time series data, between  $\varepsilon$  dependencies can be approximated by relatively low dimensional relationships. This is the motivation for the graphical model developed in this chapter and shown in Figure 7.17.

It is interesting to note that, as with Markov Random Field models that are used to describe spatial dependencies, and which can also be represented graphically, see Besag (1974), high dimensional, or long range, dependency structures can be built up and explained by very low dimensional, or short range, conditional dependencies. This has considerable advantages in controlling the number of parameters that are required to model the multivariate dependency structure of high dimensional times series data.

Inspection of Figure 7.17 now shows that there is one 3 dimensional relationship, involving UK RPI, US RPI and £/\$ exchange rates, with all other relationships two dimensional. All  $\varepsilon$ s are dependent on every other  $\varepsilon$ , although there are many conditional independence properties apparent in the model.

For example, because the UK Mortgage Yield  $\varepsilon$  is connected to UK RPI via UK Cash Yield, it follows that, conditional on UK Cash Yield, the UK Mortgage Yield and UK RPI  $\varepsilon$ s are independent. Unconditionally, however, the UK Mortgage Yield and UK RPI  $\varepsilon$ s are, nevertheless, dependent. So the dependence of UK Mortgage Yield and UK RPI is explained by UK Mortgage Yield's dependence on UK Cash Yield and UK Cash Yield's dependence on UK RPI.

In defining the graphical model shown in Figure 7.17, we have used Porteous (1995) as a driver and also conventional wisdom in determining which response variables should be directly connected to each other. For example, it is reasonable that the UK Short Term Cash and UK Mortgage Yield response variables should be connected in Figure 7.17 as these two response variables are strongly dependent. However, we are certainly not "stuck on" this particular graphical model and other models can certainly also be used if it is felt that they are more appropriate.

The graphical model for the investment type response variable  $\varepsilon$ s is shown above the dashed line in Figure 7.17, with the demographic/behavioral response variables shown below the line. The Mortality Improvement variable is not connected to any other variable, as it is not plausible that it will depend directly on any of the other response variables.

Instead, future Mortality Improvement will generally depend on future advances in medical science, the aging process and on other factors such as diet, exercise and retirement age amongst the population of

interest. We therefore model Mortality Improvement independently of the other response variables as described below in Section 7.3.8.

There is a directional dependency from the investment type response variable  $\varepsilon_s$  to the Persistency response variable. This represents a causal relationship between the variables. In other words, the investment response variables influence the Persistency response variable, but not vice versa.

Therefore, for example, when UK Mortgage Yields have fallen to low levels, fixed rate mortgage customers tend to be less loyal and may remortgage more frequently, as compared to when UK Mortgage Yields are high. In other words, low mortgage yields cause low persistency experience because it is then in the economic interest of fixed rate mortgage customers to remortgage.

Similarly, when UK Dividend Yields are high, which usually corresponds to “low” UK equity capital values, unit linked life insurance product customers, or mutual fund customers, tend to redeem their units. In other words, high dividend yields can cause low persistency experience.

Whilst the existence of a causal relationship for persistency is clear, these two examples show that the precise nature of the relationship will be product specific and will need to be modeled on a case by case basis. The specific relationships used in our modeling work are described in each particular example.

See Lauritzen (1996), Edwards (1995) or Porteous (1985) for more information on graphical models. Talih and Hengartner (2005) also give a very recent application of graphical models to financial time series.

### 7.3.5 Individual correlation model

The correlations of many of the  $\varepsilon_s$ s that we wish to model, investment time series response variables for example, can be non stationary and, in fact, can exhibit strong autoregressive type behaviors. See Tsay (2002) or Tse and Tsui (1998).

If our graphical model requires a correlation between the error terms  $\varepsilon_{it}$ , and  $\varepsilon_{jt}$ , for  $i \neq j$  and denoting it by  $\rho_{ijt}$ , we model it in its most general form as

$$\begin{aligned} \rho_{ijt} = & u_\rho(\rho_{ij(t-1)}, \rho_{ij(t-2)}, \dots) + v_\rho(y_{i(t-1)}, y_{j(t-1)}, y_{i(t-2)}, y_{j(t-2)}, \dots) \\ & + w_\rho(\varepsilon_{i(t-1)}, \varepsilon_{j(t-1)}, \varepsilon_{j(t-2)}, \varepsilon_{j(t-2)}, \dots) \end{aligned}$$

Here,  $u_\rho$ ,  $v_\rho$  and  $w_\rho$  are general functions to be defined by specifying both their functional forms and the values of the parameters on which they depend. For  $i = j$ ,  $\rho_{ijt} = 1$  by definition.

We must also be careful to ensure that our  $\rho_{ijt}$ s always fall in the range  $-1$  to  $1$ .

### 7.3.6 Tail dependence

The correlation structure of  $\varepsilon_i$  and  $\varepsilon_j$  may depend on the values of the corresponding response variables  $y_i$  and  $y_j$ . In particular, correlation may increase in the tails of the  $Y_i$  and  $Y_j$  distributions. For example, as bond yields increase, government and corporate bonds tend to become more highly correlated.

Although copulas, Joe (1997), have been used to model this type of behavior, we prefer a more direct approach, similar to that outlined by Engle (2003). For example, if we want to model an increased level of dependence between  $\varepsilon_i$  and  $\varepsilon_j$  when  $Y_i$  and  $Y_j$  are both large, we can achieve this by including a term in the definition of  $\rho_{ijt}$  that is both large and positive in these circumstances.

### 7.3.7 Simulating the general high dimensional stochastic model

Simulating the  $\varepsilon$ s at time  $t$ , conditional on their values prior to time  $t$ , involves simulating a 21 dimensional multivariate normal random vector. Note that our full 23 dimensions have reduced to 21 as, for the moment, we are not considering the demographic/behavioral response variables at this point.

The conditional independence properties of our general high dimensional model, as shown in Figure 7.17, fortunately allow the simulation exercise to be carried out in dimensions of at most three. Provided that our graphical model is decomposable, see Lauritzen (1996) and Porteous (1985) for a full explanation, the method of simulation that we describe here is always possible.

The simulation algorithm that we use at time  $t$  is as follows:

1. First simulate the {UK RPI, US RPI, £/\$ Exchange Rate}  $\varepsilon$ s. These  $\varepsilon$ s form the largest clique in Figure 7.17 where a clique is a maximal set of  $\varepsilon$ s that are all connected to each other. Let us call this the clique of order 0. The simulation involves generating a three dimensional multivariate normal random vector using the usual Cholesky decomposition approach.
2. Identify cliques that contain  $\varepsilon$ s connected to an  $\varepsilon$  in the clique of order 0. We call these order 1 cliques. We then simulate the clique 1  $\varepsilon$ s, conditional on the clique of order 0. This involves simulating a multivariate normal random vector of dimension at most 1, for example, the conditional distribution of the {UK RPI, UK Cash Yield} clique, conditional on the clique of order 0.

3. Identify cliques that contain  $\varepsilon$ s connected to an  $\varepsilon$  in a clique of order 1. These are cliques of order 2. We then simulate the order 2 clique  $\varepsilon$ s, conditional on the clique 1  $\varepsilon$ s. This involves simulating multivariate normal random vectors of dimension at most 1.
4. Repeat step 3 for the order 2 cliques and thereafter.
5. As the graph shown in Figure 7.17 is decomposable, the algorithm will terminate having successfully simulated the 21 dimensional  $\varepsilon$  random vector with the correct conditional correlation matrix at time  $t$ .

Once we have the  $\varepsilon$ s, we can then recursively generate the response variables, and the time varying volatilities and correlations.

Computationally this gives us a huge saving. For example, if we are generating monthly realizations of our response variables over a 25 year time period and doing this, say 10,000 times, the number of multivariate normal simulations required is  $25 \times 12 \times 10,000 = 3,000,000$ . If this is done with correlation matrices of dimension at most 3, rather than 21, then a very considerable saving is achieved.

### 7.3.8 Mortality improvement

The UK actuarial profession, amongst other professional bodies, UK government departments and international agencies, studies mortality and regularly publishes mortality tables, including allowances for future mortality improvements. The data that are used for these actuarial studies are provided by the UK life insurance industry. See Willets *et al.* (2004) and Willets (2004), two recent mortality studies prepared under the auspices of the UK actuarial profession, and which provide good overviews of current mortality trends, for more information.

Generally speaking, mortality has tended to improve very much faster than has been forecast particularly, in recent years, at higher ages. Moreover, there is now also a distinct possibility that anti-ageing research may soon bear fruit, indicating that future improvements in mortality may well run at even faster levels than has been observed in the recent past.

At the broadest level, rates of mortality improvement depend on three important risk factors: age, sex and “cohort.” Willets (2004) has described the UK “cohort effect” whereby people born in the UK between 1925 and 1945, centered on the generation born in 1931, have experienced much faster improvements in mortality than generations born either side of this period.

The UK cohort effect is probably explained by historic smoking behavior patterns and also by diet in early life. Similar cohort effects

have been observed in Norway, Sweden, Denmark, France, Italy, USA and Japan. See Willets (2004).

Tables 7.9 and 7.10, taken from Willets (2004), show estimated annual mortality improvement rates by age, calendar year and sex for the general population of England and Wales. The improvement rates are estimated over a five year period centered on the calendar year shown. See Willets (2004).

The cohort effect can be seen in the bold figures shown in Table 7.9 and Table 7.10. Note also that, over calendar years, improvement rates have fallen at the younger ages and have increased at the older ages. Willets *et al.* (2004) discuss the reasons for this in detail.

**Table 7.9** Average annual mortality improvement rate for males in the population of England and Wales (%)

Age group	Calendar year					
	1975	1980	1985	1990	1995	2000
40–44	<b>3.1</b>	2.1	1.6	0.1	0.3	0.9
45–49	<b>2.9</b>	<b>3.5</b>	<b>2.8</b>	<b>3.1</b>	0.4	0.2
50–54	1.0	<b>3.7</b>	<b>2.6</b>	<b>2.3</b>	2.9	1.7
55–59	1.5	1.8	<b>2.6</b>	<b>3.1</b>	2.4	3.5
60–64	1.0	2.1	2.0	<b>3.6</b>	<b>3.6</b>	3.2
65–69	1.6	2.2	1.7	2.1	<b>3.8</b>	<b>4.5</b>
70–74	1.6	1.9	1.8	2.0	2.5	<b>4.6</b>
75–79	0.5	2.1	1.4	2.2	2.6	2.8

**Table 7.10** Average annual mortality improvement rate for females in the population of England and Wales (%)

Age group	Calendar year					
	1975	1980	1985	1990	1995	2000
40–44	<b>2.7</b>	<b>3.7</b>	1.0	2.7	1.6	2.3
45–49	<b>2.4</b>	<b>3.0</b>	1.6	2.6	1.3	0.3
50–54	1.0	<b>3.6</b>	<b>2.5</b>	2.0	1.7	1.6
55–59	0.4	1.1	<b>2.4</b>	<b>3.2</b>	1.7	2.5
60–64	0.4	0.5	0.6	<b>2.8</b>	<b>3.2</b>	2.5
65–69	1.2	1.3	0.7	1.4	<b>2.8</b>	<b>3.7</b>
70–74	1.7	1.3	1.0	1.2	1.4	<b>4.0</b>
75–79	1.7	1.9	1.3	1.4	1.3	2.0

### 7.3.9 Forecasting future improvements in mortality

As is discussed in Willets *et al.* (2004), the methods that are used in practice to estimate future improvements in mortality are very wide ranging. The two most popular approaches are

1. Target rates of mortality are set with the aim of achieving these by a prescribed time in the future. Starting from current mortality levels, improvement factors are then derived to ensure that the target rates are achieved by the prescribed time.
2. Future improvement rates are extrapolated from past rates.

We use the extrapolation method in this book, as we believe that this is more realistic than a target based method.

### 7.3.10 Approach to mortality risk stochastic modeling

Our approach to modeling mortality risk stochastically is as follows:

- We start with a base mortality table that represents a good estimate of current mortality for the population under consideration.
- Expected improvement factors, along the lines set out in Tables 7.9 and 7.10, are then postulated and represent our best estimate expected mortality improvement rate factors.
- These expected improvement factors will generally depend on the starting ages of the lives being modeled in the projection, their sex, and any cohort effects as described above and by duration within the projection.
- We perturb these expected improvement factors by the addition of a stochastic error term  $\varepsilon \sim N(0, \sigma^2)$  to represent the uncertainty that is prevalent in estimating future mortality improvement factors.
- The stochastically generated improvement factors are then used to project the base mortality table forward in time.

## 7.4 SPECIFIC HIGH DIMENSIONAL STOCHASTIC MODEL

In this section, we finally propose a relatively simple specific parameterization of the general high dimensional stochastic model described in Section 7.3. To motivate this, we rely heavily on the specific low

dimensional stochastic models that we considered earlier on in this chapter.

We again model each response variable as a first order autoregressive time series with constant volatilities and correlations. In other words, each  $Y_{it}$  is modeled as

$$Y_{it} = \beta_i Y_{i(t-1)} + \varepsilon_{it},$$

where  $\varepsilon_{it} \sim N(0, \sigma_{it}^2)$ .

The  $\varepsilon_{it}$ s are assumed to be independently distributed across response variables and time.

We model the unconditional expectation  $\mu_i$  of the  $i$ th response variable, assuming that it is non zero, by the addition of  $\mu_i$  to  $Y_{it}$  to form the  $Z_{it}$ s, exactly as described in Section 7.2.1.

We use the graphical model, as shown in Figure 7.17, and also propose an initial constant correlation model where

$$\rho_{ijt} = \omega_{ij},$$

for all  $i \neq j$  and  $t$  and for each  $(i, j)$  pair which is connected in Figure 7.17.

As always,  $\rho_{ijt} = 1$  for  $i = j$ .

Our proposed parameterization of the specific high dimensional stochastic model is shown in Tables 7.11 and 7.12.

The parameters shown in Table 7.11 represent economic conditions at the time of writing and, additionally, are also mutually consistent.

Our assumed constant correlation coefficients, for the cliques shown in Figure 7.17, are shown in column B of Table 7.12. We have chosen three levels of correlation strength corresponding to high (0.6), medium (0.3) and low (0.1).

The inverse correlation matrix  $R^{-1}$  and the correlation matrix  $R$  corresponding to this graphical model with constant correlations are shown in Appendix 7.1. The properties of graphical models allow these  $21 \times 21$  matrices to be constructed from the marginal correlation matrices of the cliques in Figure 7.17, which are of dimension at most three.

It can be seen that non zero, non diagonal, entries of  $R^{-1}$  correspond to the  $\varepsilon$ s that are connected in Figure 7.17. From  $R$ , it can also be seen that the correlation matrices of the clique marginals are preserved in the full correlation matrix. In other words, the 0.1s, 0.3s and 0.6s are preserved. It can also be observed that every response variable is correlated with every other response variable, even though there are relatively few response variables that are directly connected in Figure 7.17.

**Table 7.11** Response variable model and volatility model parameterizations – specific high dimensional model

	Unconditional expectation $\mu_i$	First order autoregressive parameter $\beta_i$	Unconditional standard deviation $\sigma_i/(1-\beta_i^2)^{1/2}$
<i>UK economic</i>			
1 Retail Price Inflation (RPI)	0.0275	0.975	0.0075
2 Equity earnings/dividend growth	0.0425	0.95	0.02
3 Equity dividend yield	0.0325	0.975	0.0075
4 Short term cash yield	0.0475	0.975	0.0075
5 Medium term government bond yield	0.0500	0.975	0.01875
6 Medium term corporate bond yield	0.0550	0.975	0.01875
7 Long term government bond yield	0.0525	0.975	0.01875
8 Long term corporate bond yield	0.0575	0.975	0.01875
9 Mortgage Yield	0.0625	0.975	0.0075
10 Property rental growth	0.0325	0.95	0.01875
11 Property rental yield	0.0425	0.975	0.0075
12 £ appreciation against \$	0.02	0.00	0.025
<i>US economic</i>			
13 Consumer Price Inflation (CPI)	0.02	0.975	0.0075
14 Equity earnings/dividend growth	0.0625	0.95	0.02
15 Equity dividend yield	0.02	0.975	0.0075
16 Short term cash yield	0.02	0.975	0.0075
17 Medium term government bond yield	0.0375	0.975	0.01875
18 Medium term corporate bond yield	0.0425	0.975	0.01875
19 Long term government bond yield	0.0450	0.975	0.01875
20 Long term corporate bond yield	0.0500	0.975	0.01875
21 Mortgage yield	0.0425	0.975	0.0075

**Table 7.12** Correlation model parameterization – specific high dimensional model

	A	B	C	D
		Constant correlation coefficients	Threshold	Stochastic correlation higher level coefficients
	$\varepsilon$ pair	$\omega_{ij0}$	$C_{ij}$	$\omega_{ij1}$
1	1,2	0.1	–	0.9
2	1,3	0.3	0.5	0.9
3	1,4	0.6	0.8	0.9
4	1,10	0.1	–	0.9
5	1,11	0.3	0.5	0.9
6	1,12	0.6	–	0.9
7	1,13	0.3	–	0.9
8	4,5	0.6	–	0.9
9	4,9	0.6	–	0.9
10	5,6	0.6	–	0.9
11	5,7	0.6	–	0.9
12	7,8	0.6	–	0.9
13	12,13	0.6	–	0.9
14	13,14	0.1	–	0.9
15	13,15	0.3	0.5	0.9
16	13,16	0.6	0.8	0.9
17	16,17	0.6	–	0.9
18	16,21	0.6	–	0.9
19	17,18	0.6	–	0.9
20	17,19	0.6	–	0.9
21	19,20	0.6	–	0.9

Figure 7.18 (see colour Plate 4) shows one simulation, or realization, of the specific high dimensional investment model over a 25 year period using the initial parameterization described above, using both constant volatilities and correlations. The numbering of the response variables shown in Figure 7.18 corresponds to that used in Table 7.11.

Although it is quite difficult to see clearly what is going on in a graph charting 21 response variables, plotted monthly over a 25 year time period, inspection of smaller groups of the response variables shows that they behave as expected. It is important to remember that these response variables exhibit both serial dependencies, within each response variable, and between response variable dependencies across all 21 response variables. In other words, a complex and high dimensional dependency structure is being displayed.

## Negative yields

Depending on the parameterization of the specific high dimensional stochastic model being used, it is possible for certain response variable yields to become negative, with a very small probability of occurrence. In our modeling work, we require that all yields are positive.

If a negative yield ever occurs in a simulation, we simply reset the negative yield as a very small positive number. An example of this can be seen in Figure 7.18 for response variable 18. Based on our experiences of using the stochastic model in practice, the negative yield adjustment described above has no material impact on the results generated by the model.

### 7.4.1 Stochastic volatilities

When we use stochastic volatilities in the specific high dimensional stochastic model, we will use the stochastic volatility model described in Section 7.2.4, which was illustrated using our specific low dimensional stochastic models. In other words, using our standard notation, for response variable  $i$ , we assume the stochastic volatility model

$$\sigma_{it}^2 = \phi_{i0} + \phi_{i1}\varepsilon_{i(t-1)}^2.$$

As before, we set the  $\phi_{i1}$ s equal to 0.5 and reset the  $\phi_{i0}$ s to ensure that the unconditional standard deviation of each response variable is unaltered from those shown in Table 7.11.

When stochastic volatility is modeled, we model it for all of the response variables, except the UK RPI and US CPI response variables. For these response variables we continue to assume a constant volatility model as, in practice, the inflation response variables do not tend to exhibit large jumps.

### 7.4.2 Stochastic correlations

When we use stochastic correlations in the specific high dimensional stochastic model, we use the same approach as described in Section 7.2.5, which was illustrated using our specific low dimensional stochastic models. In particular, we assume that the correlation between the  $i$ th and  $j$ th  $\varepsilon$ s, conditional on the past prior to time  $t$ ,  $\rho_{ijt}$ , is defined as follows:

$$\rho_{ijt} = \begin{cases} \omega_{ij0} & \text{for } t < T \\ \omega_{ij0} & \text{for } t > T \text{ and provided that } c_{ijt} < C_{ij} \text{ for at least one of} \\ & \text{the } (i, j) \text{ pairs } (1,3), (1,4), (1,11), (13,15), (13,16) \\ \omega_{ij1} & \text{for } t > T \text{ and provided that } c_{ijt} > C_{ij} \text{ for all } (i, j) \text{ pairs} \\ & (1,3), (1,4), (1,11), (13,15), (13,16) \end{cases}$$

Here  $-1 < \omega_{ij0}, \omega_{ij1}, C_{ij} < 1$  and

$$C_{ijt} = \frac{(\sum \varepsilon_{i(t-s)} \varepsilon_{j(t-s)})}{\{(\sum \varepsilon_{i(t-s)}^2)(\sum \varepsilon_{j(t-s)}^2)\}^{1/2}}$$

for  $s = 1, 2, \dots, T$ .

In other words,  $C_{ijt}$  represents the rolling correlation between  $\varepsilon_i$  and  $\varepsilon_j$  over the previous  $T$  months. The values of the  $\omega_{ij0}$ s,  $\omega_{ij1}$ s and  $C_{ij}$ s are set out in Table 7.12 and a value of  $T = 12$  months is used.

The trigger that we use for the higher correlations is that UK Equity Dividend Yields, UK Short Term Cash Yields and UK Property Yields all become very highly correlated with the UK RPI response variable, in conjunction with US Equity Dividend Yields and US Short Term Cash Yields both becoming very highly correlated with the US CPI response variable.

As a consequence, cash, equity and property yields then all become very highly correlated with each other, in both the UK and the US, and also with fixed interest asset yields. At times of market stress, yields tend to take on extreme values together and we, therefore, believe that our trigger represents a reasonable first order approximation to behaviors that have been observed in practice.

The model allows other triggers to be accommodated if it was felt that they were more appropriate.

### 7.4.3 Calibrating the specific high dimensional stochastic model

The approach that we have taken to calibrating our specific high dimensional stochastic model is as follows:

1. Based on our experience, we have chosen a model that is capable of replicating, to a good first order of approximation, many of the most important financial and behavioral features that drive financial services firm economic capital.
2. We parameterize the model by
  - a. Ensuring that the model is representative of current market conditions. For example, we require expected government bond yields, as generated by the model, to be “near” to current bond yields.
  - b. Ensuring that key features of the model output are “similar” to corresponding key features observed in real data. For example,

we ensure that total equity return volatility, as generated by the stochastic model over the projection time period, is “close” to historic total equity return volatility.

- c. Sense checking our parameterization by carrying out sensitivity testing to establish how economic capital varies when key parameter values are altered.
3. We always try to use models that are well defined and estimable using formal mathematical statistical techniques.
4. Although our models are generally well defined, our intention is, nevertheless, not to estimate unknown parameters by fitting models to data using maximum likelihood estimation, for example. This is because our projection periods are generally so long, typically around 25 years that no model will provide a good fit to real data. Our goal, which is much less ambitious, and more realistic, is to develop models that provide good first order approximations to financial and behavioral markets over these long time periods.

An advantage of our model structure is that it allows the long term unconditional expectations and standard deviations of the key response variables to be specified. As we saw in the sections of this chapter dealing with the specific low dimensional stochastic model, the UK RPI, UK Equity Dividend Yield and UK Equity Earnings Growth response variable parameterization and model structure is able to closely reproduce the behavior of the broad UK equity market over very long periods of time.

In particular, the distributions of key derived variables, such as equity total return indices, exhibit the positive skewness and fat tails that are observed in practice and which can be difficult to model. Further discussion on the calibration of the specific high dimensional stochastic model, particularly bond modeling, is provided in Chapter 11 which contains the with profits life insurance economic capital examples.

## 7.5 OTHER STOCHASTIC MODELS

Although we feel that the stochastic model used in this book has a number of attractive features, many other models are certainly available and could also be used by firms in calculating their economic capital amounts. Provided that these other models have been calibrated in a manner consistent with the model used here, it is very likely that they will produce similar results to our model.

Many of these models are, however, proprietary to the consultancy firms, or financial services firms, that have developed them and the level

of disclosure of these models is almost always very limited. Some of the models developed by consultancy firms, for example, are used like black boxes with only the model output simulations being available to the consultant's clients. This is hardly satisfactory.

We have, however, checked our with profits life insurance results in Chapter 11 using the seminal "Wilkie" model which is very well known to UK actuaries. The version of Wilkie's model that we used is described in Wilkie (1995).

To conclude, we believe that our main qualitative conclusions will be robust to the specific stochastic model used, provided that the stochastic models describe the underlying response variables in a consistent manner.

## 7.6 SUMMARY

In this chapter, we have developed a specific high dimensional stochastic model, which we use in all of our later economic capital applications. In developing this specific high dimensional model, we have also gone through the intermediate stages of developing both specific low dimensional stochastic models and more general high dimensional stochastic models.

We have shown how our specific high dimensional model can be built up from very low dimensional building blocks and have demonstrated that it is capable of very closely replicating the behaviors of real series of investment data.

We now move on to consider a number of economic capital banking applications in Chapter 8.

# Banks

## 8.1 INTRODUCTION

In this chapter, we consider economic capital for banking firms. Obviously, the range and type of both banking products, and the firms themselves, is enormous. For these reasons, we focus our attention on those products and firms that we consider are most interesting, of most importance and are also those for which we have some practical experience. The principles and methods that we discuss, however, are applicable to any banking product or firm, regardless of their type, or complexity.

This chapter covers both “on” balance sheet assets and “off” balance sheet assets. The on balance sheet examples cover retail business whereas the off balance sheet examples take more of a wholesale perspective. Again, we would stress that the principles and methods that we describe are applicable to any mix of retail, or wholesale, business, irrespective of whether it is carried out on balance sheet, or off.

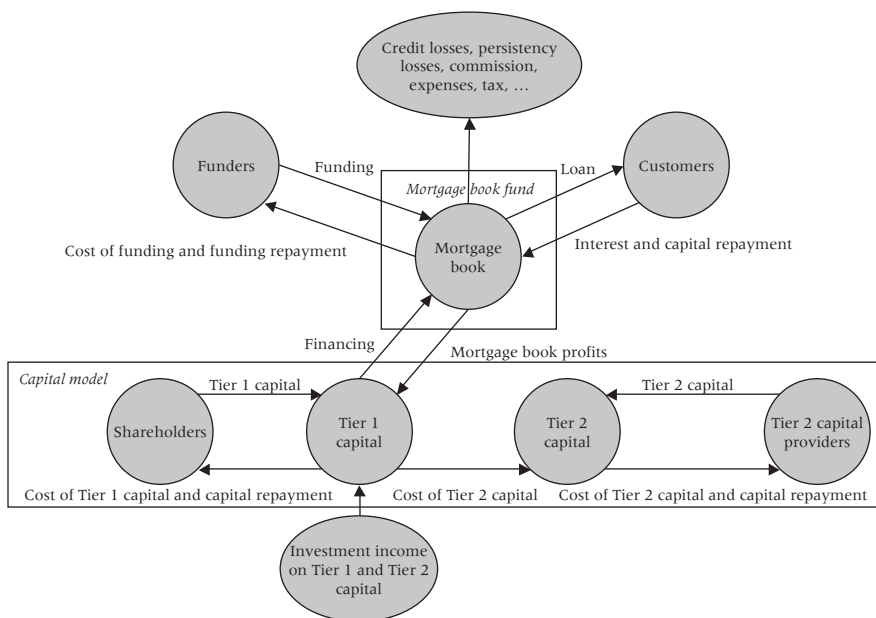
We now describe the firm, or corporate structure, that we use for our bank examples. As we will see from the examples that follow in later chapters, this structure is, in fact, applicable quite generally across all of our practical examples of financial services firms.

## 8.2 RETAIL BANK EXAMPLES

### 8.2.1 Corporate structure

The corporate structure that we have assumed for our retail banking examples is set out in Figure 8.1.

Although the structure looks very complicated, close inspection of Figure 8.1 reveals that the structure simply models the important cash-flows affecting a bank’s mortgage book. For example, on the asset side



**Figure 8.1** Retail mortgage bank corporate structure

of the balance sheet, income from the mortgage book's assets is generated by the mortgage yield paid by the customers to the bank. Similarly, on the liability side of the balance sheet, it can be seen that the funding providers are paid their required funding costs, and so on.

Any financing that the mortgage book requires to cover expense strains, for example, is assumed to be provided by Tier 1 capital. All mortgage book profits are released back to Tier 1 capital at the end of each month and are subsequently released back to the shareholders when appropriate. The cost of Tier 2 capital is also met from Tier 1 capital.

The bank's shareholders finance Tier 1 capital, which is required to back the bank's mortgage book regulatory capital requirement and also the mortgage book financing requirements described above. Tier 2 capital, which is also determined by the bank's mortgage book regulatory capital requirements, and the bank's desired mix of Tier 1 and Tier 2 capital, is provided for by the Tier 2 capital providers.

All of the cashflows relating to the mortgage book, except those associated with capital, are modeled within the mortgage book component of the structure. The capital cashflows are modeled separately in the capital structure model. This allows us to keep separate the core mortgage book business cashflows and the capital cashflows.

The advantage of this approach is that the bank's core mortgage book economic capital requirement, as described below, is then independent of the bank's capital structure, as is required and as described in Section 5.3.

At any point in time, and according to Definition 5.1, we calculate *deterministic* economic capital as the amount of capital that must be injected into the mortgage book's realistic, or market value, balance sheet to ensure that this balance sheet remains solvent, over a prescribed time period, under all deterministic stresses.

Similarly, using Definition 5.1, we calculate *stochastic* economic capital, at any point in time, as the amount of capital that must be injected into the mortgage book's realistic, or market value, balance sheet to ensure that this balance sheet remains solvent over a prescribed time period, with a prescribed probability.

As we proceed through the various chapters of this book, we will demonstrate in our examples that the corporate structure set out in Figure 8.1 is applicable to all of our financial services firm, and conglomerate, examples. Whether the firm is a with profits life insurance firm, or a retail bank, the same structure applies. Obviously, this has considerable appeal when building the financial models and infrastructure required to determine economic capital.

Note that the very detailed assumptions that underpin our financial services firm examples are set out in full in the Appendices at the end of the book. It is our intention that the main body of the text can be read, without having to refer to these Appendices, unless the reader specifically wishes to do so.

## 8.2.2 Deterministic retail bank example

We start off with a relatively simple deterministic economic capital example, before moving on to consider a more challenging stochastic economic capital example.

In this first example, we assume that a mortgage bank's balance sheet is made up of £500 million of floating rate residential mortgages, funded 100% by floating rate instant access deposit accounts. Although our example is relatively "simple," the base case assumptions that underlie our example are very detailed. We have set these assumptions out in full in Appendix 8.1.

We calculate economic capital for the mortgage bank, at duration one month, according to Definition 5.1, and using the set of deterministic stresses set out in Table 8.1.

We believe that these stresses represent a reasonable compromise between risk events that are unexpected, but yet could still reasonably occur in practice for this retail mortgage bank. We also believe that these

**Table 8.1** Deterministic stresses – bank example

1.1 Stress	Mortgage				Savings	
	Prepayment rates	Fixed expenses	Interest rate margin	Bad debt cost	Withdrawal	Fixed expenses
1	Base	Base	Base – 50 bp	Base	Base – 50%	Base + 15%
2	Base + 50%	Base	Base	Base	Base – 50%	Base + 15%
3	Base	Base + 15%	Base	Base	Base – 50%	Base + 15%
4	Base	Base	Base	Base + 5 bp	Base – 50%	Base + 15%
5	Base + 50%	Base + 15%	Base – 50 bp	Base + 5 bp	Base – 50%	Base + 15%

**Table 8.2** Economic value – deterministic bank example

Stress	Pricing 1 (£ million)	Pricing 2 (£ million)
Base	2.1	5.6
1	(9.3)	(5.5)
2	(4.9)	(2.2)
3	(2.5)	0.9
4	(3.0)	0.4
5	(11.1)	(8.0)

stresses cover the risk response variables that are of most importance for this bank. Ultimately, with deterministic economic capital, the choice of which stresses to use will always involve a certain amount of judgment.

The bank's mortgage products are priced according to the following two criteria:

- Pricing Basis 1: To achieve a 12% post-tax rate of return on Tier 1 capital, assuming that the Basel 1 regulatory capital requirement is backed entirely by Tier 1 capital.
- Pricing Basis 2: To achieve a 16% post-tax rate of return on Tier 1 capital, assuming that the Basel 1 regulatory capital requirement is backed entirely by Tier 1 capital.

The estimated economic values of the future profits to be generated by the mortgage book's in force business are given in Table 8.2. Note that, with reference to Definition 5.1, these economic values represent the market, or realistic value, of mortgage book assets less liabilities.

**Table 8.3** Capital requirements – deterministic bank example

<i>Method</i>	<i>Requirement (£ million)</i>
Economic capital: Pricing Basis 1	11.1
Economic capital: Pricing Basis 2	8.0
Basel 2	12.0
Basel 1	20.0

Note that, as expected, the Pricing Basis 2 estimated economic values are always higher than the Pricing Basis 1 values. This is simply because Pricing Basis 2 prices are more expensive than those for Pricing Basis 1.

As shown in Table 8.3, using Definition 5.1 and deterministic stress 5, which contains all of the individual response variable stresses, the economic capital for the mortgage bank is seen to equal £11.1 million under Pricing Basis 1 and £8.0 million under Pricing Basis 2. This compares with a Basel 1 regulatory capital requirement of £20 million and a Basel 2 advanced internal ratings based Pillar 1 requirement of £12 million, including the Basel 2 standardised approach operational risk Pillar 1 capital charge.

It can also be seen that the interest rate margin stress consumes the most economic capital and the fixed expense stress the least. Table 8.2 also shows that economic capital under the stresses is not additive.

In fact, economic capital under all of the stresses in aggregate is less than the sum of the individual stress economic capital amounts. In this example, the mortgage prepayment rate stress becomes beneficial, in combination with the other stresses.

This is because, under the remaining non persistency stresses, the mortgage business becomes loss making and the faster it runs off, the better. Section 9.2.1 describes a simple deterministic non profit life insurance example where the stresses, in aggregate, give more economic capital than the sum of the individual stresses.

If we recall from Section 2.2.8, and as defined by the Basel Committee, operational risk is “the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. This definition includes legal risk, but excludes strategic and reputational risk.”

In our approach to economic capital, as described in Section 2.2.8, we have not explicitly allowed for the additional capital that is required for the bank’s mortgage book realistic balance sheet to absorb an additional specific external event operational risk stress. Instead, we have assumed

that the deterministic stresses implicitly allow for the operational risk losses that occur as a result of external event operational risk stresses. So, for example, an unspecified component of the fixed expense stress, that Base fixed expenses increase by 15%, is assumed to be due to operational risk losses resulting from external event operational risk stresses.

For our simple retail mortgage bank, the Basel 1 capital requirement appears too high relative to the risks that the bank is running and the Basel 2 charge appears to better reflect the underlying risks. However, economic capital increases as the price of the mortgage falls and may eventually exceed the Basel 2 or 1 regulatory capital requirements if the mortgage price is cheap enough.

This simple deterministic stress test example introduces the approach that we have adopted to economic capital in this book. However, as with all deterministic approaches, there is a very high level of subjective judgment involved in developing the stresses. Although one can still get a qualitative feel for the amount of economic capital that is required to cover the risks that the firm is running, calibration is also ultimately subjective. It is for this reason, amongst the others described in Chapter 4, that we believe that the stochastic approach has a clear advantage.

We now move on to consider a more realistic stochastic economic capital example where we determine a mortgage book's economic capital at all durations throughout the lifetime of the mortgage book.

### **8.2.3 Stochastic retail bank example**

In this section, we build on the deterministic example described above to develop a fully stochastic retail mortgage bank example. The detailed assumptions that underpin the example are set out in Appendix 8.2. However, we describe the more important features and assumptions that underlie the example here.

#### **8.2.3.1 Stochastically modeled response variables**

We use the constant volatility, constant correlation stochastic model described in Chapter 7, parameterized according to Table 7.11, to generate the stochastic stresses for the example. In particular, we model the response variables, and associated derived variables, stochastically as described below.

1. The mortgage yield, or standard variable rate, that is payable under the mortgages.
2. We assume that the bank funds its mortgages using the wholesale funding markets and that the cost of this funding equals the short term UK cash yield, as generated by the stochastic model, plus 10 bp.

3. From Table 7.11 it can be seen, therefore, that the bank's expected interest rate margin equals  $0.0625 - 0.0475 - 0.0010 = 0.0140$ . This is reasonably representative of the UK banking industry at the time of writing. The corresponding interest rate margin monthly standard deviation under the Table 7.11 parameterization, and which is driven mainly by the assumed correlation between the short term UK cash yield and the UK mortgage yield, is 0.0067. This would not be unusual for a wholesale funded firm but may be on the high side for a retail funded firm. In the numerical results presented below, we will therefore vary both the interest rate margin expected value and the interest rate margin standard deviation to demonstrate the effect that these assumptions have on the firm's economic capital amount.
4. It is assumed that the bank's fixed expenses increase in line with UK RPI, as generated by the stochastic model.
5. Both "Expected" and "High" levels of prepayment are modeled. The High levels are assumed to apply when mortgage yields are "high," as described in Appendix 8.2. In other words, high mortgage yields cause high prepayment rates and this type of behavior is certainly seen in the UK mortgage market.
6. "Expected" and "High" probabilities of repossession are also modeled. The high levels of repossession are assumed to apply when either:
  - (a) Mortgage yields are high as defined in Appendix 8.2 or;
  - (b) There is negative equity in the property. Negative equity is broadly assumed to occur when a loss of at least 1% of the value of the property would be made on repossessing the property. The value of the property is estimated as its starting value, increased in line with UK House Price Inflation (HPI), as generated by the stochastic model.

The UK mortgage market tends to exhibit higher repossession rates when mortgage yields are either high or there is negative equity in a property. In other words, high mortgage yields or negative equity are a cause of high repossession rates.

7. The Basel 2 credit risk regulatory capital requirement depends on the bank's default probabilities and loss given defaults and we derive these from the stochastically generated repossession probabilities and losses given repossession as described in Appendix 8.2. Similarly, the Basel 2 operational risk regulatory capital requirement depends on the bank's interest income at any point in time, as generated by the stochastic model. The total Basel 2 regulatory capital requirement is, therefore, also stochastically generated from the outputs of the stochastic model.

8. The Basel 1 regulatory capital requirement is calculated as 4% of the loan outstanding at any point in time.

Based on the stochastic elements of this example, the economic capital requirement that is generated by the stochastic model is the amount of capital required by the bank to cover its aggregate:

1. Interest rate margin risks
2. Expense risks
3. Credit risks
4. Persistency risks

We now describe how stochastic economic capital and the corresponding regulatory capital requirements are calculated.

### **8.2.3.2 Stochastic economic capital calculation**

The process that we use to calculate the bank's economic capital and regulatory capital requirement at any time point is as follows:

#### *Step 1*

The stochastic model is used to generate one "future" scenario.

#### *Step 2*

Based on this simulated future, at every month  $t$  over the lifetime of the bank, the present value,  $(PVIF_t)$ , of the future profits that will emerge from the bank's mortgage book is calculated.  $PVIF_t$  represents the economic value of the bank's mortgage book at time  $t$ . This present value is also an estimate of the market value of the bank's mortgage book assets less the market value of the bank's mortgage book liabilities at duration  $t$ .

#### *Step 3*

In calculating  $PVIF_t$ , we discount the future profits that emerge from the bank's mortgage book using the short term UK cash yields as generated by the stochastic model under this simulated future. It is appropriate to use a risk free rate in this context as the risks that the firm is running in its mortgage book are explicitly modeled by the stochastic model in the mortgage book cashflows.

#### Step 4

If  $PVIF_t$  is negative, the market value of the bank's mortgage book assets is less than the market value of its mortgage book liabilities. In other words, the market value balance sheet of the bank's mortgage book is insolvent and capital of amount  $-PVIF_t$  must be injected to restore solvency.

#### Step 5

For each month  $t$ , we calculate the maximum value of all future  $-PVIF_s$  for all  $s \geq t$ , allowing for discounting at the future short term UK cash yield from  $s$  back to  $t$ . This amount, which we denote  $EC_t$  and which is subject to a minimum value of zero, represents the amount of capital that must be injected at time  $t$  to ensure that the bank's mortgage book market value balance sheet remains solvent throughout its remaining lifetime.

#### Step 6

The stochastic model is re-run to generate another future scenario and the above computations are recalculated.

#### Step 7

Once the above exercise has been repeated a large number of times, 10,000 times in this example, the  $EC_t$ s are put in increasing order over the 10,000 simulations at each duration  $t$ . The high percentiles of the  $EC_t$ s then determine the economic capital requirements of the bank's mortgage book at each duration  $t$ . For example, the 99.5th percentile represents an estimate of the amount of capital that must be injected at time  $t$  to ensure that, with approximate probability 0.995, the bank's mortgage book market value balance sheet does not go insolvent over its remaining lifetime.

#### Step 8

The Basel 1 and Basel 2 regulatory capital requirements are also calculated, at each duration, for all of the 10,000 stochastic simulations. Average capital requirements, across simulations and for each duration, are then calculated. It is these average regulatory capital requirements that we compare to our stochastically generated economic capital amounts.

We use average regulatory capital requirements in our comparisons for the following reasons:

1. Pillar 1 regulatory capital requirements tend to be calibrated to achieve low probabilities of firm insolvency under normal, or average, economic conditions.

- It is the Pillar 2 regulatory capital requirement that is designed to capture the capital requirements of less normal, or extreme, economic conditions.

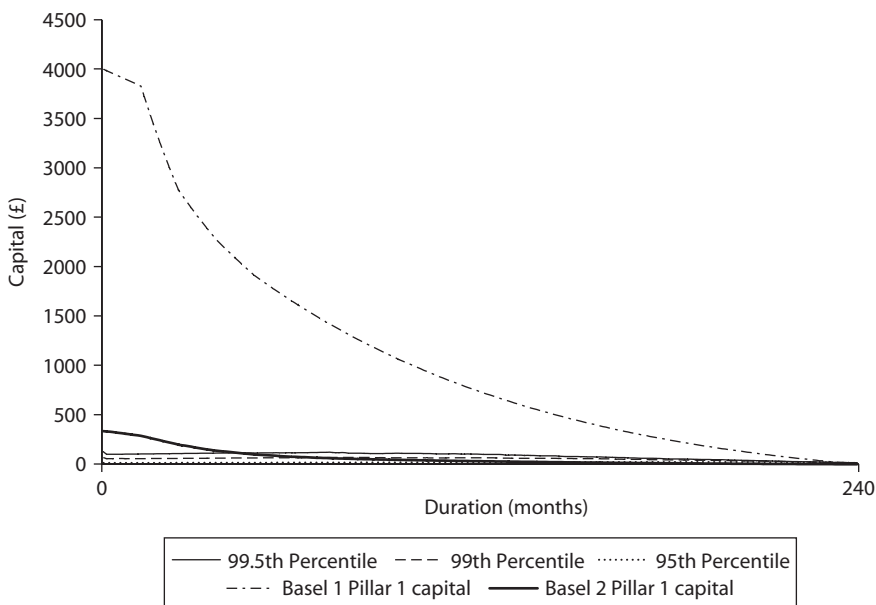
Our results are now described in the following section.

## 8.2.4 Results

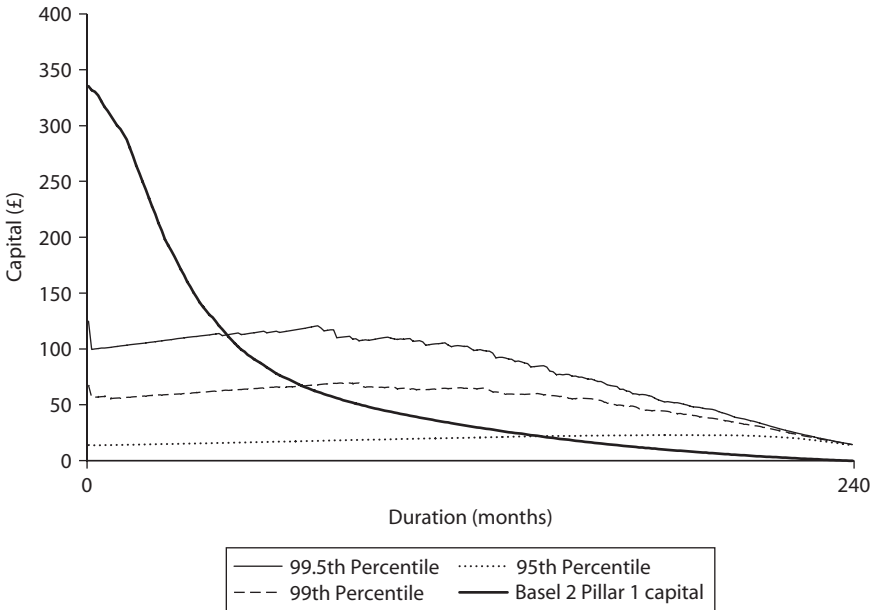
We present results for both capital repayment mortgage and interest only mortgages. Our results are provided graphically in the form of a series of figures. Each figure compares average Pillar 1 regulatory capital requirements, under either the Basel 1 or Basel 2 regimes, with 95th, 99th and 99.5th percentile economic capital, calculated according to the method described in Section 8.2.3.2.

### 8.2.4.1 Base case capital repayment mortgage

From Figure 8.2, we can first observe that the Basel 1 Pillar 1 regulatory capital requirement is far too high, relative to both the Basel 2 Pillar 1 regulatory capital requirement and also relative to economic capital. In order to help see better what is going on, we therefore exclude the



**Figure 8.2** Mortgage book economic capital versus Pillar 1 capital – base case capital repayment mortgage – Basel 1 Pillar 1 capital charge included



**Figure 8.3** Mortgage book economic capital versus Pillar 1 capital – base case capital repayment mortgage

Basel 1 Pillar 1 regulatory capital requirement from our graphical results, which are redisplayed in Figure 8.3.

Figure 8.3 shows that the Basel 2 Pillar 1 capital requirement has the wrong shape, relative to economic capital and, in particular, is far too low, except at the very early durations where it is far too high.

As we shall see later, interest rate margin economic capital is quite a large driver of aggregate economic capital in this example. The Basel 2 Pillar 1 regulatory capital requirement is designed to cover only credit and operational risks and is therefore not expected to cover interest rate margin risks. These risks are covered by the Pillar 2 risk capital assessment, as described in Chapter 14. Nevertheless the gap between Basel 2 Pillar 1 capital and economic capital is large.

It is also worth noting that there is little credit risk in this example. Even though the starting (LTV) on the mortgage is 100%, it is only at the very early durations in the mortgage, when there is a chance that house prices may have fallen, that the firm might incur a loss as a result of credit risks. Once one gets far enough into the mortgage, the general upward trend in house prices that is implicit in the stochastic model makes it unlikely, although not impossible, as we shall see in later examples, that house prices will fall below the value of the loan outstanding.

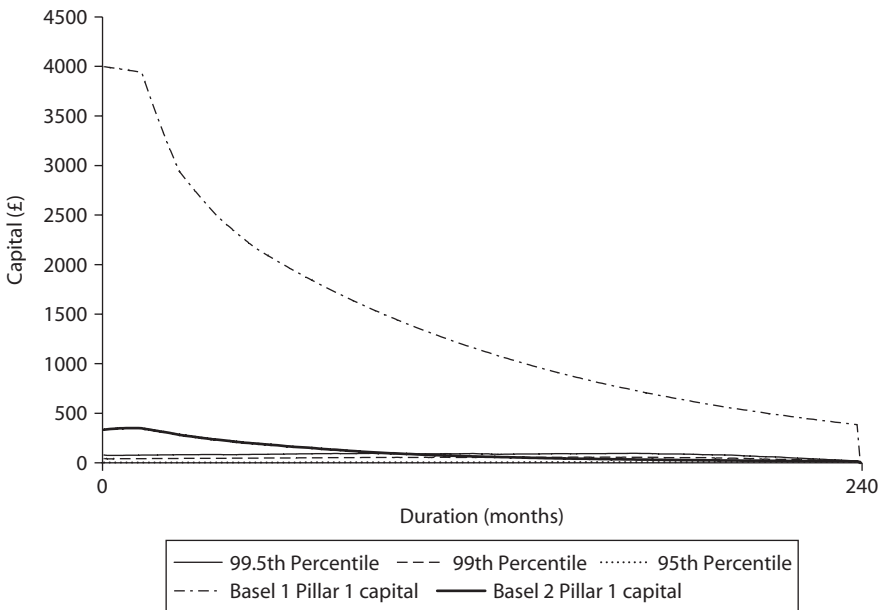
Obviously, if a lower rate of upward trend in house prices is assumed, or higher HPI volatility, then credit risk economic capital will increase. However, we believe that our assumptions, as described in Table 7.11, are reasonable.

### 8.2.4.2 Base case interest only mortgage

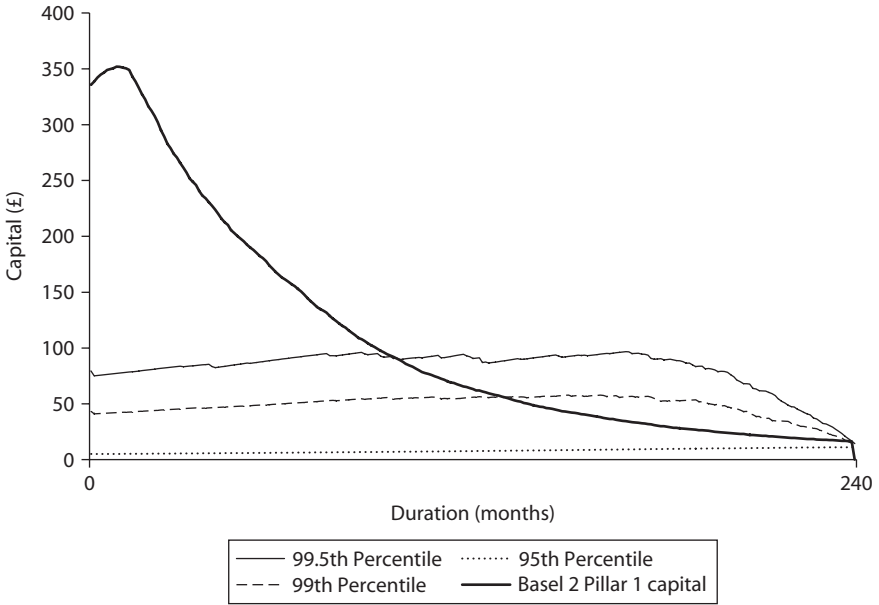
Figures 8.4 and 8.5 show the same results as described above, but this time for an interest only mortgage, rather than a capital repayment mortgage.

The same conclusions apply as regards comparing the Basel 1 Pillar 1 regulatory capital requirement and the Basel 2 Pillar 1 regulatory capital requirement with economic capital. In other words, Basel 1 Pillar 1 capital is far too high and Basel 2 Pillar 1 capital has the wrong shape, being too high in the early part of the projection, and too low in the later part.

The economic capital amounts for the capital repayment mortgage and the interest only mortgage are similar in both size and shape although, as expected, capital repayment mortgage economic capital falls to zero faster. Later examples will, however, highlight larger differences between the two. Hereafter, we will not show the Basel 1 Pillar 1 regulatory capital requirement in our results as, in every case, it is always far too high relative to economic capital.



**Figure 8.4** Mortgage book economic capital versus Pillar 1 capital – base case interest only mortgage – Basel 1 Pillar 1 capital charge included



**Figure 8.5** Mortgage book economic capital versus Pillar 1 capital – base case interest only mortgage

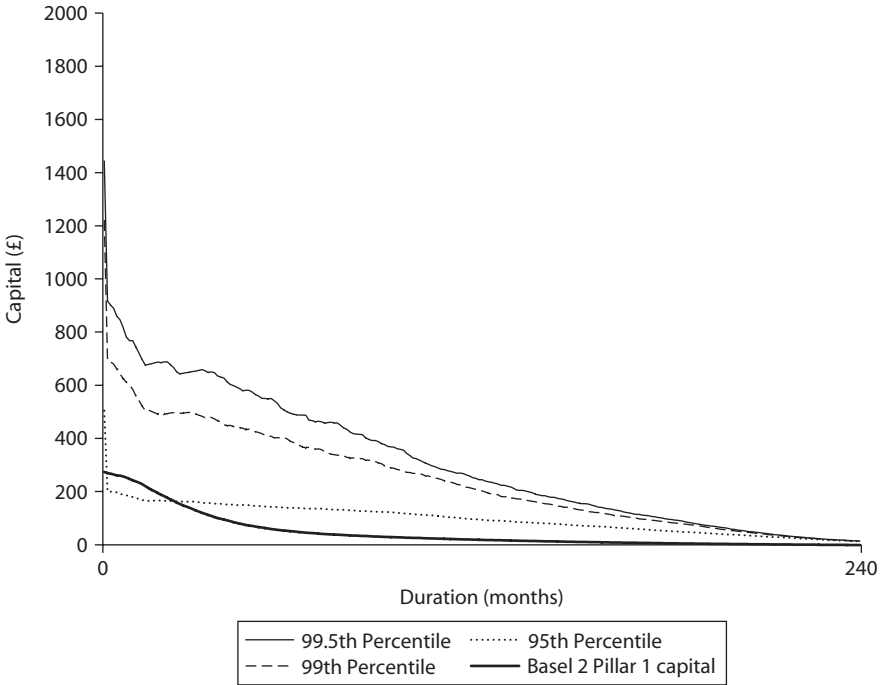
We now move on to show the effect that narrowing the expected interest rate margin has on economic capital for a mortgage book.

### 8.2.4.3 *Capital repayment mortgage with expected mortgage yield decreased by 0.005*

Figure 8.6 shows our results when the expected mortgage yield is reduced by 0.005 to 0.0575.

Comparing Figure 8.6 with Figure 8.3, it can be seen that economic capital has increased significantly as a result of having narrowed our expected interest rate margin. This is entirely as we had anticipated. However, the mismatch between Basel 2 Pillar 1 capital and economic capital is now extremely large, implying that a very significant Basel 2 Pillar 2 capital top up is required. In fact, the mismatch is so large as to question the validity and usefulness of the Basel 2 Pillar 1 capital requirement.

The large spikes in economic capital that occur at duration zero are due to the effect of the initial expenses incurred by the firm in putting the mortgage on its books. In other words, under certain scenarios, as generated by the stochastic model, the future profits that emerge from the mortgage are not adequate to recoup these initial expenses.



**Figure 8.6** Mortgage book economic capital versus Pillar 1 capital – capital repayment mortgage with expected mortgage yield decreased by 0.005

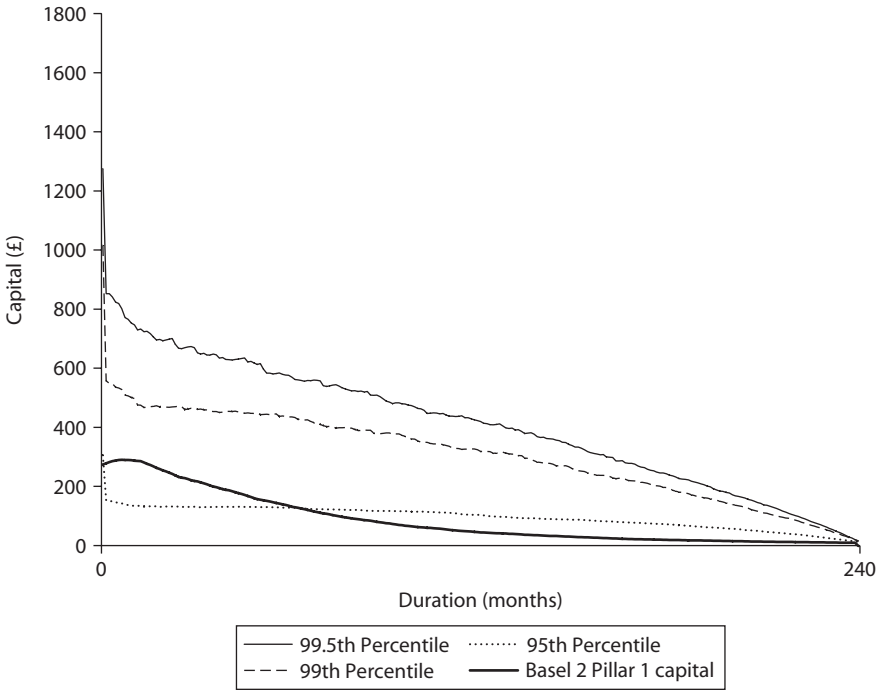
Again, our main conclusion is that the Basel 2 Pillar 1 capital is too low to fully capture the risks that are being run by the firm.

#### **8.2.4.4 Interest only mortgage with expected mortgage yield decreased by 0.005**

Figure 8.7 shows the results of reducing the expected interest rate margin by 0.5% for an interest only mortgage. The conclusions are exactly the same as for the capital repayment mortgage.

#### **8.2.4.5 Capital repayment mortgage with repossession rates increased by a factor of 10**

We now move on to show what effect increasing our assumed repossession probabilities has on economic capital. We have increased our assumed repossession rates by a factor of 10 and our results are shown in Figure 8.8.



**Figure 8.7** Mortgage book economic capital versus Pillar 1 capital – interest only mortgage with expected mortgage yield reduced by 0.005

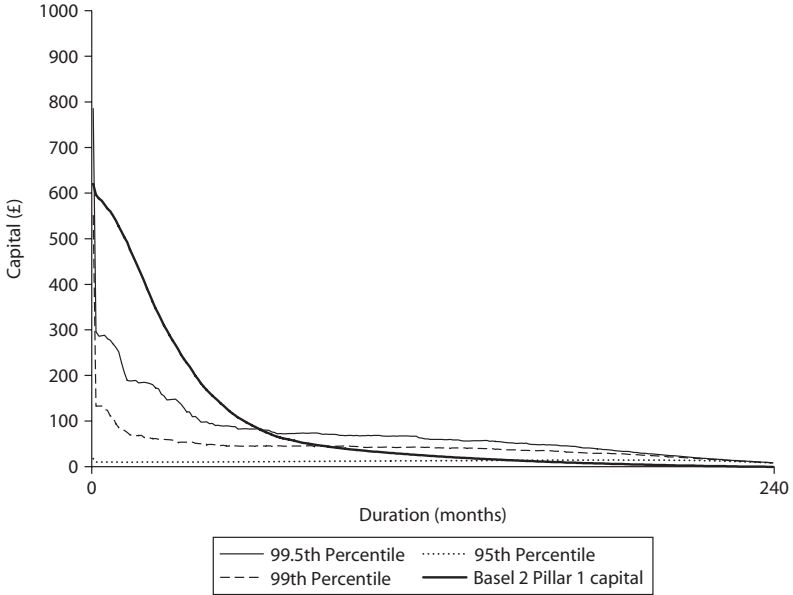
Comparing Figure 8.8 to Figure 8.3, it can be seen that both Basel 2 Pillar 1 capital and economic capital have increased at all durations. However, the same conclusions apply although the shape of Basel 2 Pillar 1 capital is now closer to economic capital.

#### **8.2.4.6 Interest only mortgage with repossession rates increased by a factor of 10**

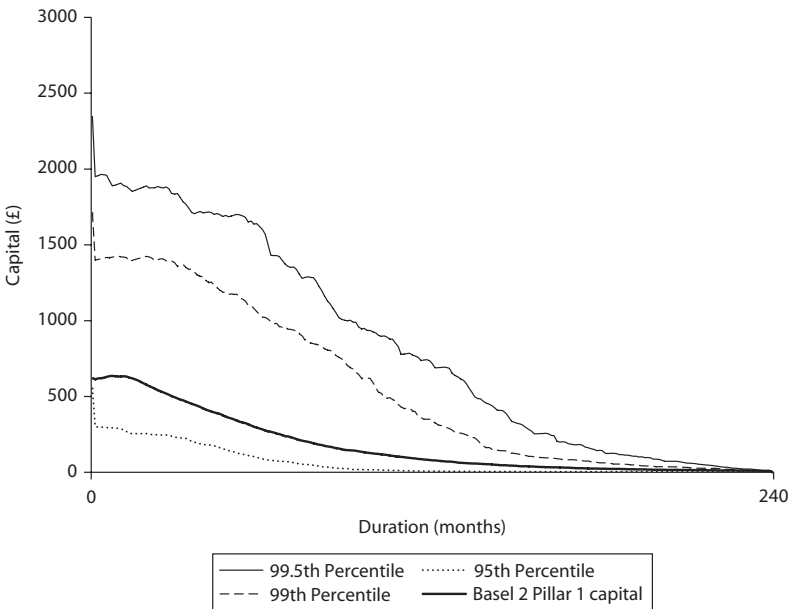
Figure 8.9 shows our results when increasing repossession rates by a factor of 10 for an interest only mortgage.

Comparing Figure 8.9 with Figure 8.5 shows that Basel 2 Pillar 1 capital and economic capital have both increased, as expected, but economic capital has increased by far more at the shorter durations. Basel 2 Pillar 1 capital has the right shape but is far too low, especially at the short durations, relative to economic capital.

Comparing Figure 8.9 with Figure 8.8 shows that interest only mortgage economic capital is now much larger than capital repayment mortgage economic capital. Obviously, the credit risks for an interest



**Figure 8.8** Mortgage book economic capital versus Pillar 1 capital – capital repayment mortgage with repossession rates increased by a factor of 10



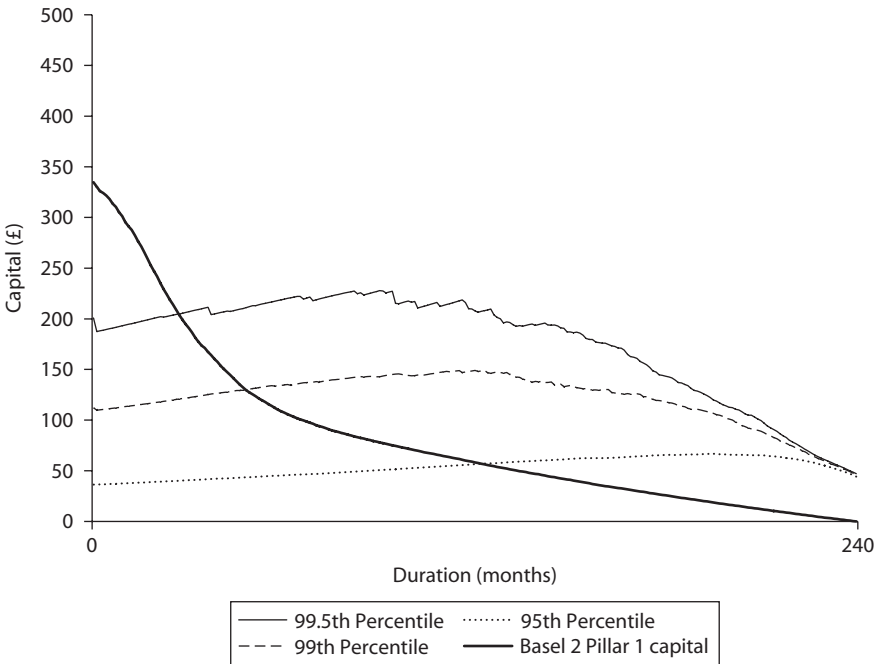
**Figure 8.9** Mortgage book economic capital versus Pillar 1 capital – interest only mortgage with repossession rates increased by a factor of 10

only mortgage will always be higher than for the corresponding capital repayment mortgage, but a certain level of repossession probability is required before this manifests itself through large unexpected credit risk losses and, therefore, economic capital.

Our “Expected” repossession probability assumptions are typical of the UK prime residential lending market at the time of writing. Increasing these probabilities by a factor of ten takes these beyond what would be reasonable for prime lending and they may even be on the high side for sub-prime lending. Nevertheless, the example does show how quickly economic capital can increase with credit risk, particularly for interest only mortgages.

#### 8.2.4.7 Capital repayment mortgage with post duration year 1 prepayment rates reduced by half

Figure 8.10 shows the results of reducing our assumed prepayment rates by half for all durations greater than one year, for a capital repayment mortgage.



**Figure 8.10** Mortgage book economic capital versus Pillar 1 capital – capital repayment mortgage with post duration year 1 prepayment rates reduced by half

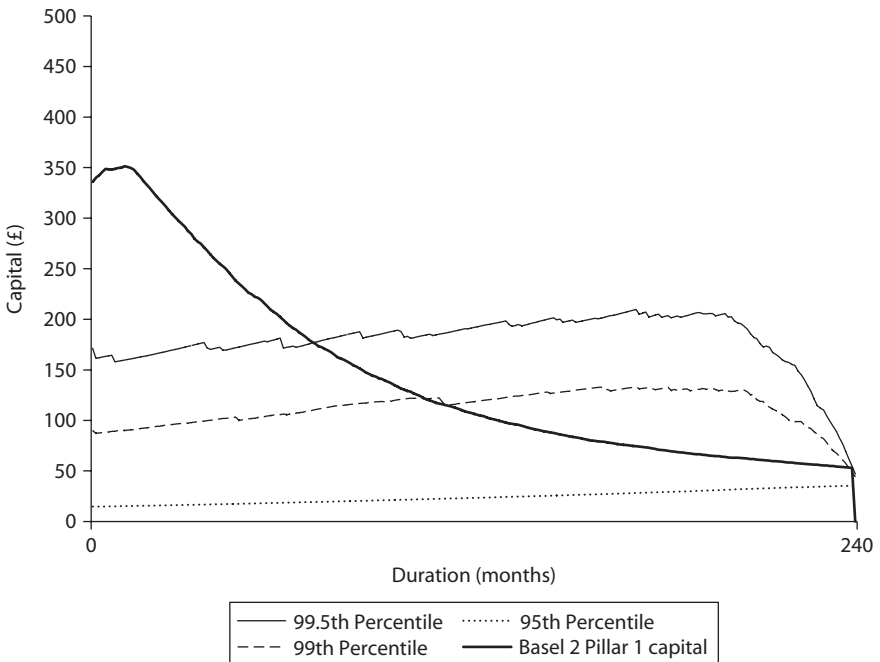
Compared with Figure 8.3, and as expected, Basel 2 Pillar 1 capital and economic capital increase everywhere. This is because lower prepayment rates mean that there is more business on the books at all points in time beyond the first year, and consequently more risk. More risk obviously increases both regulatory capital requirements and economic capital.

As with all of our other examples, however, Basel 2 Pillar 1 capital remains too low relative to economic capital at the medium and longer durations and too high at the shorter durations.

#### 8.2.4.8 Interest only mortgage with post duration year 1 prepayment rates reduced by half

Figure 8.11 shows the results of reducing our assumed prepayment rates by half for all durations greater than one year, for an interest only mortgage.

Compared with Figure 8.5, and as expected, Basel 2 Pillar 1 capital and economic capital increase everywhere. As with the capital repayment mortgage, this is because lower prepayment rates mean that there is more business on the books at all points in time beyond the first year, and consequently more risk, so increasing both regulatory capital requirements and economic capital.



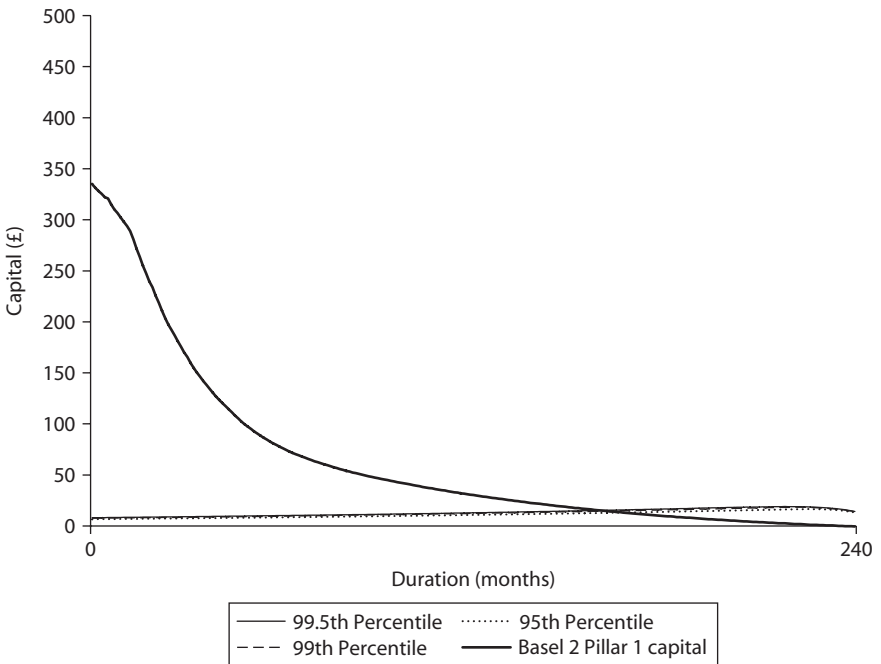
**Figure 8.11** Mortgage book economic capital versus Pillar 1 capital – interest only mortgage with post duration year 1 prepayment rates reduced by half

What is different for the interest only mortgage is that economic capital increases far more at the medium term durations than Basel 2 Pillar 1 capital does. In fact, the economic capital curves change shape to slightly increase, rather than decline, with duration until the longer durations are reached. In other words, reduced prepayment rates, and so increased levels of business on the books, cause risk, and therefore economic capital, to increase with duration until these later durations are reached. Economic capital eventually falls as the business runs off, but this happens relatively late in the projection.

As with our other examples, Basel 2 Pillar 1 capital again has the wrong shape.

#### 8.2.4.9 *Capital repayment mortgage with short term UK cash yield and UK mortgage yield correlation increased to 0.9*

Figure 8.12 shows the effect on economic capital of increasing the correlation between the short term UK cash yield and UK mortgage



**Figure 8.12** Mortgage book economic capital versus Pillar 1 capital – capital repayment mortgage with short term UK cash yield and UK mortgage yield correlation increased to 0.9

yield from 0.6 to 0.9, for a capital repayment mortgage. As a consequence, the standard deviation of the monthly interest rate margin reduces from 0.0067 to 0.0034, so reducing the volatility of the margin.

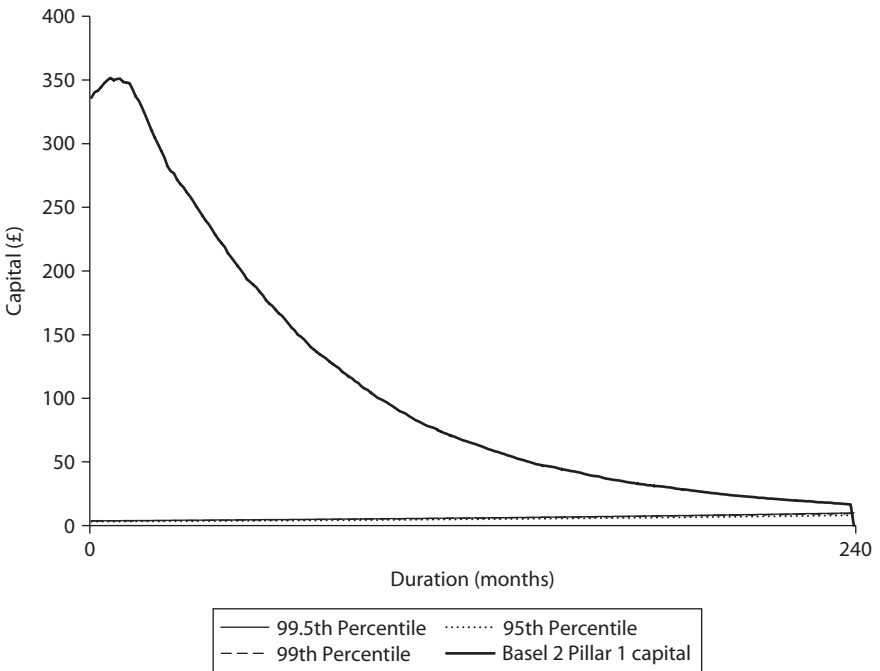
Comparing Figure 8.12 to Figure 8.3 shows that, as expected, economic capital has fallen although, perhaps unexpectedly, the fall is extremely large. The shape mismatch between Basel 2 Pillar 1 capital and economic capital has become even more extreme.

Clearly, and as expected, economic capital for this mortgage example is being driven very strongly by interest rate margin volatility, with credit, persistency and expense risk economic capital being much less significant.

Basel 2 Pillar 1 capital allows only for credit and operational risks.

#### 8.2.4.10 *Interest only mortgage with short term UK cash yield and UK mortgage yield correlation increased to 0.9*

Figure 8.13 shows the effect on economic capital of increasing the correlation between the short term UK cash yield and UK mortgage



**Figure 8.13** Mortgage book economic capital versus Pillar 1 capital – interest only mortgage with short term UK cash yield and UK mortgage yield correlation increased to 0.9

yield from 0.6 to 0.9 for an interest only mortgage. As before, the standard deviation of the monthly interest rate margin reduces from 0.0067 to 0.0034.

Comparing Figure 8.13 to Figure 8.5 shows that, as expected, economic capital has fallen once more. Again, the fall is extremely large and much more so than for the capital repayment mortgage.

The reason for this larger fall is that the  $-PVIF_t$ s for the interest only mortgage, when interest rate margin volatility is low, will tend to be smaller than the corresponding  $-PVIF_t$ s for the capital repayment mortgage. This reflects the higher economic value of the interest only mortgage, as a consequence of its higher average loan size throughout the remaining lifetime of the mortgage, and the relatively low risks that are therefore present.

Relative to economic capital, Basel 2 Pillar 1 capital again has the wrong shape and is generally far too large at all durations.

#### **8.2.4.11 Capital repayment mortgage with stochastic volatilities and correlations**

Figure 8.14 compares Basel 2 Pillar 1 capital with economic capital when the stochastic model with both stochastic volatilities and stochastic correlations included is used, and is parameterized according to Sections 7.4.1 and 7.4.2.

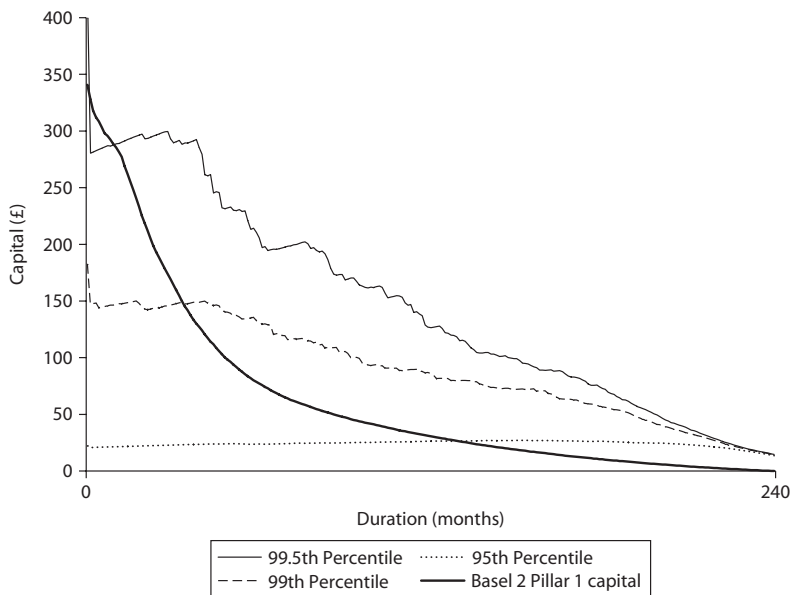
Comparing Figure 8.14 with Figure 8.3, which shows the results for the comparable non stochastic volatility and non stochastic correlation example, it can be seen that, as expected, economic capital increases at all durations.

The size of the increase is significant and is driven by the large jumps in the short term UK cash yield response variable that are now possible when stochastic volatilities and stochastic correlations are included. This results in corresponding large discrete falls in the bank's interest rate margin becoming possible over very short periods of time, and this drives up economic capital.

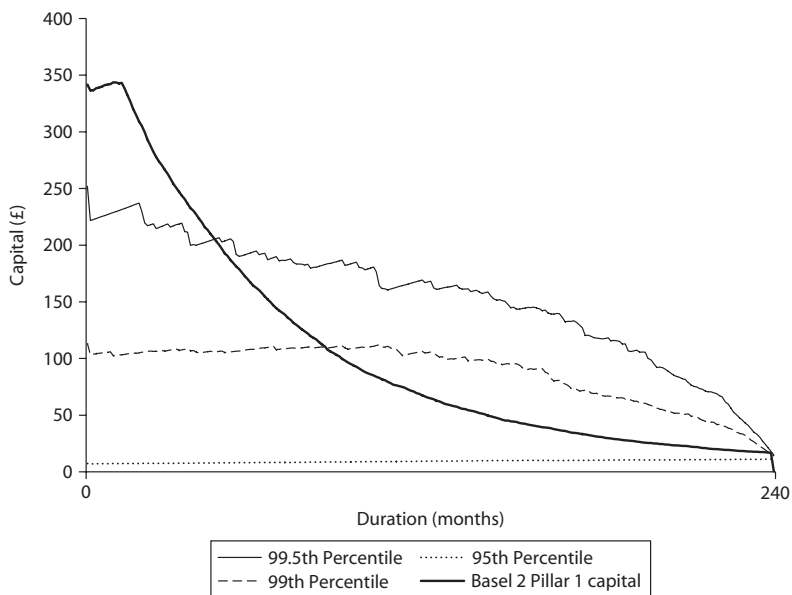
Basel 2 Pillar 1 capital is now too low everywhere relative to economic capital.

#### **8.2.4.12 Interest only mortgage with stochastic volatilities and correlations**

Figure 8.15 compares Basel 2 Pillar 1 capital with economic capital when the stochastic model with both stochastic volatilities and stochastic correlations included is used, and is parameterized according to Sections 7.4.1 and 7.4.2.



**Figure 8.14** Mortgage book economic capital versus Pillar 1 capital – capital repayment mortgage with stochastic volatilities and stochastic correlations



**Figure 8.15** Mortgage book economic capital versus Pillar 1 capital – interest only mortgage with stochastic volatilities and stochastic correlations

Economic capital has again increased, for the same reasons as set out for the capital repayment mortgage above. The same shape mismatch between Basel 2 Pillar 1 capital and economic capital is evident as in the non stochastic volatility and correlation results, shown in Figure 8.5, although Basel 2 Pillar 1 capital is now far too low at the medium durations, as well as the longer durations.

### 8.2.4.13 Rates of return on capital

For each of the 10,000 simulations, and for each example, we have calculated the rate of return earned on capital for each of Basel 1 Pillar 1 capital, Basel 2 Pillar 1 capital, 95th percentile economic capital, 99th percentile economic capital and 99.5th percentile economic capital. We are then able to study the distribution of these rates of returns on capital over the 10,000 simulations.

Summary statistics for our base capital repayment mortgage are shown in Table 8.4.

From Table 8.4 it can be seen that, under each definition of capital, the distribution of the rate of return on capital induced by the stochastic model is very close to Normal. We have checked that the density histograms of the calculated rates of return on capital over the 10,000 simulations confirm this.

Table 8.4 shows that, as expected, Basel 1 Pillar 1 capital rates of return on capital are much lower, on average, than the other rates of return on capital. This is because Basel 1 Pillar 1 capital is higher than economic capital at all percentiles. The relative values of the remaining average rates of return on capital are again very much as expected and reflect the relative sizes of the respective capital requirements.

Table 8.4 also demonstrates the distorting effect that a relatively arbitrary choice of capital measure, such as Basel 1 Pillar 1 capital, has on

**Table 8.4** Rates of return on capital for capital repayment mortgage

	<i>Capital amount</i>				
	<i>Basel 1 Pillar 1</i>	<i>Basel 2 Pillar 1</i>	<i>95th Percentile economic capital</i>	<i>99th Percentile economic capital</i>	<i>99.5th Percentile economic capital</i>
Mean	17%	73%	107%	98%	90%
Standard deviation	5%	31%	51%	46%	42%
Skewness	0.10	0.39	0.63	0.60	0.57
Kurtosis	(0.01)	0.15	0.54	0.47	0.41

**Table 8.5** Rates of return on capital for interest only mortgage

	<i>Capital amount</i>				
	<i>Basel 1 Pillar 1</i>	<i>Basel 2 Pillar 1</i>	<i>95th Percentile economic capital</i>	<i>99th Percentile economic capital</i>	<i>99.5th Percentile economic capital</i>
Mean	17%	73%	105%	84%	68%
Standard deviation	5%	30%	49%	38%	30%
Skewness	0.14	0.36	0.68	0.60	0.53
Kurtosis	0.41	0.58	1.40	1.17	1.01

risk unadjusted financial returns. If 99.5th percentile economic capital is the appropriate amount of capital that the firm should be holding to cover the risks it is running, the product is earning, on average, a post-tax rate of 90% on that capital. This compares with an average rate of 17% earned on Basel 1 Pillar 1 capital and this is a significant differential.

The Basel 2 Pillar 1 capital rate of return on capital is fairly close to the 99.5th percentile economic capital rate but, as can be seen from Figure 8.3, this is completely fortuitous. Basel 2 Pillar 1 capital, as we have seen, has the wrong shape relative to economic capital.

Summary statistics for our base interest only mortgage are shown in Table 8.5.

Similar conclusions apply, although the distributions of rates of return on economic capital are more peaked, or fat tailed.

### 8.2.5 Comparison of deterministic and stochastic examples

The deterministic and stochastic examples discussed above are very different and, consequently, are quite difficult to compare. However, it is worth noting in passing that they do give the same qualitative conclusions.

For Pricing Basis 2, the nearest deterministic pricing to our base case stochastic examples, the deterministic example shows that economic capital is around 73% of Basel 2 Pillar 1 capital at duration 1 month. For our base case stochastic example, 99.5th percentile economic capital represents around 26%, on average, of Basel 2 Pillar 1 regulatory capital at duration 1 month.

So both examples, even though they are very different, give the same qualitative conclusion at month one that Basel 2 Pillar 1 capital may be on the high side, given the risks that these banking firms are running.

## 8.3 STOCHASTIC WHOLESALE BANK EXAMPLE

We now move on to consider an example, which has a less retail focus, although the underlying product, a lifetime mortgage is still a retail product. We first describe the product itself and then the corporate structure of the firm.

### 8.3.1 Lifetime mortgage products

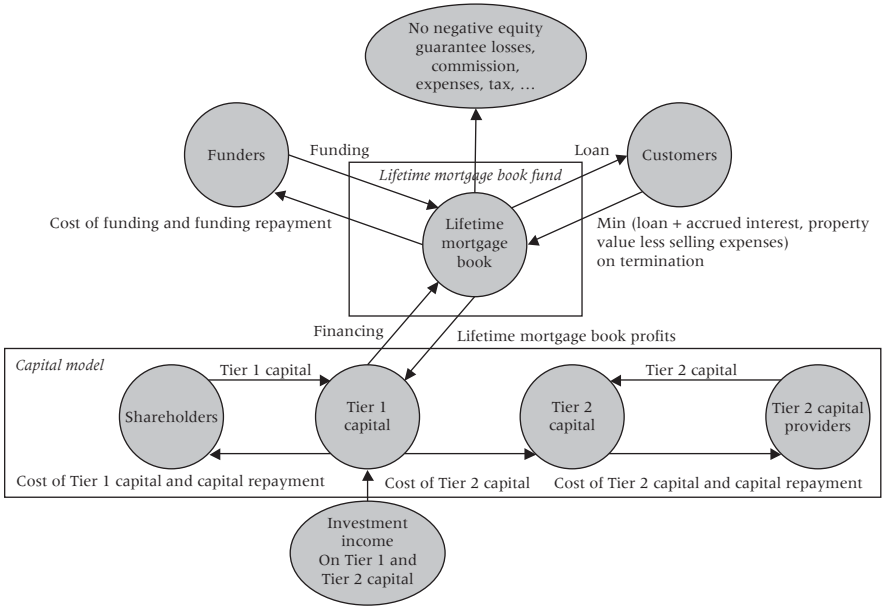
This type of product is aimed at older, asset rich, income poor, customers, typically aged over 65. The product is used by these customers to release equity, or value, from their homes without them having to sell and leave the home. Therefore, for example, customers may use the released equity to supplement their pensions, or to fund luxury items that they may not otherwise be able to afford.

With this type of mortgage, the interest rate is usually fixed, or sometimes capped, and interest is rolled up, or accumulated, within the mortgage to be repaid on mortgage termination. Compared to normal residential mortgages, loans tend to represent relatively low proportions of the value of the customers' property. The mortgage is usually taken out by joint lives and is terminated once both of the lives have either died, or have entered into long term care (LTC). The mortgage may also be voluntarily repaid at any time but, just like a regular fixed rate mortgage, redemption penalties tend to apply in the early years of the mortgage.

As the rate of interest on the loan is typically well in excess of the expected rate of house price growth, if the mortgage runs for long enough, the value of the loan will, almost certainly, overtake the value of the house against which it is secured. The mortgages therefore carry a no negative equity guarantee (NNEG) which ensures that, on termination, the customers, or their estates, never owe more than the sale value of the property, less reasonable selling expenses.

Initial LTVs therefore tend to be much lower on lifetime mortgages than for conventional mortgages, as this helps to control and mitigate the NNEG risk. Note that lifetime LTVs increase with the ages of the customers at loan completion. This is because, as the expected duration of the mortgage reduces as these ages increase, this reduces the chances of the NNEG biting, and so allowing the awarding of higher LTVs for older customers.

The UK actuarial profession has carried out a number of detailed studies on lifetime mortgages and also on the general UK equity release market. These studies are available on the profession's website [www.actuaries.org.uk](http://www.actuaries.org.uk).



**Figure 8.16** Lifetime mortgage firm corporate structure

### 8.3.2 Lifetime mortgage firm corporate structure

The lifetime mortgage firm corporate structure we have assumed for this example is shown in Figure 8.16.

Broadly speaking, two corporate structure models are currently used by firms in the UK market as follows:

#### *The bank model*

With this model banks, or building societies, write the lifetime mortgage on their own balance sheet, and take all of the risks associated with the product. The lifetime mortgage is also funded by the bank. This results in an initial cash flow strain, as the lifetime mortgages do not generate any income until they start terminating, which may occur many years after the mortgage is sold. The NNEG risk, which is essentially a life insurance risk, tends to be ignored and is not reserved for.

#### *The life insurance model*

With this model, the lifetime mortgage is written by a non bank finance firm subsidiary of a life insurance firm. The life insurance firm provides funding for the lifetime subsidiary firm and insures the NNEG risk in

exchange for a life insurance premium. Once the lifetime subsidiary firm has generated enough volume, typically at least £250 million of mortgages, the lifetime loans are transferred into a SPV and securitized into the debt capital markets. At the time of writing in 2005, the UK life insurance firm, Norwich Union, is the market leader with this business model and Norwich Union has been able to securitize all risks associated with its lifetime mortgages into the debt capital markets.

The lifetime mortgage firm corporate structure model that we have assumed covers both the banking firm model and also the life insurance firm model, after the lifetime mortgage loans have been securitized.

### 8.3.3 Stochastically modeled response variables

We assume that the lifetime mortgage interest rate is fixed at 0.07 p.a. and use the stochastic model described in Chapter 7, parameterized according to Table 7.11, to generate the stochastic elements of the example. The full detailed set of assumptions that we have used to model this product are set out in Appendix 8.3.

In particular, we model the response variables, and derived variables, stochastically as described below:

1. We assume that the lifetime mortgage firm funds the mortgages itself, or using the securitization markets, and that the cost of this funding equals the short term UK cash yield, as generated by the stochastic model, plus 75 bp. It is assumed that this funding is available, at the same cost, to fund the liquidity requirements of the lifetime mortgage firm in the early years when the business is cash flow negative.
2. It is assumed that the resultant asset/liability interest rate mismatch risk is unhedged and is borne by the lifetime mortgage firm.
3. From Table 7.11, it can be seen that the bank's expected interest rate margin equals  $0.0700 - 0.0475 - 0.0075 = 0.0150$ . This is reasonably representative of the UK lifetime mortgage market at the time of writing. The corresponding interest rate margin monthly standard deviation, under the Table 7.11 parameterization, and which is driven by the short term UK cash yield, is 0.0075. In the numerical results presented below, we will vary the expected interest rate margin to demonstrate the effect that this has on the firm's economic capital.
4. It is assumed that the bank's fixed expenses increase in line with UK RPI, as generated by the stochastic model.

5. Both “Expected” and “High” levels of aggregate prepayment/LTC rates are modeled, although the levels are set to be the same during the first five years of the product when early redemption charges apply. It is assumed that these charges stop the majority of customers prepaying in the early years. The High levels are assumed to apply when short term UK cash yields are “low,” as described in Appendix 8.3. In other words, low short term UK cash yields cause high aggregate prepayment/LTC rates as new lifetime mortgage products come onto the market at cheaper rates, so causing lifetime mortgage customers to remortgage onto these cheaper products.
6. Stochastic mortality improvement factors are used, based on “cohort” mortality, where future male and female mortality improvement rates are assumed to follow a simple stochastic process, with the mean rate of improvement increasing each year, up to a maximum mean improvement rate of 0.075 p.a.
7. The value of the customers’ property is estimated as its starting value, increased in line with the derived property capital index growth, as generated by the stochastic model. The NNEG bites if the value of the property, less selling expenses of 5% of the property value, is less than the customers’ loan rolled up at 0.07 p.a., on termination. If the NNEG benefit bites, it is the lifetime mortgage firm itself that bears the cost.
8. The lifetime mortgage Pillar 1 regulatory capital requirement is calculated as 1% of the accumulated loan outstanding at any point in time. This is the regulatory capital requirement for a UK non bank finance company. The capital requirement for the SPV under the life insurance model above will, in practice, depend on the ratings that debt investors require on the securitization bonds issued by the SPV.

Therefore, based on the stochastic elements of this example, the economic capital amount that is generated by the stochastic model is the amount of capital required by the lifetime mortgage firm to cover its aggregate:

1. Interest rate margin risks
2. Interest rate risks
3. Expense risks
4. Prepayment/LTC risks
5. NNEG risks, which are a combination of house price inflation and mortality risks.

The method described in Section 8.2.3.2 is used to determine stochastic economic capital.

### 8.3.4 Results

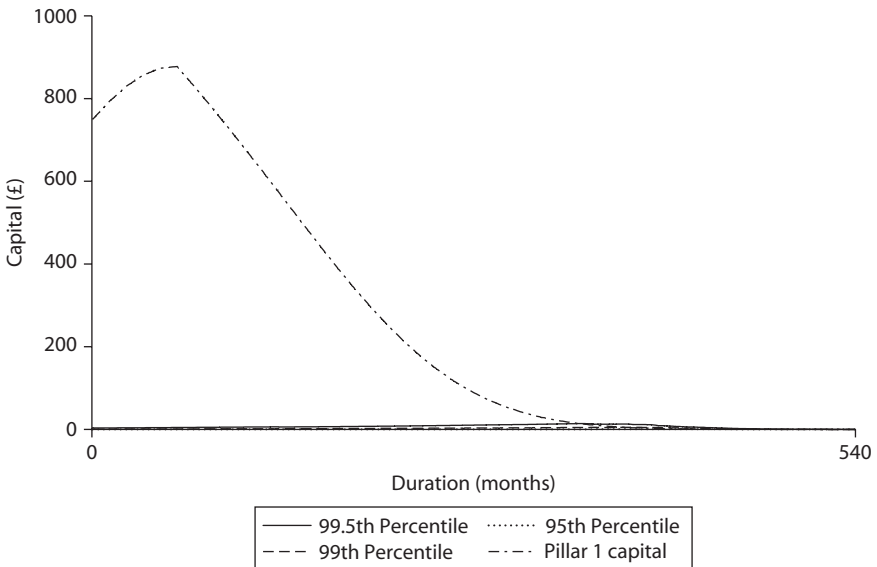
Our results are provided graphically in the form of a series of figures. Each figure compares average Pillar 1 capital with 95th, 99th and 99.5th percentile economic capital calculated according to the method described in Section 8.2.3.2.

#### 8.3.4.1 Base case example

Results for our base case example are shown in Figure 8.17.

From this Figure we can see that the Pillar 1 capital has the wrong shape, being far too high, relative to economic capital, throughout the term of the projection.

Note that, as the assumed aggregate prepayment/LTC rates are relatively high at durations  $\geq 6$  years, once the prepayment penalties have ceased, this causes the business to run off quite fast after that point. This explains why all of the capital requirements fall quite rapidly from year 6 onwards.



**Figure 8.17** Lifetime mortgage book economic capital versus Pillar 1 capital – base case

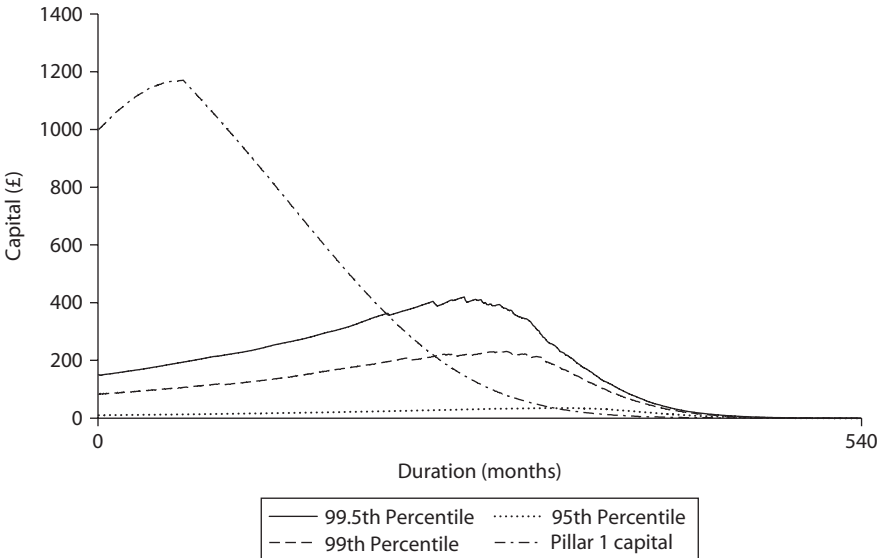
### 8.3.4.2 Initial LTV increased to 40% from 30%

Figure 8.18 compares Pillar 1 capital with economic capital when the initial LTV under the product is increased to 40% from 30%.

It can be seen that the Pillar 1 capital shape is, as expected, essentially unaltered. Economic capital has, however, increased quite dramatically. This is because the higher starting LTV results in much larger NNEG losses being incurred by the firm, with these losses occurring at the later durations.

Economic capital rises steadily to a peak, and then falls. This is because, if we work backwards from the end of the projection

- The  $EC_{t,s}$ , as described in Section 8.2.3.2, rise with reducing duration  $t$  as there are more opportunities for large values of  $-PVIF_s$  for  $s > = t$ .
- As duration  $t$  falls, there comes a point,  $t^*$ , when opportunities for large  $-PVIF_s$ , for  $s > = t$ , do not increase. This is because, before  $t^*$ , the accumulated loan will generally fall below the value of the customers' property, so eliminating NNEG losses at these shorter durations. So, the large  $-PVIF_t$  generally occur at durations  $s > t^*$  and discounting back to  $t < t^*$  then causes the  $EC_{t,s}$  to fall with reducing duration  $t$ .



**Figure 8.18** Lifetime mortgage book economic capital versus Pillar 1 capital – initial LTV increased to 40%

We are also able to conclude from Figure 8.18 that Pillar 1 capital is far too low at these longer durations.

Note also that, economic capital peaks at around duration 21 years, roughly 5 years in advance of when a 40% LTV loan growing at 0.07 p.a. equals the value of a house growing at an expected rate of 0.0325 p.a. This is very plausible, as economic capital will be driven by those scenarios where rents are growing at less than the expected rate of 0.0325.

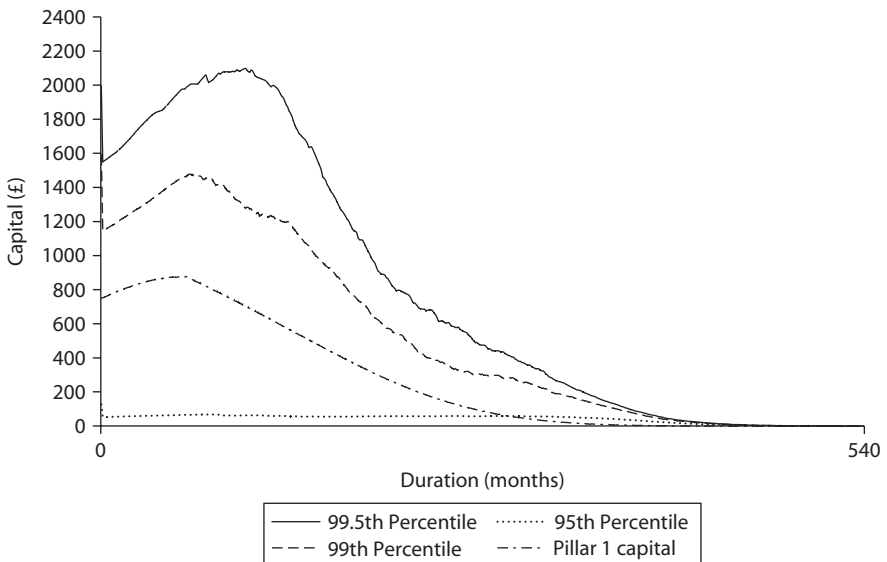
### 8.3.4.3 Expected funding cost increased by 75 bp

Figure 8.19 compares Pillar 1 capital with economic capital when the firm's expected cost of funding increases by 75 basis points (0.0075).

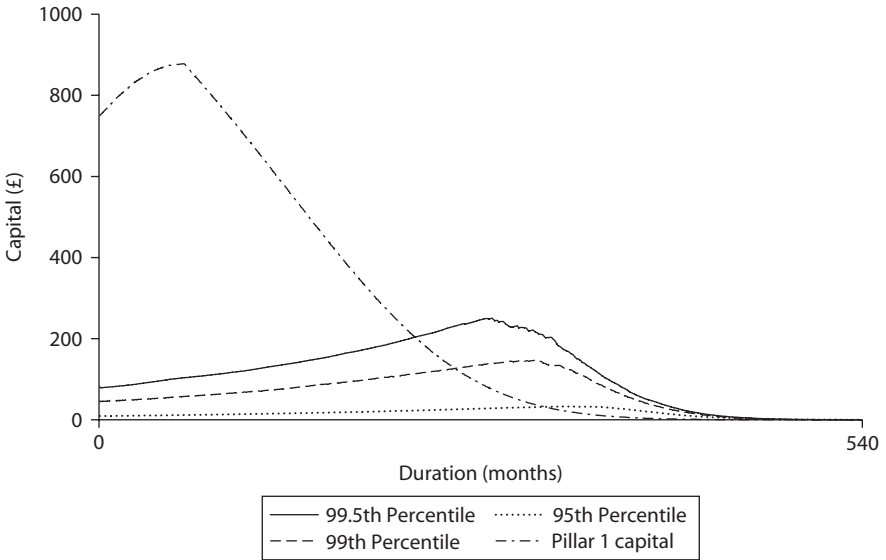
Economic capital increases very dramatically at all durations and is well in excess of Pillar 1 capital at all times. This is because, at all durations, the potential for future losses has increased significantly as a result of the lower expected margin that is available to cover the firm's costs.

### 8.3.4.4 Property expected rental growth reduced to 0.0225 p.a.

Figure 8.20 compares Pillar 1 capital with economic capital when the expected property rental growth assumption in our stochastic model is reduced from 0.0325 p.a. to 0.0225 p.a.



**Figure 8.19** Lifetime mortgage book economic capital versus Pillar 1 capital – funding cost increased by 75 bp



**Figure 8.20** Lifetime mortgage book economic capital versus Pillar 1 capital – property rental growth reduced to 0.0225 p.a.

As expected, because NNEG losses are now more likely, as compared to the base case example, economic capital increases. Pillar 1 capital again has the wrong shape and is too low at the later durations.

#### **8.3.4.5 Mortality improvement factor upper limit increased to 0.15 p.a.**

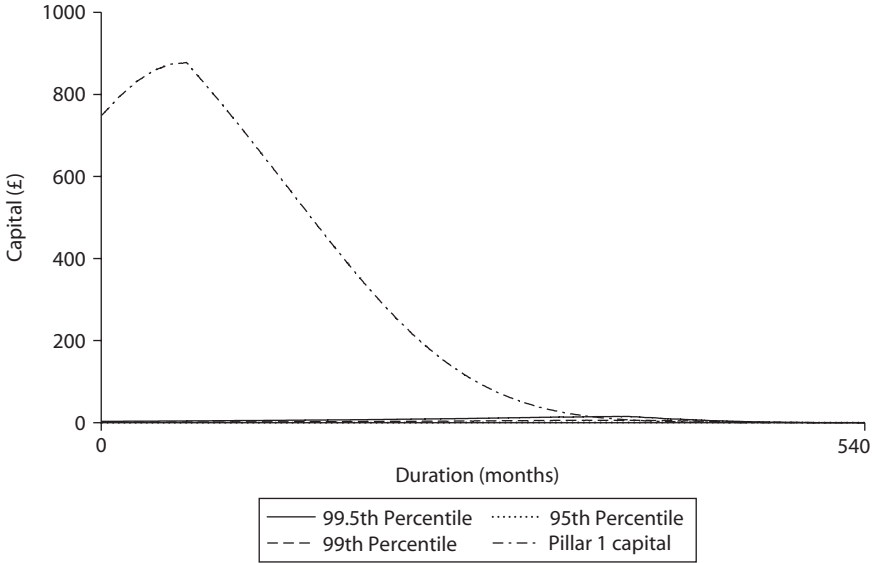
Figure 8.21 compares Pillar 1 capital with economic capital when the expected annual mortality improvement factors are allowed to increase up to a maximum level of 0.15 p.a., rather than the base case level of 0.075 p.a.

Comparing Figure 8.21 to our base case results in Figure 8.17 shows that economic capital is essentially unaltered by the change to the mortality improvement factors.

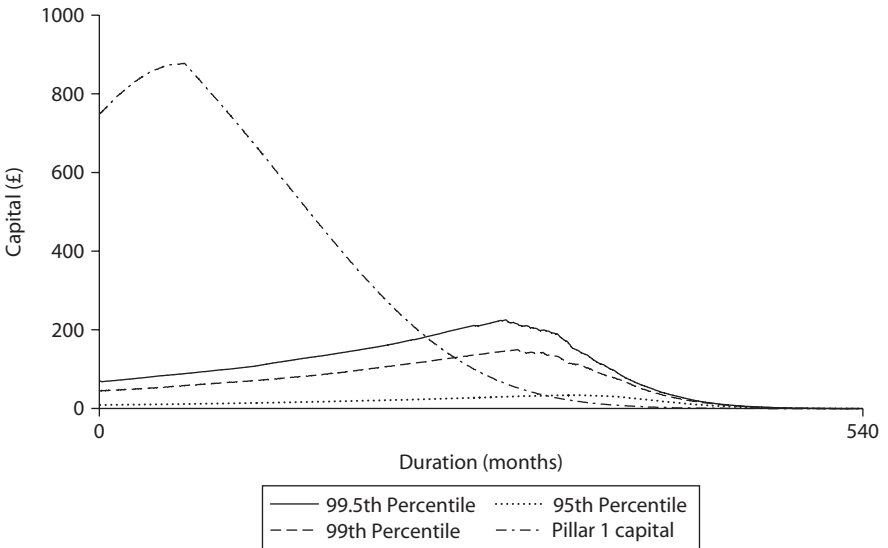
This is because this change does not impact our results until the projections have been running for at least ten years and, by which time, much of the lifetime mortgage business has run off due to the high aggregate prepayment/LTC rates that apply beyond the first five years of the projection.

#### **8.3.4.6 Expected property rental growth reduced to 0.0225 p.a. and mortality improvement factor upper limit increased to 0.15 p.a.**

Figure 8.22 compares Pillar 1 capital with economic capital when the expected property rental growth assumption in the stochastic



**Figure 8.21** Lifetime mortgage book economic capital versus Pillar 1 capital – mortality improvement factor upper limit increased to 0.15 p.a.



**Figure 8.22** Lifetime mortgage book economic capital versus Pillar 1 capital – expected property rental growth reduced to 0.0225 p.a. and mortality improvement factor upper limit increased to 0.15 p.a.

model is reduced from 0.0325 p.a. to 0.0225 p.a. and the expected annual mortality improvement factors are allowed to increase up to a maximum level of 0.15 p.a., rather than the base case level of 0.075 p.a.

Comparing Figure 8.22 with Figure 8.20, although it is difficult to see from the graphs themselves without having access to the underlying capital values, shows that economic capital when both the expected property rental growth assumption is reduced and lighter mortality is assumed, increases at the longer durations and decreases at the medium and shorter durations, relative to economic capital when only the property rental growth assumption is reduced.

This is because, at the longer durations, when losses start to be incurred as a consequence of the NNEG biting, there is more business in force, so resulting in larger losses and inflating economic capital at these durations.

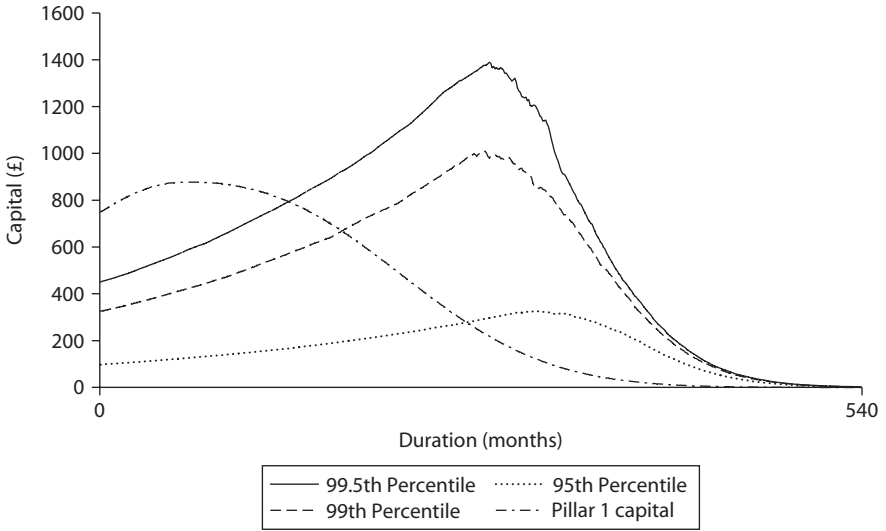
At the medium durations, when profits are still being earned because the NNEG is not yet biting, the additional in force business, and so larger profits, has the effect of more than compensating for the larger losses that are incurred at the later durations. The net effect is that economic capital reduces as these larger profits more than make up for the larger losses incurred later.

#### **8.3.4.7 Expected property rental growth reduced to 0.0225 p.a., mortality improvement factor upper limit increased to 0.15 p.a. and the duration $\geq$ 6 year prepayment/ltc rates halved**

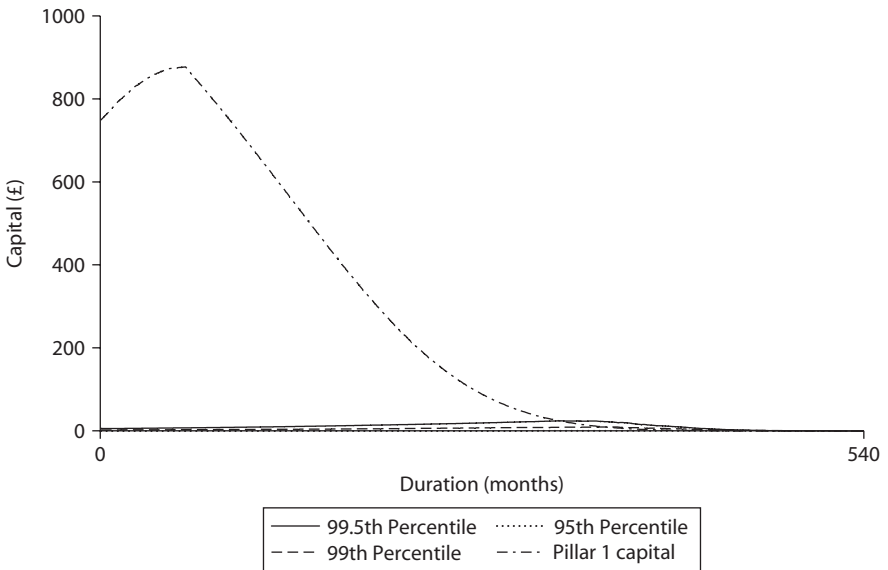
Figure 8.23 compares Pillar 1 capital with economic capital when the expected property rental growth assumption in the stochastic model is reduced from 0.0325 p.a. to 0.0225 p.a., the expected annual mortality improvement factors are allowed to increase up to a maximum level of 0.15 p.a. and the duration  $\geq$  6 year prepayment/LTC rates are halved.

Comparing Figure 8.23 to Figure 8.22 shows that if the prepayment/LTC rates are halved, this causes economic capital to increase very substantially. This is because the additional business that is in force at the later durations, when the firm's profits are negative due to the NNEG benefit biting, dominates the effect of the additional business that is in force when the firm's profits are positive.

We can also conclude that Pillar 1 capital is far too low relative to economic capital at medium and later durations.



**Figure 8.23** Lifetime mortgage book economic capital versus Pillar 1 capital – expected property rental growth reduced to 0.0225 p.a., mortality improvement factor upper limit increased to 0.15 p.a. and duration  $\geq 6$  year prepayment/LTC rates halved



**Figure 8.24** Lifetime mortgage book economic capital versus Pillar 1 capital – stochastic volatilities and stochastic correlations

### 8.3.4.8 Stochastic volatilities and correlations

Figure 8.24 compares Pillar 1 capital with economic capital when we use the stochastic model with both stochastic volatilities and stochastic correlations included, parameterized according to Sections 7.4.1 and 7.4.2.

Comparing Figure 8.24 with Figure 8.17, which gives the results for the comparable non stochastic volatility and non stochastic correlation example, it can be seen that, as expected, economic capital increases at all durations. Although the size of the increase is small in absolute terms the relative increase is large and amounts to a doubling of economic capital at many durations.

This is mainly due to the increased volatility of the cost of funding assumption, which is driven by short term UK cash yields.

### 8.3.4.9 Rate of return on capital

For each of the 10,000 simulations, and for each example, we have also calculated the rate of return earned on capital for each of Pillar 1 capital, 95th percentile economic capital, 99th percentile economic capital and 99.5th percentile economic capital. We can then study the distribution of these rates of return on capital over the 10,000 simulations.

Summary statistics for our base case lifetime mortgage example are shown in Table 8.6.

From Table 8.6, it can be seen that the mean rates of return on capital are all very high, for each definition of capital, and the corresponding standard deviations of the rates of return on capital are all low. The product, at this pricing, is therefore very attractive financially for the firm.

**Table 8.6** Rates of return on capital for base case lifetime mortgage example

	<i>Capital amount</i>			
	<i>Basel 1 Pillar 1</i>	<i>95th Percentile economic capital</i>	<i>99th Percentile economic capital</i>	<i>99.5th Percentile economic capital</i>
Mean	26%	40%	40%	40%
Standard deviation	4%	6%	6%	6%
Skewness	(0.54)	(0.60)	(0.60)	(0.59)
Kurtosis	1.42	1.65	1.65	1.64

**Table 8.7** Rates of return on capital lifetime mortgage example with expected cost of funding increased by 75 bp

	<i>Capital amount</i>			
	<i>Basel 1 Pillar 1</i>	<i>95th Percentile economic capital</i>	<i>99th Percentile economic capital</i>	<i>99.5th Percentile economic capital</i>
Mean	17%	26%	15%	13%
Standard deviation	6%	9%	5%	4%
Skewness	(0.67)	(0.88)	(0.55)	(0.48)
Kurtosis	0.70	1.71	0.29	0.12

It can also be seen that the distributions of the rates of return on capital are negatively skewed, and are more fat tailed, than they would be if they were Normally distributed. We can conclude, therefore, that, overall, the distributions of the rates of return on capital under this product are very favorable.

For comparison, we have included the corresponding results for the lifetime example where the expected cost of funding was assumed to have increased by 75 bp. This is the example where our economic capital amounts are largest. The rate of return on capital results are shown in Table 8.7.

Compared to Table 8.6, the mean rates of return on capital are all much lower, but still have low standard deviations. As expected, the product is less attractive with this pricing, although the returns are, arguably, still acceptable.

The rates of return on 99th and 99.5th percentile economic capital are close to being Normally distributed. However, the distributions of the rate of return on Pillar 1 capital and 95th percentile economic capital are negatively skewed and fat tailed, relative to a Normal distribution.

## 8.4 SUMMARY

In this chapter we have calculated both deterministic and stochastic economic capital for several banking applications and have compared this to the corresponding Pillar 1 regulatory capital requirements. Stochastic economic capital was determined using the stochastic model developed in Chapter 7.

Our results show that the Pillar 1 regulatory capital requirements are generally very poor approximations to economic capital and we illustrated the misleading impact that this can have on performance measurement. Obviously, these results and conclusions have quite serious implications for banks themselves, regulators, bank customers and shareholders.

We now move on to consider in Chapter 9 a number of insurance economic capital applications.

# Non Profit Life and General Insurance Firms

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## 9.1 INTRODUCTION

In this chapter, we consider economic capital for non profit life insurance firms and general insurance firms. With profits life insurance firms and pension funds are very different and more complex than non profit life insurance and general insurance firms. We, therefore, discuss their economic capital requirements separately in Chapter 11.

Obviously, the range and type of both insurance products and firms is enormous. For these reasons, we focus our attention on those products and firms that we consider to be of most importance in the market, and for which we also have some experience. The principles and methods that we discuss, however, are applicable to any type of insurance product or firm.

Traditional protection life insurance, such as term insurance or annuities, is covered in Section 9.2, which deals with what we term “non profit” life insurance. This business is “non profit” in the sense that the price of the life insurance product is fixed at the point of sale and the customer does not share in any potential experience profits or surpluses that may emerge thereafter, unlike with profits business.

With profits life insurance business is discussed in full detail in Chapter 11.

The main type of long term savings life insurance business, besides with profits, is unit linked business, which is another type of non profit life insurance. Here customer premiums, net of charges, are invested in a range of investment linked funds by purchasing units in those funds. The customer’s fund is individually identified by the number of units that they hold in each investment linked fund. The choice of which fund to invest in is usually made by the customer, following advice from their

financial adviser. The cost of any associated life insurance is typically charged for via a monthly deduction from the customer's fund. Unit linked business is covered in Section 9.3.

General insurance business, such as motor, house buildings and contents and short term health insurance, such as private medical insurance, is dealt with in Section 9.4.

## 9.2 TRADITIONAL NON PROFIT LIFE INSURANCE

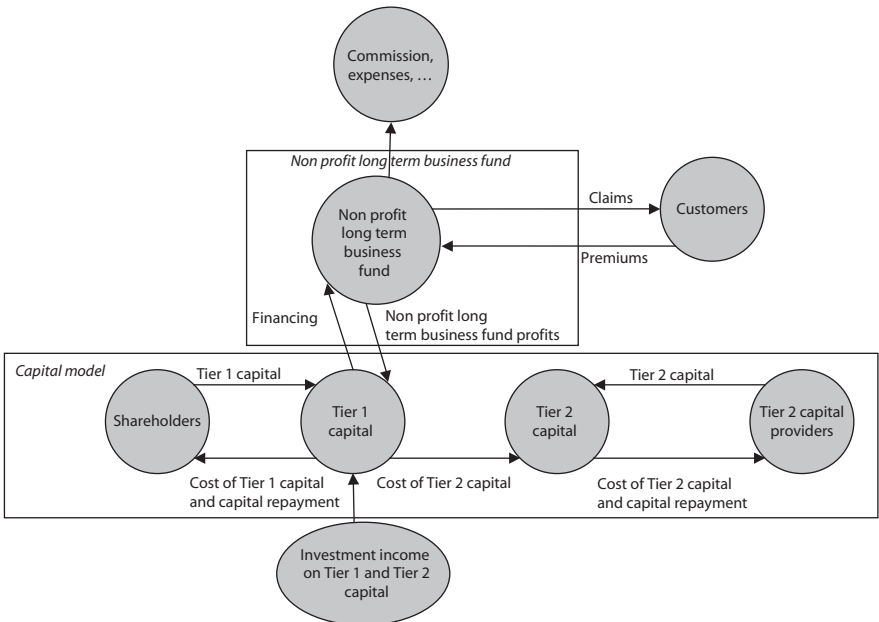
We now move on to consider, both deterministic, and stochastic examples of non profit life insurance firm economic capital.

We first set out the corporate structure that we have assumed for these examples. As with all of our examples, the corporate structure that we use follows the same broad model as shown in Figure 9.1.

All of the important cashflows for our non profit life insurance firm examples can also be seen in this Figure.

### 9.2.1 Deterministic annuity life insurance firm example

This first example is based on a life insurance firm whose non profit long term business fund (NPLTBF) is made up of £1 billion of annuities.



**Figure 9.1** Annuity life insurance firm corporate structure

Annuities are products that allow customers to convert a cash lump sum into an income that is guaranteed to be paid for the lives of the customers.

There is a huge variety of annuities that are available to customers, for example:

- The annuity can be written on the life of a single customer, or may be written on joint lives, either on a joint life first death basis (the annuity ceases on the death of the first of the customers to die) or a joint life last survivor basis (the annuity ceases on the second customer's death).
- The annuity income can be level, guaranteed to increase at a prescribed annual rate, or guaranteed to increase in line with inflation, defined relative to a retail price index.
- For joint life annuities, the income may reduce on the death of the first named customer.

The NPLTBF is the internal policyholder fund that contains the assets backing the annuity business and must, at all times, comprise of assets equal to at least the amount of the annuity business mathematical reserves. Mathematical reserves are the reserves that actuaries set up to cover life insurance liabilities.

The annuity products that we have chosen to model are described in Appendix 9.1. Although our example is relatively “simple”, the base case assumptions that underlie our example are quite detailed.

We calculate economic capital for the life insurance firm using the deterministic stresses set out in Table 9.1.

We believe that these stresses represent a reasonable compromise between risk events that are unexpected, yet could still conceivably occur in practice. These response variables are, we believe, the most important variables to consider for pensions annuity business. Ultimately, the choice of which stresses to use will always involve a certain amount of judgment, however.

**Table 9.1** Deterministic stresses – annuity example

<i>Stress</i>	<i>Fixed expenses</i>	<i>Mortality improvements</i>	<i>Corporate bond yields</i>
1	Base + 15%	Base	Base
2	Base	Twice as fast as Base	Base
3	Base	Base	Fall from 5% to 3%
4	Base + 15%	Twice as fast as Base	Fall from 5% to 3%

We have priced our annuities to achieve a rate of return on capital according to the following two definitions of capital:

- Pricing Capital 1: the financing provided by Tier 1 capital to ensure that the NPLTBF contains sufficient assets to cover its mathematical reserves.
- Pricing Capital 2: Pricing Capital 1 plus the additional Tier 1 capital required to cover the NPLTBF's Pillar 1 regulatory capital requirement.

Three annuity prices have been calculated as follows:

- Pricing Basis 1: to achieve a rate of return on Pricing Capital 1 of 5%.
- Pricing Basis 2: to achieve a rate of return on Pricing Capital 1 of 10%.
- Pricing Basis 3: to achieve a rate of return on Pricing Capital 2 of 10%.

As the Pricing Basis 1 rate of return on capital  $<$  the Pricing Basis 2 rate of return on capital and Pricing Capital 1  $<$  Pricing Capital 2, it follows that Annuity Price 1  $<$  Annuity Price 2  $<$  Annuity Price 3.

Corresponding PVIFs, or economic values, of the firms in force business at duration one month are given in Table 9.2.

Note that, as expected, Annuity Price 3 economic values are always higher than Annuity Price 2 values which, in turn, are always higher than Annuity Price 1 values. This is simply because Annuity Price 3  $>$  Annuity Price 2  $>$  Annuity Price 1.

In other words, economic capital depends not just on the risks that the firm is running, but the price it is charging for accepting those risks. The lower the price it charges for these risks, the more economic capital that it needs to cover the risks.

It can also be seen from Table 9.2 that the corporate bond yield stress consumes the most economic capital and the fixed expense stress the

**Table 9.2** Economic values – deterministic annuity example

Stress	Economic value (£ million)		
	Pricing 1	Pricing 2	Pricing 3
Base	0	5.2	32.0
1	(0.2)	5.0	31.8
2	(32.4)	(27.1)	0.9
3	(55.6)	(49.3)	(16.2)
4	(103.7)	(97.1)	(62.4)

**Table 9.3** Capital requirements – deterministic annuity example

	<i>Pricing Basis 1</i>	<i>Pricing Basis 2</i>	<i>Pricing Basis 3</i>
Economic capital	103.7	97.1	62.4
Pillar 1 regulatory capital requirement	135.1	134.2	129.2

least. Table 9.2 also shows that economic capital under the stresses is not additive. In fact, economic capital under the stresses in aggregate is more than the sum of the individual stress economic capital amounts.

This is because the effect of the mortality improvement stress becomes greater as it interacts with the other stresses. Under these other stresses, the annuity business becomes loss making and the longer it takes for the business to run off, or the lighter that mortality is, the worse this problem becomes.

The resultant economic capital amounts are compared with the corresponding Pillar 1 regulatory capital requirements in Table 9.3.

In Table 9.3, we have taken the Pillar 1 regulatory capital requirement as the excess amount of the annuity mathematical reserves over the realistic reserves, plus the resilience capital requirement and the long term insurance capital requirement (LTICR). It can be seen that, for this particular example, the Pillar 1 regulatory capital requirement is comfortably in excess of the economic capital amount, particularly for the more expensively priced annuities.

It can also be seen that, as the annuity price becomes cheaper, the economic capital amount moves closer to the Pillar 1 regulatory capital requirement. It is clear that, if annuities are priced cheaply enough, there will come a point when the economic capital amount will exceed the Pillar 1 regulatory capital requirement.

In fact, based on work carried out at the time of writing, on the cheapest priced annuities in the highly competitive UK market, there is evidence to suggest that this point has already been reached.

### 9.2.2 Stochastic non profit life insurance firm example

We now move on to consider a stochastic non profit life insurance example, which is again based on an annuity product. We first describe the product itself and then the corporate structure of the non profit life insurance firm.

### **9.2.2.1 Annuity life insurance product**

In this example, we have chosen to model a joint life last survivor annuity for a male aged 65 and a female aged 65. The annuity income is assumed to be level throughout and is payable until both lives have died. Our detailed assumptions that underpin the example are set out in Appendix 9.2.

### **9.2.2.2 Annuity life insurance firm corporate structure**

The firm corporate structure is shown in Figure 9.1. This is the same structure as was assumed for the deterministic example considered above.

### **9.2.2.3 Stochastically modeled response variables**

We use the stochastic model described in Chapter 7, parameterized according to Table 7.11, to generate the stochastic elements of the example. In particular, we model the following response variables stochastically.

1. Long term UK corporate bond yields
2. The credit risks associated with investing in long term UK corporate bonds. Credit risks are assumed to increase with bond yields, as described in Appendix 9.2
3. The life insurance firm's fixed expenses are assumed to increase in line with UK RPI, as generated by the stochastic model
4. Stochastic mortality improvement factors are used, based on "cohort" mortality, where future male and female mortality improvement rates are assumed to follow a simple stochastic process. The mean rate of improvement, for both males and females, is assumed to increase each year, up to a maximum mean improvement rate of 0.075 p.a.
5. The Pillar 1 regulatory capital requirement is calculated as the LTICR, plus the resilience capital requirement, plus the difference between the mathematical reserves, which contain prudential margins, and the realistic reserves, which contain no margins. See Appendix 9.2 for further details.

Based on the stochastic elements of this example, the economic capital requirement that is generated by the stochastic model is the amount of capital required by the annuity life insurance firm

to cover its aggregate

1. Market risks as a result of long term UK corporate bonds not generating adequate returns to support the annuity product pricing
2. Credit risks
3. Expense risks
4. Mortality risks

#### **9.2.2.4 Stochastic economic capital calculation**

The method described in Section 8.2.3.2, which was used for our stochastic retail mortgage bank example, is used. Note that, for this example however, we have used 2,500 simulations in our runs, rather than the 10,000 used for our banking examples. This is because, as the annuity projections are more complex and are for longer terms, they take longer to run and our computing resources precluded the running of the full 10,000 simulations.

### **9.2.3 Results**

Our results are provided graphically in the form of a series of figures. Each figure compares average Pillar 1 regulatory capital with 95th, 99th and 99.5th percentile economic capital.

#### **9.2.3.1 Base case example**

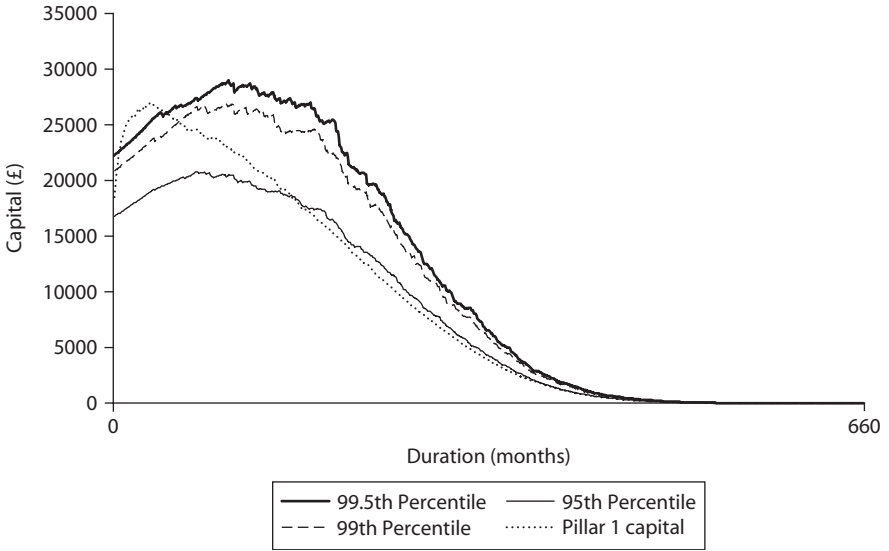
For the base case example, we have assumed a level annuity payment of £1,400 p.a. Results for this base case example are shown in Figure 9.2.

From this figure we can see that Pillar 1 capital generally has the correct shape. However, after around five years, Pillar 1 capital falls too rapidly relative to 99th and 99.5th percentile economic capital and, thereafter, is significantly lower than economic capital at these percentile levels.

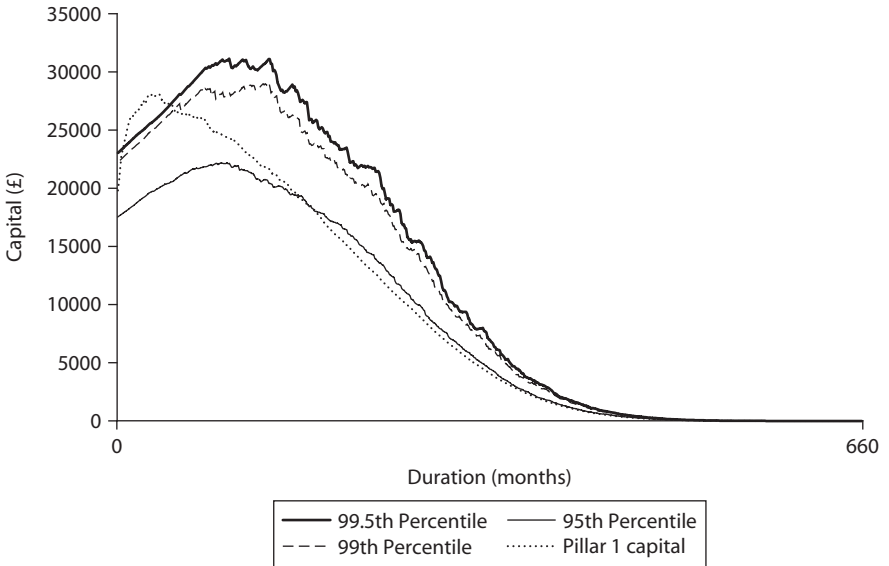
#### **9.2.3.2 Increase annuity to £1,500 p.a. from £1,400 p.a.**

We now increase the annuity in payment from £1,400 p.a. to £1,500 p.a. with our results shown in Figure 9.3.

Compared to Figure 9.2, and as expected, both Pillar 1 capital and economic capital increase everywhere. However, the same general conclusions apply as for the base case example. Although Pillar 1 capital has the correct shape relative to economic capital, it is generally too low to cover the risks that are being run, as measured by economic capital.



**Figure 9.2** Annuity economic capital versus Pillar 1 capital – base case



**Figure 9.3** Annuity economic capital versus Pillar 1 capital – increase annuity to £1,500 p.a. from £1,400 p.a.

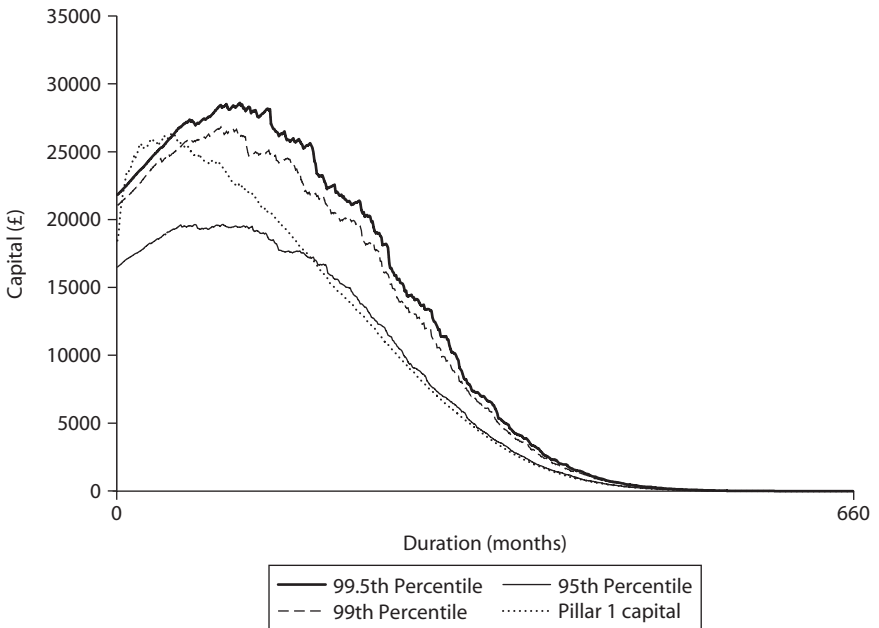
### 9.2.3.3 Lighter mortality assumption

In this example we have assumed lighter mortality by increasing the upper limit on both the male and female mortality mean improvement factors from 0.075 p.a. to 0.15 p.a. See Appendix 9.2 for further details. We have used this lighter mortality both in our modeled expected mortality experience and also in our reserves, both realistic and mathematical. Our results are shown in Figure 9.4.

Comparing Figure 9.4 to Figure 9.2 it can be seen that the results are almost identical. In fact, both economic capital and Pillar 1 regulatory capital, under the lighter mortality assumption increase relative to the base case assumption, simply because there is more in force business as a consequence of the lighter experienced mortality assumption.

We have also checked that if we use heavier, rather than lighter mortality in our modeled experience and reserves, we can again conclude that both economic capital and Pillar 1 regulatory capital change very little.

The reason for this lack of change is explained in the example, after next.



**Figure 9.4** Annuity economic capital versus Pillar 1 capital – lighter mortality assumption in both experience and reserves

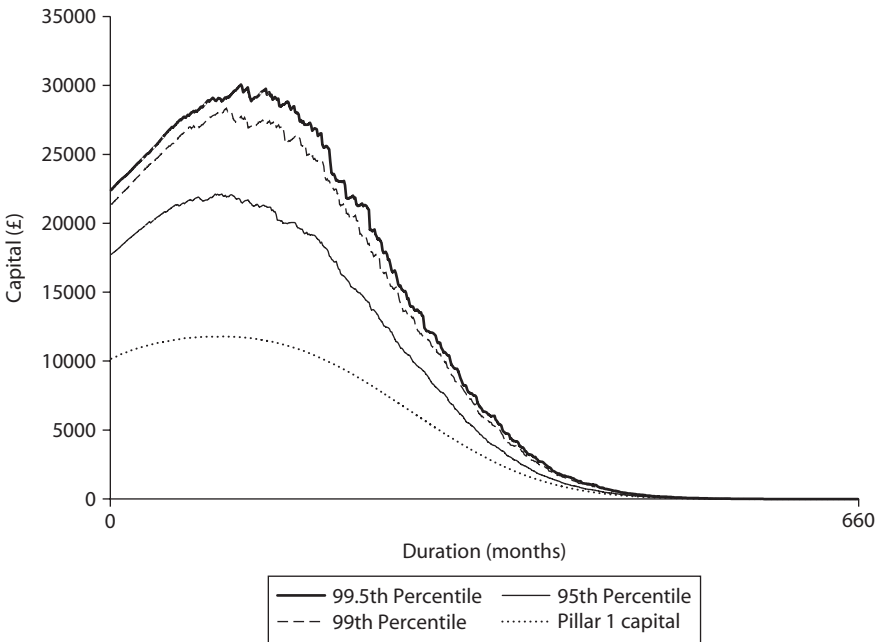
### 9.2.3.4 *Assets are invested in long term UK government bonds, rather than long term UK corporate bonds*

In this example, we assume that the annuity premium, and liability, is backed by long term UK government bonds, rather than corporate bonds. As a consequence, our mathematical reserves and realistic reserves are then equal as we calculate both of them using the long term UK government bond yield as our risk discount rate. See Appendix 9.2 for further details. Our results are shown in Figure 9.5.

Comparing Figure 9.5 to our base case results shown in Figure 9.2, it can be seen that Pillar 1 capital has fallen significantly. This is because the margin for prudence in the mathematical reserves, relative to realistic reserves, is always zero in this example causing a direct fall in Pillar 1 capital.

Economic capital, on the other hand, is relatively unaltered and the reason for this is explained in the next example.

We can, nevertheless, conclude that Pillar 1 capital is far too low relative to economic capital in this example.



**Figure 9.5** Annuity economic capital versus Pillar 1 capital – assets invested in long term UK government bonds, rather than long term UK corporate bonds

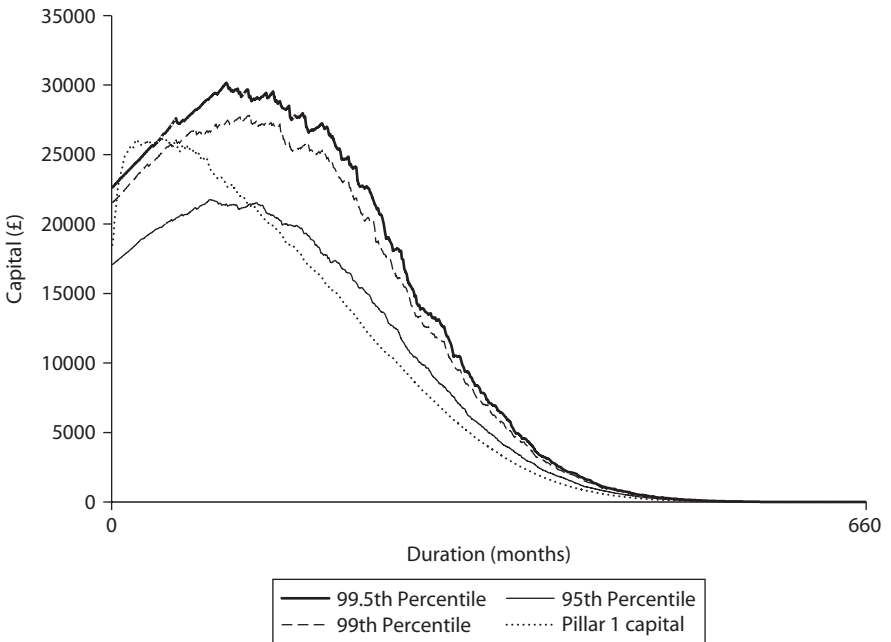
### 9.2.3.5 *Lighter mortality assumption used in modeled expected mortality experience, but not in reserves*

In this example we have assumed that the upper limits for the male and female mean improvement factors are both increased from 0.075 p.a. to 0.15 p.a. These higher rates of future mortality improvement are assumed for our modeled expected mortality experience, but not in our reserves, where we continue to reserve using the base case cohort improvement factors as set out in Appendix 9.2.

We therefore under reserve for expected mortality risks at all durations throughout the term of the projection. Our results are shown in Figure 9.6.

Comparing Figure 9.6 to Figure 9.2 it can be seen that, for both Pillar 1 capital and economic capital, the capital curves are relatively unaltered at the shorter durations, but become progressively higher, relative to our base case example, throughout the term of the projection.

In fact the curves are generally higher throughout. In the first instance, this is due to the lighter expected mortality experience assumption which causes the in force business to be higher at all durations, especially at the longer durations due to the cumulative effect of the lighter mortality assumption.



**Figure 9.6** Annuity economic capital versus Pillar 1 capital – lighter mortality assumption in experience, but not reserves

Second, and more importantly, the economic capital curves are higher because we under reserve in our realistic reserves for mortality, relative to experience. The reserves that the firm sets up are therefore not adequate to cover expected liabilities. As a consequence, the firm incurs losses towards the end of the projection as the reserves run out before all customers have died. It is these losses that drive up economic capital, and especially at the later durations, as compared to our base case example.

In practice, life insurance firms will adjust their reserving assumptions to match their experience as it emerges. This helps to ensure that the future profits emerge from the product in a stable and consistent fashion, and are broadly independent of the firm's actual experience.

It is for this same reason that, in our previous examples with lighter mortality or government bond asset investment, economic capital showed little change from the base case results. In other words, as the firm's realistic reserves always reflected its actual experience, emerging future profits, and so economic capital, were relatively unaffected by the assumption changes.

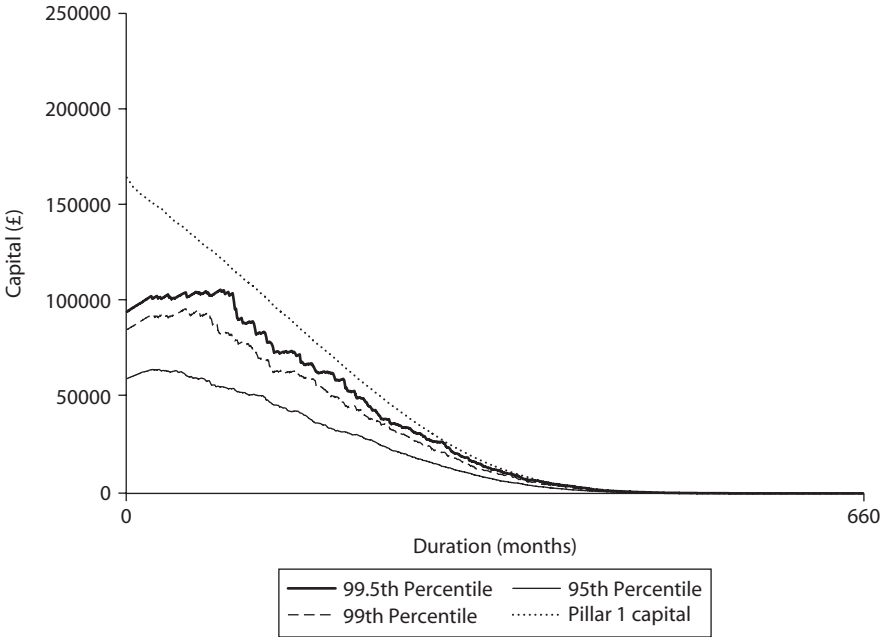
### **9.2.3.6 *Assets are invested in UK equities, rather than long term UK corporate bonds***

In this example, we assume that the annuity premium, and liability, is backed by UK equities, rather than long term UK corporate bonds. In other words, we are backing a liability with high levels of guarantee with volatile assets, but where the volatile assets have the potential to generate higher returns than the less volatile long term UK corporate bond assets. See Appendix 9.2, which sets out our full assumptions for this example. Our results are shown in Figure 9.7.

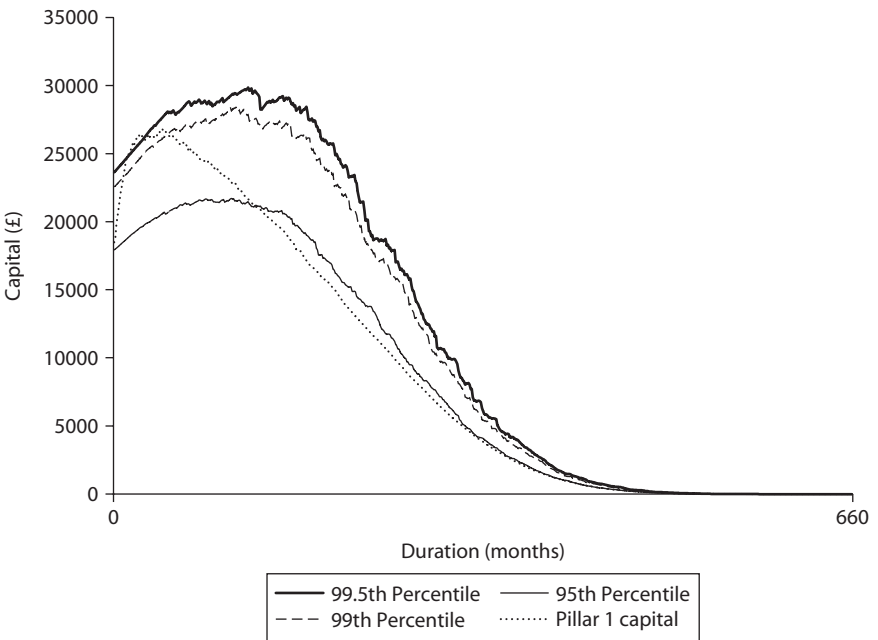
Comparing Figure 9.7 to our base case results shown in Figure 9.2, we can see that, as expected, both Pillar 1 capital and economic capital have increased very significantly. Moreover, Pillar 1 capital is now too large relative to economic capital whereas, in our previous corporate bond asset examples, it was always too low. Therefore, we can see that, relative to corporate bonds, Pillar 1 capital penalizes equity asset backing of annuities. This example is discussed in more detail in the "Rate of Return on Capital" Section below.

### **9.2.3.7 *Stochastic volatilities and correlations***

Figure 9.8 compares Pillar 1 capital with economic capital when we use the stochastic model with both stochastic volatilities and stochastic correlations included and parameterized according to Sections 7.4.1 and 7.4.2.



**Figure 9.7** Annuity economic capital versus Pillar 1 capital – assets invested in UK equities, rather than long term UK corporate bonds



**Figure 9.8** Annuity economic capital versus Pillar 1 capital – stochastic volatilities and stochastic correlation

Comparing Figure 9.8 with Figure 9.2, which shows the corresponding results for the constant volatility and constant correlation stochastic model, it can be seen that, as expected, economic capital has increased slightly at all durations whereas Pillar 1 capital is essentially unaltered.

We can again conclude that Pillar 1 capital is too low relative to economic capital.

### **9.2.3.8 Rate of return on capital**

For each of the 2,500 simulations, and for each example, we have calculated the rate of return earned on capital for each of Pillar 1 capital, 95th percentile economic capital, 99th percentile economic capital and 99.5th percentile economic capital. We can then study the distribution of these rates of returns on capital over the 2,500 simulations.

Summary statistics for our base case example are shown in Table 9.4.

From Table 9.4, it can be seen that the rates of return on economic capital are well behaved, being close to Normally distributed, and also show reasonable returns. Rates of return on Pillar 1 capital are less well behaved, however. The Pillar 1 capital returns, although respectable, exhibit very fat tails and high positive skewness.

We now discuss the same summary statistics for our annuity example where we have assumed that UK equities are used to back the annuity. Our results are shown in Table 9.5.

First of all, we can see that the distribution of each rate of return on capital is both extremely positive skewed and fat tailed, relative to a Normal distribution.

Comparing Table 9.5 to Table 9.4 it can be observed that

- The returns on economic capital are lower when corporate bonds are used to back the annuity, as compared to equities. Therefore, although equity asset investment requires very large amounts of economic capital, a higher rate of return can, nevertheless, be earned on this capital.
- For equity asset backing, rates of return on Pillar 1 capital are deflated relative to economic capital because Pillar 1 capital discriminates against equity assets, relative to corporate bond assets. The converse applies for corporate bond assets.
- Corporate bond asset investment may also be attractive to certain firms as it gives them the option of running with less capital than is needed to back the risks they are running. This assumes that these certain firms would be prepared to do this in practice.

**Table 9.4** Rates of return on capital for the base case annuity example

	<i>Pillar 1</i>	<i>Capital amount</i>		
		<i>95th Percentile economic capital</i>	<i>99th Percentile economic capital</i>	<i>99.5th Percentile economic capital</i>
Mean	13%	14%	9%	8%
Standard deviation	13%	4%	2%	2%
Skewness	2.56	0.77	(0.10)	(0.16)
Kurtosis	19.17	2.38	0.41	0.38

**Table 9.5** Rates of return on capital for the annuity example with assets invested in UK equities

	<i>Pillar 1</i>	<i>Capital amount</i>		
		<i>95th Percentile economic capital</i>	<i>99th Percentile economic capital</i>	<i>99.5th Percentile economic capital</i>
Mean	8%	26%	12%	11%
Standard deviation	2%	18%	5%	4%
Skewness	1.30	1.71	1.85	1.89
Kurtosis	4.33	2.72	6.16	7.17

### 9.2.4 Comparison of deterministic and stochastic examples

The deterministic and stochastic examples discussed above are very different and are quite difficult to compare. However, because they result in slightly different conclusions, we felt that it would be worthwhile carrying out an approximate reconciliation of the two examples.

The examples result in different conclusions because, at duration 1 month, the deterministic example shows that economic capital is lower than Pillar 1 capital, whereas the stochastic example gives the opposite conclusion. In fact, for Pricing Basis 3, the nearest deterministic pricing to our base case stochastic example, the deterministic example shows that economic capital is around 48% of Pillar 1 capital at duration 1 month.

For our base case stochastic example, 99.5th, 99th and 95th percentile economic capital represent, respectively, 116%, 108% and 87% of Pillar 1

capital at duration 1 month. Crude interpolation then shows that a ratio of 48% corresponds to economic capital at around the 88th percentile level in the stochastic example.

In the deterministic example, the corporate bond yield stress of a fall of 2% is a main driver of economic capital and, likewise, in the stochastic example, the corporate bond market risk stress also drives economic capital. Under our stochastic model, parameterized according to Table 7.11, a fall of 2% corresponds to market risk economic capital at around the 86th percentile level.

Therefore, we can see that, based on this fairly crude analysis, the examples are, in fact, broadly consistent.

## **9.3 UNIT LINKED LIFE INSURANCE**

We now consider a stochastic unit linked life insurance example. We first describe the product itself, then the corporate structure of the unit linked life insurance firm before moving on to compare economic capital with Pillar 1 regulatory capital requirements.

### **9.3.1 Unit linked life insurance product**

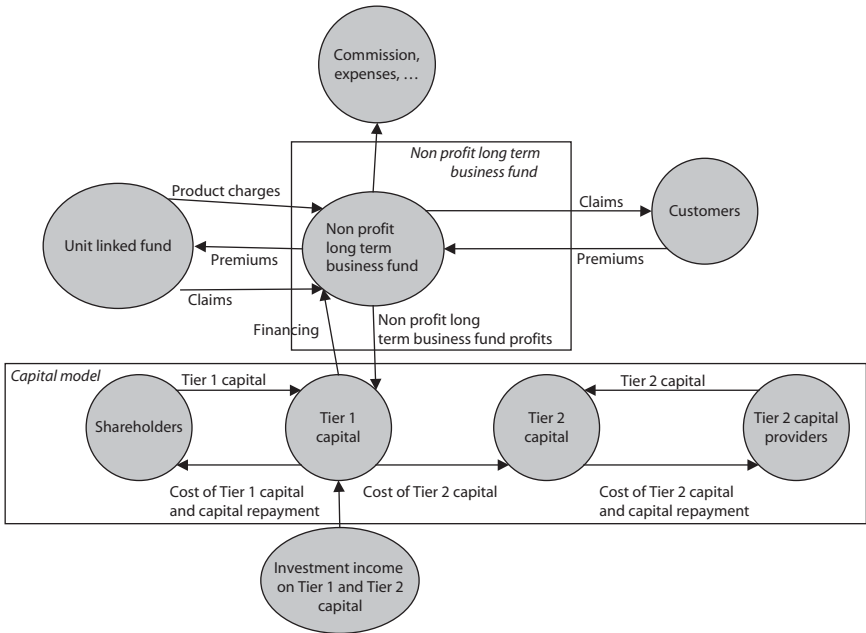
The product is a 25 year regular premium savings product with monthly premiums which, net of product charges, are invested 50% in UK equities and 50% in US equities. The premiums remain invested in these funds and are accumulated over the 25 year term of the product to be paid out on maturity. On death, the product pays out the product sum assured, or the market value of the customer's unit linked fund, if this is larger.

Similarly, on the surrender of the product, the market value of the customer's unit linked fund is paid. The full product, and the assumptions underlying it, is described in detail in Appendix 9.3.

### **9.3.2 Unit linked life insurance firm corporate structure**

The firm corporate structure is shown in Figure 9.9. Note that this structure again follows the same general corporate firm structure model as all of our previous examples.

With this structure, the customer pays premiums to the NPLTBF, which then passes these to the unit linked fund for investment in UK and US equities. The charges under the product, both fund management charges and mortality charges, are then passed back to the NPLTBF from the unit linked fund. The fund management charges are used by the NPLTBF to pay for all of the expenses and commission associated with the product and the mortality charges are used to pay for the product's death benefits.



**Figure 9.9** Unit linked life insurance firm corporate structure

On maturity, or surrender, the unit linked fund pays the NPLTBF the market value of the customer's fund, which is then paid out by the NPLTBF to the customer. On death, the same flows occur, but if the customer's fund is less than the product sum assured, the NPLTBF makes up the difference and pays the full amount of the sum assured to the customer's estate.

With this structure, it can be seen that the main risk that the NPLTBF faces is that the product charges may not be adequate to recoup the expenses that it incurs, both in putting the unit linked business on its books, and in maintaining the business over its lifetime. This risk is particularly likely to bite if the firm's expense management processes, controls and skills are weak.

### 9.3.3 Stochastically modeled response variables

The full detailed set of assumptions that we have used to model this product are set out in Appendix 9.3. We use the stochastic model described in Chapter 7, parameterized according to Table 7.11, to generate the stochastic elements of the example.

In particular, we model the following response variables stochastically:

1. UK equity earnings/dividend growth rates and dividend yields
2. US equity earnings/dividend growth rates and dividend yields

3. The US dollar/UK sterling exchange rate
4. The life insurance firm's fixed expenses are assumed to increase in line with UK RPI, as generated by the stochastic model
5. Stochastic lapse rates are used, where higher rates are assumed following a period of either UK, or US, stock market falls
6. The Pillar 1 regulatory capital requirement is calculated as the LTICR. See Appendix 9.3 for further details.

Based on the stochastic elements of this example, the economic capital requirement that is generated by the stochastic model is the amount of capital required by the unit linked life insurance firm to cover its

- Persistency risks
- Expense risks

### 9.3.4 Stochastic economic capital calculation

The method described in Section 8.2.3.2, which was used for our stochastic retail mortgage bank example, is used. We use 10,000 simulations to calculate economic capital.

### 9.3.5 Results

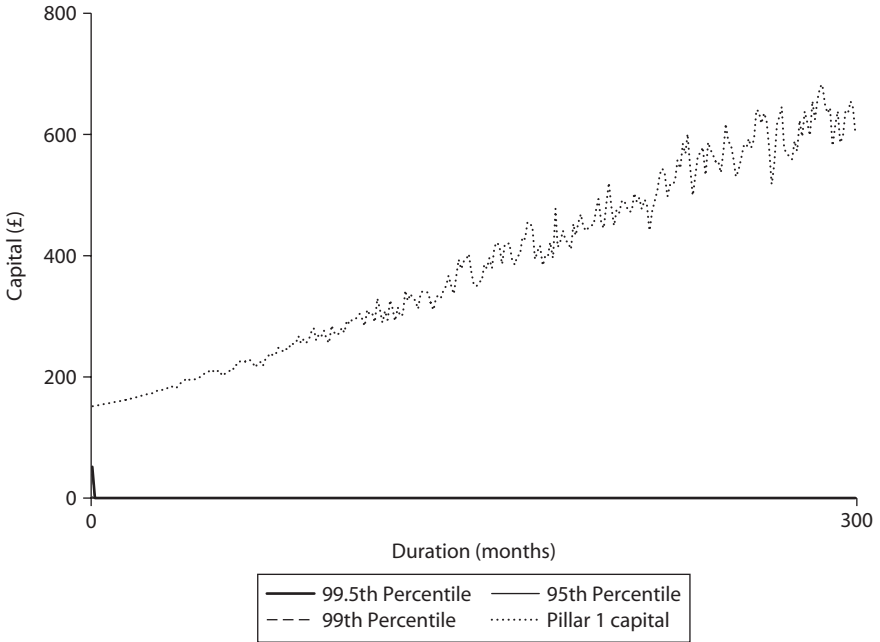
Our results are provided graphically in the form of a series of figures. Each figure compares average Pillar 1 regulatory capital with 95th, 99th and 99.5th percentile economic capital.

#### 9.3.5.1 Base case example

Our base case results are set out in Figure 9.10.

Figure 9.10 shows that economic capital is effectively zero throughout the term of the unit linked product in contrast to Pillar 1 capital, which is positive and increases with duration. In other words, the charges levied under the product are large enough to ensure that they will always be more than adequate to cover the expenses incurred by the firm under the product. As a consequence the PVIFs calculated under this product are, except at durations zero, always positive. The duration zero PVIFs are negative due to, as discussed previously, the effect of the initial expenses incurred at time zero under the product.

Note that Pillar 1 capital appears to become more volatile with duration. This is, in fact, a scale effect simply due to the fact that the size of



**Figure 9.10** Unit linked life insurance economic capital versus Pillar 1 capital – base case

the unit linked fund, on which the Pillar 1 capital depends, increases with duration.

We have increased the investment expense assumption used in this example from 0.25% to 0.40% to see what effect this has. Exactly the same conclusions continue to apply.

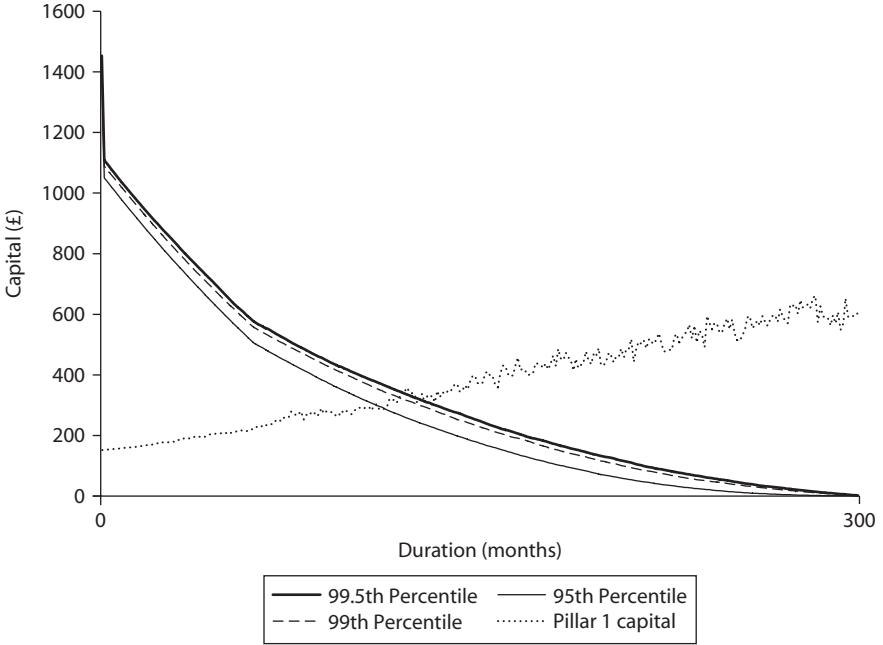
We are able to conclude, therefore, that Pillar 1 capital is too large and has the wrong shape.

### 9.3.5.2 Increased fixed expenses example

Figure 9.11 sets out our results when the fixed maintenance expenses under the product are increased from £50 p.a. to £250 p.a., with all other assumptions unaltered. This increase could result as a consequence of either the firm not controlling its expenses in absolute terms, or relative to the size of its funds under management, particularly if these funds decrease as a result of the firm losing business to competitor firms, say.

From Figure 9.11, it can be seen that economic capital is high at the initial durations and then falls steadily to zero as duration increases. Pillar 1 capital does the opposite.

The reason why economic capital falls with duration is that, as duration increases, there is less opportunity for the firm's future expenses, as



**Figure 9.11** Unit linked life insurance economic capital versus Pillar 1 capital – fixed maintenance expenses increased to £250 p.a.

generated by the stochastic model, to be so large that they cannot be recouped by the product charges.

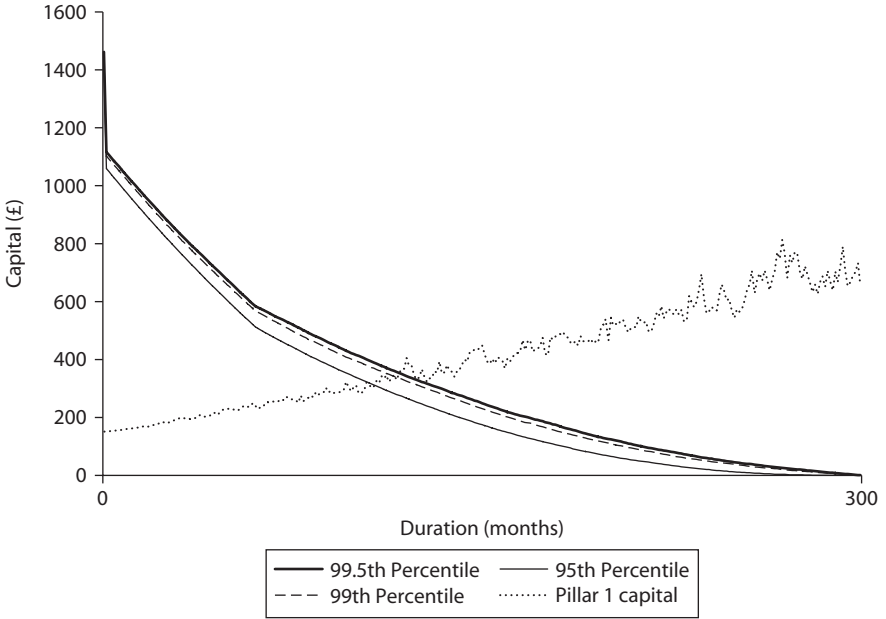
We can again conclude that Pillar 1 capital has completely the wrong shape.

### 9.3.5.3 Stochastic volatilities and correlations

Figure 9.12 compares Pillar 1 capital with economic capital when we use the stochastic model with both stochastic volatilities and stochastic correlations included, parameterized according to Sections 7.4.1 and 7.4.2, in conjunction with increased fixed maintenance expenses of £250 p.a.

Although it is difficult to see from Figure 9.12 and Figure 9.11, which shows the corresponding results for the constant volatility and constant correlation stochastic model, an inspection of the underlying capital data shows that, as expected, economic capital has increased slightly at the shorter and medium term durations. Longer term economic capital is also seen to have fallen slightly.

At the shorter and medium term durations, this is due to the stochastic volatilities and stochastic correlations causing jumps in stock market volatility over the outstanding term of the projection. This results in



**Figure 9.12** Unit linked life insurance economic capital versus Pillar 1 capital – fixed maintenance expenses increased to £250 p.a. – stochastic volatilities and stochastic correlations

lower unit linked fund values in the extreme runs, and economic capital increases as a consequence.

At the longer durations, economic capital falls slightly as stock market returns have less opportunity for volatility jumps over the outstanding term of the projection. As is explained in Section 7.2.4, stock market returns are therefore less volatile, as a consequence, and it then follows that economic capital falls.

Pillar 1 capital increases slightly due to slightly increased stock market returns, but the main change is that it is more volatile due to the increased volatility of the unit linked fund, which is caused by increased stock market volatility.

We can again conclude that Pillar 1 capital has the wrong shape relative to economic capital.

#### 9.3.5.4 Rate of return on capital

For each of the 10,000 simulations, and for each example, we have calculated the rate of return earned on capital for each of Pillar 1 capital, 95th percentile economic capital, 99th percentile economic capital and

**Table 9.6** Rates of return on capital for the base case unit linked example

	<i>Pillar 1</i>	<i>Capital amount</i>		
		<i>95th Percentile economic capital</i>	<i>99th Percentile economic capital</i>	<i>99.5th Percentile economic capital</i>
Mean	6%	8%	8%	8%
Standard deviation	2%	4%	4%	4%
Skewness	2.55	3.61	3.61	3.61
Kurtosis	7.03	17.14	17.10	17.08

99.5th percentile economic capital. We can then study the distribution of these rates of returns on capital over the 10,000 simulations.

Summary statistics for our base case example results are shown in Table 9.6.

From Table 9.6, it can be seen that the rates of return on capital are both positively skewed and have very fat tails, as compared to a Normal distribution. The other point worth noting is that, even though the capital requirements of this product are very low, the rates of return earned on this capital are quite modest.

In other words, unit linked business based on these product charges, which reflect the current UK market, is low margin business, even though it requires very little capital backing. This contrasts with some of our other examples, which are far more capital intensive, but which generate better returns on this capital.

We now move on to our final insurance example, which is based on a general insurance firm.

## 9.4 GENERAL/HEALTH/PROPERTY AND CASUALTY INSURANCE

We first describe the product itself and then the corporate structure of the general insurance firm.

### 9.4.1 General insurance product/portfolio

The product is an annually renewable buildings insurance policy where the insurance cover is equal to the 100% of the market reconstruction costs of the property insured. In other words, if the insured property is destroyed, or

damaged, and must be rebuilt from scratch, the policy pays out the full market reconstruction costs of the property at the point of claim.

We model a portfolio of 100,000 policies and also assume that each policy is written for a maximum term of ten years, with the book of policies running off over this ten year period. Both premiums and property reconstruction costs are assumed to increase in line with UK HPI, as generated by the stochastic model, parameterized according to Table 7.11.

The full details of the assumptions that underlie the general insurance example are given in Appendix 9.4.

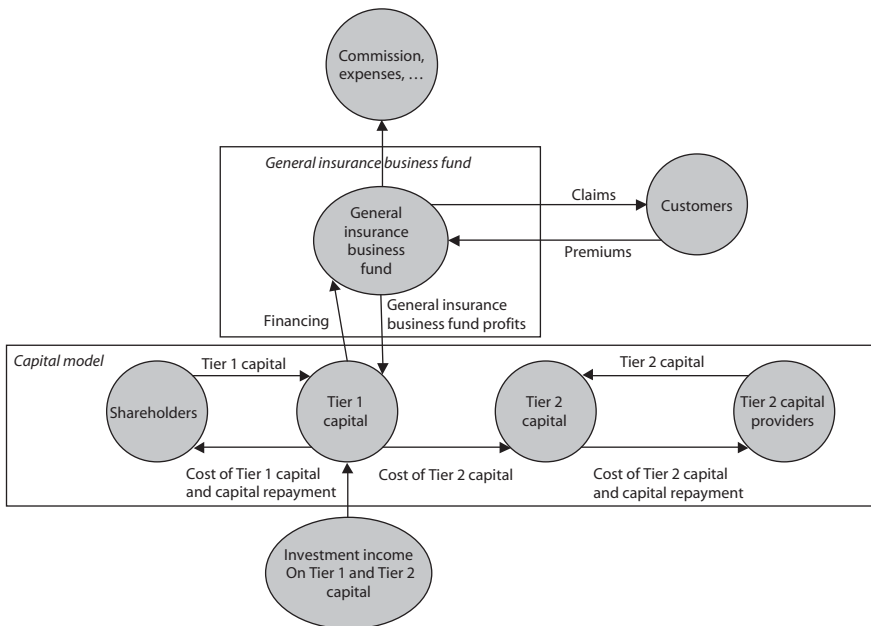
### 9.4.2 General insurance firm corporate structure

The general insurance firm corporate structure that we have assumed is shown in Figure 9.13. Note that this structure again follows the same broad corporate firm structure model as for our previous examples.

This firm structure is relatively simple and the firm cashflows are also displayed in the figure.

### 9.4.3 Stochastically modeled response variables

We use the stochastic model described in Chapter 7, parameterized according to Table 7.11, to generate the stochastic elements of the



**Figure 9.13** General insurance firm corporate structure

example. However, the stochastic claims distribution, as described below, and in full detail in Appendix 9.4, is developed outside of our Chapter 7 stochastic model.

The following response variables are stochastically modeled:

1. The general insurance firm's fixed expenses are assumed to increase in line with UK RPI, as generated by the stochastic model.
2. The number of claims in the portfolio in month  $t$  is assumed to follow a binomial distribution. The probability of a claim depends on whether or not a catastrophic event has occurred. In particular, if a catastrophe has occurred, then claims are certain to happen for all in force policies in the portfolio. By a catastrophic event, we have in mind a flood, or earthquake, which destroys all of the properties in the portfolio when it occurs. In practice, general insurance firms will diversify their businesses geographically to reduce the concentration risk of the firm being exposed to a catastrophic event in one region, or they will attempt to place this concentration risk with the reinsurance markets. For the purposes of this example, however, we will assume that the firm takes all of the catastrophe risks, so reflecting the position of the firm, gross of risk mitigants.
3. In our base case example, we assume that the probability of a claim occurring, given that a catastrophe has not occurred, is 0.0001 in that month. The probability of a claim occurring, given that a catastrophe has occurred is assumed to equal 1, and where the probability of a catastrophe occurring is assumed to equal 0.000025 per month. The full details are provided in Appendix 9.4.
4. Claim amounts are assumed to follow a log normal distribution, increased in line with UK HPI, as generated by the stochastic model. The log normal distribution models the distribution of property reconstruction costs in the firm's portfolio.
5. The Pillar 1 regulatory capital requirement is calculated as the general insurance capital requirement described in Appendix 9.4.

Based on the stochastic elements of this example, the economic capital requirement that is generated by the stochastic model is the amount of capital required by the general insurance firm to cover its aggregate

- Claim experience risks
- Expense risks

#### 9.4.4 Stochastic economic capital calculation

The method described in Section 8.2.3.2, which was used for our stochastic retail mortgage bank example is again used. We use 10,000 simulations in our runs.

#### 9.4.5 Results

Our results are provided graphically in the form of a series of figures. Each figure compares average Pillar 1 capital with 95th, 99th, 99.5th and 99.9th percentile economic capital.

Note that, in our figures, we plot the natural logarithm of each capital amount. This is because certain of the economic capital amounts, 99.9th percentile economic capital for example, are too large to be plotted meaningfully without transformation.

##### 9.4.5.1 Base case example

Note that, with the assumptions described in Appendix 9.4, where we assume a catastrophe probability of 0.000025 per month, we expect that  $0.000025 \times 12 \times 10 \times 10,000 = 30$  catastrophes will occur in total over all of the 10,000 simulations, for the entire ten year projection term of each simulation. Therefore, for this example, we expect catastrophes to impact 99.9th percentile economic capital, but not 99.5th, nor lower percentile, economic capital.

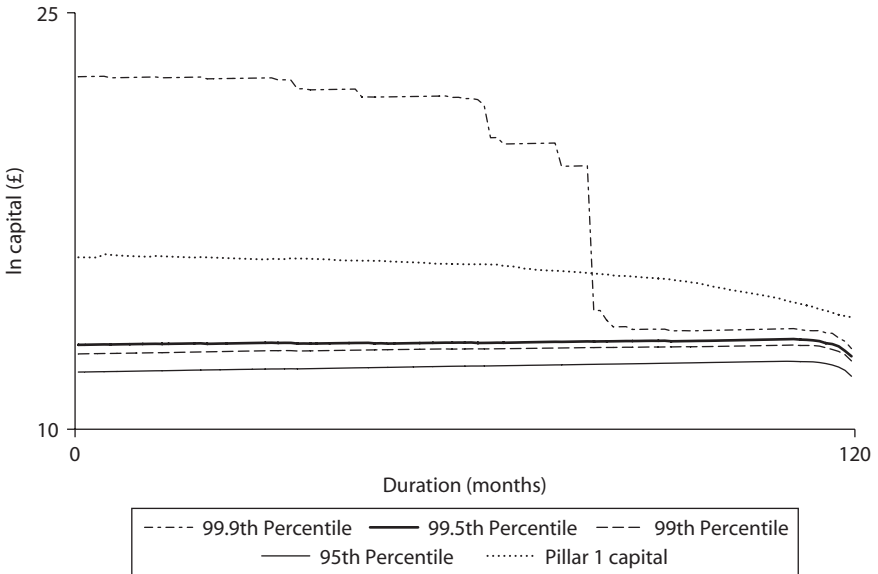
Note also that, for each simulation, the further into the projection term that one is, the less likelihood there is of catastrophes occurring over the remaining lifetime of the projection term from that point onwards. Therefore, we expect that catastrophes will impact economic capital at the shorter durations, with the impact reducing, and ultimately there being no impact at all at the medium and longer durations.

Figure 9.14 shows the results for our base case.

As expected, catastrophes only affect 99.9th percentile economic capital and only at the shorter durations. Catastrophes cause the 99.9th economic capital to be at the initial very high levels shown in Figure 9.14, before dropping back down to the level of economic capital at the other percentile levels.

The amount of 99.9th percentile economic capital that is required at this higher level is extremely large, relative to Pillar 1 capital, although the natural logarithm transformation hides this difference. In fact, 99.9th percentile economic capital is nearly 700 times as large as Pillar 1 capital at the shorter durations.

Conversely, at the later durations, when future catastrophes do not have adequate time to occur over the remaining lifetime of the



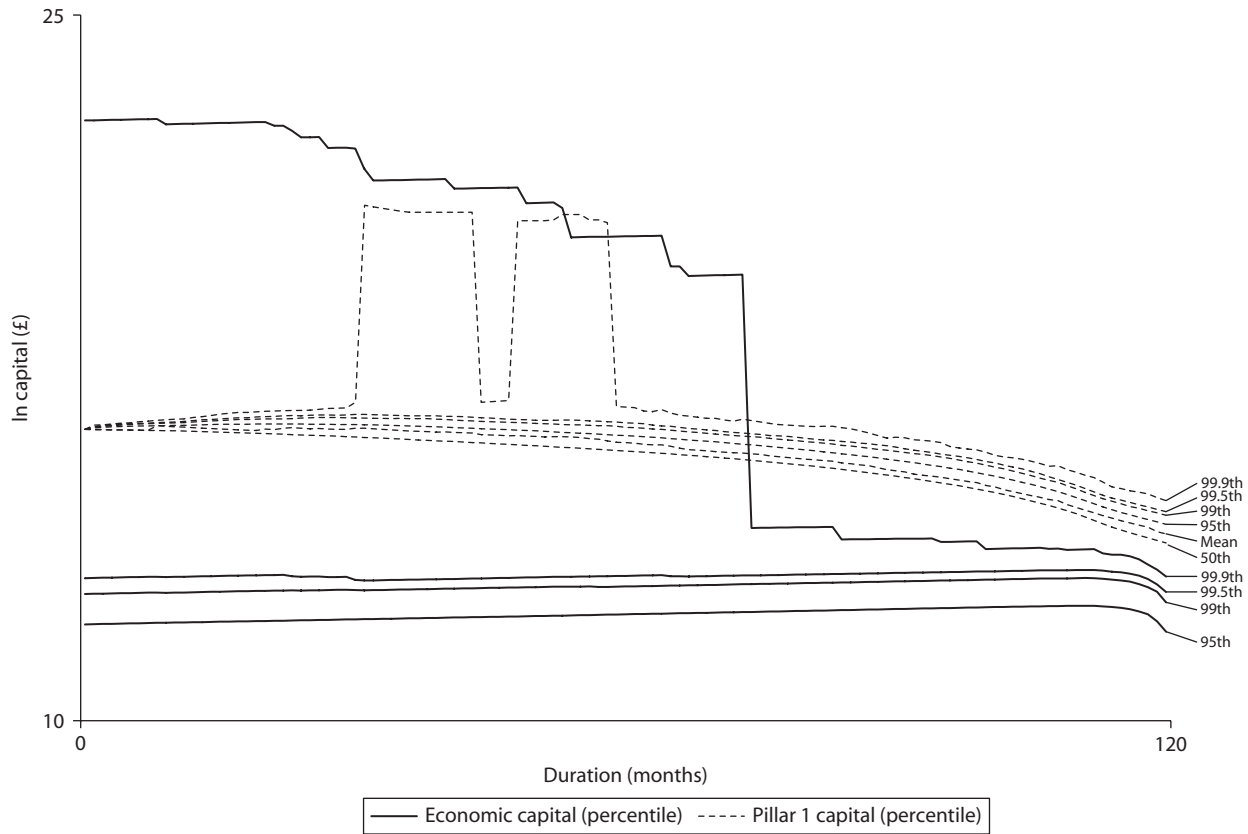
**Figure 9.14** General insurance economic capital versus Pillar 1 capital – base case

projection, Pillar 1 capital is higher than economic capital at all percentile levels.

In practice, general insurance firms would not be prepared, or able, to provide 99.9th percentile economic capital to cover the catastrophe risks that they are running. Nor would they be able to reinsure these risks. Instead, general insurance firms attempt to limit catastrophe risks by diversifying their businesses. For example, they may put upper limits on the proportion of their total business that they may accept in a particular geographical region.

Note that the Pillar 1 capital calculation is conceptually flawed because, as is described in Appendix 9.4, it is based on what has happened over the previous three years, rather than what might happen in future. If a catastrophe has occurred in the previous three years, Pillar 1 capital will respond to this, although this will be after the event. So, Pillar 1 capital reacts to past events, rather than being based on what might happen in the future, as economic capital is.

We cannot see this effect in Figure 9.14 as the Pillar 1 capital shown there is average Pillar 1 capital, averaged over all of the 10,000 simulations. We have therefore rerun the base case example and have graphed the percentiles of Pillar 1 capital also. Our results are shown in Figure 9.15.



**Figure 9.15** General insurance economic capital versus Pillar 1 capital – base case with Pillar 1 capital percentiles

It can be seen that only 99.9th percentile Pillar 1 capital is affected by catastrophes, and this occurs only when at least 10 of the 10,000 simulations has a catastrophic event in the previous three years. The odd shape of 99.9th percentile economic capital reflects the movement of these catastrophes through this retrospective three year window across simulations.

Figure 9.15 nevertheless shows that even 99.9th percentile Pillar 1 capital is not a good approximation to economic capital, as it is generally too low. Moreover, as we have seen, Pillar 1 capital reacts to catastrophes after the event, when it is too late, rather than anticipating them.

#### **9.4.5.2 Catastrophe probability increased from 0.000025 to 0.00005 per month**

In this example, we double the catastrophe probability from 0.00025 to 0.0005 per month.

Note that, with the increased catastrophe probability assumption, we expect that  $0.00005 \times 12 \times 10 \times 10,000 = 60$  catastrophes will occur in total over all of the 10,000 simulations, for the entire ten year projection term of each simulation. Therefore, for this example, we expect catastrophes to impact 99.5th and higher percentile economic capital, but not 99th, nor lower percentile, economic capital. Again, we expect that catastrophes will affect economic capital at the shorter durations.

Figure 9.16 shows the results for this example.

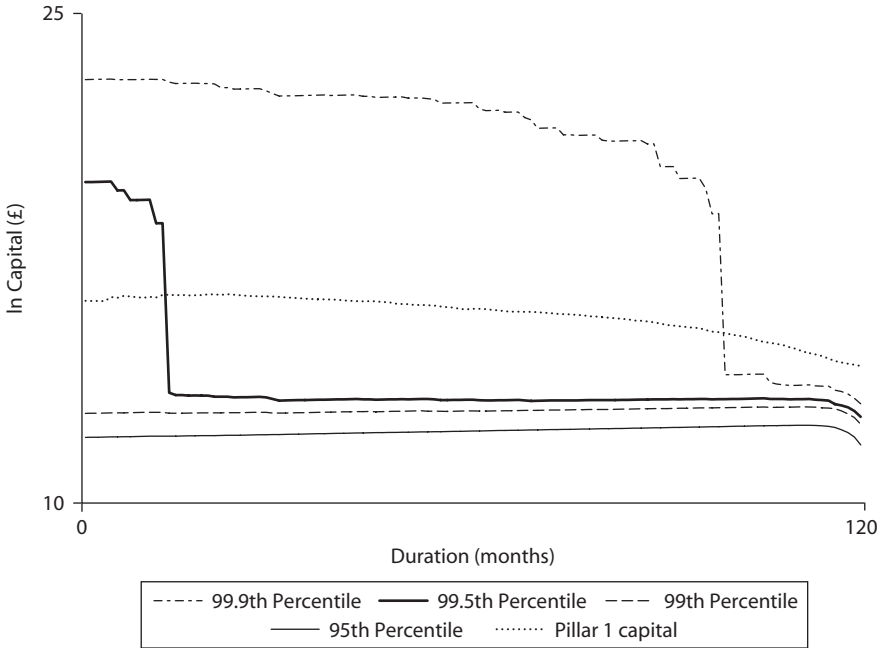
Comparing Figure 9.16 with Figure 9.14 shows that, where 99.9th percentile economic capital is being driven by catastrophic events, it increases with the higher catastrophe probability and persists at the higher catastrophic level for longer. This is simply because there are more catastrophes around to drive up economic capital to higher levels and for longer. As expected, 99.5th percentile economic capital is also now being driven by catastrophes at the shorter durations, again because of the increased numbers of catastrophes.

The lower percentile economic capital amounts, as they are not being driven by catastrophic events, are relatively unaffected by the increased catastrophe probability.

Pillar 1 capital increases slightly because more catastrophes occur, giving higher claims and slightly higher technical provisions.

#### **9.4.5.3 Non catastrophic claim probability increased from 0.0001 to 0.0002**

The same numbers of catastrophes are expected in this example as for our base case example. However, non catastrophic claims are more likely to occur, so we expect to see economic capital increase at all those



**Figure 9.16** General insurance economic capital versus Pillar 1 capital – catastrophe probability increased from 0.000025 to 0.00005

durations where economic capital is not being driven by a catastrophic event. Similarly Pillar 1 capital should increase as actual claims and technical provisions will increase.

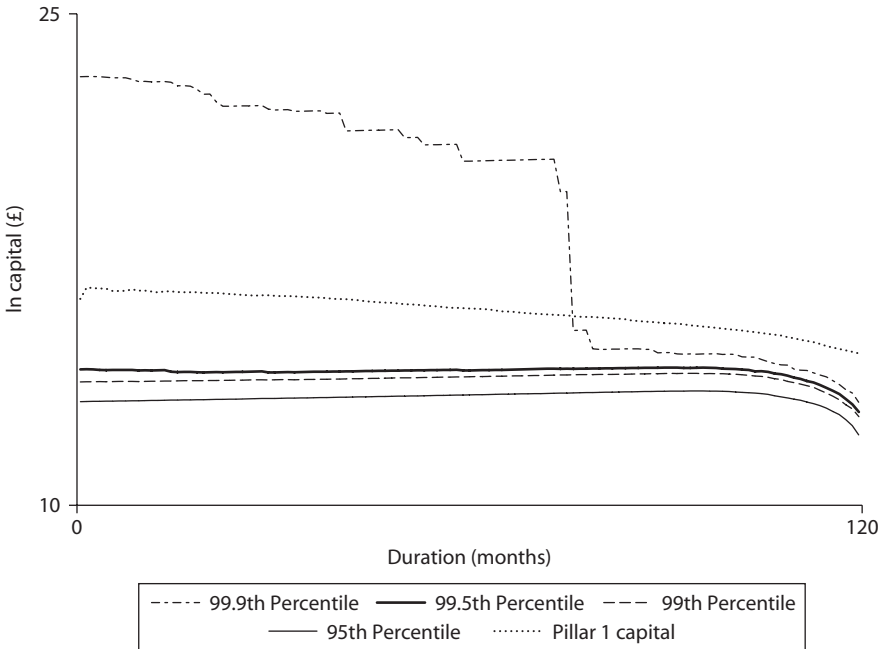
Figure 9.17 shows the results for this example.

As the logarithmic scale makes it difficult to compare Figure 9.17 to Figure 9.14, inspection of the capital amounts that underlie these figures shows that, except for 99.9th percentile economic capital, all capital amounts increase everywhere as a consequence of increasing the non catastrophic claims probability.

Economic capital, at the 99.9th percentile level, is determined using a relatively few number of simulations and, consequently, is volatile. For the particular 10,000 simulations shown in Figure 9.17, economic capital consequently does not always increase with increased claim probability, relative to Figure 9.14, due to this stochastic volatility. It does, however, increase for the majority of durations.

#### **9.4.5.4 Standard deviation of the claim amount distribution is increased by 50%**

In this example, modeled claim amounts, whether they are due to a catastrophic event, or not, are more volatile as the claim amount standard



**Figure 9.17** General insurance economic capital versus Pillar 1 capital – non catastrophic claim probability increased from 0.0001 to 0.0002 p.m.

deviation is increased by 50%. Note that we have left the mean claim amount value unaltered. We expect, therefore, to see economic capital and Pillar 1 capital increase at all durations.

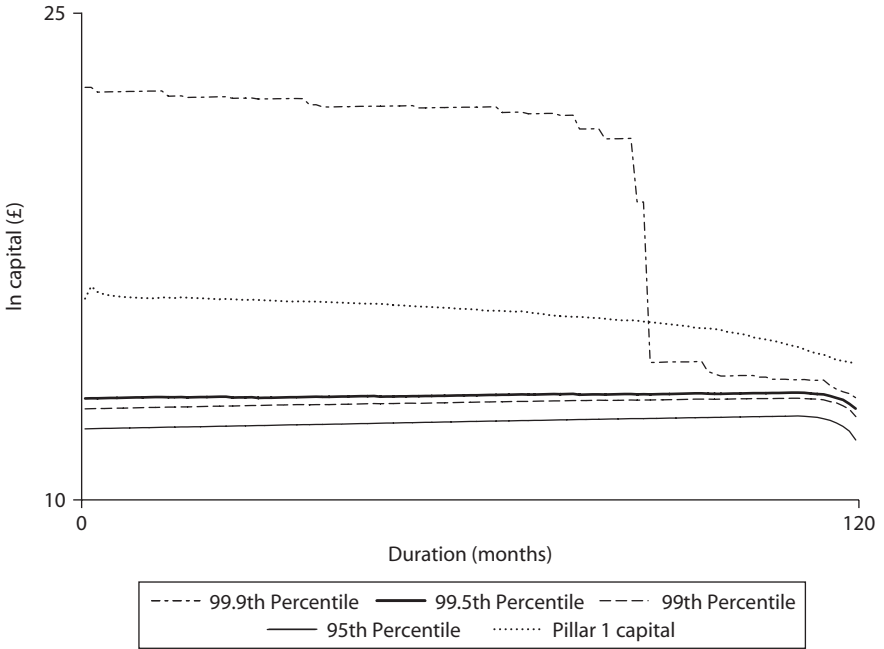
Figure 9.18 shows the results for this example.

Although it is difficult to see from comparing Figure 9.18 with Figure 9.14, which shows the corresponding base case results, inspection of the underlying capital amounts shows that both Pillar 1 capital and economic capital have increased as a consequence of increasing the claim amount distribution standard deviation.

#### 9.4.5.5 Rate of return on capital

For each of the 10,000 simulations, and for each example, we have calculated the rate of return earned on capital for each of average Pillar 1 capital, 95th percentile economic capital, 99th percentile economic capital, 99.5th percentile economic capital and 99.9th percentile economic capital. We can then study the distribution of these rates of returns on capital over the 10,000 simulations.

Summary statistics for our base case example are shown in Table 9.7.



**Figure 9.18** General insurance economic capital versus Pillar 1 capital – standard deviation of claim amount distribution increased by 50%

**Table 9.7** Rates of return on capital for base case general insurance firm example

	<i>Capital amount</i>				
	<i>Pillar 1</i>	<i>95th Percentile economic capital</i>	<i>99th Percentile economic capital</i>	<i>99.5th Percentile economic capital</i>	<i>99.9th Percentile economic capital</i>
Mean	141%	388%	379%	371%	4%
Standard deviation	17%	73%	71%	69%	0%
Skewness	0.41	0.71	0.70	0.70	(0.10)
Kurtosis	0.81	1.15	1.14	1.14	0.86

From Table 9.7, it can be seen that the rates of return on capital are reasonably well behaved, although they are generally slightly more positive skewed and fat tailed than for a Normal distribution.

The most striking aspect, however, is the difference between the rate of return on 99.9th percentile economic capital and the rates of return on the

other capital amounts. The rate of return on 99.9th percentile economic capital is very much lower than the other rates of return on capital.

It can be seen, therefore, that if firms price for extremely unlikely risks, catastrophic risks in this example, rates of return on capital amounts that do not reflect these unlikely risks, can be enormous. This conclusion is predicated on the assumption that such catastrophic risk pricing will result in premium rates that are competitive in the market place, although it is probably not likely that this will be the case.

## 9.5 SUMMARY

In this chapter we have calculated both deterministic and stochastic economic capital for a range of diverse insurance applications and have compared our results to corresponding Pillar 1 regulatory capital requirements. Stochastic economic capital was determined using the stochastic model developed in Chapter 7.

Our results show that the Pillar 1 regulatory capital requirements are generally very poor approximations to economic capital and we have illustrated the misleading impact that this can have on performance measurement. Obviously, these results and conclusions have quite serious implications for insurers themselves, regulators, insurance firm customers and shareholders.

We now move on to consider in Chapter 10 asset management firms.

# Asset Management Firms

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### 10.1 INTRODUCTION

In this chapter we give a short discussion of economic capital for asset management firms. This discussion is brief because, as we describe below, the treatment of economic capital for asset management firms is very similar to that for unit linked life insurance firms, as described previously in Section 9.3.

### 10.2 REGULATION OF ASSET MANAGEMENT FIRMS

It is first worth pointing out that, at least in the EU, asset management firms are subject to the same regulatory capital regulations and requirements as banks. That is, the EU's implementation of the Basel 2 Accord, via its corresponding Capital Adequacy Directive, applies to asset management firms, as well as to banks. See Chapter 14, where this is described in more detail. As asset management firms do not generally collect market or credit risks, most firms will be required to set up a Pillar 1 regulatory capital requirement for operational risk only, and this may lead to increased regulatory capital requirements for many firms.

### 10.3 RISK AND ECONOMIC CAPITAL

Although asset management firms can provide a very wide range of investment services, their business is often quite narrow comprising, in

the main, fund management. The assets that they manage may either be managed on behalf of third parties, for example pension funds or life insurance firms, or may have been collected by the firm itself through its own retail product channels, retail mutual fund money, for example.

In either case, however, the risks that the firm itself is subject to are very limited. Asset management firms would not normally be direct collectors of credit risk, for example. The funds that they manage for their clients will, however, certainly have exposures to such risks but it is the client, as the ultimate beneficiary of the assets in the fund, who carries this risk.

The client will generally specify and control the amount of risk that they are prepared to take in their fund, via the terms of the investment management agreement that they have entered into with the firm. This agreement governs how the fund is managed by the firm on behalf of the client. If credit losses occur in the fund, the performance of the fund may suffer and the asset management firm could risk losing the business if the client decides to place the assets with an alternative firm.

An asset management firm's income is directly related to the amount of assets that it has under management, as generated by the investment management charges that it applies to these assets. The main risk that asset management firms run, therefore, is that their income falls with falling assets, so resulting in profit falls if they are not able to reduce their expenses in line. Asset management firms are, therefore, very similar to unit linked life insurance firms as described in Section 9.3.

The main risks that asset management firms are subject to are as follows:

- Persistency
- Expense
- Operational
- Liquidity

The first two risks are covered in our unit linked life insurance firm example in Section 9.3 and the latter two risks, as discussed previously in Section 2.2.7, apply to all types of financial services firms. The methods and techniques developed in this book can be used to quantify the amount of economic capital that is required to cover these risks. In particular, see the unit linked life insurance firm example described in Section 9.3.

## 10.4 SUMMARY

In this chapter we have described how asset management firms are regulated like banks, although their businesses are, in fact, very similar

to those of unit linked life insurance firms. Economic capital for asset management firms is therefore very similar to that described in Section 9.3 for unit linked life insurance firms and the same results and conclusions apply.

We now move on to consider in Chapter 11 the more complex topics of with profits life insurance and pensions funds.

# With Profits Life Insurance and Pension Funds

---

## 11.1 INTRODUCTION

In Chapter 9, we gave a brief introduction to what we termed non profit life insurance. We now move on to give a similar brief introduction for so called “with profits,” or participating, life insurance. The term “with profits” is used in Europe whereas “participating” is used in North America. Throughout this book we will use the term “with profits.”

With profits life insurance business is a type of life insurance business where the customer shares in the emerging experience profits or surpluses of the business. Typically, this type of business is long term savings life insurance business, such as pensions, both individual pensions and group pensions, and individual endowment savings business, rather than pure protection life insurance.

Experience profits, or surpluses, on with profits life insurance business are usually distributed to customers by way of annual bonuses, and claim bonuses, that enhances the returns earned by the customer on their premiums. Typical characteristics of this type of business, at least in the UK, is that very significant investment guarantees are provided to customers in combination with high equity investment backing ratios. To provide such products, firms therefore take on very large amounts of market risk.

Smoothing is another fairly unique feature of with profits business. Life insurance firms smooth investment fluctuations out of the payments that customers receive. At least in theory, in good times, when markets

may be overvalued, assets are held back and are used to finance payments during the bad times, when markets may be undervalued.

In this chapter, we set out how economic capital can be calculated for this type of financial services business, and also for pensions fund business, which is closely related. In terms of complexity, these types of businesses are very much towards the high end of the scale and our examples must, correspondingly, also take a step up in complexity.

## **11.2 STOCHASTIC WITH PROFITS LIFE INSURANCE INVESTMENT GUARANTEE EXAMPLE**

### **11.2.1 Introduction**

The objective of this section, which is based on Porteous (2004), is to estimate the amount of economic capital that a UK life insurance firm needs to back the investment guarantees written in its with profits long term business fund (WPLTBF) and to compare this with corresponding Pillar 1 regulatory capital requirements.

At the time of writing, this section is particularly pertinent because

1. Falling equity markets have caused life insurance firms, shareholders and regulators to reconsider the risks that result when long term savings products, containing significant investment guarantees, are backed with volatile assets, particularly equities.
2. Recent new regulations for UK life insurers, which are modeled very closely on the banking industry's Basel 2, require UK life insurance firms to self assess their economic capital requirements on a regular basis and to disclose these to the regulator. The regulator will then use the firm's self assessed economic capital amount to help set each firm's regulatory capital requirements. This process is discussed in more detail in Chapter 14.

The new prudential regulations for UK with profits life insurance business are based on the so called "twin peaks" approach. Muir and Waller (2003) have given a very full description of the complex twin peaks approach, together with a discussion of the business and regulatory background that has resulted in these new regulations. Full details on the mechanics of the calculation, including how the Pillar 1 regulatory capital requirement is financed by Tier 1 capital, and by surplus from within the WPLTBF, are given in Appendix 11.1.

The UK regulatory capital requirements for life insurance firms have evolved over many years in mainly ad hoc and arbitrary ways. A common theme, nevertheless, has been the prevalence of deterministic, rather than stochastic approaches. Important recent developments that have helped to drive the new regulations are

- The emergence of the UK's FSA as the single regulator across all UK financial services firms and the FSA's desire to regulate life insurance firms like banking firms.
- Falling equity markets exposed the limitations of the previous prudential regulatory system. In particular, the vagaries of the previous system put pressure on life insurance firms to sell their equity investments as equity markets fell, so causing markets to fall further.

The twin peaks approach proposes that the Pillar 1 regulatory capital requirement should be based on the higher of a firm's regulatory and realistic liability ("peak"). It has been designed to achieve a regulatory system that is hoped to perform better in times of market stress.

In particular, the realistic peak requires investment guarantees and options to be valued using modern financial risk management techniques. Nevertheless, the Pillar 1 regulatory capital requirement covering investment guarantee, or market risk, is still based on an arbitrary deterministic stress, included in the Risk Capital Margin (RCM). See Appendix 11.1 for the full details.

We now describe the stochastic model that we use for our with profits life insurance firm examples. As with our general model, described in Chapter 7, readers not interested in the technical details of the model should proceed directly to Section 11.2.3.

### 11.2.2 The stochastic model

The stochastic model that we have used for this example is a special case of the general model described in Chapter 7. In particular, we model the following four key response variables in this example:

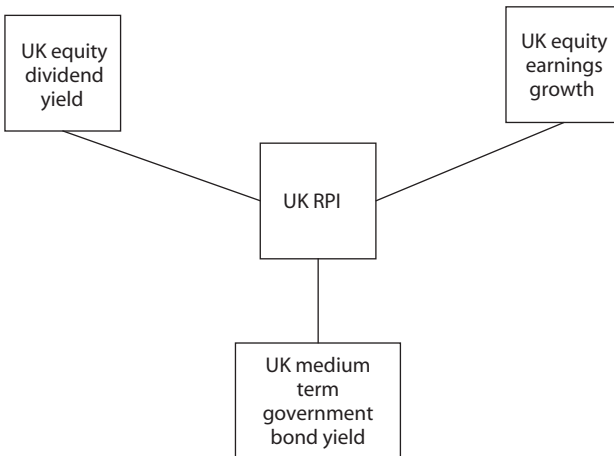
1. UK RPI
2. UK equity dividend yield
3. UK equity earnings growth
4. UK medium term government bond yield

As described in Chapter 7, we use first order autoregressive time series models to model the within response variable dependencies, with

**Table 11.1** Correlation model parameterization – with profits life insurance examples

<i>Response Variable Pair.</i>	<i>Assumed correlation</i>	<i>Corresponding Chapter 7 correlation</i>
RPI/equity dividend yield	0.3	0.3
RPI/equity earnings growth	0.1	0.1
RPI/government bond yield	0.6	0.36*

\* As shown in Appendix 7.1.



**Figure 11.1** Graphical model of between response variable dependency model

parameter values set equal to those shown in Table 7.11. The graphical model that we have used to describe the between response variable dependencies is shown in Figure 11.1. It is a special case of our general model as shown in Figure 7.17.

Using the conditional independence properties of the graphical model, we can see that it can also be represented as a one factor model, where the usual error term  $\varepsilon$ 's are correlated only through the common UK RPI  $\varepsilon$ , or factor.

The correlation coefficient parameter values that we have chosen for our base case stochastic model are shown in Table 11.1, alongside the corresponding values for the full model described in Chapter 7.

The correlation that we have assumed for the UK RPI/UK medium term government bond yield is therefore slightly stronger than that implied by our full model, as described in Chapter 7.

Given that the correlations of investment time series are highly non stationary, our approach in this example is to choose correlation values that we believe are plausible over the longer term, supported by sensitivity analyses to assess what impact alternative correlation assumptions have on our results. These analyses show, in fact, that economic capital increases as the correlations increase.

The corresponding full  $4 \times 4$  correlation matrix, and the  $4 \times 4$  inverse correlation matrix, are both shown in Appendix 11.2.

### *Model validation and calibration*

Real total return means, standard deviations, skewness and kurtosis coefficients, for both UK equities and UK government bonds, as estimated from the output of 2,500 runs of the stochastic model, and for UK historical data, are shown in Table 11.2.

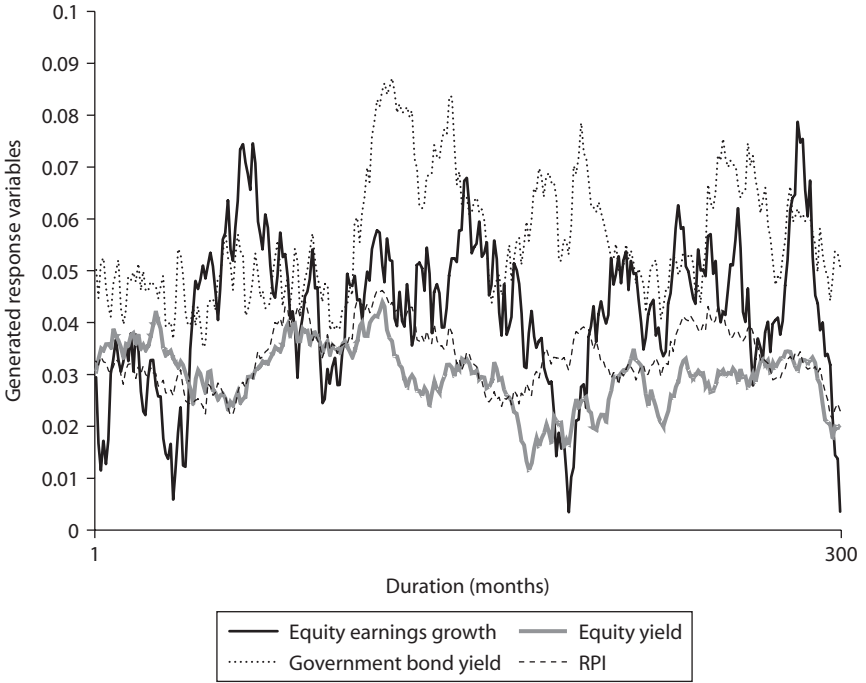
These results are similar to those that were shown in Chapter 7, for equity returns only. Table 11.2 gives bond returns in addition and shows that total returns, as generated by the stochastic model, are plausible and are consistent with the pattern of returns that have been observed over very long periods of time in the past: see Dimson, Marsh and Staunton (2002) for more detail on the historical data.

Specimen monthly model output of the four response variables over a 25 year period is displayed in Figure 11.2. Figure 11.3 shows specimen

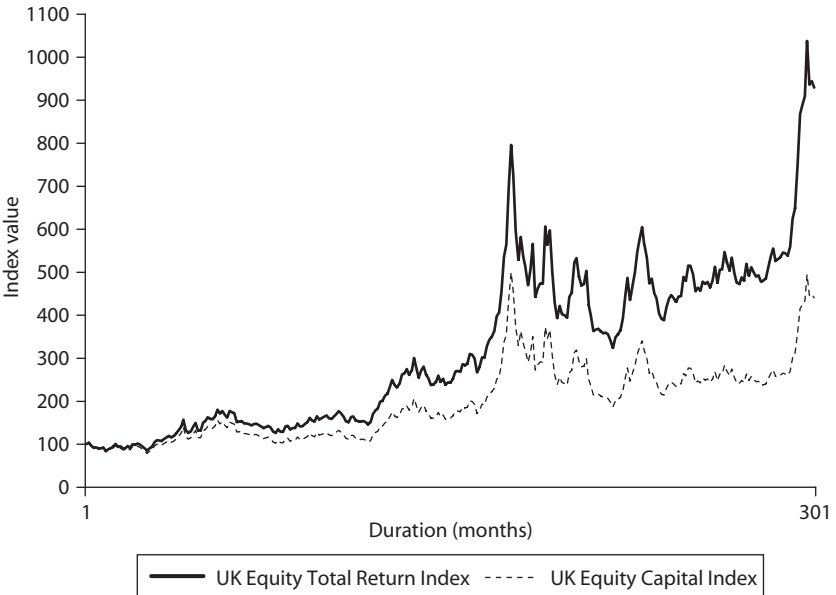
**Table 11.2** Estimated statistics computed from the stochastic model output versus historical data – with profits life insurance investment guarantee example

<i>Statistic</i>	<i>Model output</i>		<i>Historical data, 1900–2000*</i>	
	<i>Real equity total return</i>	<i>Real bond total return</i>	<i>Real equity total return</i>	<i>Real bond total return</i>
	<i>p.a.</i>	<i>p.a.</i>	<i>p.a.</i>	<i>p.a.</i>
Mean return (arithmetic)	0.07	0.03	0.08	0.02
Standard deviation	0.20	0.14	0.20	0.14
Skewness	0.5	0.3	0.7	1.0
Kurtosis	0.8	0.2	0.8	0.2

\* Dimson, Marsh and Staunton (2002). Mike Staunton, Director of the London Share Price Database provided the skewness and kurtosis data. Note that normal random variables have zero skewness and kurtosis values.



**Figure 11.2** Stochastic model specimen output – with profits life insurance examples



**Figure 11.3** Stochastic model specimen index output – with profits life insurance examples

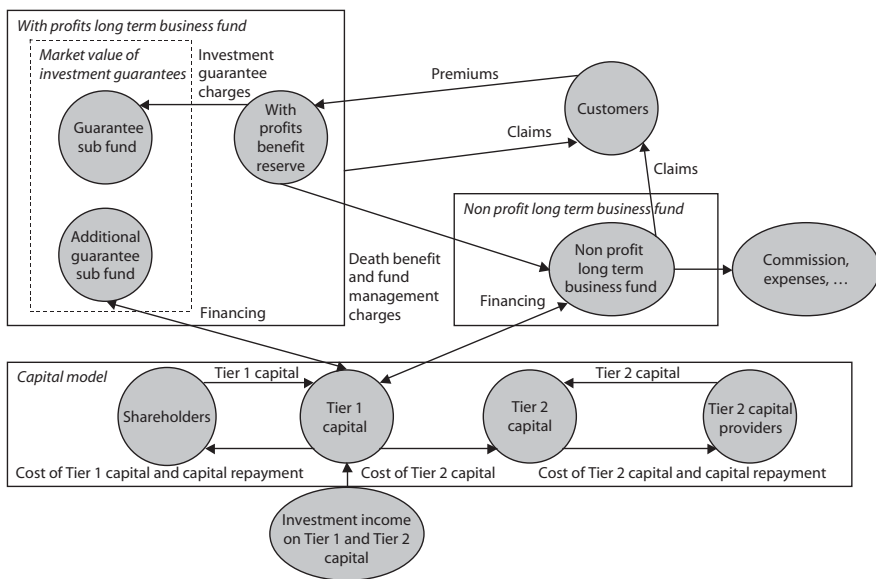
UK equity capital return and UK equity total return, capital plus income, indices derived from the response variable model output, as described in Chapter 7. It can be seen from these figures that the model produces results that are qualitatively very similar to real investment time series data.

### 11.2.3 With profits funds, assets, asset shares and customer benefits

Figure 11.4 shows our assumed firm corporate structure model which, although much more complicated than our banking corporate structure models, is essentially the same model. This corporate structure is described in detail below, together with the main corporate cashflows, which are also shown in Figure 11.4.

#### Funds

Although the detailed corporate structure that we have assumed is complex, it is fairly typical of shareholder owned UK life insurance companies, particularly those with newer or reorganized with profits funds. Crucially, the structure allows us to quantify, in a transparent way, the amount of economic capital that is required to back the investment guarantees offered by with profits life insurance firms. Brief descriptions



**Figure 11.4** With profits life insurance firm corporate structure

of the key corporate funds are as follows:

1. The WPLTBF contains the assets backing the with profits liabilities. Within this fund, three segregated sub funds are identified as follows:
  - a. The with profits benefit reserve (WPBR) which contains customer premiums, net of all product charges, aggregated over all with profits customers, and accumulated using actual investment returns.
  - b. The guarantee sub fund (GF) contains the accumulated investment guarantee product charges that the life insurance firm charges to cover the cost of the product investment guarantees, aggregated over all with profits customers.
  - c. The additional guarantee sub fund (AGF) which contains the assets which, together with the GF, equals the estimated *expected* value of the product investment guarantees, aggregated over all with profits customers.
2. A NPLTBF containing the assets backing the non profit liabilities.

### *Fund asset mixes*

The WPBR is assumed to be invested 75% in equities and 25% in medium term government bonds in our base case. As we shall see later, it is this fund that determines customer benefits and life insurance firms have tended to invest such funds heavily in equities in order to generate high long term investment returns for their customers. All other modeled corporate funds are assumed to be invested 100% in medium term government bonds.

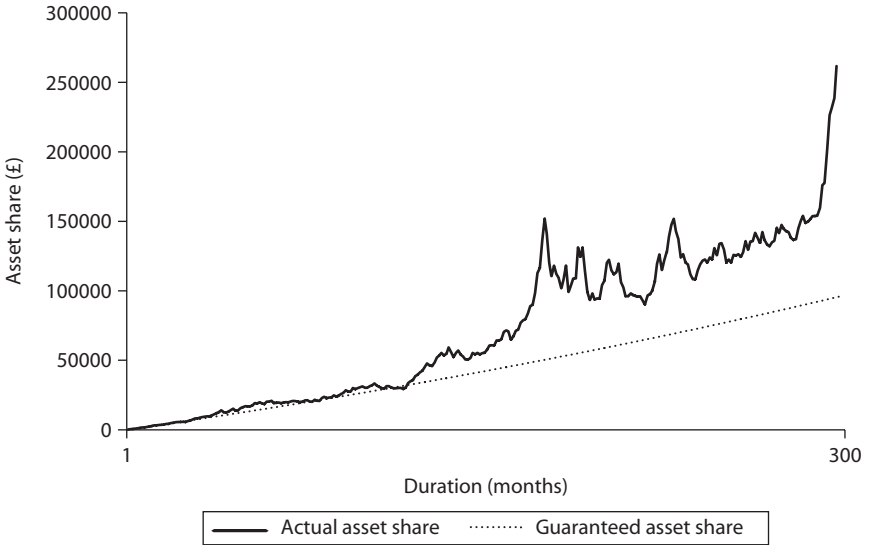
### *Government bond modeling*

For the purposes of our modeling work, we have assumed that the medium term government bonds in which the life insurance firm invests are rebalanced at the end of each month to take their term back to 15 years. This reflects the matching strategy of many firms who tend to target a particular term for the average outstanding duration of their bond portfolios. In other words, the bonds are sold at the end of each month and the proceeds are reinvested in new 15 year bonds at the yield prevailing at that time.

Each with profits customer's benefits are individually identified by

### *Actual asset share*

This equals customer premiums accumulated using actual investment returns, net of all product charges. The WPBR, within the WPLTBF, equals actual asset shares aggregated over all of the policies written in the WPLTBF.



**Figure 11.5** Specimen Regular Premium Actual and Guaranteed Asset Shares

### *Guaranteed asset share*

This equals customer premiums, less death benefit charges, accumulated at the guaranteed investment return.

### *With profits fund*

This equals the larger of actual and guaranteed asset shares.

Figure 11.5 shows a comparison of an actual asset share versus a guaranteed asset share for a typical run of the regular premium product model.

Product charges flow between the corporate funds as follows:

### *Death benefit charges*

These charges are transferred from the WPBR to the NPLTBF and cover the excess death benefit claims that are met from the NPLTBF.

### *Fund management charges*

These charges are transferred from the WPBR to the NPLTBF and are used to cover the fixed and variable expenses that are met from the NPLTBF.

### *Investment guarantee charges*

These charges are transferred from the WPBR to the GF and are used to meet the cost of the investment guarantees.

Similarly, profit/surplus and loss/deficit flows between the corporate funds occur as follows:

- All shareholder transfers flow through Tier 1 capital in accordance with our general corporate structure model.
- All surpluses/deficits in the NPLTBF are released/financed to/by Tier 1 capital as they emerge.
- The AGF which, together with the GF, equals the estimated expected value of the investment guarantees, is financed by Tier 1 capital.
- If, at any duration, the WPBR, GF and AGF, in aggregate, are not large enough to cover aggregate guaranteed asset shares, the deficit is financed by Tier 1 capital.

Table 11.3 summarizes customer benefits and sets out which funds pay for these benefits.

### *Guarantees*

Investment guarantees apply to premiums, net of death benefit charges, invested in the WPBR. The guarantee takes two forms

- A guaranteed minimum investment return of 0% p.a.
- A bonus investment return, assumed 2% p.a., that is declared annually in advance each policy year and which applies in addition to the

**Table 11.3** Customer benefits – with profits life insurance investment guarantee example

<i>Type of claim</i>	<i>Benefit</i>
Death	The greater of the guaranteed death benefit and the customer's with profits fund. The WPBR pays out actual asset share and any excess claim is paid for by the NPLTBF.
Surrender	Actual asset share and paid for by the WPBR. On surrender, it is normal for firms to withdraw investment guarantee benefits. This helps firms to avoid selection problems when these benefits have value in advance of maturity. Surrenders are explicitly modeled, as is described in Appendix 11.1.
Maturity	With profits fund. The WPBR pays actual asset share. The GF and AGF pay the estimated expected value of the investment guarantees, if required, with Tier 1 capital financing any remaining deficit.

guaranteed minimum investment return. Once added to a policy, these bonus returns cannot be taken away.

The level of guarantees considered in this section may appear high, particularly in association with the assumed asset mixes of the WPBR. However both these guarantees, and asset mixes, have been fairly typical of UK practice.

### *Future premiums*

The investment guarantees apply on death and maturity, but not on surrender and may be withdrawn at any time in respect of future premiums. Life insurance firms can withdraw the guarantees on future premiums by closing their existing WPBR to future premiums and replacing it with a new fund in which all future premiums must be invested.

The new fund will generally provide lower investment guarantees, so allowing firms to avoid exposing themselves to completely open ended future guarantees. We therefore ignore future regular premiums when determining economic capital for our regular premium with profits life insurance products.

### *Charging for the cost of the guarantees*

Most life insurance firms charge customers for investment guarantees by deducting an arbitrary amount from the actual investment return that is credited to their actual asset share each year. We price for the investment guarantee charge by requiring that, under our expected assumptions, the charges achieve a specified target, net of tax, rate of return for Tier 1 capital on the financing it provides to the WPLTBF to finance the sum of

1. The AGF
2. The WPLTBF's Pillar 1 regulatory capital requirement.

The sum of these two items represents total Tier 1 capital financing of the WPLTBF.

We now describe how the AGF is determined.

### *Determining the AGF*

We estimate the AGF, which represents the estimated expected value of the guarantees, net of the GF, as the average amount of capital, net of the GF, that the WPLTBF requires to cover its guarantees. In other words, at each duration, the AGF equals the amount of capital required to ensure that, on average over the stochastic runs, the aggregate WPBR, GF and

AGF always exceed guaranteed asset shares, over the remaining lifetime of the fund.

At present, there is no genuinely liquid market for financial instruments matching guarantees with durations as long as those offered by life insurance firms. Therefore, establishing a genuine market value for the guarantees described here may not be possible in practice.

#### **11.2.4 Method**

To avoid cross-subsidies between different new business generations, all our modeling work is based on one new business product.

##### **11.2.4.1 Fund management charge pricing**

The fund management charge is priced, under our expected assumptions, to achieve a specified target, net of tax, rate of return for Tier 1 capital on the financing it provides to the NPLTBF. A fund management charge of 0.75% p.a. achieves a net rate of return of around 8% for single premium products and 9% for regular premium products.

##### **11.2.4.2 Investment guarantee charge pricing**

The investment guarantee charge is priced, under our expected assumptions, to achieve a specified target net rate of return for Tier 1 capital on its financing of the AGF and the Pillar 1 regulatory capital requirement of the WPLTBF. An investment guarantee charge of 0.5% p.a. achieves a net rate of return of around 10% for single premium products and 11% for regular premium products.

##### **11.2.4.3 Investment guarantee economic capital**

The stochastic model and life insurance firm model is run 2,500 times and, for each run and at all monthly durations, the amount of Tier 1 capital that is required to support the WPBR is determined as follows:

1. The capital requirement, subject to a minimum value of zero, is calculated as the amount of additional capital that is needed to ensure that the aggregate WPBR and GF have sufficient assets to cover guaranteed asset shares, throughout the remaining lifetime of the WPBR. As described above, future regular premiums are set to zero in performing this calculation, as the investment guarantees may not be available to them.
2. For each duration, the 2,500 capital requirements are then ordered and the 95th, 99th, 99.5th percentiles and average capital calculated.

3. The AGF is set equal to the average capital requirement at each duration.
4. The percentiles, less the AGF, and subject to a minimum value of zero, are then compared with the corresponding WPLTBF Pillar 1 regulatory capital requirements at each duration. The AGF is deducted as this amount of capital must be injected by Tier 1 capital into the WPLTBF to satisfy its reserving requirements.

All of the above is repeated after having varied one or more of the key assumptions. Our results are set out in Section 11.2.5 below.

### 11.2.5 Results

We present our results in graphical form by comparing economic capital throughout the lifetime of a single generation of with profits business with the corresponding expected Pillar 1 regulatory capital requirements. We assume, throughout, that the Pillar 1 regulatory capital requirement is financed entirely by Tier 1 capital. All of the figures show expected Pillar 1 regulatory capital, 95th percentile economic capital, 99th percentile economic capital and 99.5th percentile economic capital.

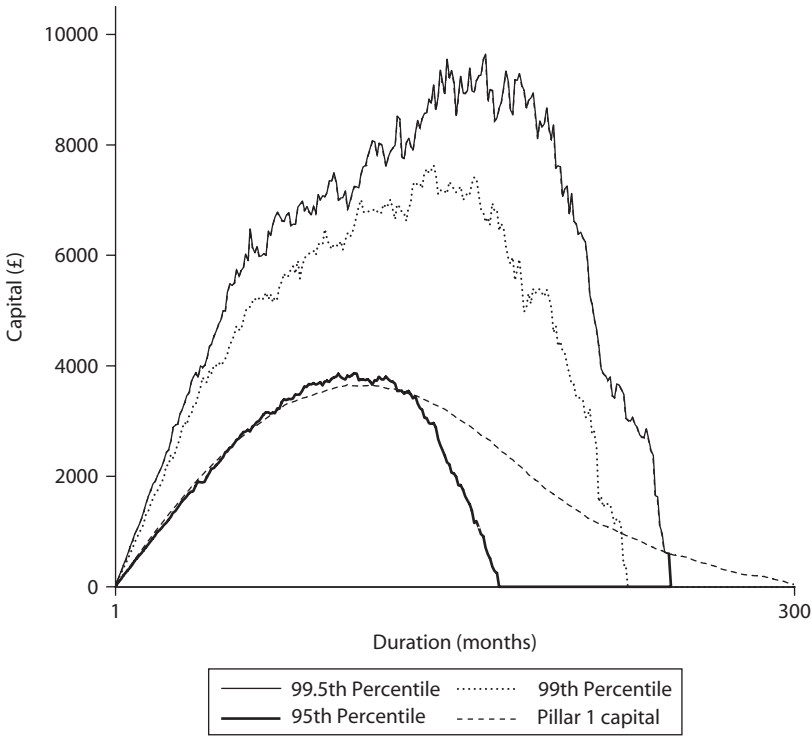
Note that our with profits life insurance figures are slightly different from those shown for our previous examples. At each duration, capital amounts are shown per unit of business in force at that duration. For all of our other examples, our figures show capital amounts per unit of business in force at the inception of the business. This difference is simply because, as asset shares are retrospective accumulations, it is slightly more convenient to display our with profits results in this way. Our conclusions are, of course, unaffected.

#### 11.2.5.1 *Base case regular premiums*

Figure 11.6 shows our regular premium base case result. The figure shows that Pillar 1 capital does have the correct shape by duration. However, the most important observation is that, for percentile levels greater than the 95th, Pillar 1 capital is generally too low relative to economic capital.

#### 11.2.5.2 *Wilkie model regular premiums*

Figure 11.7 shows our regular premium base case result using the stochastic model proposed in Wilkie (1995) and using Wilkie's suggested parameterization. Note that the economic capital graphs shown in Figure 11.7 are not as smooth as those shown in Figure 11.6. The Wilkie model is a yearly model and applying it to calculate monthly returns can



**Figure 11.6** Regular premium economic capital versus Pillar 1 capital – base case

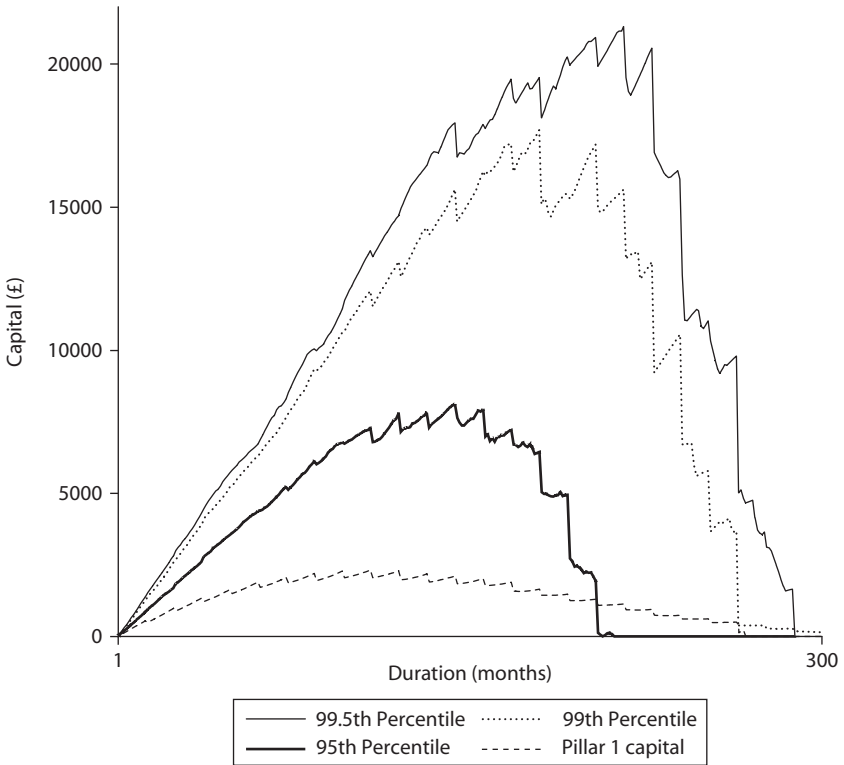
result in discontinuities at year ends. This is because capital movements as result of yield changes from one projection year to the next all occur in the first month of the new projection year.

Comparison of Figure 11.7 with Figure 11.6 shows that the economic capital amounts estimated using the Wilkie model are far greater than those obtained using the stochastic model described in Section 11.2.2.

Comparing Table 11.4, which shows the moments of the Wilkie total equity and bond returns, with Table 11.2 it can be seen that Wilkie total equity returns are far more volatile and have greater skewness and kurtosis than the returns generated by the stochastic model described in Section 11.2.2. This explains why the economic capital amounts in Figure 11.7 exceed those shown in Figure 11.6.

Reparameterizing the Wilkie model to produce total equity and bond return moments that are much closer to those shown in Table 11.2, see Table 11.4, results in the economic capital amounts shown in Figure 11.8 and these are now very similar to those shown in Figure 11.6.

The reparameterized Wilkie stochastic model therefore reinforces the qualitative conclusion that Pillar 1 capital is too low relative to economic capital.



**Figure 11.7** Regular premium economic capital versus Pillar 1 capital – Wilkie Model and parameterization

### 11.2.5.3 Single premiums

Figure 11.9 shows our result for single premiums. As for regular premiums, Pillar 1 capital is again too low compared to economic capital.

The regular premium product is an aggregation of a series of recurring single premium products, each of reducing term. It then follows that the Pillar 1 and economic capital amounts for the regular premium product are broadly the aggregation of the underlying recurrent single premium capital amounts. In the rest of this Section, we therefore concentrate on single premium economic capital under a range of scenarios. The results for any mix of regular and single premium business can then be inferred from these single premium results.

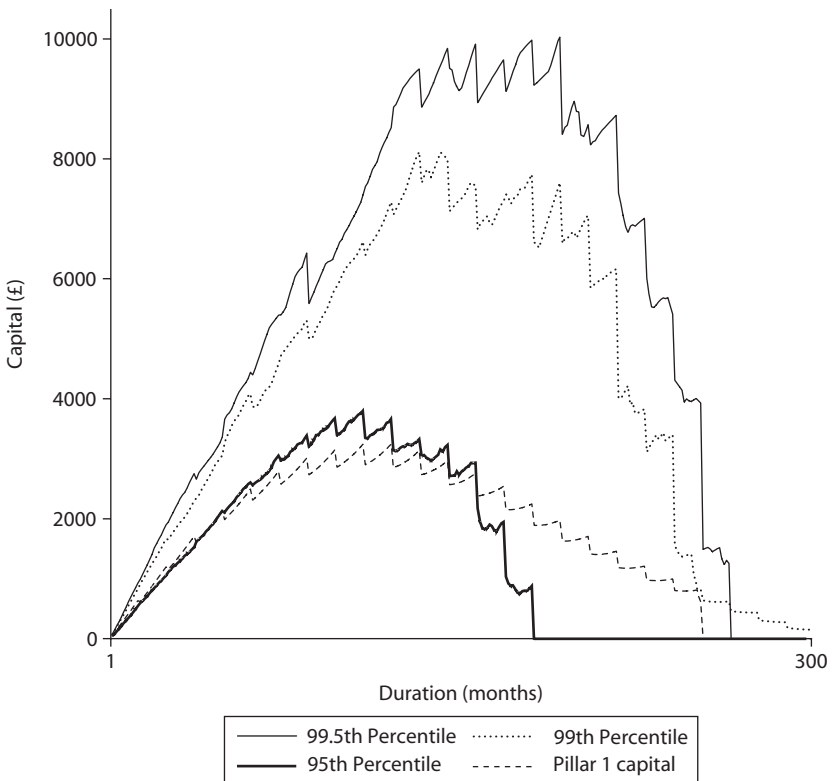
### 11.2.5.4 Reducing the equity content of the WPBR to 25%

Figure 11.10 shows the effect of reducing the equity content of the WPBR to 25%. In reducing the equity content, we reduce asset volatility, but actual asset shares also tend to fall in value. This is because modeled

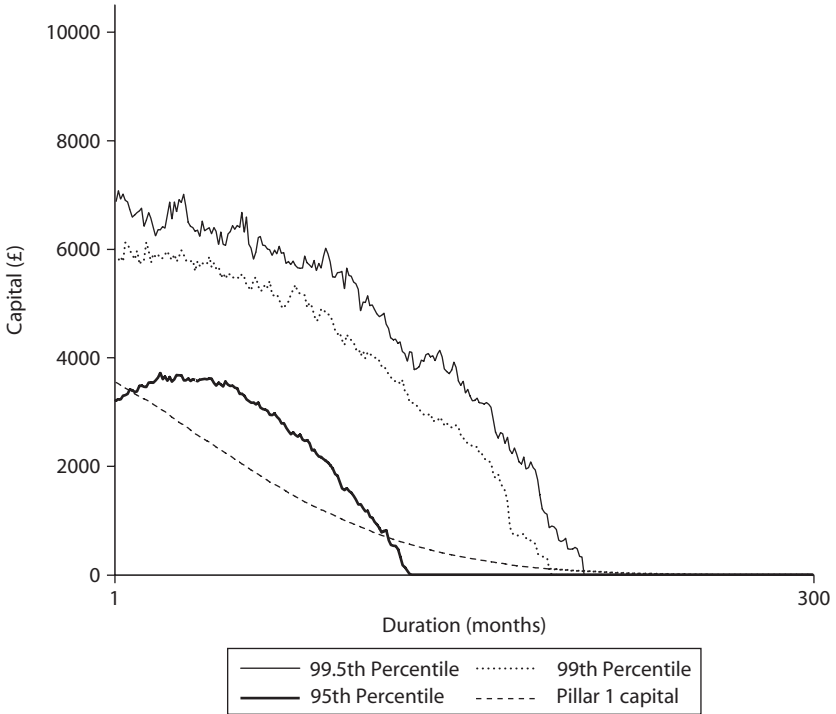
**Table 11.4** Estimated statistics computed from the Wilkie model output – with profits life insurance investment guarantee example

Statistic	Wilkie (1995) parameterization		Wilkie reparameterization*	
	Real equity total return p.a.	Real bond total return p.a.	Real equity total return p.a.	Real bond total return p.a.
Mean return (arithmetic)	0.15	0.04	0.07	0.03
Standard deviation	0.47	0.09	0.20	0.13
Skewness	1.0	0.3	0.5	0.3
Kurtosis	1.3	0.1	0.3	0.2

\* See Porteous (2004).



**Figure 11.8** Regular premium economic capital versus Pillar 1 capital – reparameterized Wilkie Model



**Figure 11.9** Single premium economic capital versus Pillar 1 capital – base case

government bond assets tend to return less than equities. There is, therefore, less of a buffer between actual and guaranteed asset shares to absorb asset volatility before capital is required.

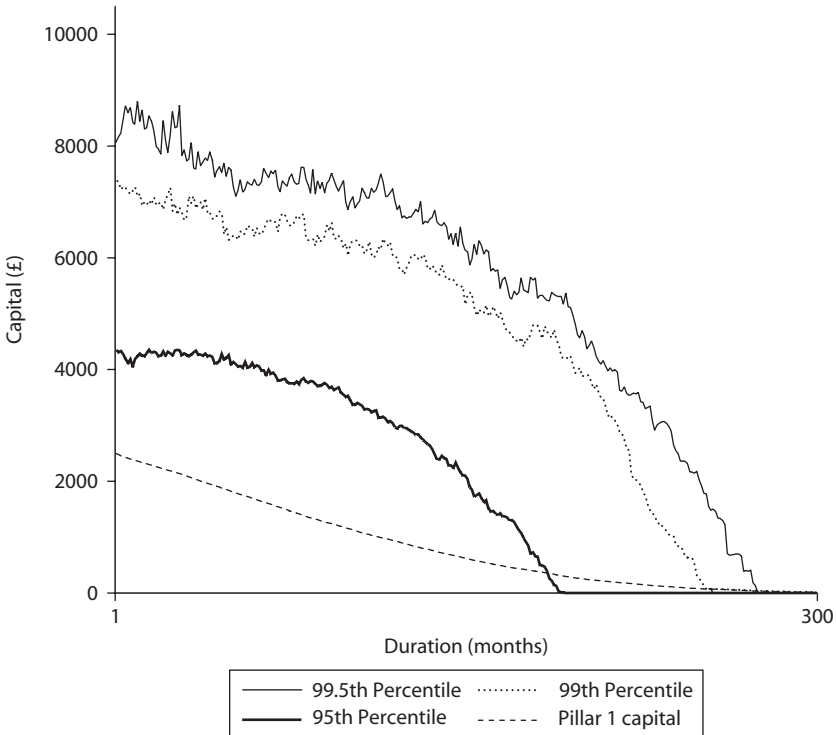
Comparison of Figure 11.10 with Figure 11.9 shows that economic capital increases at all durations. In other words, the reduced buffer has the larger effect.

Somewhat perversely, Pillar 1 capital has fallen everywhere however. This is because the resilience/RCM stress, see Appendix 11.1, is relatively gentle on government bonds, as compared to equities, so resulting in the Pillar 1 capital fall.

We can conclude, therefore, that an investment strategy more weighted towards government bonds, rather than to equities, results in economic capital that is even larger relative to Pillar 1 capital.

#### **11.2.5.5 Reducing the bonus investment return from 2.0% p.a. to 1.0% p.a**

Comparison of Figure 11.11 with Figure 11.9 shows that cutting bonus rates has the effect of causing all economic capital amounts to fall. This



**Figure 11.10** Single premium economic capital versus Pillar 1 capital – reduce equity content of with profit benefit reserve to 25%

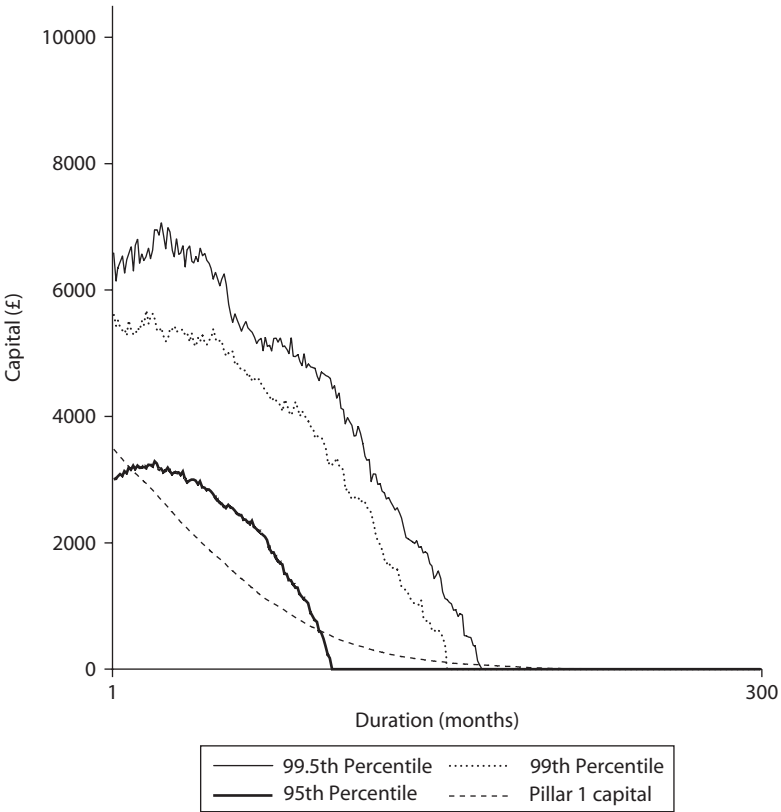
is because the buffer between the actual and guaranteed asset shares, which can be used to absorb asset fluctuations before capital is required, is larger under the reduced bonus rate. Although Pillar 1 capital also falls, the size mismatches noted earlier remain.

### 11.2.5.6 Strengthening the resilience/RCM stress

Figure 11.12 shows the result of doubling the strength of our assumed resilience/RCM stress. Pillar 1 capital is now of a size and shape that much better approximates to economic capital.

Note that the RCM stresses used in this example are those proposed by the FSA in its consultation papers with the industry. This consultation is now complete and the FSA has slightly weakened the RCM stresses that it has included in its final rules. Appendix 11.1 provides the details.

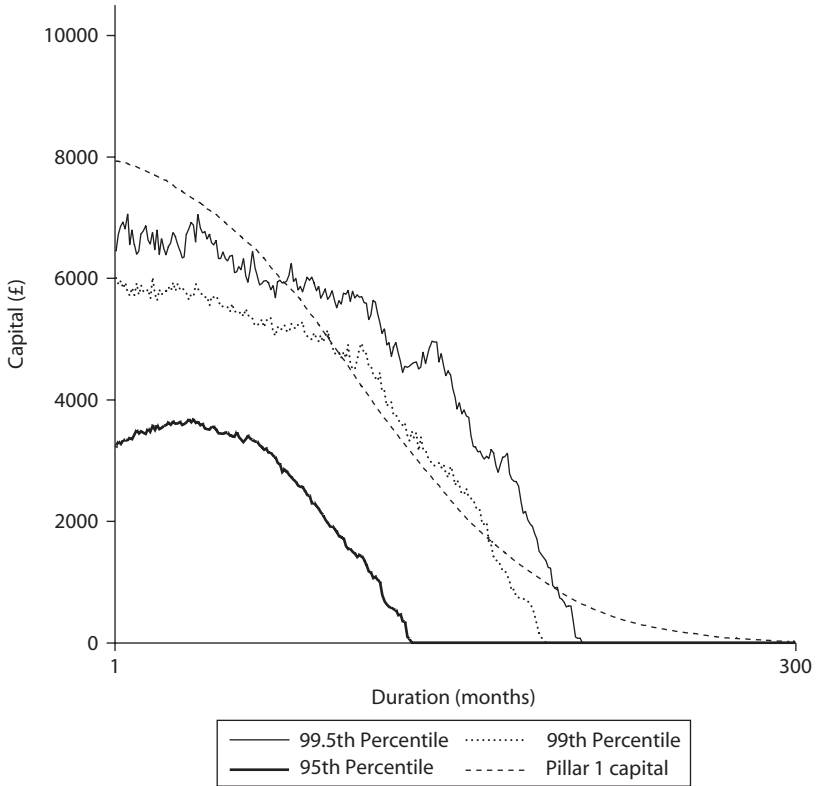
This weakening was based on a calibration exercise carried out by a firm of actuarial consultants. The report entitled “Calibration of the Enhanced Capital Requirement for with-profit life insurers” is available on the FSA’s website [www.fsa.gov.uk](http://www.fsa.gov.uk).



**Figure 11.11** Single premium economic capital versus Pillar 1 capital – bonus investment return reduced from 2% p.a. to 1% p.a

This report acknowledges, in its paragraph 2.10, that “the correlation assumptions had a significant effect on the stress test levels derived” and that “As there is some empirical evidence to suggest that correlations tend to increase in extreme adverse market conditions, it is worth noting that the stress tests derived might understate the true capital required to survive low probability events”. The correlations referred to are broadly those that we have modeled in our general stochastic model, as described in Chapter 7, and in the more specific stochastic model used here, as described in Section 11.2.2.

The correlation modeling in the report does appear somewhat tentative. However, as the correlation assumptions used in the report are not explicitly disclosed, it is not possible to comment much further. However, this uncertainty over the correlation modeling and the heavy qualifications given in the report does cause one to question the calibration results reported.

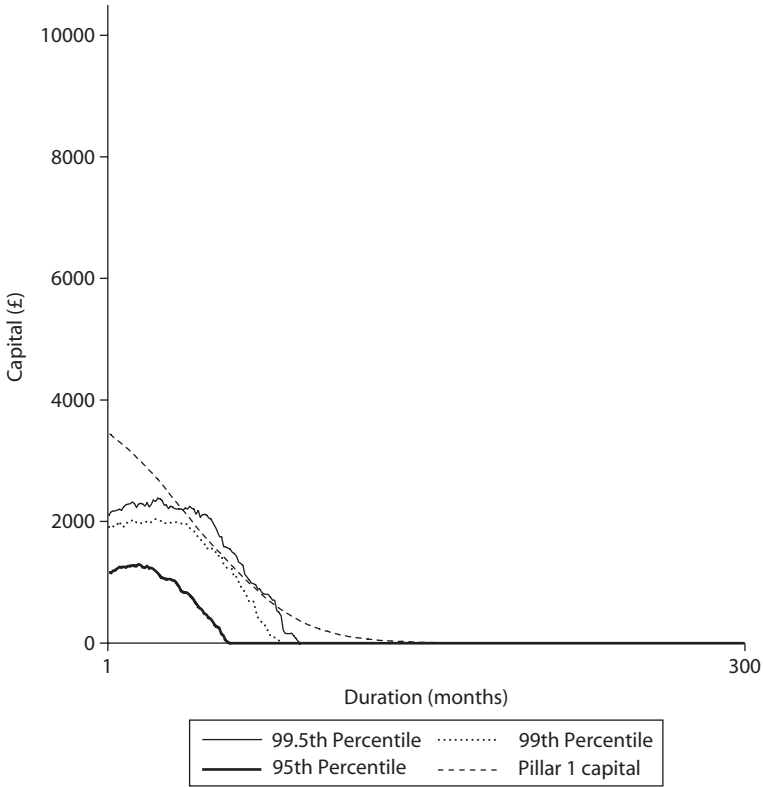


**Figure 11.12** Single premium economic capital versus Pillar 1 capital – resilience/RCM stress increased by a factor of 2

This slight weakening of the RCM stresses in fact strengthens the conclusions of this example as it has the effect of slightly reducing Pillar 1 capital.

### 11.2.5.7 Reducing the standard deviations in the stochastic model by 50%

Figure 11.13 shows the effect of reducing our base case standard deviations by 50%. As expected, economic capital falls very substantially to levels that are broadly in line with Pillar 1 capital. However with this model parameterization, the standard deviations of the total real equity and bond returns, as generated by the model, are too low relative to historical returns and this explains why the economic capital amounts have fallen.



**Figure 11.13** Single premium economic capital versus Pillar 1 capital – reduce stochastic asset model standard deviations by 50%

### 11.2.5.8 Rates of return on capital

For each of the 2,500 simulations, and for each example, we have calculated the rate of return earned by the investment guarantee charge on Tier 1 capital financing of the sum of the AGF and, either, WPLTBF Pillar 1 regulatory capital, or, WPLTBF economic capital.

The rate of return earned by the fund management charge on the Tier 1 capital financing of the NPLTBF is also calculated.

We can then study the distribution of these rates of returns over the 2,500 simulations. Summary statistics for our base case regular premium example are shown in Table 11.5 below.

The results and conclusions for our base case single premium example are similar.

From Table 11.5, it can be seen that the distributions of the rates of returns induced by the stochastic model are close to Normal.

**Table 11.5** Rates of return on capital for the base case regular premium example – with profits life insurance investment guarantee example

	<i>Investment guarantee charge</i>				<i>Fund management charge</i>
	<i>Pillar 1 regulatory capital</i>	<i>capital amount</i>			<i>financing</i>
		<i>95th Percentile economic capital</i>	<i>99th Percentile economic capital</i>	<i>99.5th Percentile economic capital</i>	
Mean	12%	12%	10%	9%	10%
Standard deviation	2.0%	2.1%	1.8%	1.7%	1.2%
Skewness	0.03	0.01	0.07	0.08	0.55
Kurtosis	(0.02)	(0.05)	(0.16)	(0.14)	2.48

The fund management charge rates of return skewness and kurtosis values, although large, are caused by two outliers. The distribution of the remaining returns is, however, again very close to Normal.

It can also be seen from Table 11.5 that the average investment guarantee charge return on Tier 1 capital financing of the AGF and WPLTBF Pillar 1 capital, which equals 12%, is close to the priced return of 11%, as described in Section 11.2.4. Similarly, the average fund management charge return on the Tier 1 capital financing of the NPLTBF, at 10%, is again close to the priced return of 9%.

Table 11.5 shows that the relative values of the average rates of return on capital are as expected. In particular, Table 11.5 shows the distorting effect that a relatively arbitrary choice of capital measure, such as the Pillar 1 capital, has on measured financial return. If 99.5th percentile economic capital is the appropriate amount of investment guarantee capital that the firm should be holding to cover the risks it is running, then the product is earning, on average, a post tax rate of 9% on that capital, compared to an average rate of 12% on Pillar 1 capital and this is a fairly significant differential.

### 11.2.6 Banking comparison

Banks also take on investment guarantee, or “market”, risks similar to those considered in this example. However there are fundamental differences

between the life insurance and banking approaches to managing these risks, as well as in the nature of the risks themselves. In particular:

### *Duration*

The risks that banks take on are generally of much shorter durations than those of life insurers. In this example, we can see that the market risk persists and accumulates over a period of 25 years for a typical with profits life insurance savings policy.

### *Hedging*

Life insurers do not generally hedge their market risks, but attempt to control them by dynamically managing their asset mixes and bonus declarations, and by using their capital to absorb the ongoing profits/losses generated by the guarantees. More recently, however, as equity markets have fallen and capital has become much tighter, life insurance firms have been making increasing use of derivative instruments to hedge, at least in part, their market risks. Banks without a trading book will generally hedge almost all of the market risk that they take on. Banks with a trading book will generally retain unhedged market risk for very short periods of time.

### *Measurement*

Banks tend to measure and manage market risks using VAR techniques, whereas life insurance firms have tended to measure their market risks using deterministic stress tests or stochastic models. Although the stochastic model approach is very similar in nature to VAR, as we have seen in this example, these models are used over much longer time periods than the banking models are.

### *Regulatory capital requirement*

The Pillar 1 regulatory capital requirement that banks must set up to cover market risk in their trading books is based on VAR whereas, for life insurance companies, it is based on fairly arbitrary deterministic asset/liability mismatch tests that are specified by the FSA from time to time. The recently introduced insurance regulations, as described in Chapter 14, require that the life insurance market risk Pillar 2 regulatory capital requirement should be set using deterministic, or stochastic, techniques more akin to VAR. However, the practical implementation of these techniques by the industry is still evolving and in development.

### 11.2.7 Conclusions

The results of this example show that Pillar 1 regulatory capital requirements may not be adequate to cover the market risks that UK life insurance firms are running and may need to be recalibrated upwards.

The FSA has carried out independent actuarial work that purports to demonstrate that the Pillar 1 regulatory capital requirement is calibrated to achieve a 99.5% confidence/percentile level over a one year confidence period. We have checked that our main qualitative conclusion still applies for economic capital defined over both one and five year confidence periods. As described earlier, the results of the FSA's calibration exercise are open to some doubts.

UK life insurance firms are required to validate the adequacy of the Pillar 1 regulatory capital requirement using an Individual Capital Assessment (ICA). The ICA is similar, in principle, to the Basel 2 Pillar 2 capital self assessment exercise proposed for banks. See Chapter 14 for full details.

Based on the ICA, the FSA will issue Individual Capital Guidance (ICG) privately to each firm in the form of an enhanced, or status quo, Pillar 1 regulatory capital requirement. The work of this Section suggests that, for market risks written in WPLTBFs, the ICG is likely to require a Pillar 1 capital increase.

#### *Practical implementations*

In practice and, as is required by the market, the stronger UK life insurance firms have tended to have capital that is well in excess of their Pillar 1 regulatory capital requirements, although this excess has eroded in recent years due to falling equity markets and very strong competition.

At an aggregate balance sheet level, firms will also benefit from the cross-subsidies generated by lines of business, or business generations, for which economic capital is less than the Pillar 1 regulatory capital requirement. See Porteous, McCulloch and Tapadar (2003) for further details.

The main industry conclusions of this example are:

- Weaker life insurance firms may require more capital to cover the risks they are running.
- There is a need for life insurance firms to develop more effective hedging tools to manage their market risks.
- The weaker life insurance firms may withdraw from the with profits market to focus on less capital intensive sectors of the long term savings market.

## 11.3 STOCHASTIC WITH PROFITS LIFE INSURANCE SMOOTHING EXAMPLE

### 11.3.1 Introduction

In this section, we move on to consider the amount of economic capital that a UK life insurance firm needs to back the “discretionary” smoothing benefits provided by its with profits long term business fund (WPLTBF).

This section extends the example of the previous section and, in the interests of brevity, and to avoid repetition, we will build on the previous section wherever possible. Similar to the previous example, with profits customer benefits are individually identified by:

#### *Actual asset share*

This equals premiums accumulated using actual investment returns and net of all product charges.

#### *Smoothed asset share*

This is a smoothed version of actual asset shares.

#### *Guaranteed asset share*

This equals premiums less death benefit charges accumulated using guaranteed investment returns.

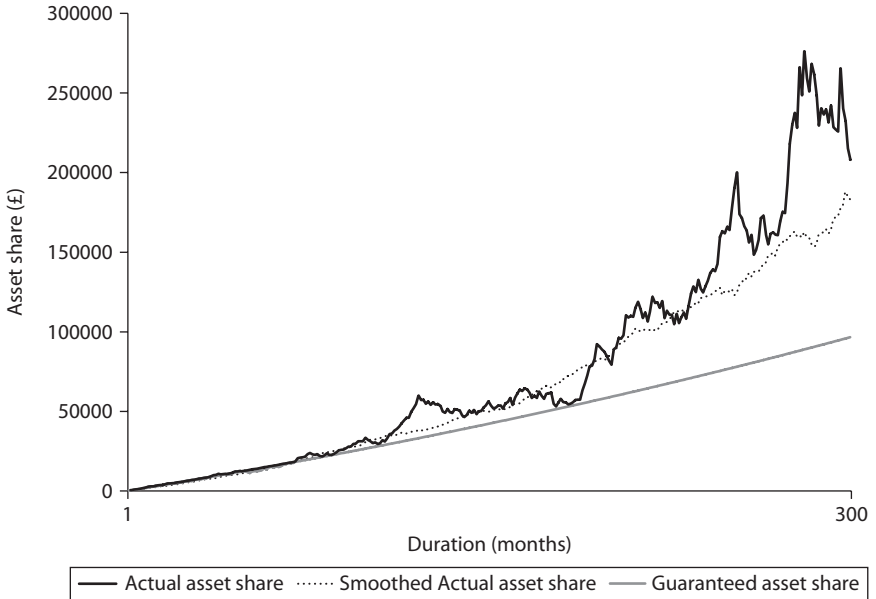
#### *With profits fund*

This is defined as the largest of actual, smoothed and guaranteed asset shares.

As we know from the previous section, actual asset shares tend to be invested in highly volatile assets, usually a mixture of equities and fixed interest bonds and are, therefore, themselves volatile. To protect customers from this volatility, most life insurance firms try to smooth volatility out of their actual asset shares by basing payouts on “smoothed” versions of actual asset shares.

Figure 11.14 shows a comparison of an actual asset share versus smoothed and guaranteed asset shares for a typical run of the regular premium product model.

Assuming that, on average, losses incurred when actual asset shares are smoothed “up” equal profits earned when actual asset shares are smoothed “down,” smoothing will be broadly financially neutral. In practice,



**Figure 11.14** Actual, smoothed and guaranteed asset shares

however, as a result of very tough competition in the UK life insurance market, it is very likely that life insurance firms may have been smoothing “up” more often than they have been smoothing “down.” We investigate the financial impact of this later.

Although smoothing benefits are discretionary in nature, life insurance firms have promoted the smoothing feature of with profits life insurance products very heavily in their sales and marketing literature. Similarly, financial advisers have often recommended with profits life insurance products in preference to unit linked life insurance products on the basis that smoothed returns are less volatile, and so more appropriate, for risk averse clients. Possibly as a result of the discretionary nature of smoothing benefits, life insurance firms are not required to hold explicit regulatory capital to cover these benefits.

The position that we take in this book is that, although smoothing benefits are in principle discretionary and are not guaranteed, customer expectations of a smoothed return are so strong that, in practice, smoothing benefits are effectively quasi-guaranteed and firms should, therefore, be required to hold capital to back these benefits. Indeed, these strong expectations have been set by the life insurance firms themselves and by the financial advisers who sold the business.

The UK regulator, the FSA, has been consulting with the UK life insurance industry on the fair treatment of with profits customers and, as

described later, has now issued broad rules on how with profits smoothing should operate in practice. The following quotation is taken from one of the FSA’s early consultation papers, Consultation Paper 207 “Treating With-Profits Policyholders Fairly”:

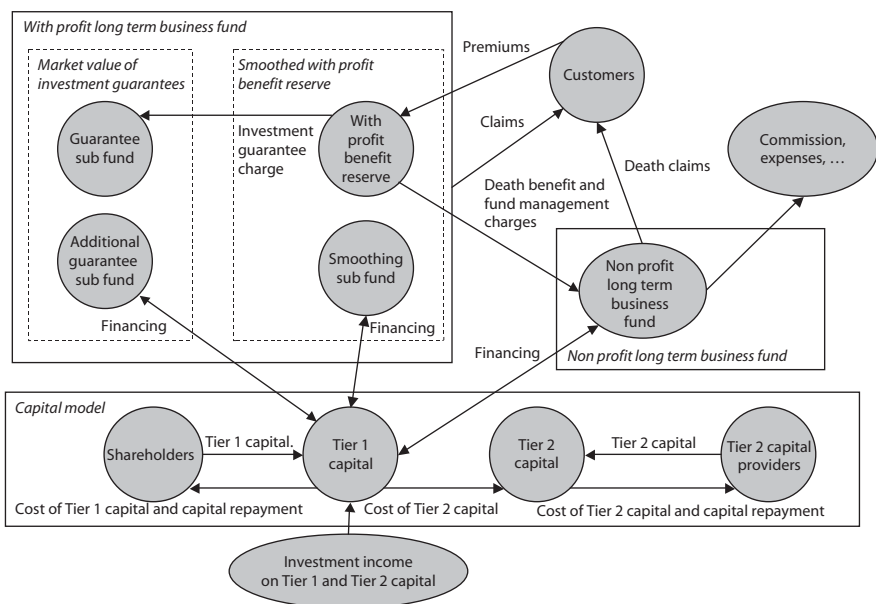
“The methods by which a with-profits firm decides how to exercise its discretion, including how it invests its with-profits fund and how it decides the level of payouts to policyholders, have so far generally been almost entirely opaque.”

### 11.3.2 The stochastic model

We use exactly the same model as was used in the previous example in Section 11.2.2.

### 11.3.3 With profits funds, assets, asset shares and customer benefits

Figure 11.15 shows the smoothed with profits life insurance corporate firm structure that we have assumed. Although the corporate structure is very complex, it does follow the general structure that we have assumed for all of our firm examples. The corporate funds that make up the structure are described in detail below, as well as the fund cashflows also shown on the structure in Figure 11.15.



**Figure 11.15** Smoothed with profits life insurance firm corporate structure

## Funds

Although the detailed corporate structure that we have assumed is complex, it is fairly typical of shareholder owned UK life insurance companies, particularly those with newer, or restructured, with profits funds. Crucially, the structure allows us to quantify, in a transparent way, the amount of economic capital that is required to back the investment guarantees and smoothing benefits offered by with profits life insurance firms. More detail is provided below and, in particular, the structure comprises

1. A WPLTBF containing the assets backing the with profits liabilities. Within this fund, four distinct segregated sub funds are identified as follows:
  - a. The WPBR, the GF and the AGF are essentially the same as those described in Section 11.2.3.
  - b. A new sub fund, the smoothing sub fund (SF), contains assets that are *expected* to be sufficient to ensure that the WPBR and the SF, in total, which we call the smoothed with profits benefit reserve (SWPBR), contain enough assets to cover aggregate actual asset shares, at all times, and aggregate smoothed asset shares, at maturity. Actual asset shares are needed to cover surrender value benefits and smoothed asset shares to cover maturity benefits, as described in Table 11.6.
2. A NPLTBF containing the assets backing the non profit liabilities.

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**Table 11.6** Customer benefits – with profits life insurance investment guarantee and smoothing example

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<i>Type of claim</i>	<i>Benefit</i>
Death	The greater of the guaranteed death benefit and the customer's with profits fund. The WPBR pays out the actual asset share with any remaining excess claim paid for by the NPLTBF.
Surrender	Actual asset share and paid for by the WPBR. On surrender, it is normal for firms to withdraw both investment guarantee benefits and smoothing benefits. This helps firms to avoid selection problems when these benefits have value in advance of maturity. Surrenders are explicitly modeled, as described in the previous section.
Maturity	With profits fund. The WPBR pays actual asset share and the SF pays expected smoothing benefits, if required. The GF and AGF pay for the expected investment guarantee benefits, if required, relative to the larger of actual and smoothed asset shares. Tier 1 capital finances any remaining deficit.

---

### *Fund asset mixes*

The WPBR and the SF are assumed to be invested 75% in equities and 25% in medium term government bonds in our base case. All other modeled corporate funds are assumed to be invested 100% in medium term government bonds.

Product charges flow between the corporate funds as described below.

### *Death benefit charges*

These charges are transferred from the WPBR to the NPLTBF and cover the excess death benefit claims that are met from the NPLTBF.

### *Fund management charges*

These charges are transferred from the WPBR to the NPLTBF and are used to cover the fixed and variable expenses paid by the NPLTBF.

### *Investment guarantee charges*

These charges are transferred from the WPBR to the GF and are used to meet the cost of the investment guarantees.

Similarly, profit/surplus and loss/deficit flows between the corporate funds as follows:

- All shareholder transfers flow through Tier 1 capital in accordance with our general corporate firm structure model.
- All surpluses/deficits in the NPLTBF are released/financed to/by Tier 1 capital.
- The SF is financed by Tier 1 capital.
- The AGF is financed by Tier 1 capital.
- The larger of the WPBR and aggregate smoothed asset shares must be as large as aggregate guaranteed asset shares, at all times throughout the remaining lifetime of the WPLTBF. If, for a particular run of the model, financing is required to achieve this, it is provided in the first instance by the GF, AGF and SF. If further financing is required beyond this, it is provided by Tier 1 capital through the AGF.
- If for a particular run of the model, additional financing is required to ensure that the SWPBR has sufficient assets cover both aggregate actual asset shares and aggregate smoothed asset shares, at maturity, this is provided by Tier 1 capital injected through the SF.

Appendix 11.4 summarizes the full corporate firm structure assumptions that underlie this section.

Table 11.6 summarizes customer benefits and sets out which funds pay for these benefits.

### *Guarantees*

The guarantees assumed in this example are as described in the with profits life insurance investment guarantee example in Section 11.2.3.

### *Charging for the cost of the investment guarantees and the smoothing benefit*

We price for the investment guarantees by requiring that, under our expected assumptions, the investment guarantee charge achieves a specified target, net of tax, rate of return for Tier 1 capital on the financing it provides to finance the total of:

1. The SF
2. The AGF
3. The WPLTBF Pillar 1 regulatory capital requirement

The sum of these three items represents total Tier 1 capital financing of the WPLTBF. Section 11.3.5 describes how the SF and the AGF are estimated.

## **11.3.4 Smoothing**

### **11.3.4.1 Background**

The amount of smoothing that has been carried out by firms, and the smoothing method used has generally been at the discretion of firms, with little or no disclosure to policyholders, shareholders or the regulator. However, as a consequence of recent consultations with the UK life insurance industry on the fair treatment of customers, the FSA has proposed rules on how UK life insurance firms should smooth with profits life insurance policies. In particular, with profits maturity and surrender values should broadly

- Fall within specified target ranges around the policy's actual asset share.
- The target ranges should be made available publicly in the firm's Principles and Practices of Financial Management (PPFM) document.

- Over the longer term, payouts should broadly be targeted on 100% of actual asset share.

The object of these proposals is to give life insurance firms less discretion over how they smooth, so reducing the risks that firms consistently under, or over, pay over the shorter or longer terms.

#### **11.3.4.2 *Methods of smoothing asset shares and maturity payouts***

There is very little information in the life insurance and actuarial literature on how firms smooth their payouts in practice. Nevertheless, methods that are known to be used by life insurance firms include

1. Valuing assets by discounting the future income generated by the assets. If the assumptions used to achieve this are stable, for example using stable long term income growth rates and risk discount rates, this method achieves asset valuations that are smoother than market valuations. This is the method that we use in this example.
2. Using smoothed investment returns, rather than actual investment returns, in the accumulation of asset shares. The method of smoothing, and the window over which the returns are smoothed, can vary considerably. However, unless a very long smoothing window is used, this technique tends to produce smoothed asset shares that are still quite rough.
3. Maturity payouts are smoothed, rather than asset shares, by requiring that the current year's payout should be within a target range of last year's payout. Recently, however, as equity markets have fallen, this approach appears to have been abandoned. For some firms, payouts have fallen by very large amounts over a two or three year period, casting real doubt on the credibility of the smoothing benefit.
4. Some firms smooth payouts by requiring that their payouts for the current financial year appear near the top of the competitor comparison payout tables. This is of considerable assistance to the firm's sales and marketing divisions in generating new business for the current financial year but, obviously, is not a genuine smoothing method.

It is not our objective to compare the merits of one smoothing method versus another. Instead, we use one smoothing technique that demonstrably does the job reasonably well and then calculate smoothing benefit economic capital for variants of this method.

### 11.3.4.3 The smoothing method

The smoothing method that we use is described below.

At each monthly duration  $t$ , the smoothed asset share is obtained by multiplying the actual asset share by a smoothing factor,  $\delta_t$ . The smoothing factor at each duration  $t$ ,  $\delta_t$ , is specified by the formula:

$$\delta_t = \theta \times \frac{y_{2t}}{E(y_{2t})} + (1 - \theta) \times \frac{y_{4t}}{E(y_{4t})}$$

Here  $\theta$  is the equity backing ratio of the WPBR and  $y_{2t}$  and  $y_{4t}$  are, respectively, the equity dividend yield and medium term government bond yields at duration  $t$ , as described in Section 11.2.2. Here, “E” denotes the unconditional expectation of a response variable.

The broad rationale for the method is: multiplying an actual asset share at time  $t$  by an income yield at that time converts the capital value into income. The income amounts will be smoother than either the actual asset shares or the yields are individually because these two items tend to be negatively correlated. In other words, yields are “low” when actual asset shares are “high,” and vice versa.

Dividing income by the unconditional expected yield converts the income amount back into capital and, because the unconditional expected yields are constant, smoothed capital values are obtained.  $\delta_t$  is then determined by computing the weighted average of these yield ratios according to the asset mix of the WPBR.

As can be seen from Figure 11.14, which compares actual and smoothed asset shares for a typical run of the regular premium with profits model, using this smoothing method, the method is effective.

Further evidence supporting the efficiency of the smoothing method is provided in our results Section 11.3.6.

### 11.3.4.4 Smoothing target ranges

Actual asset shares are surprisingly volatile and can diverge very far from smoothed asset shares. In order to limit the distance between smoothed and actual asset shares, we introduce tolerance limits  $\tau$  and  $\lambda$  into our smoothing formula as follows:

First, we define  $\delta_t^*$  as:

$$\delta_t^* = \max(\min(\delta_t, 1 + \tau), 1 - \tau)$$

The constrained smoothing parameter  $\delta_t^*$  ensures that, in relative terms, smoothed asset shares always stay within  $\tau$  of actual asset shares.

We next define  $\delta_t^{**}$  as:

$$\delta_t^{**} = \max \left( \min \left( \delta_t^*, \frac{1 + \lambda}{AAS_t} \right), \frac{1 - \lambda}{AAS_t} \right)$$

where  $AAS_t$  is the actual asset share at duration  $t$ . The further constrained smoothing parameter  $\delta_t^{**}$  ensures that, in absolute terms, smoothed asset shares always stay within  $\lambda$  of actual asset shares.

Figure 11.16 compares actual, smoothed and guaranteed asset shares for the regular premium product model run shown in Figure 11.14, but with the smoothed asset share constrained by setting  $\tau = 0.25$  and  $\lambda = \text{£}60,000$ . It can be seen from Figure 11.16 that, for the more extreme values of the actual asset share, the smoothed asset share runs parallel to the actual asset share and, consequently, is less smooth in those areas.

The base case and reduced smoothing range parameter values that we use are shown in Table 11.7. The  $\lambda$ s broadly equal  $\tau \times (\text{expected actual asset share}) \times 1.5$  and prevent smoothed asset shares moving too far from actual asset shares, in absolute terms.

### 11.3.5 Method

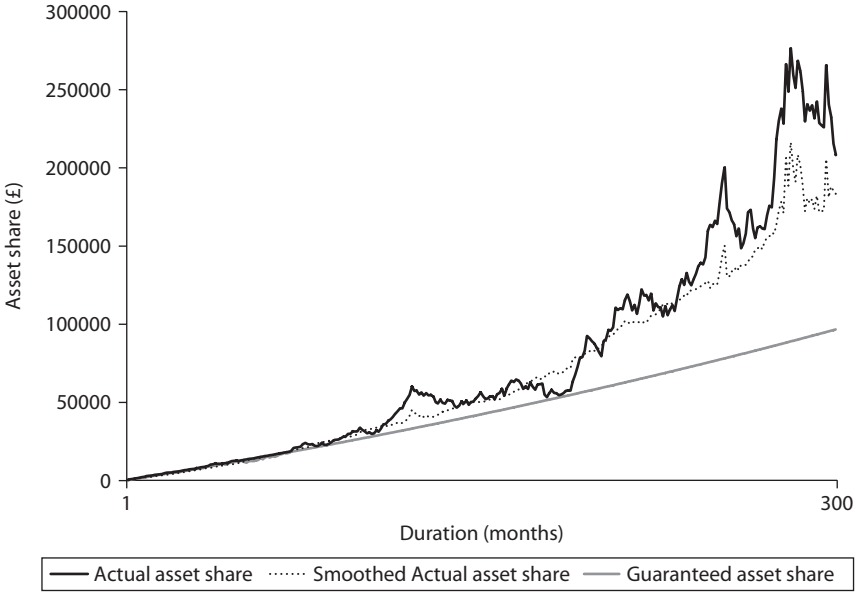
Having defined and parameterized our models, our approach to estimating the amount of economic capital that life insurance firms should hold to cover the smoothing benefits and the investment guarantees they write in their WPLTBFs is described below.

#### 11.3.5.1 Pricing the fund management and investment guarantee charges

To avoid cross-subsidies between different new business generations, all our modeling work is based on one new business product.

The fund management charge is priced, under our expected assumptions, to achieve a specified target, net of tax, rate of return for Tier 1 capital on the financing it provides to the NPLTBF. A fund management charge of 0.75% p.a. achieves a net rate of return of around 8% for single premium products and 9% for regular premium products.

The investment guarantee charge is priced, under our expected assumptions, to achieve a specified target, net of tax, rate of return for Tier 1 capital on its financing of the SF, the AGF and the WPLTBF's Pillar 1 regulatory capital requirement. An investment guarantee charge of 0.5% p.a. achieves a net rate of return of around 9% for single premium products and 10% for regular premium products.



**Figure 11.16** Actual, smoothed and guaranteed asset shares – base case smoothing target range

**Table 11.7** Smoothing target range parameters

Premium type	Smoothing target range	$\tau$	$\lambda$
Regular premiums	Base case	0.25	£60,000
Single premiums	Base case	0.25	£22,500
Regular premiums	Reduced	0.10	£25,000
Single premiums	Reduced	0.10	£9,000

### 11.3.5.2 Calculating the capital requirements at each duration

#### (i) Smoothing benefit capital

The stochastic model is run 2,500 times and, for each run and at all monthly durations, the amount of Tier 1 capital that is needed to support the smoothing benefits is calculated. This is the amount of capital needed to ensure that the WPBR has sufficient assets to cover both aggregate actual asset shares, at all times, and aggregate smoothed asset shares, at maturity.

*(ii) Investment guarantee capital*

For each run of the stochastic model, and at all monthly durations, the amount of Tier 1 capital that is needed to support the investment guarantees is calculated. This is the amount of capital that is required to ensure that the greater of the WPBR and aggregate smoothed asset shares, plus the GF, is as large as guaranteed asset shares, aggregated over all customers, for the remaining lifetime of the WPLTBF.

*(iii) Future premiums*

As described in Section 11.2.3, at each duration, future regular premiums are set to zero in performing these calculations. This is because the investment guarantees and also smoothing benefits may not be available to them.

**11.3.5.3 Calculating the SF, the AGF and economic capital at each duration**

*(i) Smoothing benefit economic capital and the SF*

At each duration, the 2,500 smoothing benefit capital requirements, as described above, are ordered and the 50th, 95th, 99th, 99.5th percentiles and their average calculated. Smoothing benefit economic capital is set equal to the smoothing benefit capital requirement percentiles at each duration. The SF is set equal to the average smoothing benefit capital requirement at each duration and represents the estimated expected value of the smoothing benefit at that duration.

*(ii) Investment guarantee economic capital and the AGF*

At each duration, the 2,500 investment guarantee capital requirements are ordered and the 95th, 99th, 99.5th percentiles and their average calculated.

1. The AGF is set equal to the average investment guarantee capital requirement at each duration. The AGF and the GF, in aggregate, then represent the estimated expected value of the investment guarantees, relative to the larger of actual and smoothed asset shares.
2. At each duration, we deduct the AGF from the investment guarantee capital requirement percentiles. This is because this capital to support the AGF must be injected into the WPLTBF by Tier 1 capital to satisfy the WPLTBF's reserving requirements.
3. We also deduct the SF from the investment guarantee capital requirement percentiles, for the same reason.
4. At each duration, investment guarantee economic capital is set equal to these net investment guarantee capital requirement percentiles, subject to a minimum value of zero, and can be compared with the WPLTBF's Pillar 1 regulatory capital requirements.

All of the above is repeated after having varied one or more of the key assumptions. Our results are set out in Section 11.3.6 below.

### 11.3.6 Results

We present our results in graphical form by displaying economic capital throughout the lifetime of a single generation of with profits business.

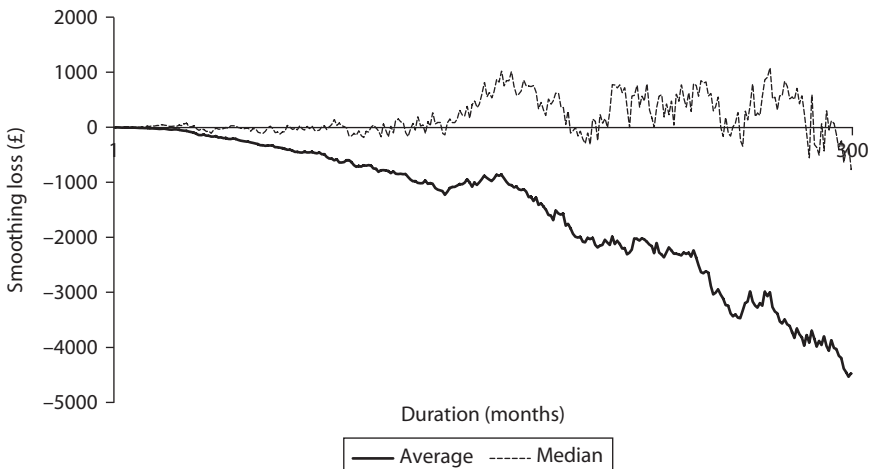
In the smoothing benefit economic capital figures, we show graphs of 50th percentile economic capital, 95th percentile economic capital, 99th percentile economic capital and 99.5th percentile economic capital.

In the investment guarantee economic capital figures, we show graphs of the expected Pillar 1 regulatory capital requirement, 95th percentile economic capital, 99th percentile economic capital and 99.5th percentile economic capital.

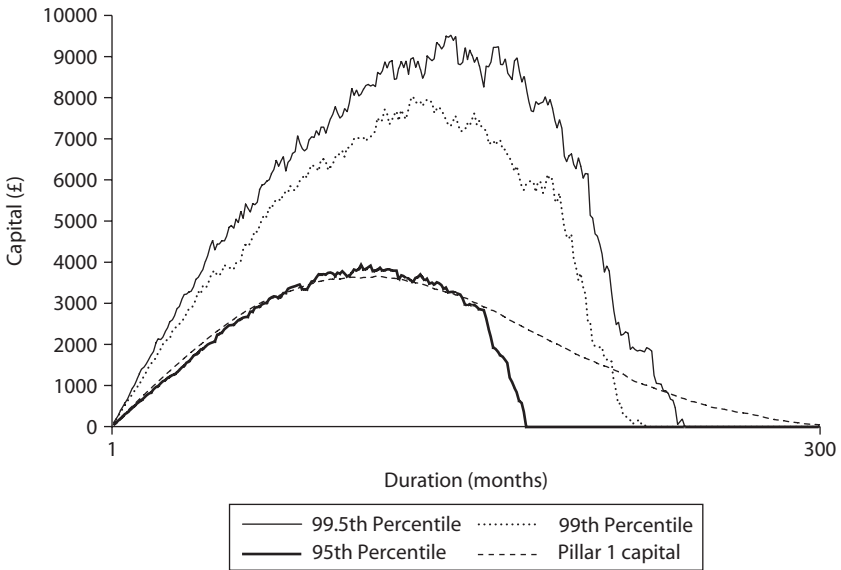
Unless stated otherwise, we use the base case smoothing target range parameters shown in Table 11.7.

Figure 11.17 shows median and average smoothing losses for typical runs of the regular premium stochastic model, based on 2,500 simulations. Here, a smoothing loss equals the smoothed asset share less the actual asset shares at that duration.

The median losses fluctuate around zero whereas, on average, smoothing profits emerge that increase with duration. Nevertheless, we can conclude from Figure 11.17 that the smoothing method used is reasonably effective in not introducing consistently large or small smoothing losses at maturity.



**Figure 11.17** Regular premium smoothing benefit loss – base case



**Figure 11.18** Unsmoothed regular premium investment guarantee economic capital versus Pillar 1 capital – base case

### 11.3.6.1 Unsmoothed regular premiums

Figure 11.18 shows investment guarantee economic capital for a typical run of the regular premium stochastic model, with no smoothing, including a comparison with Pillar 1 capital. As is discussed in the previous section in much more detail, investment guarantee economic capital is well in excess of Pillar 1 capital.

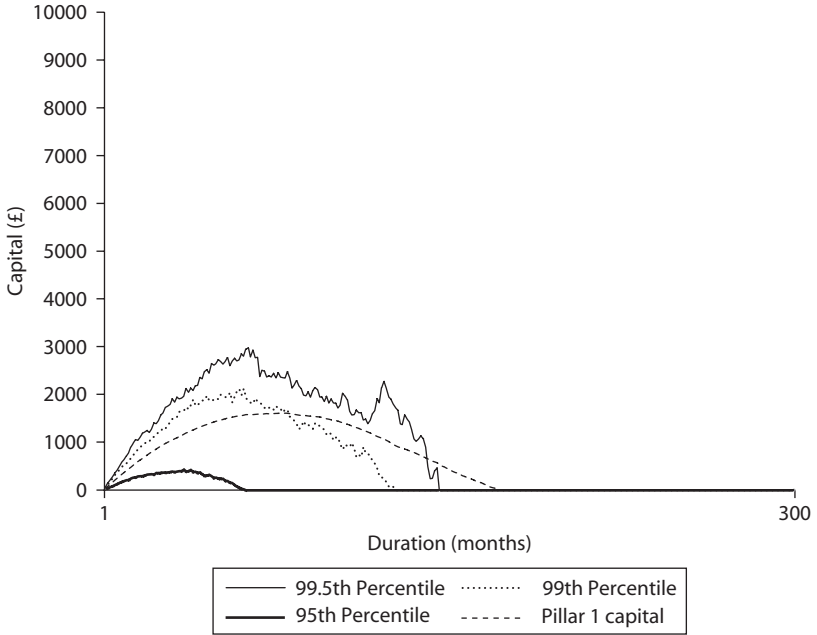
As smoothing is not used in this first example, smoothing benefit economic capital is obviously zero.

From Figure 11.18, and as will be apparent from the later results reported in this section, we can see that aggregate investment guarantee and smoothing benefit economic capital is well in excess of Pillar 1 capital.

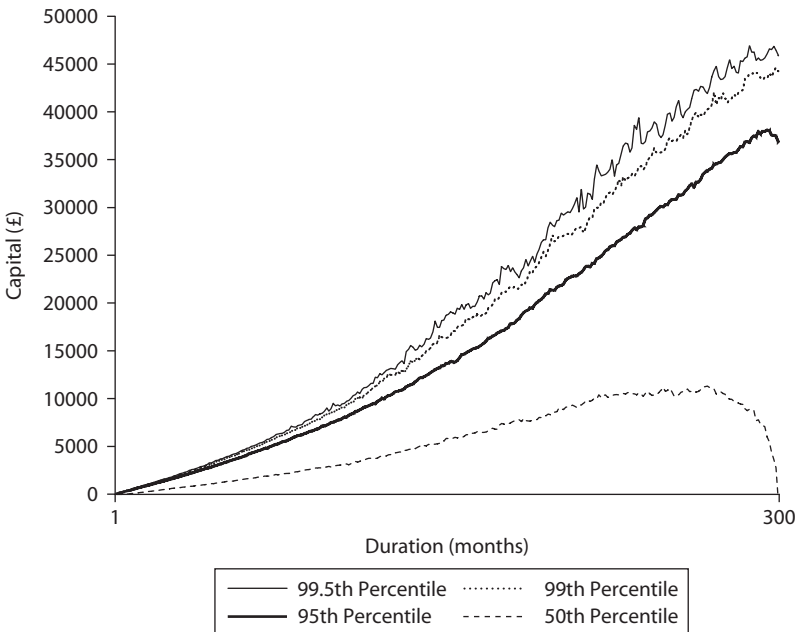
### 11.3.6.2 Smoothed regular premiums

Figures 11.19 and 11.20 show economic capital amounts when smoothing is introduced.

Comparing Figure 11.19 with Figure 11.18 we can see that all investment guarantee economic capital amounts have fallen, as has Pillar 1 capital, and that Pillar 1 capital is now quite well aligned with investment guarantee economic capital. Smoothing reduces Pillar 1 capital because the WPLTBF now contains more assets, due to the SF. More WPLTBF statutory surplus is then available to cover Pillar 1 capital before Tier 1 capital is required.



**Figure 11.19** Smoothed regular premium investment guarantee economic capital versus Pillar 1 capital – base case



**Figure 11.20** Regular premium smoothing benefit economic capital – base case

Investment guarantee economic capital also falls, partly for this same reason. More importantly, however, the larger of smoothed asset share and actual asset share is less volatile than the actual asset share is on its own and, consequently, is less likely to fall below guaranteed asset share and by smaller amounts. As a result, less capital is required to ensure that the larger of aggregate smoothed asset shares and aggregate actual asset shares is always in excess of aggregate guaranteed asset shares, throughout the remaining lifetime of the WPLTBF.

Figure 11.20 shows that smoothing benefit economic capital is low initially, but rapidly increases in size with duration. After 25 years, smoothing benefit economic capital amounts are substantial, reflecting the fact that smoothed asset shares can be much larger than actual asset shares, even at the 95th percentile level. This may be of concern to with profits customers, regulators and life insurance firms themselves as firms are not required to hold, and generally do not hold, capital to cover smoothing benefit risks.

Aggregate investment guarantee and smoothing benefit economic capital is again well in excess of Pillar 1 capital.

### **11.3.6.3 Wilkie model smoothed regular premiums**

We have checked our results using a version of the well known Wilkie model that has been reparameterized to produce investment returns similar to those generated by the model described in Section 11.2.2.

Our results are shown in Figures 11.21 and 11.22 and are similar to those of Figures 11.19 and 11.20.

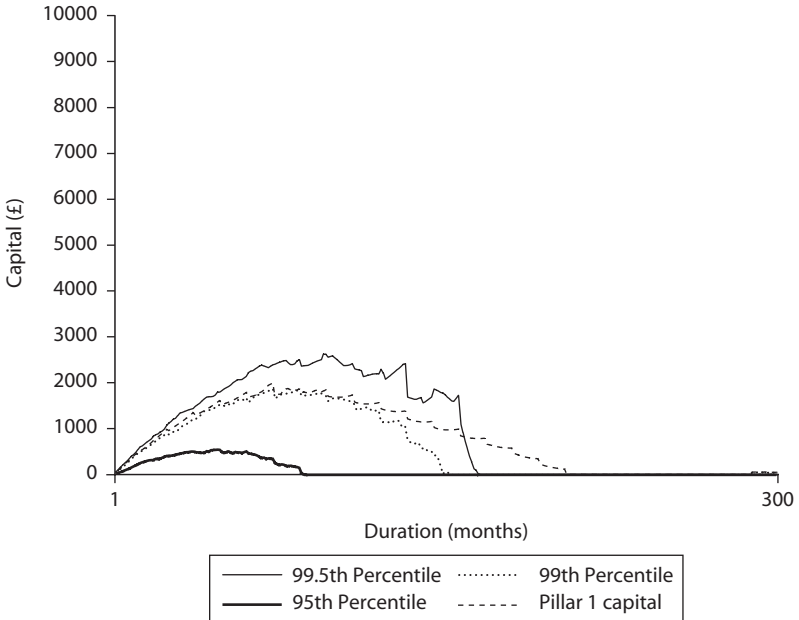
Note that the economic capital graphs shown in Figures 11.21 and 11.22 are not as smooth as those shown in Figures 11.19 and 11.20. This is for the same reasons described in the Section 11.2.5. Nevertheless, the results are qualitatively the same as those obtained using the stochastic model described in Section 11.2.2.

### **11.3.6.4 Smoothed single premiums**

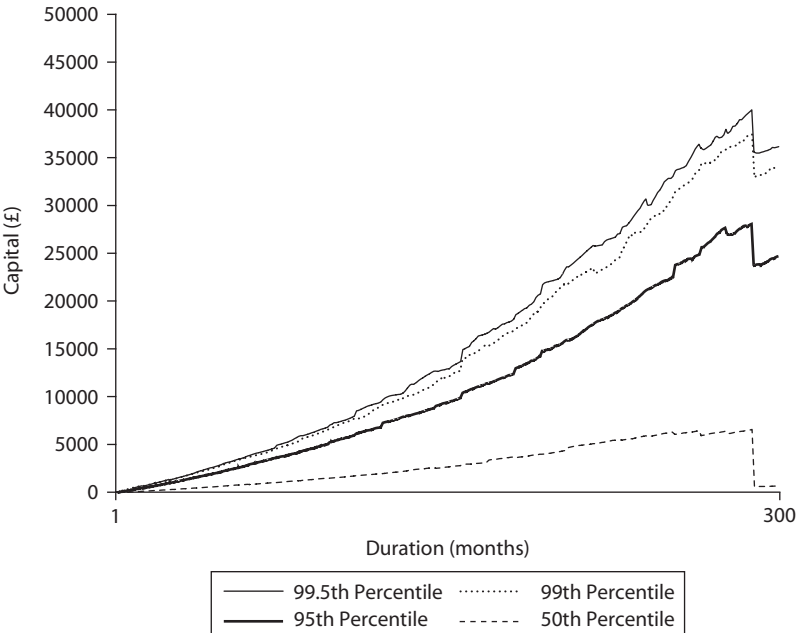
Figures 11.23 and 11.24 give our results for a typical run of the single premium stochastic model. Pillar 1 capital is now too low relative to investment guarantee economic capital but, otherwise, the same conclusions apply as for regular premiums.

### **11.3.6.5 Reducing the equity content of the SWPBR to 25%**

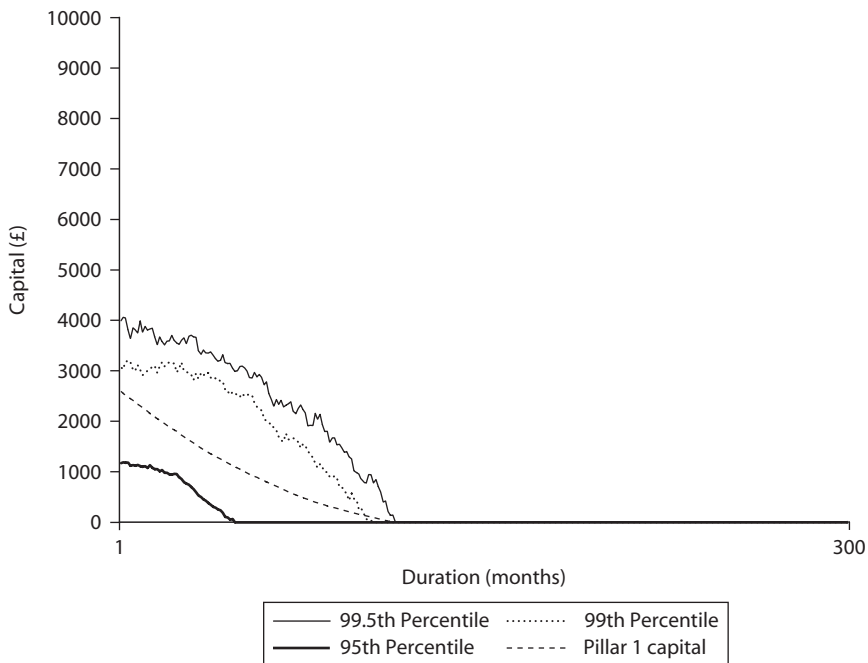
Figures 11.25 and 11.26 give our regular premium results when the equity content of the SWPBR is reduced from 75% to 25%. Comparing Figure 11.25 with Figure 11.19 shows that, reducing the equity content



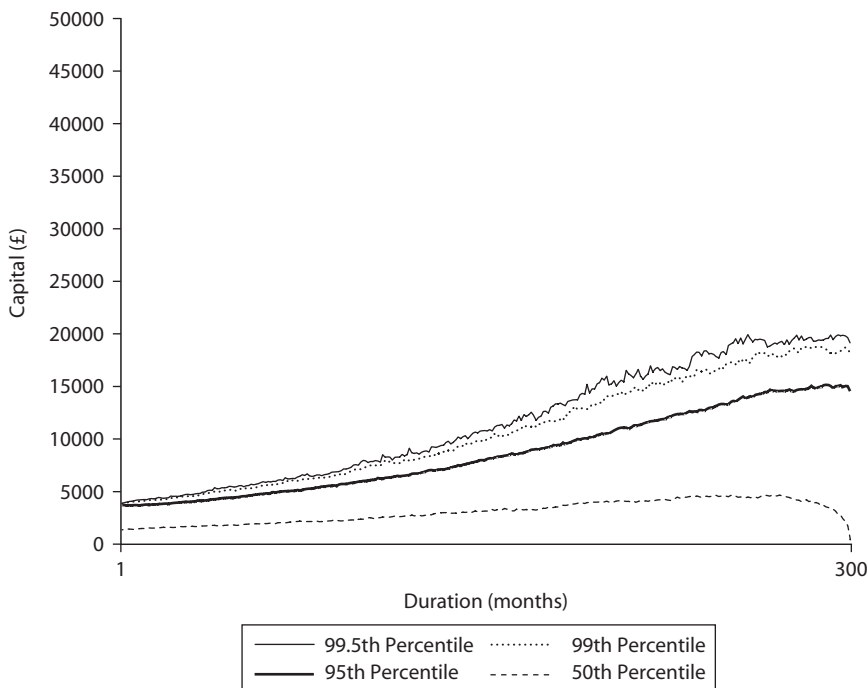
**Figure 11.21** Smoothed regular premium investment guarantee economic capital versus Pillar 1 capital – base case Wilkie Model



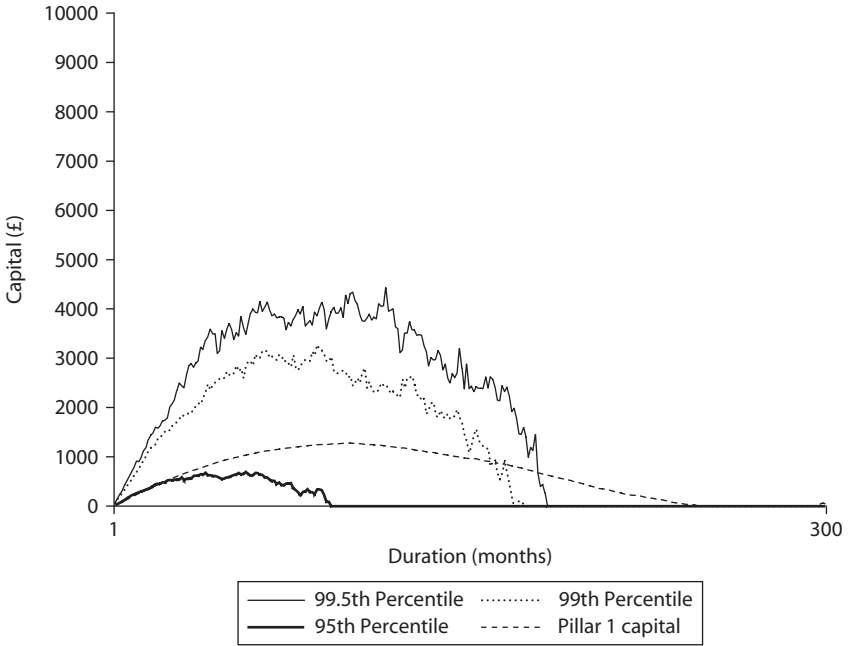
**Figure 11.22** Regular premium smoothing benefit economic capital – base case Wilkie Model



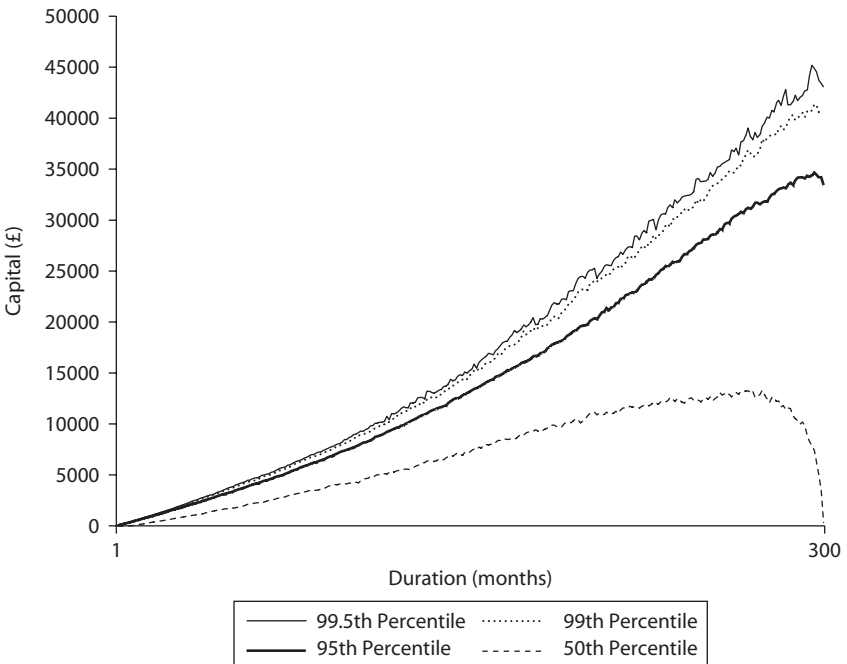
**Figure 11.23** Smoothed single premium investment guarantee economic capital versus Pillar 1 capital – base case



**Figure 11.24** Single premium smoothing benefit economic capital – base case



**Figure 11.25** Smoothed regular premium investment guarantee economic capital versus Pillar 1 capital – equity content of with profit benefit reserve reduced to 25%



**Figure 11.26** Regular premium smoothing benefit economic capital – equity content of with profit benefit reserve reduced to 25%

of the SWPBR, results in investment guarantee economic capital increasing and Pillar 1 capital falling.

Pillar 1 capital falls because the deterministic stress test that is used to calculate the RCM component of Pillar 1 capital is relatively gentle on government bond assets, as compared to equities. Investment guarantee economic capital increases because both actual and smoothed asset shares tend to fall in value with increased government bond investment, so resulting in a lower margin over guaranteed asset shares before capital is required to support the WPLTBF's guarantees.

Comparing Figure 11.26 with Figure 11.20 shows that smoothing benefit economic capital falls very slightly with increased government bond asset investment. This is because, although increased government bond investment reduces the volatility of actual asset shares, significant volatility still remains.

#### **11.3.6.6 Reducing the smoothing target range parameters to $\tau = 10\%$ , $\lambda = £25,000$**

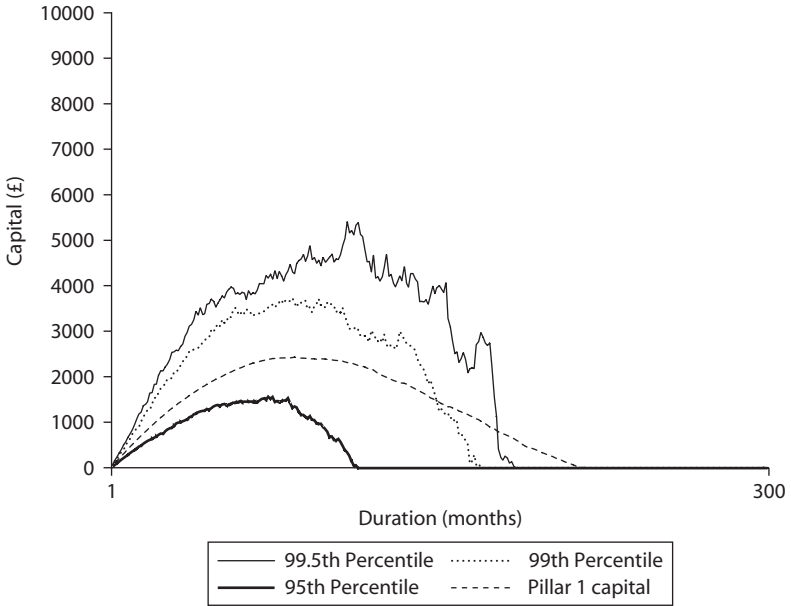
Figures 11.27 and 11.28 give our results when less smoothing is applied to actual asset shares. As expected we achieve results that are intermediate between our base case smoothing target range results and our results with no smoothing. In particular, compared to our base case smoothing target range results, as expected, investment guarantee economic capital and Pillar 1 capital increase whereas smoothing benefit economic capital falls. In other words, smoothing benefit economic capital generally increases, and investment guarantee economic capital generally falls, as smoothing increases.

#### **11.3.6.7 Smoothing up only**

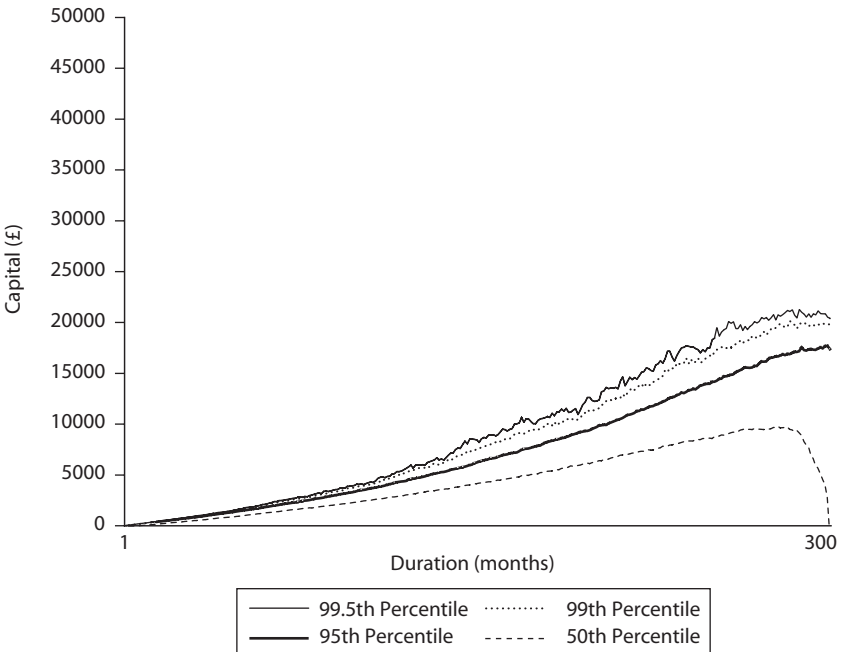
Figure 11.29 shows median and average smoothing losses, at each duration, for typical runs of the regular premium stochastic model using 2,500 simulations, when asset shares are smoothed up only. The median losses fluctuate above zero, and stay small, whereas average smoothing losses increase with duration. Nevertheless, at any duration, average losses never exceed 7% of expected actual asset share.

Figures 11.30 and 11.31 show our investment guarantee and smoothing benefit economic capital results when smoothing up only. Comparing these with Figures 11.19 and 11.20 it can be seen that investment guarantee economic capital and Pillar 1 capital fall slightly, whereas smoothing benefit economic capital is broadly unaffected.

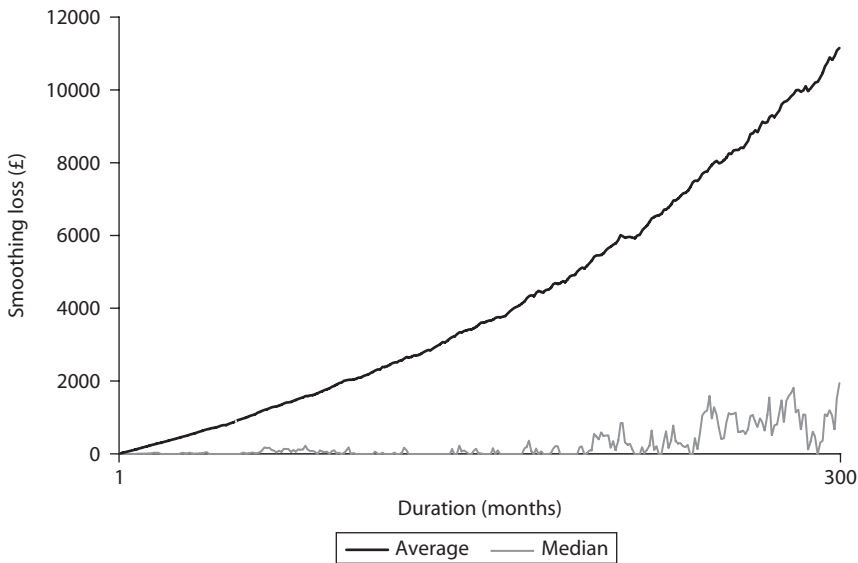
Investment guarantee economic capital and Pillar 1 capital fall because, when smoothing up only, the SF increases slightly and the



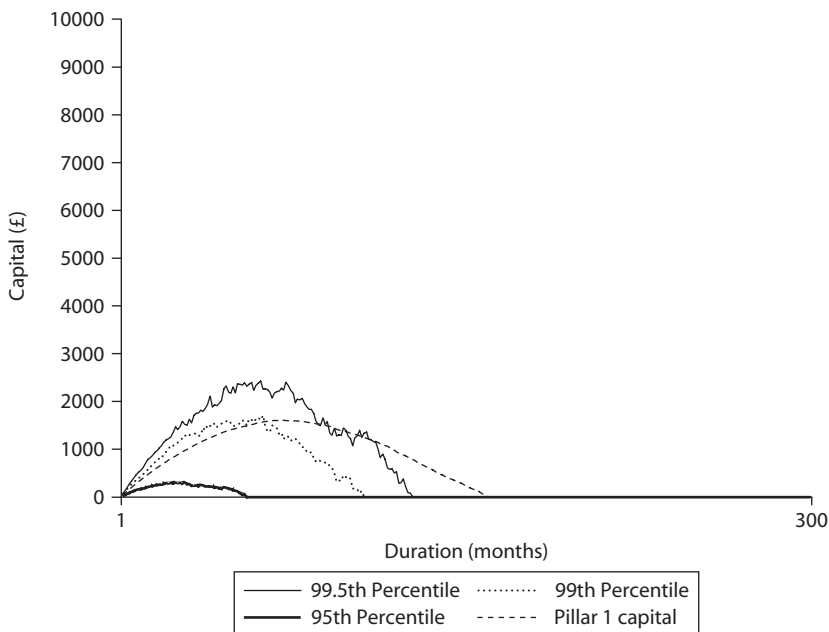
**Figure 11.27** Smoothed regular premium investment guarantee economic capital versus Pillar 1 capital – reduced target smoothing ranges



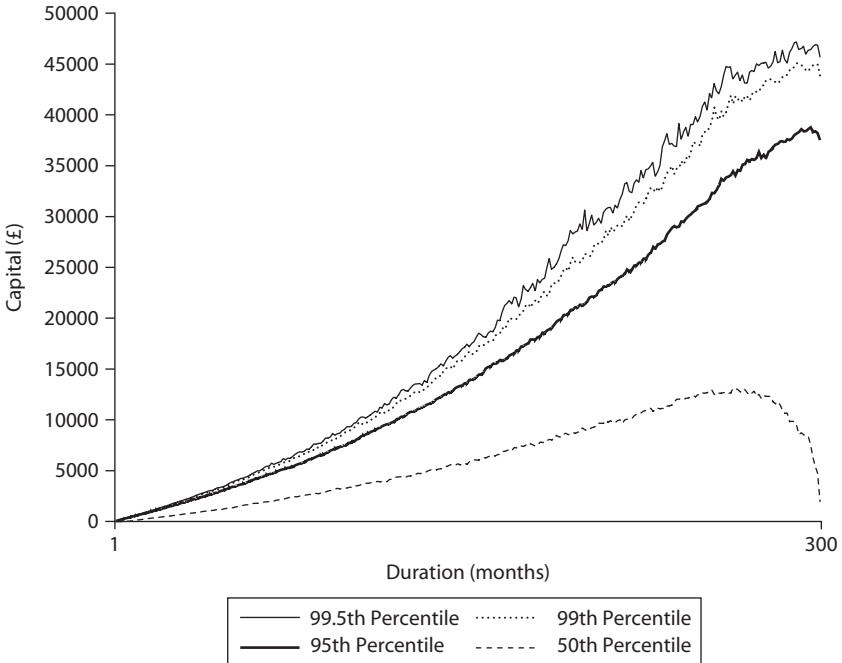
**Figure 11.28** Regular premium smoothing benefit economic capital – reduced target smoothing ranges



**Figure 11.29** Regular premium smoothing benefit loss – smoothing up only



**Figure 11.30** Smoothed regular premium investment guarantee economic capital versus Pillar 1 capital – smoothing up only



**Figure 11.31** Regular premium smoothing benefit economic capital – smoothing up only

WPLTBF therefore contains an increased level of assets. Smoothing benefit economic capital is relatively unaffected, however, as the upper percentiles of the smoothing benefit capital requirements, as expected, are themselves unaffected.

The financial effect of smoothing up only is that the regular premium investment guarantee charge earns a reduced, net of tax, rate of return on capital of 6% for Tier 1 capital, rather than the priced return of 10%. This is because Tier 1 capital must provide increased financial support to the WPLTBF as a consequence of the increased SF.

### 11.3.6.8 Rates of return on capital

For each of the 2,500 simulations, and for each example, we have calculated the rate of return earned by the investment guarantee charge on the Tier 1 capital financing of the sum of

1. The SF
2. The AGF

3. Either the WPLTBF Pillar 1 regulatory capital requirement, or WPLTBF aggregate investment guarantee and smoothing benefit economic capital.

The rate of return earned by the fund management charge on the Tier 1 capital financing of the NPLTBF is also calculated.

We can then study the distribution of these rates of returns over the 2,500 simulations. Summary statistics for our base case regular premium example are shown in Table 11.8. The results and conclusions for our base case single premium example are similar.

From Table 11.8, it can be seen that the distributions of the rates of return induced by the stochastic model are close to Normal. The fund management charge rates of return skewness and kurtosis values, although large, are caused by a handful of outliers out of the 2,500 runs. The distribution of the remaining returns is, however, very close to Normal.

It can also be seen that the average investment guarantee charge rate of return on the Tier 1 capital financing of the SF, AGF and Pillar 1 capital, which equals 11%, is close to the priced return of 10%, as described in Section 11.3.5. Similarly, the average fund management charge rate of return on the Tier 1 capital financing of the NPLTBF, at 10%, is again close to the priced return of 9%.

Table 11.8 shows the distorting effect that Pillar 1 capital has on financial performance measures. If 99.5th percentile economic capital

**Table 11.8** Rates of return on capital for base case smoothing target range regular premium – with profits life insurance investment guarantee and smoothing example

	<i>Investment guarantee charge</i>				<i>Fund management charge</i>
		<i>capital amount</i>			<i>financing</i>
	<i>Pillar 1 regulatory capital</i>	<i>95th Percentile economic capital</i>	<i>99th Percentile economic capital</i>	<i>99.5th Percentile economic capital</i>	
Mean	11%	2%	2%	2%	10%
Standard deviation	2%	3%	3%	3%	1%
Skewness	0.08	(0.56)	(0.61)	(0.56)	0.48
Kurtosis	0.03	0.29	0.39	0.30	1.16

is the appropriate amount of aggregate smoothing benefit economic capital and investment guarantee economic capital that the firm should be holding to cover the risks it is running, then the product is earning, on average, a post tax rate of return of 2% on that capital. This compares with an average rate of return of 11% on the corresponding Pillar 1 regulatory capital requirement, a very significant differential.

Note also that, as compared to Table 11.5, the rates of return earned on economic capital are much lower and are relatively constant across the percentiles considered. This is because of the effect of smoothing benefit economic capital, which dominates investment guarantee economic capital, and which is very large for all of the percentiles considered.

In other words, if firms were required to set up economic capital to cover smoothing benefit risks, as well as investment guarantee risks, as we believe they should, their achieved rates of return on this capital would be very significantly deflated, to reflect the risks that they are running.

### 11.3.7 Conclusions

In this example, we have estimated the amount of economic capital that UK life insurance firms should hold to cover the smoothing benefits and investment guarantees that they write in their WPLTBFs. Our life insurance firm model and parameterization, although complicated, is fairly typical of UK practice, especially for newer, or restructured, with profits funds. The smoothing method used is again fairly typical of UK practice and we have also shown that it is very effective in smoothing out asset volatility from actual asset shares.

Our main conclusion is that smoothing benefit economic capital is substantial, even though life insurance firms are not currently required to hold capital to cover smoothing benefit risks.

Although our results have been derived using one particular UK with profits life insurance firm model, it is evident that our conclusions will apply to most, if not all, with profits life insurance firms that smooth their payouts. In fact, as is again fairly self evident, our conclusions apply quite generally to any financial services firm that provides products offering the customer an expectation, or guarantee, of a smoothed return, whilst backing the product with assets that yield volatile returns.

Unless the firm hedges its smoothing benefit risks, or is prepared to withdraw the smoothing benefit from its customers at short notice and at its own discretion, it would appear that capital should be held to support

smoothing benefit risks. The three possible risk takers that correspond with these options are

1. Third party risk takers, who accept the risk on commercial terms agreed with the firm.
2. Customers, who accept the risk on terms that may, or may not, be clear to them.
3. Firms, who should back the risk with capital, as they do with all of their other risks.

To date, and somewhat ironically, it does appear to be the case that it is with profits customers themselves who have accepted the risks associated with their own smoothing benefits!

The conclusions and practical implications set out in Section 11.2.7 are also highly relevant to the smoothing benefit economic capital example set out in this section. However, if it is accepted that life insurance firms should hold capital to cover their smoothing benefit risks, this will affect all life insurance firms, not just the weaker ones. This may persuade certain undecided firms to finally exit the with profits life insurance market to focus on less capital intensive segments of the long term savings market.

## 11.4 PENSIONS

### 11.4.1 Introduction

At the time of writing, the UK private sector and public sector pensions industries, as well as those of most other developed and developing nations, are in a state of flux. Many employer sponsored defined benefit schemes, where employee benefits are expressed as proportion of their final salary, are substantially in deficit as a result of falling stock markets and improved pensioner mortality.

Falling fertility levels and improving mortality rates have also meant that unfunded public sector pension arrangements, where the working population pay for the public sector pensions of the retired population, are no longer economically viable. They imply a higher and higher tax burden on the working population, which, in due course, the working population will simply refuse to accept.

As the true cost of employer sponsored defined benefit pension schemes has become apparent, when stock markets do not increase by 20% p.a. year after year, many employers are now shifting the focus of

their pension provision away from defined benefit pension schemes to defined contribution schemes. With defined benefit pension schemes, it is the sponsoring employer that, in principle, takes investment risk whereas, with defined contribution pension schemes, the employee takes the investment risk that their fund may not grow to an adequate size to provide them with a decent pension in retirement.

It seems only a matter of time, therefore, before successive UK governments will have no choice but to make public sector pension benefits means tested. It also seems likely that more and more of UK pension provision will be pushed out into the private sector, with individuals being asked to accept more and more responsibility for their own pensions.

The UK Inland Revenue tax incentive rules that all types of pensions arrangements benefit from have also become tortuously complex. As a consequence, a major pension simplification initiative is due to be implemented in April 2006.

Given all that is happening in pensions at present, and the major problems that the pensions industry is facing, it is appropriate to devote a few pages of this book to the financial risk management and associated economic capital requirements of employer sponsored defined benefit pension schemes.

## **11.4.2 Defined benefit pension schemes**

### **11.4.2.1 Background**

There is a very large literature on defined benefit pension schemes and it is not the object of this book to reproduce or replace that literature. Instead, we give a high level introduction to these schemes in order that we can discuss their economic capital requirements.

The website of the UK actuarial profession, [www.actuaries.org.co.uk](http://www.actuaries.org.co.uk), provides access to a large number of current pension papers and articles. The website of the Department for Work and Pensions (DWP) at [www.dwp.gov.uk](http://www.dwp.gov.uk) provides information on The Pensions Regulator, the very recently formed new regulator for UK occupational pensions schemes.

Defined benefit pensions schemes are managed on behalf of the scheme members by the scheme trustees, who are appointed to run the scheme according to the trust under which the scheme has been set up. Regular actuarial valuations, typically every three years, must be carried out by the scheme actuary, on behalf of the trustees, to establish if the scheme can meet its statutory funding objective.

This broadly means that schemes are required to have sufficient and appropriate assets to cover their technical provisions, which equal the present value of benefits accrued to date under the scheme. The actuarial valuation will also determine the ongoing funding contribution that is required to secure both the accrued and future benefits that are expected to be provided by the scheme over its entire membership and lifetime.

Having received the actuarial advice, the trustees are then charged with agreeing a strategy with the sponsoring employer to fund the pension scheme commitments and to correct any funding deficits. There is no specific solvency or capital requirement for defined benefit pensions schemes to protect the scheme members even though, as we have seen recently, defined benefit pension schemes can go technically insolvent when stock markets perform poorly.

#### **11.4.2.2 Benefits**

The principal benefit provided by a defined benefit pension scheme, namely a pension on retirement, is typically determined as a fraction,  $N/60$ ths say, of final salary. Here  $N$  is the service, in years, accrued by the member at retirement. Variations of this formula apply on early, or late, retirement and for members who leave the scheme before retirement as a result of changing employer.

A pension scheme offering an accrual rate of  $1/60$ ths would be a generous scheme. Other schemes may base pensions on the member's average salary over the last few years before their retirement, or on career average salary. In any case, it can be seen that the pension benefit granted depends on both the member's accrued service and on their salary.

When a member retires, the scheme may purchase an annuity from a life insurance firm to secure the pension benefit. Alternatively, it may pay the pension directly out of the scheme's income and assets. The cost of the pension, whether it is provided for by the purchase of an annuity or not, therefore depends mainly on

1. The mortality experience of the pensioner.
2. For pensions secured by the purchase of an annuity, fixed interest bond yields at the time of retirement. This is because life insurance firms generally back their annuity business with fixed interest assets.
3. For pensions paid out of the scheme's income and assets, fixed interest bond returns throughout the remainder of the pensioner's

lifetime. This is because pensions in payment tend to be backed by fixed interest assets.

### **11.4.2.3 Backing assets**

As mentioned in the previous section, pensions in payment tend to be backed by fixed interest type assets, or secured by purchasing a life insurance firm annuity. Pensions in deferment, or pensions benefits that are accruing before the member's retirement, tend to be backed by a mix of more volatile assets including equities and property.

Equities and properties have generated excellent real returns over very long periods of time and have traditionally been considered as a very good hedge of salary inflation. However, stock market falls in the early 2000s and increased levels of volatility have exposed the fact that, at least over shorter time periods, stock markets and salary inflation may not be closely correlated.

In other words, when stock markets fall sharply, salaries do not fall in tandem. Salary inflation, at most, simply tends to slow down. The lack of a solvency margin, or capital requirement, to protect scheme members is therefore somewhat surprising. When schemes are technically insolvent, or in deficit, in the sense that their assets are not adequate to cover the value of scheme accrued benefits, scheme trustees are simply required to agree a funding strategy with the sponsoring employer to remedy the deficit in due course.

### **11.4.2.4 Scheme member protection**

In the UK, if a sponsoring employer is insolvent and the associated defined benefit pension scheme is not adequately funded, the Pensions Protection Fund, which is funded by a levy on all defined benefit pensions schemes, guarantees all deferred pensions up to a level of around 90%, subject to certain compensation caps. Pensions in payment are guaranteed 100%. Again, see the DWP's website [www.dwp.gov.uk](http://www.dwp.gov.uk).

Therefore, it can be seen that, although defined benefit pension schemes are not required to hold capital to back their risks, they are required to contribute to the Pensions Protection Fund. As this fund may be made most use of by those schemes that are the most poorly managed, requiring pension schemes, or equivalently their sponsoring employers, to explicitly hold capital to back the risks they are running, may be a more effective way of influencing pension schemes to manage their risks more effectively.

### 11.4.2.5 *Economic capital*

If we now consider a defined benefit pension scheme with a large proportion of younger members, we see a fund which is invested in volatile assets, such as equities and property, with associated liabilities that are essentially guaranteed and which increase with both members' service and with future salary inflation. As salary inflation tends to be highly correlated with RPI inflation, we can conclude that the fund's liabilities are essentially RPI linked and carry high levels of guarantees.

Based on the with profits life insurance examples considered earlier in this chapter, and from the fact that, over short time periods, stock market and property returns need not be highly correlated with RPI, we can see that the investment guarantee economic capital requirements of pension funds will not be small. Moreover, this is before we have considered the other risks that pension funds are subject to, such as mortality risk, persistency risk and expense risk.

We can conclude, therefore, that defined benefit pension schemes run by employers with large numbers of younger members, and which are invested substantially in equities, are running very large risks on behalf of their members. It certainly seems reasonable that, to improve the security of the members, pension schemes should be required to hold capital to cover the risks that they are running.

If pension schemes do not have the capital available to do this, or it is uneconomic for them to do so, then employers should withdraw from these defined benefit arrangements. Although that would be very regrettable, at least scheme members would not be potentially misled into believing that their pension benefits were guaranteed, so forcing members to take on more responsibility for their own retirement provision.

## 11.5 SUMMARY

In this chapter, we have calculated stochastic economic capital for with profits life insurance firm applications, and have compared our results to corresponding Pillar 1 regulatory capital requirements. Stochastic economic capital was determined using a special case of the stochastic model developed in Chapter 7. By comparing defined benefit pensions schemes to with profits life insurance, we were also able to deduce that our with profits life insurance firm economic capital conclusions also apply to pension schemes.

Our results show that Pillar 1 regulatory capital requirements are generally very poor approximations to with profits life insurance economic

capital and are generally far too low. We also saw that, although with profits life insurance firms are not required to hold capital to cover smoothing benefit risks, smoothing benefit economic capital is, in fact, very large.

We illustrated the potentially misleading impact that the mismatch between Pillar 1 regulatory capital and economic capital can have on performance measurement.

It goes without saying that the results and conclusions presented in this chapter have great significance to regulators, with profits life insurance firms, shareholders and, perhaps most importantly, to with profits customers.

# Financial Services Conglomerates

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## 12.1 INTRODUCTION

Financial services conglomerates that possess many different types of balance sheets within their group, on which they may write risk, can enjoy certain advantages over monoline firms. Perhaps for this reason, the larger financial services firms have, in recent years, been broadening their businesses. Moreover, each firm has achieved this in its own particular way, rather than by following a set formula.

For example, amongst the UK banks, we can compare and contrast Royal Bank of Scotland (RBS) and HBOS.

### *Royal Bank of Scotland*

RBS is a clear manufacturer of non life insurance products through its highly successful Direct Line start up and the acquired Churchill, both of which are wholly owned subsidiaries. RBS is less clearly a manufacturer of life insurance as its life insurance products are either 100% or 50% manufactured by the Aviva group. In respect of life insurance, therefore, RBS appears to be a committed distributor, but a less committed manufacturer.

### *HBOS*

HBOS is more clearly a manufacturer of life insurance products through its acquired and wholly owned Clerical Medical life insurance subsidiary, as well as a being a manufacturer of non life insurance products through its Esure start up.

Amongst the UK insurers, we can compare and contrast Aviva and Prudential.

### *Aviva*

Aviva is a committed manufacturer of life insurance, non life insurance, including healthcare, and asset management products. It appears to have no interest in manufacturing traditional banking products, but has entered into bancassurance arrangements where the partner banks distribute Aviva's products through their branches in exchange for a fee.

The Aviva product that is closest to being a banking product is its pioneering lifetime mortgage product. However, Aviva generally securitizes this business once it has reached critical mass and passes on most, if not all, of the risks associated with the product to third party investors.

### *Prudential*

In terms of insurance, Prudential is now a pure life insurer having withdrawn from both the non life insurance and reinsurance markets. Prudential is also a manufacturer of asset management products through M & G and offers banking products through its internet bank start up Egg, although it now seems keen to exit banking by selling Egg.

The above points are not intended to be summaries of the business strategies of some of the UK's leading financial services firms. The only point that we are making is to confirm that certain financial services firms are indeed broadening their businesses, and that no single business model is prevalent. The main drivers for this broadening can be debated at some length but, in our opinion, are likely to include

### *Defensive reasons*

As financial services markets become ever more competitive, firms are diversifying away from their core markets into other markets that they perceive are less competitive, with higher margins. In practice, however, these other markets may often be just as competitive as the firm's core market.

### *To exploit synergies*

Financial services firms may identify synergies that they feel are exploitable. For example, some banks believe that they can distribute life insurance products through their branches and, moreover, want to manufacture such products themselves, rather than distribute those of a third party provider, in order to maximize margins (the bancassurance model). Banks have acquired life insurance firms in furtherance of this aim although, at least in the UK, the bancassurance model is still unproven.

### *To strengthen intermediary relationships*

Financial services firms that distribute their products through intermediaries may believe that they can strengthen and protect these relationships by widening their product range, so making them more attractive to intermediaries.

### *Entrepreneurial opportunities*

Certain financial services firms have simply tried out ideas that, in the event, have turned out to be highly innovative and successful and which have grown and developed into large businesses in their own right. Financial services start up firms that distribute their products via the telephone, or internet, are examples of these types of entrepreneurial opportunities.

### *Customer retention*

As discussed in earlier chapters of this book, persistency risk is now a major risk facing all financial services firms. If a firm can offer a customer financial services products across the entire range, it may be more likely that the firm will be able to retain that customer.

### *Regulation*

As is discussed in Chapter 14, the regulation of financial services firms is converging towards a more homogeneous model across all financial risks. Therefore, in the UK, for example, life insurance regulation is moving towards banking regulation and international accounting changes may also make financial services firms' financial statements more comparable.

These changes could either be a cause of, or more likely, a consequence of the trend towards large financial services conglomerates. Nevertheless, the position taken by the regulators, at least in principle, agrees with that of this book. In other words, the amount of economic capital required to back a particular risk should not depend on the type of balance sheet on which the risk is written.

We now move on to consider financial conglomerates from a more detailed financial risk perspective.

## **12.2 AGGREGATE VERSUS BOTTOM UP APPROACHES TO ECONOMIC CAPITAL**

In considering economic capital for financial services conglomerates, two possible models or approaches are possible as follows.

### 12.2.1 The aggregate approach

With this approach, one balance sheet is constructed for the whole group containing all of the business risks, and the corresponding assets and liabilities, written by the group, possibly sub-aggregated by business line to reflect the actual matching of assets and liabilities in the constituent firms that make up the group. As is described in previous chapters, the conglomerate's capital is not included in the aggregate balance sheet when determining aggregate approach economic capital.

Our aim is to determine, according to our Definition 5.1 of economic capital, the amount of capital that is required to ensure that, with a high specified probability, the realistic version of the aggregate business balance sheet remains solvent under a series of deterministic or stochastic stresses.

The assets and liabilities associated with risks written by firms that are not wholly owned by the conglomerate should be pro-rated in the aggregation process, according to the percentage of Tier 1 capital that the group owns of these firms.

The main alternative to the aggregate approach is the "bottom up" approach as described in the next section.

### 12.2.2 The bottom up approach

With this approach, economic capital is calculated for each corporate entity, or firm, in the conglomerate on a standalone basis. Economic capital for the entire conglomerate is determined by applying the following "algorithm," starting from those firms that are furthest removed from the top firm in the conglomerate, and working up the conglomerate hierarchy to eventually reach the top firm.

#### *Bottom up algorithm*

The economic capital of *Firm T* equals the sum of the economic capital of all firms owned by *Firm T*, plus *Firm T's* own economic capital in respect of business written on its own balance sheet, all determined on standalone bases. If *Firm T* does not own a firm below it outright, *Firm T's* share of that firm's economic capital is obtained by pro-rating the firm's economic capital in accordance with *Firm T's* percentage share of its Tier 1 capital.

## 12.3 BOTTOM UP APPROACH ANOMALIES

A problem with the bottom up approach is that it can be prone to the creation of capital anomalies when the risks associated with products are allocated across separate balance sheets within the conglomerate. An example illustrating this, based on Porteous (2002), is provided below.

### *Bottom up regulatory/economic capital anomaly example*

Consider the example of a financial services firm offering a reversion lifetime mortgage product to asset rich, income poor, pensioners owning their own home. In other words, the firm receives a share in the ownership of the home, valued at a discount to its market value, and realizable only when the property is vacated by the pensioners. The product terminates on either the death of the pensioners, their entry into long term care, or if they chose to redeem the product.

The pensioners, in return, receive an income for life and/or a cash lump sum together with the right to live in their home for life, or until they are unable to look after themselves and must go into long term care.

### *Combined bank/life insurance firm bottom up regulatory capital*

We will consider the pure income variant of the product where, for a bank, the income is provided by the purchase of an RPI linked life annuity from a life insurance firm in the conglomerate. In this instance, the bank's asset is the reversion and its associated liability is, broadly, the funding that is required to purchase the annuity.

The reversion is, in effect, an HPI linked zero coupon bond of uncertain term. The funding needed to purchase the annuity might take the form of an RPI linked zero, with term equal to the expected term of the reversion, and with the excess (HPI – RPI) exposure hedged, where possible. In this example, therefore, the bank's assets and liabilities are reasonably well matched, both durationally and from a cashflow point of view.

When the bank writes this product on its balance sheet, the amount of Basel 1 regulatory capital that is required is around 8% of the market value of the booked reversion, assuming that the bank has an individual capital ratio of around 8%. We assume that no additional capital is required for interest rate risk as the reversion assets and liabilities are broadly matched.

To this initial 8%, we now add the capital that must be held by the life insurance firm to back the RPI linked annuity. This equals 4% of mathematical reserves, the LTICR, assuming that the annuity assets, RPI linked gilts for example, and the annuity liabilities are well matched in the life fund of the life insurance firm and no resilience capital requirement is needed.

Therefore, assuming that the annuity mathematical reserve is approximately equal to the initial market value of the reversion, the conglomerate regulatory capital requirement for the reversion lifetime mortgage product is around 12% of the initial market value of the reversion asset.

### *Life insurance firm bottom up regulatory capital*

If the life insurance firm writes the reversion lifetime mortgage on its own balance sheet, it will treat the reversion as an asset of the life fund with the income, or the RPI linked annuity, the corresponding liability, as measured by its mathematical reserve. So, an effective HPI linked zero may be used to back an RPI linked annuity, so resulting in a reasonably good asset/liability match, although there will be a cashflow mismatch as the reversion does not generate any income until the product is terminated, usually on the death or entry into long term care of the customers.

A life insurance firm will hold regulatory capital of more than 12% of the initial market value of the reversion asset only when the associated resilience capital requirement is greater than 8% of the RPI linked annuity mathematical reserve. It is fairly easy to demonstrate, using specimen calculations, that this will generally not be the case.

This example shows, therefore, that if a life insurance firm writes a reversion lifetime mortgage in its life fund, it will generally require less bottom up regulatory capital than a bank/life insurance firm combination product would. This anomaly is mainly explained by the relatively large regulatory capital requirement that applies to a bank holding a reversion asset on its balance sheet.

Irrespective of how the product is structured within the conglomerate, the risks are identical and the regulatory capital requirement ought to be independent of the product structuring.

### *Bottom up economic capital*

It is now relatively easy to see that, with a bottom up approach to economic capital, the regulatory capital requirement anomaly described above, may also apply. In other words, bottom up economic capital may depend on how a product is structured across the different balance sheets within the conglomerate.

### *Aggregate economic capital*

If we now consider the lifetime mortgage reversion product under an aggregate balance sheet approach, we will see that the economic capital requirements of the product are broadly the same under the two proposed product structures.

Under the combined bank/life insurance firm product structure, the bank's liability in respect of the funding used to purchase the annuity will approximately match the life insurance firm assets backing the annuity. These two items then approximately "cancel out" in the aggregate balance

sheet, leaving the reversion on the asset side and the life insurance annuity mathematical reserve on the liability side. This is essentially the life insurance firm product structuring.

Aggregate economic capital is, therefore, broadly independent of how the product is structured across individual balance sheets within the conglomerate.

## 12.4 PROS AND CONS OF THE TWO APPROACHES

The various pros and cons of the two approaches can be summarized as follows:

1. In practice, the aggregate approach is more difficult for firms to implement as it involves constructing one model of the conglomerate's aggregate risks and this will be far from straightforward. In addition, constructing credible stress tests, or stochastic models, that can adequately represent the dependencies and causal relationships in such high dimensions may not be straightforward.
2. As the risks written by the firms within the conglomerate may not be perfectly positively correlated, the aggregate approach will give a lower amount of economic capital than the bottom up because it allows for the diversification benefits of these different risks. The aggregate approach, which is the more theoretically "correct" when viewing the conglomerate as a whole may, therefore, be preferred by conglomerates themselves, whereas the bottom up approach may be preferred by regulators as it is more conservative.
3. The regulators may argue that, in times of real financial stress, risks tend to become highly correlated and capital flows between distinct firms, even within the same conglomerate, can no longer be relied upon. In addition, regulators may argue that being a part of a conglomerate may actually increase risk for the individual firms within the conglomerate. This is as a result of potential operational weaknesses in conglomerate systems, reduced control over firm strategy, reputational damage arising from failures elsewhere in the conglomerate and intra-conglomerate counterparty concentration risks. For these reasons, therefore, regulators may usually prefer the bottom up approach.
4. With the aggregate approach, it may not be possible to separately identify the amount of economic capital that a particular firm within the conglomerate should hold on a standalone basis. This will cause problems for both firms and regulators when assessing and validating

the standalone regulatory capital requirement of the firm relative to its standalone economic capital amount.

5. As demonstrated in Section 12.3, bottom up economic capital can result in anomalies when product risks are allocated across different balance sheets within the same group.

From the above list of points, we can see that the aggregate approach is arguably the more “correct” approach, but implementing it may be harder in practice. The aggregate approach is, however, we believe of great importance to conglomerates in understanding the risks that they are running and, in particular, helps them to understand how they can optimize the use of their capital going forward.

For example, consider a group comprising a holding company, with total Tier 1 capital of £2.25 billion, owning a retail bank and an investment bank. The aggregate approach may give a total economic capital amount of £1.5 billion, whereas the bottom up approach may give £0.75 billion for the retail bank and £1.25 billion for the investment bank separately. Given that the group appears to have much more capital than it needs under the aggregate approach, how should the group manage its businesses or reallocate its capital going forward? We return to this and related questions in Chapter 13.

## 12.5 DOUBLE COUNTING OF CAPITAL

Regulators may require each firm within a conglomerate to hold sufficient capital to cover their own standalone regulatory capital requirement. Until very recently, it has been possible for conglomerate capital to be used more than once to back the regulatory capital requirements of conglomerate constituent firms.

Consider a banking firm that is wholly owned by its parent, a life insurance firm. The life insurance firm is also a subscriber to the bank’s issued Tier 2 capital. Prior to the implementation of the Financial Groups Directive (FGD) and other related legislation, see Chapter 14 for details, the life insurance firm’s investments in the banking subsidiary’s Tier 1 and Tier 2 capital could be counted towards both the life insurance firm’s regulatory capital requirement, and the bank’s, as follows:

- Clearly the bank’s Tier 1 and Tier 2 capital both count towards the regulatory capital requirement of the bank.
- The bank’s net assets, essentially Tier 1 capital, could also be valued in full in the life insurance firm’s balance sheet as an asset, and;

- The life insurance firm's investment in the bank's Tier 2 capital could also be treated as an asset in the life insurance firm's balance sheet.

This is not theoretically correct as Tier 1 and Tier 2 capital should be "on risk" only once to back the risks run by the banking firm. Only Tier 1 and Tier 2 capital that is surplus to the bank's regulatory capital requirements should be counted towards the parent life insurance firm's regulatory capital requirement.

Recent UK legislation, including the FGD which itself came into effect in the UK from 1 January 2005, has helped to eliminate these anomalies. Only Tier 1 capital in excess of the subsidiary banking firm's own regulatory capital requirement is now allowed to count towards the parent firm's regulatory capital requirement. Similarly, the investment in the bank's Tier 2 capital, to the extent that it is covering the bank's regulatory capital requirement, must be deducted from the capital resources of the life insurance firm parent.

Likewise, at the top level firm in the conglomerate hierarchy, unless regulators give credit for the diversification benefits of the risks written within the conglomerate, it is likely that only the surplus capital of the top firm's subsidiaries will be eligible to count towards its own regulatory capital requirement.

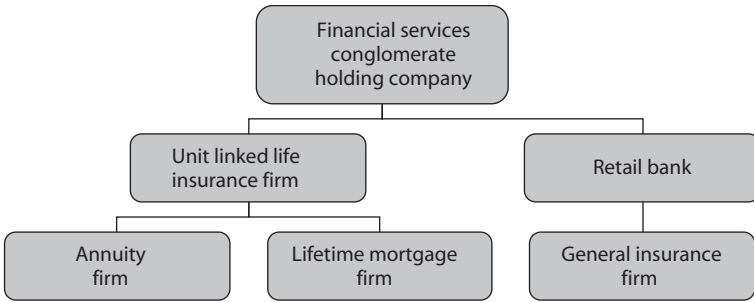
## **12.6 EXAMPLE OF ECONOMIC CAPITAL FOR A FINANCIAL SERVICES CONGLOMERATE**

In this section, we now compare and contrast the aggregate and bottom up approaches to economic capital using the financial services firm examples we developed in the earlier chapters of the book.

The financial services conglomerate structure that we will use is set out in Figure 12.1. Except for the lifetime mortgage firm and the unit linked life insurance firm, each of the standalone firms in Figure 12.1 is modeled using the corresponding base case firm examples considered in the earlier chapters of the book.

So, for example, the retail bank firm shown in Figure 12.1 will be modeled using the base case stochastic retail bank firm example as described in Section 8.2.2, and where we model capital repayment mortgages only.

The lifetime mortgage firm is modeled using the 40% LTV example described in Section 8.3.4.2. We have not used the base case example in this instance as the economic capital amounts are too low to be interesting in the full conglomerate example. For the same reason, we have used the unit linked life insurance example described in Section 9.3.5, where the fixed maintenance expenses are increased from £50 p.a. to £250 p.a.



**Figure 12.1** Financial services conglomerate example

**Table 12.1** Business mix of conglomerate

<i>Firm</i>	<i>Percentage of products</i>
Unit linked life insurance	0.53
Annuity	0.02
Lifetime mortgage	1.33
Retail bank	5.33
General insurance	92.79

The mix of business that we have assumed within the conglomerate is shown in Table 12.1, where these mix percentages are per product or policy.

So, for example, 92.79% of the conglomerate's business, which we model as one product in aggregate, will comprise of general insurance products. We have chosen this mix in order that individual firm stand-alone 99.5th percentile economic capital is approximately uniformly distributed across the 5 individual firms. As general insurance firm 99.5th percentile economic capital is very low, relative to that of the other firms in the conglomerate, we need a very high proportion of general insurance business to equalize its economic capital with that of the other firms.

Our approach to determining economic capital for a financial services conglomerate is as follows:

1. Starting from the lowest level in the conglomerate hierarchy, we calculate both aggregate and bottom up economic capital at each level, within each branch of the hierarchy.
2. Except for the bottom level of the firm, aggregate economic capital can then be compared to the corresponding amount of bottom up economic capital. Bottom up economic capital is determined as the

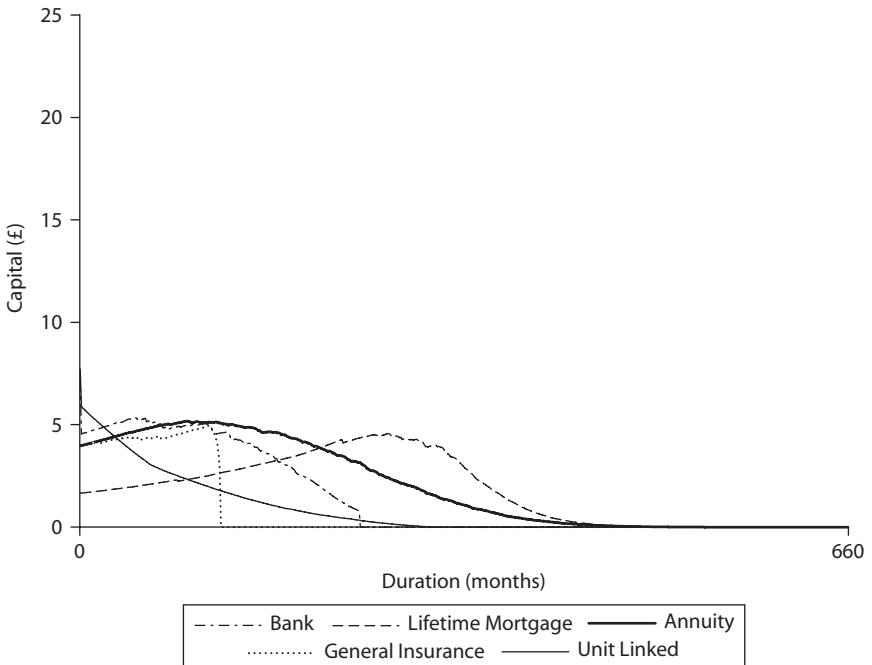
sum of the individual firm standalone economic capital amounts at that level, and below, for that part of the conglomerate hierarchy.

3. Differences between the aggregate and bottom up economic capital amounts then reflect the diversification benefits implicit in the conglomerate structure at each level.
4. For comparison, we also show the corresponding sum of standalone Pillar 1 regulatory capital requirements. In practice, however, it is important to note that Pillar 1 regulatory capital at a particular level in the hierarchy may not be calculated simply by summing the individual standalone Pillar 1 regulatory capital amounts. Aggregate Pillar 1 regulatory capital will depend on the specific regulatory capital rules that apply at that level for the conglomerate.

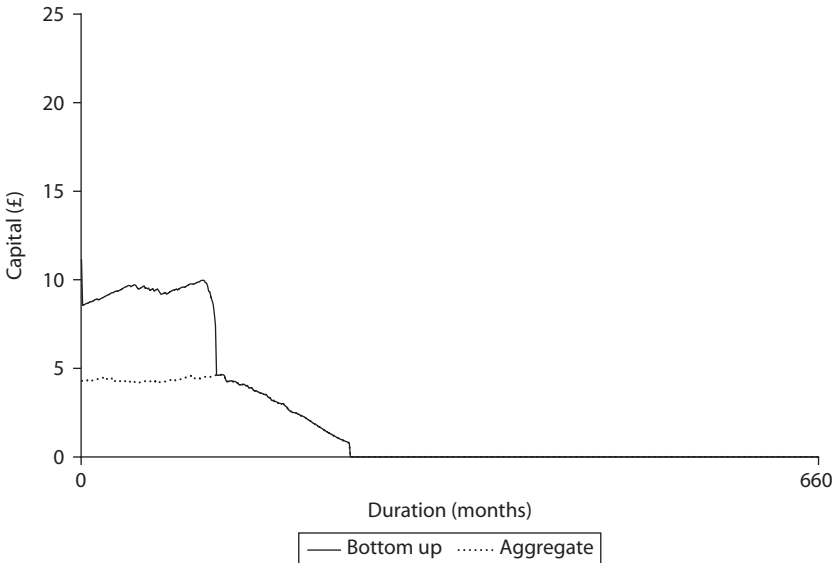
### 12.6.1 Results

Figure 12.2 shows our results for standalone 99.5th percentile economic capital for each of the firms that we have modeled, weighted by the business mix percentages shown in Table 12.1.

Figure 12.2 shows that, as expected, 99.5th percentile economic capital is approximately uniformly distributed across the five firms.



**Figure 12.2** Standalone 99.5th percentile economic capital for each firm



**Figure 12.3** Comparison of bank/general insurance firm bottom up and aggregate 99.5th percentile economic capital

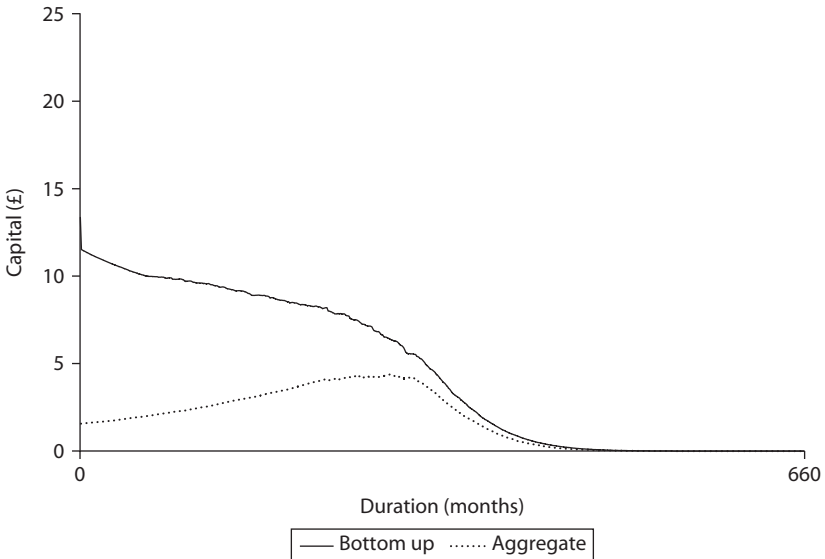
In Figure 12.3, we now compare 99.5th percentile bottom up and aggregate economic capital for the bank/general insurance firm at the level of the bank in the conglomerate hierarchy.

From Figure 12.3 we can see that, whilst both the bank and the general insurance firm have business in force, aggregate economic capital is roughly half of bottom up economic capital. The bottom up and aggregate economic capital curves coincide when the general insurance firm business has run off completely, which happens before the bank's business does. Thereafter, it is only the bank business that is being modeled until it runs off completely also.

It can be seen that, the diversification benefits during the initial ten years of the firm are, by any standards, extremely significant. In other words, the risk events that drive retail mortgage bank economic capital tend not to occur at the same time as the risk events that drive general insurance firm economic capital. More specifically for this example, interest rate margin risk, which is a principal driver of retail mortgage bank economic capital, is not related to claims experience risk, the main driver of general insurance firm economic capital.

Figure 12.4 shows 99.5th percentile bottom up and aggregate economic capital for the unit linked/lifetime mortgage/annuity firm at the level of the unit linked life insurance firm in the conglomerate hierarchy.

Figure 12.4 shows that aggregate economic capital starts at around 15% of bottom up economic capital and gradually converges to bottom



**Figure 12.4** Comparison of unit linked/lifetime mortgage/annuity firm bottom up and aggregate 99.5th percentile economic capital

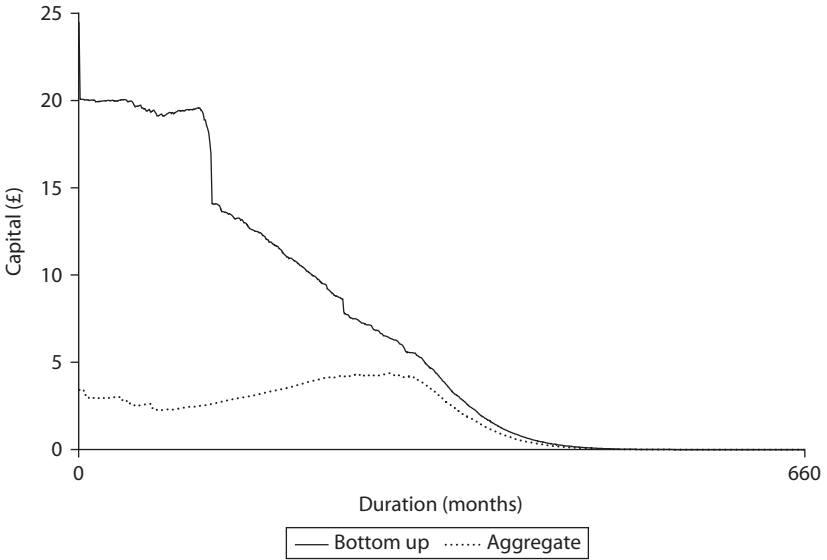
up economic capital as the businesses of the three firms run off. Again, the diversification benefit as a result of combining the firms is enormous, because the risk events that drive economic capital for each of the firms are not closely related.

Finally, Figure 12.5 compares 99.5th percentile bottom up and aggregate economic capital for the whole conglomerate at the top level of the conglomerate.

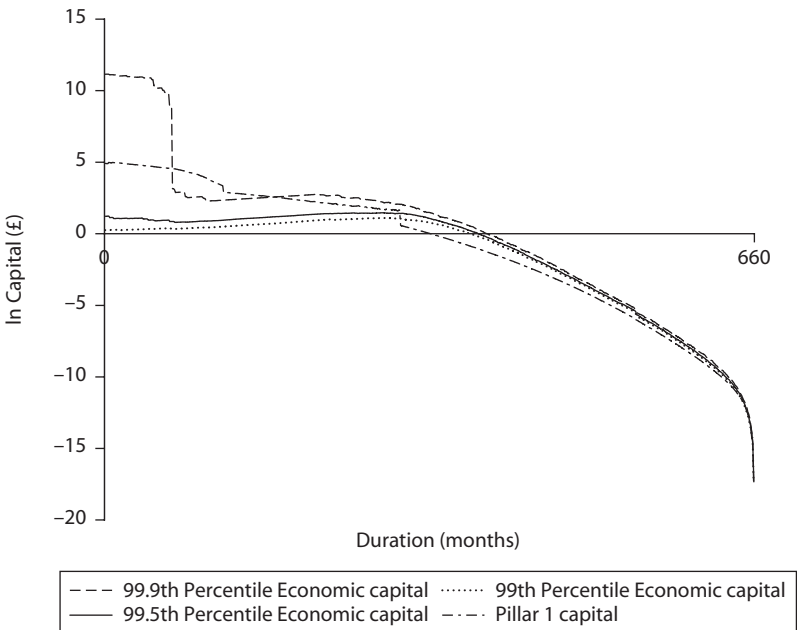
Once again the diversification benefit is large and we can see that, the more diverse are the types of firm that make up the conglomerate, the larger that the diversification benefit will be.

We finish off this section by comparing, in Figure 12.6, bottom up Pillar 1 capital with aggregate economic capital. Figure 12.6 is shown on a natural logarithmic scale because, when considering 99.9th percentile economic capital, as we have seen previously in Chapter 9, catastrophes drive general insurance firm economic capital up to extremely high levels.

Figure 12.6 shows, allowing for the logarithmic scale, that bottom up Pillar 1 capital has completely the wrong shape relative to, say, 99.5th percentile economic capital. It is far too high at the shorter durations, and far too low at the later durations.



**Figure 12.5** Comparison of bank/general insurance/unit linked/lifetime mortgage/annuity firm bottom up and aggregate 99.5th percentile economic capital



**Figure 12.6** Comparison of bank/general insurance/unit linked/lifetime mortgage/annuity firm bottom up Pillar 1 capital and aggregate economic capital

## 12.6.2 Conclusions of financial services conglomerate example

The main conclusion that we can draw from our conglomerate example is that, when the constituent firms of a conglomerate are genuinely diverse and are involved in businesses that are not closely related, aggregate economic capital will be substantially lower than bottom up economic capital. Or, in simpler terms, things do not go wrong at exactly the same time across this range of businesses.

If regulators allow for this diversification benefit in determining the conglomerate's regulatory capital requirements, then the economic value of this diversification benefit is both very real and, potentially, very large.

## 12.7 MANAGEMENT OF DIVERSIFICATION BENEFITS

Having confirmed that diversification benefits exist within financial services conglomerates, how should these benefits be managed? For example, if a manager within a business unit in the conglomerate reduces aggregate economic capital by an action taken within their own business unit, should the manager be rewarded for that action and, if so, how? Reduced aggregate economic capital has real economic value and it does seem reasonable that managers should be rewarded, or at least recognized, if they can reduce the firm's economic capital through their own actions.

The action may involve a deliberate action of increasing the business unit's investment in an asset that is negatively, or weakly, correlated with another asset in a different business unit. However, it is also possible that the manager may be completely unaware of the effect that their action has on the rest of the conglomerate.

We understand that certain firms are already grappling with these problems, and indeed have found their own firm-specific solutions. The approach that we propose to managing diversification benefits within a financial services conglomerate is set out below.

For each business unit within a conglomerate

- A senior manager, usually the Chief Risk Officer (CRO) or CEO, within the business unit is assigned responsibility for aggregate economic capital for that business unit. Let us call this manager the Chief Economic Capital Officer (CECO).

- It is the CECO who is tasked with owning aggregate economic capital for the business unit. This means, not only determining economic capital, but also being in a position to understand how the actions taken by managers within the business unit, and its subsidiary firms, may affect aggregate economic capital for the unit. Any action that could affect aggregate economic capital for the business unit will therefore be of interest to the CECO and, beyond a certain material level, may also require CECO approval.
- It is the CECO who is responsible for allocating the amount of economic capital that is used within the business unit to assess manager performance. In particular, if the business of a manager within the unit contributes significantly to reducing the unit's aggregate economic capital, and that manager is aware of this, and specifically manages his business to achieve this, the CECO may give back some of this diversification benefit to the manager. In other words, the manager will be assessed on their standalone economic capital requirement, less the diversification reduction allocated by the CECO.
- Alternatively, if a manager runs his business on a standalone basis, he should be assessed using standalone economic capital.
- In practice, this method can be used to cascade diversification benefits down into the business by
  - a. Starting at the top level firm in the conglomerate, diversification benefits are quantified by comparing aggregate economic capital, at this level, to bottom up economic capital, at this level.
  - b. The CECO at the top level firm then decides how much, if any, of this diversification benefit should be pushed down to the next level.
  - c. Move down to the next level and repeat the process for firms at that level, allowing for the diversification benefits that have reached that level.

### *Allocation of diversification benefits*

In practice, a range of methods of allocating diversification benefits down into the business is being used. A few of these methods are listed below, together with some of their pros and cons:

#### *Pro-rata according to business unit size*

Pro: Straightforward to apply in practice.

Con: Favors the large business units and is not risk based.

*Pro-rata according to economic capital at that level*

Pro: Straightforward to apply in practice.

Con: Favors the business units carrying the largest amounts of risk at that level.

*Pro-rata according to the marginal diversification benefits of each firm*

For level  $(L - 1)$  firms, marginal diversification benefits are determined by calculating by how much the diversification benefit at firm level  $L$  changes, per unit of business increase for each of the level  $(L - 1)$  firms.

Pro: Allocates most of the diversification benefit to those firms that, at least marginally, contribute most to it.

Con: More complicated to apply and communicate in practice.

## 12.8 SUMMARY

In this chapter we have discussed the business reasons why we believe financial services conglomerates have been formed in recent years. We defined and considered the relative advantages of both aggregate and bottom up economic capital.

Most importantly, however, we have demonstrated that the diversification benefits present in financial services conglomerates can be extremely large in practice. Having established that these diversification benefits exist and are very real, we have discussed how firms might manage these benefits.

We now move on to draw together in Chapter 13 the practical issues associated with performance measurement and capital management for financial services conglomerates.

# Capital Management and Performance Measures

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## **13.1 INTRODUCTION**

In this chapter, we bring together the material presented in the previous chapters to describe practical approaches to capital management and risk consistent performance measurement. Obviously, individual firms will manage their capital and measure performance in different ways and according to their own philosophies. Nevertheless, at least at the broad level of principle, we believe that the approaches set out in this chapter represent or, at the very least, are similar to approaches adopted by many firms in practice.

The main topics that we cover in this chapter are

1. Pricing
2. Performance measurement
3. Leverage
4. Capital allocation
5. Business mix optimization
6. Practical implementation issues
7. Regulatory capital arbitrage

Before moving on to discuss pricing, we first briefly discuss performance measurement and capital deployment in a business.

### *Performance measurement*

The performance measurement approaches that we recommend are “risk adjusted performance measurement” (RAPM) approaches. In other words, in assessing financial performance, the performance measure adjusts, or allows for, the amount of risk inherent in the business being assessed. See Matten (2001) for a general discussion of RAPM and related topics. However, we prefer the terminology “risk consistent,” rather than “risk adjusted,” as a key purpose of the risk adjustment is to allow comparisons to be made on a like for like basis.

### *Capital deployment*

Although most financial services firms may manage their businesses using an economic capital approach, the amount of capital actually deployed in the firm will usually be determined by a combination of other factors such as:

1. The firm’s regulatory capital requirements
2. The firm’s target financial strength relative to its competitors
3. The amount of capital that it requires to achieve its target credit rating from ratings agencies
4. Accumulated retained earnings that may be earmarked for future corporate activity.

Except by accident, firm wide actual capital employed will usually not equal firm wide economic capital.

## **13.2 PRICING**

We now consider how firms price their products to achieve target profitability and rates of return on capital. Our main focus will, however, almost always be on rate of return on capital. This is the measure that will be of most interest to the providers of the firm’s capital.

### **13.2.1 Tier 1 capital pricing**

Traditionally, firms have tended to price their products to achieve a target rate of return on their Tier 1 capital deployed. In other words, pricing is based on the return earned on the amount of Tier 1 capital that backs the firm business, where the calculation will explicitly allow for the cost of the firm’s actual Tier 2 capital.

Tier 1 capital is the capital that is genuinely on risk in the event that the cost of the risks collected by the firm exceeds the expected cost loaded into the firm's pricing of those risks. However, because of mismatches between actual and economic capital, as discussed previously, this approach may tell us very little about an appropriate risk consistent price that should be charged by the firm for collecting the risks associated with its products.

In other words, accepting that an appropriate risk consistent price is based on achieving a target rate of return on economic capital, the actual Tier 1 capital pricing approach may tell us nothing, or may even mislead us, about the appropriate risk consistent price for firms' products.

For example, for retail mortgages, we saw in Section 8.2 that economic capital is generally much lower than the Basel 1 Pillar 1 regulatory capital requirement. Therefore, if the Basel 1 Pillar 1 regulatory capital requirement is backed entirely by Tier 1 capital, pricing mortgages using actual Tier 1 capital will result in an overpricing of retail mortgage product risks. Ultimately, this is to the detriment of the end customer.

Our preferred approach to pricing financial services products, in a risk consistent manner, is based on economic capital, as described in the next section.

### 13.2.2 Economic capital pricing

An appropriate risk consistent price for a financial services product can be based on the return required to be earned on its economic capital. This is what we call the pure economic capital pricing approach.

If a firm's actual Tier 1 capital is in excess of its economic capital, then excess risk capital is being held and this results in additional costs to the firm, some of which may be able to be passed on to the end customer through increased pricing. In any case, as is described later, the performance drag of this over capitalization, relative to economic capital, can be quantified.

Likewise, if a firm's actual Tier 1 capital is less than its economic capital amount, and assuming that the firm is prepared to hold this smaller actual Tier 1 capital amount, then the effect of this under capitalization is also quantifiable.

The economic capital approach to pricing has certain advantages over the actual Tier 1 capital pricing approach as follows:

1. First, pricing all of the firm's products against their underlying economic capital requirements, ignoring actual and regulatory capital requirements, allows consistent pricing of these products, having allowed for their relative risks. So, for example, the price of a motor insurance policy will be risk consistent with that of a unit linked life

insurance policy, even though these products involve collecting completely different types of risk. This consistency should be an ultimate aim for a firm's shareholders, customers and management as it allows the profitability of all of the firm's products to be compared on a like for like basis.

2. Having priced the products using economic capital pricing, the expected profitability of the products, allowing for each product's actual Tier 1 and Tier 2 capital mix, can then be determined. This allows the firm to quantify the drag effect, or boost, that actual capital has on product pricing, versus the more theoretically correct economic capital pricing approach.

Although competition will, nevertheless, almost always have the final say on where a firm pitches its prices, economic capital pricing will greatly assist the firm in understanding the fundamental profitability of its businesses, allowing for both the risks that it is running and for any actual and regulatory capital requirement anomalies.

For example, if Tier 1 regulatory capital requirements are far in excess of economic capital for a particular business line, the firm may choose not to offer this line of business if it can deploy its capital more effectively. It may be able to achieve this, for example, by backing a business line where there is less of a mismatch. On the other hand, if the market pricing of the business line is still favorable enough for the firm to earn a good rate of return on its actual Tier 1 capital, the firm may choose to continue competing in that business line.

Note, however, that this results in capital inefficiency, as more capital is required to back this business line's risks than is necessary. Ultimately, it is the end customer that will pay for this and, in total market terms, less capital will be available to support other business lines, which is clearly undesirable and inefficient.

### 13.3 PERFORMANCE MEASUREMENT

We next consider measuring the performance of the capital deployed in a financial services firm, having allowed for the risks inherent in the firm.

Many approaches and methods have been proposed over the years. We choose, however, to focus on only two of these approaches because, based on our own practical experiences, these are the approaches that have proven to be of most value. The two approaches are

1. Comparing the earned rate of return on actual Tier 1 capital deployed to the risk adjusted cost of this capital. We call this approach the CAPM approach.

2. Comparing the earned rate of return on economic capital to the corresponding risk adjusted cost of capital. We call this approach the economic capital approach.

With either of these approaches, the earned rate of return on capital is calculated over the lifetime of the product, or firm.

### 13.3.1 The CAPM approach

The CAPM is so well known in finance that it requires virtually no introduction (see Elton and Gruber, 1991). Under a large number of simplifying and, in general, fairly unrealistic assumptions, CAPM shows how the annual expected return on a risky asset is related to the annual risk free rate of return and the annual expected return on the market asset. This depends on a measure  $\beta$  of the relative riskiness of the risky asset as compared to the market asset.

CAPM has worked very well in practice and, despite many of the reservations surrounding the assumptions required to derive the model, is the standard tool used in finance to calculate a risk adjusted cost of capital.

Our CAPM approach to performance measurement is described as follows:

#### *Calculating the earned return*

1. The stochastic model is run a large number of times.
2. The earned rate of return on actual Tier 1 capital deployed, for each stochastic model run, is calculated.
3. For each run, this return equals the risk discount rate for which the firm's present value of expected future profits, or PVIF, equals zero where these expected future profits allow for all of the capital cash-flows, including costs, that are required to support the business.
4. We denote these returns by  $r_{\text{TOC}}$ .
5. We have the distribution of these returns across stochastic model runs.

#### *Calculating the cost of capital*

CAPM is next used to estimate, or approximate, the risk adjusted cost of the Tier 1 capital deployed in the firm. This is usually achieved by estimating a firm's  $\beta$  using the firm's share price correlation and volatility relative to the market (see Elton and Gruber, 1991). The more risky a

firm is relative to the market, the higher its  $\beta$  and the higher its risk adjusted cost of capital. We denote this return  $r_{coc}$ .

The CAPM approach to quantifying cost of capital is relatively straightforward to apply in practice, but can often yield surprising and unpalatable conclusions, especially when applied at the firm level within conglomerates. The article by Wilson (2003) shows how CAPM can be applied to financial services conglomerates to explain how cost of capital varies by

1. A conglomerate's leverage.
2. Level of diversification.
3. The types of firms that make up the conglomerate.

### *Calculating the added value return*

Performance measurement is based on the distribution of the added value returns:

$$r_{av} = (r_{roc} - r_{coc}) \cdot$$

If average  $r_{av} > 0$ , for example, then genuine value is being added, on average over the stochastic model runs, allowing for the risks that are being run by the firm and the amount and type of capital that it has deployed.

If average  $r_{av} < 0$ , for example, then value is being destroyed, on average over the stochastic model runs, and some action is required. This might include increasing the prices of the firm's products, so increasing the firm's  $r_{roc}$ s, exiting certain markets or de-risking the firm's balance sheet. The latter action should have the effect of reducing the firm's  $r_{coc}$ .

Note that as we have an estimate of the distribution of the  $r_{av}$ s, we are also in a position to consider other performance measurement characteristics. For example, if the distribution of a firm's  $r_{av}$ s has a long negative tail, then this is poorer performance than for a firm with a more symmetrically shaped  $r_{av}$  distribution. This is because extreme negative  $r_{av}$ s are more likely under the former distribution.

### **13.3.2 The economic capital approach**

An alternative to the CAPM approach is the economic capital approach. This is our preferred approach, described as follows:

#### *Calculating the earned return*

1. The stochastic model is run a large number of times and economic capital, at a prescribed confidence level, is identified.

2. The stochastic model runs that are used to determine economic capital are saved and then reused to calculate earned rates of return on economic capital.
3. The earned rate of return on economic capital, across stochastic model runs, is then calculated.
4. For each run of the stochastic model, this earned rate equals the risk discount rate for which a firm's present value of expected future profits, or PVIF, equals zero.
5. The calculations are carried out using, as a capital requirement, the firm's economic capital amount and allows for all of the cashflows associated with this capital requirement.
6. We denote these returns by  $r_{\text{roec}}$ .
7. We have the distribution of these returns across stochastic model runs.

### *Calculating the cost of capital*

We next determine a best estimate cost of economic capital, which we denote by  $r_{\text{coec}}$ . The value of  $r_{\text{coec}}$  depends on both the percentile level and the time horizon over which economic capital has been calculated.

For example, if economic capital is calculated at the 99.5th percentile level, over a ten year time horizon, a benchmark value for  $r_{\text{coec}}$  might be the yield of a ten year bond for which the probability of losing all of the bond's nominal value over the ten year period is rated at 0.995.

### *Calculating the added value return*

Performance measurement is based on the economic capital added value return:

$$r_{\text{avec}} = (r_{\text{roec}} - r_{\text{coec}}).$$

If average  $r_{\text{avec}} > 0$ , then genuine value is being added, on average over the stochastic model runs, and allowing for the risks that are being run.

If average  $r_{\text{avec}} < 0$ , then value is being destroyed, on average over the stochastic model runs, and some action is required. This might include increasing the prices of the firm's products, exiting certain markets or de-risking the firm's balance sheet. These actions will have the effect of reducing the firm's economic capital requirement, so inflating  $r_{\text{roec}}$ .

Note that, as we have an estimate of the distribution of the  $r_{\text{avec}}$ s, we are also in a position to consider performance measurement based on

characteristics such as the shape of the distribution, as well as average value.

### *Mismatch between economic capital and Tier 1 capital*

If there is a large mismatch between a firm's economic capital and actual Tier 1 capital deployed, the financial effect of this can be quantified by calculating  $r_{\text{drag}} = (r_{\text{av}} - r_{\text{avec}})$ .

So in our base case banking example, where Tier 1 capital is used to back the Basel 1 Pillar 1 regulatory capital requirement, Tables 8.4 and 8.5 show that  $r_{\text{drag}}$  will be very large indeed. Table 11.5, which shows corresponding results for our with profits life insurance investment guarantee example, illustrates that, if life insurance firms are prepared to hold Tier 1 capital equal to their Pillar 1 regulatory capital requirement, which is less than economic capital, the converse conclusion applies, although they increase risk by doing so as can also be seen in Table 11.5.

The shape of the distribution of the  $r_{\text{drag}}$ s, will also usually tell us something useful about the effect of the capital mismatch.

### **13.3.3 Pros and cons of the two approaches**

As the economic capital approach requires a firm to identify its economic capital explicitly, this allows

1. The firm to carry out pure economic capital pricing, and so risk consistent pricing, of its product range.
2. The financial consequences of any mismatch between economic capital and actual Tier 1 capital to be quantified directly.

For these reasons we prefer the economic capital approach.

The CAPM approach is also dependent on the accuracy of the market's assessment of a firm's relative riskiness. In other words, if a firm is deploying an excess/deficit of actual Tier 1 capital relative to the risks it is running, the market may, or it may not, recognize this through a low/high estimate of  $\beta$  and so a low/high estimated costs of capital.

## **13.4 LEVERAGE**

### **13.4.1 On balance sheet leverage**

One way that a firm can "leverage up" their balance sheets is by using extra Tier 2 capital, rather than Tier 1 capital, to write more business.

Firms can write more business up to the level of the Tier 2 capital eligibility constraints that apply for that type of firm and are then able to write more business with the same quantum of Tier 1 capital.

The economic capital approach of this book handles this situation as follows:

- Under our definition of economic capital, as described in Chapter 5, a firm's economic capital amount is independent of the firm's capital structure. Economic capital should, however, always be backed by genuine risk capital, which we regard as Tier 1 capital, and not Tier 2 capital.
- When the firm increases the size of its business to generate higher future profits, economic capital increases exactly in proportion to these increased future profits. In other words, if future profits increase by a factor two, say, then percentile economic capital also increases by this same factor of two.
- The rate of return  $r_{\text{roec}}$ , as defined in Section 13.3.2, is therefore inflated by the higher future profits, but is deflated in exactly the same proportion by the firm's higher economic capital amount, so leaving  $r_{\text{roec}}$  unaltered.
- On balance sheet leveraging therefore leaves a firm's economic capital financial performance unaltered.

Although the argument presented above lacks mathematical rigor, it is intuitively obvious. Broadly, we can conclude that on balance sheet leverage does not change a firm's risk consistent financial performance.

Note that this result is similar, although not the same, as the famous Modigliani-Miller theorem. That theorem states that, under a number of fairly restrictive assumptions, the value of a firm is independent of its capital structure. The result of this book, which is more analogous to the theorem, is that  $r_{\text{roec}}$  does not depend on the firm's capital structure. This is because economic capital, as defined in this book, does not itself depend on the firm's capital structure.

The allocation of Tier 1 and Tier 2 capital within a financial services conglomerate to optimize returns earned on that capital is discussed in full in Section 13.5. Section 13.6 then discusses business mix optimization within a financial services conglomerate to further enhance the rates of return earned on capital.

We now move on to consider off balance sheet leverage, which, as we shall see, can improve firm performance. This is as a result of inconsistent regulatory capital requirements causing firms to put different prices and valuations on the same risk.

### 13.4.2 Off balance sheet leverage

Examples of off balance sheet leverage include

- A life insurance firm reinsuring annuity longevity risk to a reinsurance firm.
- A wholesale bank may transfer some of its loan asset risks by issuing a full cash collateralized debt obligation (CDO).
- A reinsurance company may transfer the catastrophe risks that it has collected by issuing a catastrophe bond CDO.
- A retail mortgage bank may issue a full cash securitization of a part of its mortgage portfolio.

What these transactions achieve for the risk collector, or risk originator, is transference of at least a part of the risk collected to third party risk takers. As a consequence, and assuming that genuine risk transference has occurred, although this need not always be the case, the risk collector's regulatory capital requirement and economic capital amounts will be reduced.

The price to be paid for this risk transference, and consequent regulatory capital relief, is that the risk collector will release a share of the profits, or value, earned as a result of accepting the risk, to the recipient third party risk taker. Depending on how the regulatory capital requirements of the third party risk taker relate to those of the risk originator, in respect of the risk transferred, the risk originator may be able to enhance its performance measures.

This is described below by considering a number of permutations of the Tier 1 capital and economic capital amounts of both the risk originator and the third party risk taker. Hereafter in this section, by Tier 1 capital, we will always mean the Tier 1 capital deployed by firms to back their regulatory capital requirements.

We make the following assumptions:

- That the risk's economic capital amount is determined on a standalone basis, ignoring diversification benefits. This amount is therefore equal for both the risk originator and the third party risk taker.
- That both the risk originator and the third party risk taker price the risk using the larger of Tier 1 capital and economic capital.
- That the total costs of Tier 2 capital are broadly the same for both the risk originator and the third party risk taker, in respect of any Tier 2 capital backing of the risk's regulatory capital requirement.

(i) *Risk economic capital < third party Tier 1 capital < risk originator Tier 1 capital*

In this instance, unless the third party risk taker's cost of capital is much higher than the risk originator's, the value of the risk to the third party risk taker should be higher than it is for the risk originator. This is because the third party risk taker can back the risk with less Tier 1 capital than the risk originator can. The third party risk taker can therefore pay the risk originator more for the risk than it is worth to the risk originator itself. The risk originator's rate of return earned on economic capital and also Tier 1 capital should therefore increase as a result of the risk transference.

The best known example of this situation is when mortgage banks securitize their mortgage assets. Under Basel 1, the total regulatory capital saving can be at least 3% of the nominal amount of the mortgages securitized. Therefore, provided that the cost of funding the securitized mortgages is not excessive, as compared to the mortgage bank's on balance sheet funding costs, securitizing can improve a mortgage bank's rate of return on Tier 1 capital.

(ii) *Risk economic capital < risk originator Tier 1 capital < third party Tier 1 capital*

In this situation, the converse argument applies and the risk originator is likely to destroy value and reduce its rate of return on Tier 1 capital.

This does not mean to say that risk originators will not pursue this option. For example, risk originators that are in financial difficulties may enter into risk transference of this nature purely for solvency purposes, for example. In other words, transferring the risk will reduce their regulatory capital requirements, thereby helping to ease their solvency difficulties but, nevertheless, destroys value and performance in the process.

There are many examples of this happening in practice, usually during times of market stress.

(iii) *Third party Tier 1 capital < risk economic capital < risk originator Tier 1 capital*

As with (i), the risk transference should be value and performance enhancing for the risk originator.

(iv) *Risk originator Tier 1 capital < risk economic capital < third party Tier 1 capital*

As with (ii), value and performance should be destroyed.

(v) *Third party Tier 1 capital < risk originator Tier 1 capital < risk economic capital*

This situation should be value and performance neutral for both parties as they will both price and value the risk using the risk's economic capital amount.

(vi) *Risk originator Tier 1 capital < third party Tier 1 capital < risk economic capital*

This situation should again be value and performance neutral to both parties as they will both price and value the risk using the risk's economic capital amount.

### **13.5 ALLOCATING TIER 1 CAPITAL TO MATCH ECONOMIC CAPITAL**

In this section, and the next, we consider perhaps the most interesting and challenging problem facing financial services conglomerates in managing their businesses: that of allocating a conglomerate's limited and precious capital resources to optimize the return that can be earned on it. In this section, we first focus on the problem of allocating Tier 1 capital to match economic capital, as closely as possible within the conglomerate, and so the risks that the conglomerate is running.

#### **13.5.1 Background**

At each organizational level in a financial services conglomerate, we can determine total actual Tier 1 and Tier 2 capital, regulatory capital requirements and economic capital. The amount of actual Tier 1 and Tier 2 capital that is eligible to back the conglomerate's regulatory capital requirement is then determined by the regulations that apply to the conglomerate at that level.

These regulations will usually be very complicated and technical to apply in practice. For example, surplus capital that is trapped in a subsidiary firm, and which may not be genuinely transferable within the group, would usually not be allowed by regulators to count as capital at organizational levels higher than that of the subsidiary firm. The regulators will usually, nevertheless, concede that, because of the diversification benefits within a group, the riskiness of the financial services conglomerate at the top level firm is generally lower than the sum of the riskinesses of the individual component firms that make up the conglomerate. Whether

or not this translates into a reduced regulatory capital requirement for the top level firm in the conglomerate, however, is another matter entirely.

On the other hand, regulators may argue that individual firms in the conglomerate may be more risky as a part of the conglomerate, than they would be on a standalone basis. This is because if one firm in the conglomerate “blows up,” all firms in the conglomerate may have their reputations and businesses damaged and tarnished, even if they are well managed businesses in their own right, with more than enough capital to cover the risks they are running. Although there may be some mileage in the regulator’s position, in our view, capital is not the answer, nor is it a mitigant, to this type of risk.

If a firm can be seriously jeopardized by the problems of a fellow conglomerate firm, then capital is not an effective mitigant against this risk. Management actions, such as communicating clearly to markets and customers, alike, that the firm’s business is unaffected and is robust to the problems of the fellow conglomerate firm, are more appropriate risk mitigants. Therefore, in all that follows, we take the view that individual firms within a conglomerate should not have their regulatory capital requirements increased, simply because they are part of a larger group.

### **13.5.2 Tier 1 capital allocation in practice**

In Chapter 12, we considered both the “aggregate” and “bottom up” approaches to economic capital for a financial services conglomerate, or group, and concluded that the aggregate approach is arguably the superior approach. In this section, we propose a method of allocating Tier 1 capital within a financial services conglomerate, based on the aggregate approach to determining economic capital.

We believe that this method is near optimal, relative to the aims of

1. Matching the conglomerate’s aggregate economic capital with Tier 1 capital, as closely as possible, at the top level firm in the conglomerate.
2. Satisfying all regulatory capital requirements, at each organizational level of the conglomerate, in a Tier 1 capital efficient manner.

We assume that the conglomerate has more than enough eligible Tier 1 and Tier 2 capital to cover its regulatory capital requirements for each firm, or sub group of firms if they are regulated on a consolidated basis, within the conglomerate’s hierarchy. Otherwise, one of the conglomerate’s firms would not be solvent. For each firm within the conglomerate,

starting at the organizational levels most distant from the top firm, the capital allocation approach is as follows:

### *Step 1*

Allocate Tier 1 and Tier 2 capital up to the respective *minimum* and *maximum* amounts required to cover the regulatory capital requirement of the firm. This allocation will be net of any Tier 1 and Tier 2 capital that is provided by third party investors from outside of the conglomerate.

### *Step 2*

Go up to the next organizational level in the conglomerate and repeat the exercise for consolidated firms at that level. At this next level, even if the regulations allow, firm assets that are invested in the Tier 1 and Tier 2 capital of lower level firms should only be counted towards the capital of these next level firms to the extent that they are surplus to the regulatory capital requirements of the lower level firms. Otherwise, such assets would be “on risk” more than once and this would not be reasonable. Again, if the surplus capital is not likely to be transferable in practice, it should be ignored.

### *Step 3*

Repeat until the top level firm in the conglomerate is reached. If aggregate Tier 1 capital at the top level firm exceeds aggregate economic capital, then this excess represents an over capitalization of the conglomerate relative to the risks that it is running. If aggregate Tier 1 capital is less than aggregate economic capital, then the converse applies and the conglomerate should raise new Tier 1 capital to increase Tier 1 capital up to the aggregate economic capital level. One option would be to replace Tier 2 capital with Tier 1 capital.

The allocation method ensures that:

- At each organizational level in the firm, all firms have enough capital to cover their regulatory capital requirements.
- The utilization of Tier 1 capital is minimized relative to Tier 2 capital. This is likely to be preferable because the cost of Tier 1 capital will usually be higher than Tier 2 capital. Moreover, Tier 2 capital costs are usually tax deductible, unlike Tier 1 capital costs.
- At the top level firm in the conglomerate, the firm has enough aggregate Tier 1 capital to cover the risks that it is running, allowing for the risk diversification benefits present in the mix of firms making up the conglomerate.

Except for the top level firm in the conglomerate, the allocation method does not ensure that allocated Tier 1 capital is sufficient to cover aggregate economic capital for firms in the conglomerate. Although theoretically

correct, this may not be acceptable to the conglomerate, to regulators, to ratings agencies or to external investors. If this is the case, then the capital allocation algorithm can be applied to selected individual firms within the conglomerate to ensure that allocated Tier 1 capital, for those firms, is at least as large as their aggregate economic capital at that level.

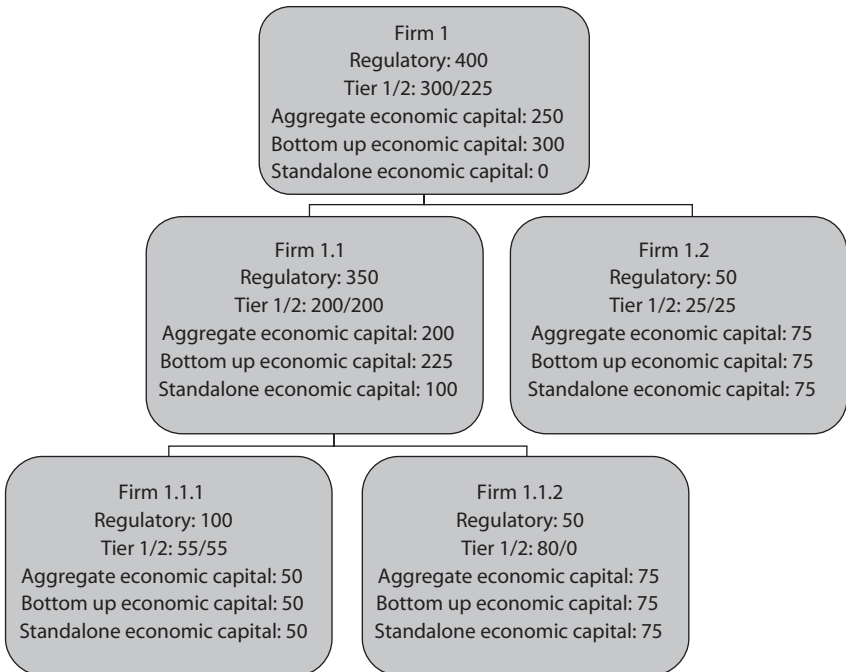
The algorithm can then be re-run, for the entire conglomerate, but with the capital allocations for these particular selected firms, and their subordinates in the hierarchy, fixed at the allocations determined by their individual capital allocations.

The allocation method also allows the conglomerate to compare its current actual capital allocation within the conglomerate to that determined by the allocation method. This will allow the firm to validate the efficiency of its current capital allocation. If inefficiencies are found, the conglomerate may wish to consider a capital reorganization.

The practical workings of the allocation method are best illustrated using specific examples, as described in the next section.

### 13.5.3 Capital allocation example

In order to demonstrate the capital allocation procedure in practice, we consider the financial services conglomerate displayed in Figure 13.1,



**Figure 13.1** Financial services conglomerate capital allocation example – base case

where at each level in the hierarchy, we have consolidated all firms at that level and below.

For simplicity, we will assume that, at each level in the hierarchy, except at the top level, each firm's Tier 1 and Tier 2 capital is provided entirely by its parent firm. We also assume that, within any firm, Tier 2 capital is limited to at most 100% of Tier 1 capital.

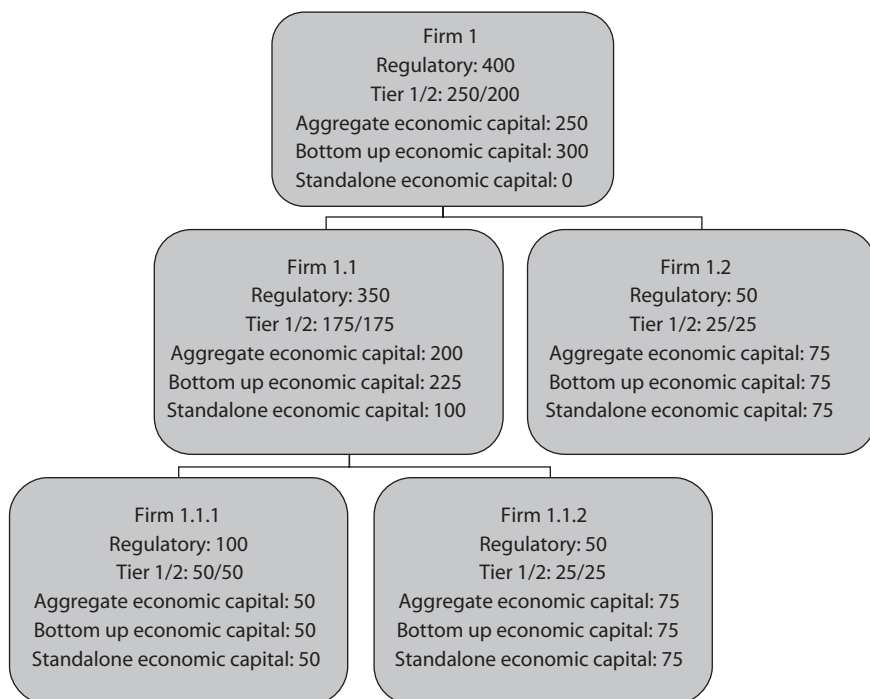
Initial observations on the firms shown in Figure 13.1 are as follows:

1. The top level firm, Firm 1, has enough Tier 1 capital to cover its aggregate and its bottom up economic capital requirements. The conglomerate therefore has sufficient Tier 1 capital to cover its aggregate risks, whether risk diversification benefits are allowed for, or not.
2. The same applies for all other firms, except Firm 1.2, which has substantially less Tier 1 capital than it needs and Firm 1.1 which has less Tier 1 capital than bottom up capital. Firm 1.1 does have enough Tier 1 capital, however, to cover its aggregate economic capital requirements.
3. Although Firm 1.2 does not have enough Tier 1 capital to cover the risks that it is running, the financial services conglomerate, at the level of the top firm does have enough Tier 1 capital to cover its aggregate risks.
4. All firms have enough aggregate Tier 1 and Tier 2 capital to cover their regulatory capital requirements, with certain firms having excess capital.

Applying the capital allocation algorithm gives the new capital distribution shown in Figure 13.2.

Observations on the capital allocation shown in Figure 13.2 are as follows:

1. Less Tier 1 and Tier 2 capital is now deployed within certain firms, Firm 1.1.1 for example.
2. All firms, except Firm 1 and Firm 1.1.1, have less Tier 1 capital than aggregate economic capital, although all firms are solvent relative to their regulatory capital requirement.
3. If the firm's management feels that it is important for all firms to have enough Tier 1 capital to cover aggregate economic capital at each level in the hierarchy, additional Tier 1 capital would need to be held in all other firms, except Firm 1.1.1 and Firm 1. For example, Firm 1.2 should then hold £75 million of Tier 1 capital and no



**Figure 13.2** Financial services conglomerate capital allocation example – post the application of the allocation method

Tier 2 capital and, as a result, will hold £25 million of capital in excess of its regulatory capital requirement.

4. Note that, although this excess capital is surplus to regulatory requirements at that level, and therefore may be used to support regulatory capital requirements at higher levels in the firm, there would be no surplus relative to aggregate economic capital at that level which can be made use of at higher levels.
5. As Firm 1 is overcapitalised relative to its regulatory capital requirement, the conglomerate may have the option of releasing £50 million of Tier 2 capital from Firm 1.1, say. This can be financed by down streaming Tier 1 capital from Firm 1, while still ensuring that Tier 1 capital exceeds aggregate economic capital at the Firm 1 level.

Obviously for real financial services conglomerates, the situation will be far more complicated than is shown for this simple example. We believe, however, that the algorithm described above is a useful tool that will assist conglomerates in allocating capital amongst their constituent firms.

## 13.6 BUSINESS MIX OPTIMIZATION

The technique described in Section 13.5 above shows how a conglomerate can allocate capital to match Tier 1 capital with aggregate economic capital at the top level firm in the conglomerate, whilst also meeting, in an efficient manner, the regulatory capital requirements of the conglomerate's constituent firms.

Combining this technique with the performance measurement techniques described in Section 13.3, then allows conglomerates to organize their strategic and business plans to try and optimize the returns earned on the allocated Tier 1 capital, or economic capital.

We propose a general method of business organizing within a conglomerate to maximize earned returns on actual Tier 1 capital or economic capital. The approach that we propose, and which we believe is being used by a number of conglomerates in practice, is described below.

### *Step 1*

First identify the firm, Firm X say, within the conglomerate for which earned returns are required to be improved, or optimized.

### *Step 2*

We use aggregate economic capital at the Firm X level and allow for the risk diversification benefits present in Firm X's businesses.

### *Step 3*

For each distinct product, or business line, that Firm X is engaged in, calculate individual  $r_{\text{roc}}$ s and  $r_{\text{roec}}$ s, as defined in Section 13.3. If the product line has been allocated some of the risk diversification benefits present in Firm X's businesses, then the  $r_{\text{roec}}$ s should be calculated net of this benefit.

### *Step 4*

Calculate  $r_{\text{roc}}$  and  $r_{\text{roec}}$  at the aggregate business level for Firm X also.

Quantitative measures are now in place for the returns that Firm X is earning on both its Tier 1 capital and economic capital, at both the firm level, and also at the individual product line, or business line, level.

### *Step 5*

Rank the individual product, or business, lines by their individual  $r_{\text{roc}}$ s, or  $r_{\text{roec}}$ s. The products, or businesses, that are most attractive on a stand-alone basis can then be identified. Based on this ranking, product, or business, line combinations that may potentially improve the performance of Firm X at the aggregate business level can be proposed and

developed. In constructing these mixes, practical constraints such as those described below will need to be taken into account.

- Firm X may, in practice, not be able to withdraw from its least attractive business lines as they may, in fact, be its core businesses. At best, Firm X may only be able to give these businesses less of a focus going forward.
- Even if Firm X wishes to expand into more attractive business lines, it may only be able to do so by reducing its prices, thereby reducing, or eliminating, the relative attractiveness of those business lines.

### *Step 6*

The performance of these new product, or business, line mixes can then be tested at the Firm X level by recalculating Firm X's  $r_{roc}$ , or  $r_{roec}$ , at this level. Note that, in doing this, Firm X's aggregate economic capital amount will need to be recalculated as it will change with the proposed altered product, or business, line mix. After a few iterations of testing out different business mixes, Firm X should be able to identify near optimal business mixes in terms of maximizing the Firm X level  $r_{roc}$  or  $r_{roec}$ .

### *Step 7*

Firm X may then wish to consider reconfiguring its businesses towards these near optimal mixes.

### *Practical application*

In practice, the business mix optimization method described above will tend to be a pragmatic, rather than a theoretical, exercise because of practical constraints noted above. In any case, we believe that the method described above will help financial services conglomerates to organize their businesses in such a way that they are able to improve their earned returns on either Tier 1 capital or economic capital.

## **13.7 IMPLEMENTATION ISSUES**

### **13.7.1 Practical constraints and costs**

There are a number of constraints, and associated costs, that make the capital allocation and business planning processes described above less

than straightforward to apply in practice. Some of these practical constraints and costs are described below:

### *Regulatory approvals*

The conglomerate's regulators will require to be consulted on the development of the conglomerate's capital plans. Only once the regulators are satisfied that a proposed capital restructuring will not damage the relative interests of the conglomerate's customers, debt holders and shareholders, both in the short and medium terms, will they approve the proposed capital reorganization. Moreover, it could take a considerable period of time for the regulators to understand the proposal, carry out a risk assessment and agree it. The regulatory approval process will also depend on the financial condition and maturity of the conglomerate. For example, a capital reorganization of a conglomerate that is relatively young, perhaps formed from a recent merger, may take longer to approve than that of a more established and stable conglomerate.

### *Technical expertise*

The very fine technical detail of the structuring will need to be considered, analyzed and finalized. For example, optimizing the tax structure of a proposed capital reorganization will be complex and will involve the use of specialist tax advisers to identify an optimal structure. The use of these specialist tax advisers will obviously incur costs, which can be considerable.

### *Documentation*

The legal documentation that formalizes the capital reorganization, including the redemption of existing capital and the issuance of new capital, is both time consuming and expensive to complete. For example, the technically complex offering circular documents, which are usually voluminous, and which are prepared to support new Tier 1 or Tier 2 capital public issuances, involve considerable time and effort to prepare.

### *Marketing*

The marketing of the proposed new capital structure to existing investors, and to potential new investors, will usually involve the conglomerate's management, and its advisers, in preparing and giving a large number of investor presentations. This process will be managed, on behalf of the conglomerate, by at least one investment bank and they will also usually provide a range of associated services. The investment bank's fees will be considerable. The price at which the conglomerate is

able to carry out its capital restructuring will depend on market sentiment at the time of the transaction and on the relative supply and demand of both prospective investors and alternative investment opportunities.

### 13.7.2 Accounting issues

In most countries, capital rules and regulations do not generally dovetail seamlessly with corresponding accounting standards and rules. This can cause quirks and anomalies that can distort the implementation of a firm's capital reorganization plan. Conglomerates, and their advisers, will therefore be mindful of the effect that accounting rules and regulations have on the desired Tier 1 and Tier 2 capital allocations and the consequent effect on the firm's financial statements. One example of this is as follows:

#### *Example*

Under Basel 2's internal ratings based approaches to credit risk it is proposed that, if a bank's total provisions exceed the bank's corresponding estimate of its expected losses, then the bank can count this excess, up to certain limits, towards its Tier 2 capital. Where estimated expected losses exceed total provisions, the deficit must be deducted 50% from Tier 1 capital and 50% from Tier 2 capital. It can be seen, therefore, that the conglomerate's provisions, which are determined by its accounting policy, can have an impact on the amount of its actual Tier 1 and Tier 2 capital that is eligible to count towards the conglomerate's regulatory capital requirement.

As discussed in Chapter 14, the International Accounting Standards Board (IASB) has, for a number of years, been developing an international accounting standard that aims to harmonize accounting rules worldwide and to base such rules on "fair values." Nevertheless, it is clear that conglomerate, or firm, accounting policy and capital will remain intertwined post the implementation of the new "fair value" accounting rules.

### 13.7.3 Financial analysts

By a "financial analyst," we will mean any finance professional who studies a conglomerate's, or firm's, financial statements and offers professional advice, or opinions, on the conglomerate. So, for example, research analysts employed by investment banks, ratings agencies or the financial press will all fall into this category.

Most conglomerates, or firms, are subject to close scrutiny and comment by financial analysts on a quarterly basis. Even firms that are

not publicly listed, for example privately owned firms, or mutual firms owned by their customers, will still be subject to some scrutiny, especially if the firm is large, although this may be less frequent.

The opinions of these analysts can affect a firm's share price, the price of its Tier 2 capital, its credit rating and the sentiment of the market and its customers towards the firm. In short, analysts opinions count and firms put considerable efforts into managing their relationships with them.

The problem facing analysts is one of truly understanding highly complex financial services conglomerates as an outsider. Consider the conglomerate HSBC, for example. HSBC operates in retail banking, corporate banking, investment banking, private banking, life insurance, general insurance, reinsurance, asset management, pensions, financial intermediation, and so on, in many countries and regions throughout the world. An outside analyst faces the enormous challenge of trying to understand the risks that a conglomerate such as HSBC is running and of deciding whether, or not, it has adequate capital to cover these risks. Their analysis will be based on publicly available information, access to limited internal data and information, and on discussions with senior management.

Even an HSBC senior management "lifer," who has been with the firm for their whole career and who has worked in many parts of the firm, may not fully understand the firm. What chance does an outsider have, especially as HSBC will be just one of the firms that they are covering? Except for very talented analysts, who work on a firm over a large number of years, the chances appear to be slim.

Nevertheless, the opinions and judgments of analysts do affect and place constraints on the capital planning, restructuring and issuing activities of conglomerates and firms. Such opinions and judgments must therefore be taken into account in practice.

### **13.8 REGULATORY CAPITAL ARBITRAGE**

Financial conglomerates are made up of a number of different types of financial services firms, with different regulatory rules applying to the balance sheets of these firms. As we have discussed in this book, however, the risks that banks, insurance firms and asset management firms write are, nevertheless, very often essentially the same.

However, because regulatory capital requirement rules have very often been developed in arbitrary and reactive ways, usually independently of the regulatory capital rules for other types of financial services firms, a large number of anomalies have arisen. Therefore, the same risk can require different amounts of regulatory capital, depending on the type of

financial services firm that writes the risk. To complicate matters further, and as we have seen in earlier chapters, regulatory capital requirements have tended not to be well aligned with economic capital.

By regulatory capital arbitrage we mean a situation where a financial services conglomerate pursues a strategy of writing a risk within the conglomerate with the clear aim of minimizing its regulatory capital requirements, either at the firm level where the risk is written, or at the top level firm in the conglomerate, or at both levels. Provided that the conglomerate's Tier 1 capital is in excess of aggregate economic capital at the top level firm, then this strategy is laudable and good management practice.

However, if the conglomerate is prepared to write risk with less Tier 1 capital than economic capital, then the strategy is obviously questionable and potentially dangerous for all of the various stakeholders in the firm.

We now give some examples of situations where a conglomerate, or firm, can reduce its regulatory capital requirement by the judicious choice of where to write a risk within the conglomerate, or firm.

### **13.8.1 Reversion lifetime mortgage product**

This example is discussed in full in Section 12.3. To recap, Section 12.3 shows that a pure life insurance firm product may have a lower regulatory capital requirement than a combined bank/life insurance firm product, even though the risks being written are essentially the same. Therefore, in writing this product, a bank without a life insurance firm within its own group may be at a disadvantage, relative to a banking group that does have a life insurance firm within its group.

### **13.8.2 Full cash securitization of residential mortgages**

Perhaps the best known example of regulatory capital arbitrage is the use of full cash securitization of residential mortgages by retail banks. At least in the UK, most of the main players in this market use this technique to greater, or lesser, degrees.

Under Basel 1, residential mortgages are risk weighted at 50%. So, for a bank with an Individual Capital Ratio (ICR) of 10% say, the regulatory capital requirement for an on balance sheet mortgage is 5% of the nominal amount of the loan outstanding at any point in time. For a securitized mortgage, held off balance sheet in a SPV, the corresponding capital requirement depends on the specific structure of the securitization transaction, including the credit ratings that attach to the Residential Mortgage Backed Security (RMBS) bonds that fund the SPV.

SPV capital requirements may lie in the range 0.25%–1.5%, although the requirement may not amortize with the loan as it does for an on balance sheet mortgage. Nevertheless, the capital saving can still amount to around 3%–4% of the nominal loan. Assuming a cost of capital of around 10% p.a., securitisation therefore equates to a saving in capital costs of around 0.3% to 0.4% p.a.

Set against this capital saving is the additional cost of funding that usually arises when securitizing. In other words, securitization as a source of funding can be more expensive than a bank's other channels of funding, such as the wholesale markets or retail deposits, although this will depend on other factors such as the bank's credit rating and its brand reputation. In any case, provided that securitization is no more expensive than around 0.3% p.a. than the bank's other funding channels, a full cash securitization may be worthwhile.

It is important to note that this regulatory capital arbitrage opportunity is a direct consequence of Basel 1's regulatory capital requirement for residential mortgages being well in excess of the corresponding economic capital amount. Note also that, as we saw in Chapter 8, the regulatory capital requirements for residential mortgages will fall significantly under Basel 2. This will reduce the regulatory capital arbitrage rationale for securitization and, at the time of writing, the future of the RMBS markets is subject to some uncertainty.

### 13.8.3 Guaranteed equity bond

The benefit that this product provides to the customer is the sum of

- The return of their initial investment.
- A percentage of the capital growth of an equity capital index over a prescribed period on their initial investment, provided that the equity index has gone up over the period. If the equity index falls over the period, the percentage exposure to this fall is 0%.

Therefore, the customer is guaranteed to at least get their money back plus, a percentage of the upside of the equity index. Note that, the customer does not receive any dividend income on their investment.

Both banks and life insurance firms offer guaranteed equity bond products and there are many different ways of structuring such products. For the sake of being specific, we will assume that either a bank, or a life insurance firm, structures the product as a cash deposit plus an Over the Counter (OTC) swap.

The investment return earned on the deposit, which is usually invested in money market instruments, pays for the firm's expenses, capital costs,

tax and also for the OTC swap that provides the exposure to the equity index.

The life insurance firm regulatory capital requirement is determined by reference to the guaranteed equity bond's liability valuation, or mathematical reserve, held on the liability side of the life insurance firm's balance sheet. Broadly speaking this capital requirement equals 4% of the sum of the present value of the deposit plus the market value of the OTC swap.

Under Basel 1, the bank's regulatory capital requirement is determined with reference to the credit risks associated with the cash deposit in which the customer's investment is held, plus a capital requirement in respect of the credit risks associated with the OTC swap counterparty. In other words, the bank regulatory capital requirement is calculated with reference to the asset side of the bank's balance sheet. If the cash deposit and the OTC swap counterparties have reasonably high credit ratings, it is straightforward to confirm that the bank's regulatory capital requirement is very substantially lower than the life insurance firm's, even though the risks that they are collecting are the same.

Bank/life insurance firm conglomerates therefore tend to write their guaranteed equity bond products in their banks, rather than in their life insurance firms.

### 13.9 SUMMARY

In this chapter we have brought together many of the important ideas discussed in previous chapters to inform a discussion on the key practical topics of pricing, performance measurement, on and off balance sheet leverage, capital allocation, business mix optimization, practical implementation issues and regulatory capital arbitrage.

We believe that the ideas discussed in this chapter, although somewhat complex, will help firms to improve and develop their capital and financial risk management methodologies and processes to facilitate improved firm performance, and so increased rates of return on their capital.

# Regulatory Change

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### 14.1 INTRODUCTION

During the course of the writing of this book, financial services firm regulation and reporting requirements have undergone very substantial and far reaching change. Moreover, this change is not complete and is expected to continue for many years to come. In fact, it may be safe to assume that ongoing change and the continuous evolution of financial services firms' regulation and reporting requirements may now be a fact of life and a part of business-as-usual. For example in the banking arena, Basel 3 is already being talked about even before Basel 2 has been implemented!

In this chapter, we describe the main regulatory capital changes that have been occurring and also those that are expected to occur over the next few years. Note that our interest will be on regulatory capital changes, a relatively small component of the overall total change package that is affecting the industry.

Our target is moving and, if we get into too much detail, this Chapter may, within a few months, represent only a historical record of the minutiae of short lived proposals and recommendations that once affected financial services firms. Not the most interesting read, nor the most useful.

For these reasons we will concentrate, at the broad business level, on what we consider to be the most important changes that are occurring and the implications that these may have on the industry. Our focus will be on the UK and, unless otherwise stated, our comments will apply to the UK market.

At least for insurers, it is likely that prospective European regulations will be very similar to insurance regulations recently implemented in the UK. We will endeavor to bring this point out wherever it is appropriate. Other proposals, such as Basel 2, are global in their application,

although local implementation may bring in slight variations by country, or economic region.

## **14.2 THE UK ENVIRONMENT**

From 1 January 2005, the UK regulator the FSA commenced regulating all UK licensed financial services firms on the basis of a unified handbook. The current handbook can be accessed on the FSA's website, [www.fsa.gov.uk](http://www.fsa.gov.uk), although it is a formidably complex document to navigate and understand.

So, for example, retail banks, building societies, investment banks, life insurers, non life insurers, friendly societies, asset management companies, brokers, and so on, are all regulated according to the relevant chapters of the FSA's handbook. Moreover, at least for solvency and capital requirements, the FSA has attempted to introduce risk based rules that are consistent across all types of firm and which are loosely based on the three Pillar approach of Basel 2.

In the past, different types of firms had different regulators and were subject to different sets of rules, even though very often the risks that the firms were writing were the same. Obviously this resulted in many anomalies and presented firms with easier opportunities to indulge in regulatory capital arbitrage.

A key driver of the current FSA regime has been the difficulties that the mutual life insurance firm Equitable Life got into by writing guaranteed annuity options (GAO) and the subsequent alleged financial mismanagement of these liabilities by the firm.

The FSA believes that, if life insurance firms had been regulated like banks, Equitable Life's problems would not have occurred and this has resulted in a strong desire by the FSA to regulate life insurance firms like banks. The Equitable Life saga is still running, and it could take many years yet to unravel.

We now move on to consider the main regulatory changes that are occurring in the UK at present and those which are likely to occur over the next few years. As is explained earlier, we will try and concentrate on regulatory capital change and, wherever we can, will focus at the broad business level, rather than on the very fine technical detail of the change.

## **14.3 BANKING AND ASSET MANAGEMENT**

### **14.3.1 Basel 1**

The following description is based largely on the HM Treasury consultation document "The new Capital Adequacy Directive,

CAD3: The transposition of the new Basel Accord into EU legislation. December 2003.” The full document can be found on HM Treasury’s website [www.hm-treasury.gov.uk](http://www.hm-treasury.gov.uk).

At the time of writing, the current Basel Accord, Basel 1, applies to the worldwide banking sector. The Basel 1 Accord was concluded in 1988 and is a non binding agreement, which was formulated in response to concerns that not all internationally active banks were well capitalized. A collapse in one of these internationally active banks could have had serious consequences for the international banking sector and the global economy as a whole. The Accord was formulated by the Basel Committee on Banking Supervision of the Bank for International Settlements, the bank representing central bankers worldwide.

Basel 1 had two main objectives:

1. It should strengthen the soundness and stability of the international banking system.
2. It should be fair and consistent in its application, so reducing the scope for differences in regulatory capital treatment between countries and so the potential for regulatory capital arbitrage.

By common consensus, Basel 1 achieved both of these aims, with banks having increased their capital ratios significantly over the period 1988–1992. The international banking system consequently became stronger and more stable.

The Basel 1 framework is built around two main concepts as follows:

1. An agreed categorization of bank capital between core capital, called Tier 1 capital, comprising essentially equity capital and retained earnings, and supplementary capital, called Tier 2 capital, comprising reserves, hybrid debt/equity capital instruments and subordinated debt.
2. Risk weights which, very crudely, reflect the relative riskiness of lending to different classes of counterparties. The framework was initially only concerned with the credit risks associated with lending to counterparties.

Basel 1 introduced a minimum capital ratio of capital to risk weighted assets of 8% with Tier 1 capital comprising at least 50% of total capital.

A later amendment to Basel 1, in 1996, introduced additional specific capital requirements in respect of the market risk associated with both on and off balance sheet positions and which were implemented from the

end of 1997. The new Basel Accord, Basel 2, leaves these market risk requirements broadly unaltered.

The main criticism of Basel 1, however, has been that its regulatory capital requirements do not accurately reflect risk. The Basel 1 risk weights do not provide a sufficient degree of differentiation between different borrowers' default risks leading to a widening gap between economic capital and regulatory capital requirements. A number of examples of this effect in practice are given in the HM Treasury consultation paper mentioned above.

Regulators have also felt that Basel 1, with its focus purely on regulatory capital requirements, to the exclusion of economic capital, has resulted in firms relying too heavily on regulatory capital for pricing purposes, for example, rather than in developing and investing in better risk management processes. As a result, banks' financial and value management processes may be less than optimal to the detriment of both investors and customers.

Although Basel 1 has served the international banking industry extremely well, the global financial system has become increasingly complex and, as a result, the Basel Committee on Banking Supervision began work, in 1998, on a new regulatory capital framework called Basel 2. The Basel Committee was aiming to produce a new accord that recognizes new and continuing developments in financial products, advances in risk measurement and management practices and which more accurately assesses capital requirements in relation to risk.

### **14.3.2 Basel 2**

As mentioned above, the Basel Committee commenced work on Basel 2 in 1998 and, at a very early stage, decided that, as a point of principle, the overall amount of capital in the banking system would remain unchanged as a result of Basel 2. Some banks would win, others would lose, but the overall amount of capital in the system should remain broadly unaltered.

Basel 2 is built on three key interlocking Pillars as follows:

#### *Pillar 1 – minimum capital requirements*

This pillar provides firms with a framework for the calculation of minimum regulatory capital requirements.

#### *Pillar 2 – supervisory review*

This pillar allows both firms and supervisors the opportunity to review the firm's risk management processes and to respond to any failings identified.

### *Pillar 3 – market discipline/disclosure*

This pillar allows comparisons to be made by other market participants and so encourages market discipline.

#### **14.3.2.1 Pillar 1**

The Pillar 1 minimum regulatory capital requirement covers credit risk, market risk (these requirements are essentially unaltered) and a new operational risk regulatory capital requirement. For credit risk and operational risk, there is a menu of approaches of increasing sophistication that is available to banks as shown in Table 14.1 below.

These approaches range from the simple formulaic to the more sophisticated where firms use their own internal risk management processes to determine their regulatory capital requirements. This progression provides incentives for better risk management practice as regulatory capital requirements reduce with the increasing sophistication of the approach used. It is hoped that this will encourage firms to invest in improved risk management in order to achieve the standards required to qualify for the more advanced approaches available under Basel 2.

#### *Credit risk*

The Revised Standardized Approach (RSA) improves the Basel 1 requirements for credit risk by introducing more risk sensitive weights. Under Basel 1, banks' assets are assigned to one of five risk weight categories based on very broad judgments of relative riskiness. Under

**Table 14.1** Pillar 1 minimum regulatory capital requirement approaches available under Basel 2

<i>Approach</i>	<i>Risk type</i>	
	<i>Credit</i>	<i>Operational</i>
Most basic	Revised standardized approach (RSA).	Basic indicator approach (BIA).
Intermediate	Foundation internal ratings based approach (FIRB).	Standardized (TSA).
Most sophisticated	Advanced internal ratings based approach (AIRB).	Advanced measurement approach (AMA).

the RSA, however, the risk weights for exposures to sovereigns, banks and corporates will be based on external credit ratings, produced by recognized ratings agencies.

The risk weights for retail exposures will reduce under the RSA as compared to the Basel 1 risk weights. For example, for residential mortgages, the Basel 1 risk weight of 50% will fall to 35%. This fall in risk weights not only reflects the introduction of a new regulatory capital requirement for operational risk, which was previously implicit in the Basel 1 credit risk capital requirement, but is an acknowledgement that the current Basel 1 regulatory capital requirement for retail assets is generally too large.

The two new Internal Ratings Based (IRB) approaches to credit risk, the Foundation (FIRB) and Advanced (AIRB) approaches, are designed to allow an even closer alignment between economic capital and regulatory capital. These approaches allow firms to use more sophisticated methods of calculating regulatory capital based on their own internal estimates of their components of risk. An objective is that firms will be able to use their own internal risk management processes and infrastructure instead of implementing separate systems for regulatory capital and internal purposes.

Subject to certain minimum conditions and disclosure requirements, firms on the AIRB approaches can use their own internal risk component estimates to calculate the regulatory capital requirements for a given exposure. Firms on the FIRB will be required, however, to use supervisory values rather than internal estimates for one, or more, of the risk components.

### *Operational risk*

Basel 2 introduces three alternative approaches to calculating a new operational risk minimum regulatory capital requirement. In increasing complexity, these approaches are the Basic Indicator Approach (BIA), the Standardized Approach (TSA) and the Advanced Management Approach (AMA). Under the BIA and TSA, the capital requirement is calculated by taking a risk weighted three year average of gross income. The BIA applies one risk weight to total gross income, whereas TSA separates gross income across eight different business lines, with a distinct risk weight for each business line and so giving a more risk sensitive approach.

The most sophisticated approach to operational risk regulatory capital is the AMA, which involves firms using internal models to calculate regulatory capital. The use of the AMA by firms is subject to the satisfaction of prescribed qualitative and quantitative criteria, as laid out in

the accord. The approaches envisaged under the AMA are likely to be similar to models used in the insurance industry to estimate claims frequency and conditional loss distributions, conditional on a claim having occurred.

### *Securitization*

The technique of securitization was not commonly used when Basel 1 was negotiated, and agreed, which has led to the regulatory capital arbitrage opportunities discussed in Section 13.8.2. The approach to securitization adopted under Basel 2 is that there should be no artificial incentive in favor of securitization and that securitization, as such, should be justified on economic grounds. The regulatory capital advantage of securitization under Basel 1 is, therefore, very likely to reduce substantially under Basel 2.

### *Credit risk mitigation*

Basel 2 introduces new rules that provide a more comprehensive approach to credit risk mitigation techniques such as collateralized transactions, on balance sheet netting, guarantees and credit derivatives.

#### **14.3.2.2 Pillar 2**

The Basel 2 second pillar introduces a supervisory review process, a concept already practiced in the UK. This process is designed to ensure that, not only do firms have adequate capital in place, but they also have the systems, controls and governance procedures in place to ensure they can carry out good risk management in practice.

Pillar 2 recognizes that it is the responsibility of the firm's directors and senior managers to develop and implement internal capital assessment processes and risk thresholds and targets that are consistent with the firm's risk profile and control environment. Supervisors are expected to check a firm's risk assessment and to take action if this is deemed necessary. Such action may involve increasing a firm's regulatory capital requirement, or it could involve requiring the firm to improve its risk management, its systems and controls, applying internal limits or increasing the firm's reserves.

As previously discussed in Chapter 3, the Basel 2 Accord identifies three specific areas that should be covered under Pillar 2 as follows:

1. Risks not captured by Pillar 1. An example may be where a firm has a large concentration of credit risk with one business sector or counterparty.

2. Internal factors not already taken into account such as interest rate risk in the banking book.
3. External factors not already taken into account such as the impact of the business cycle on the firm's experience.

Assessing the compliance of a firm to the qualifying requirements of the more advanced approaches described earlier also falls under Pillar 2.

### **14.3.2.3 Pillar 3**

The third Pillar, which deals with market disclosure, is designed to complement the minimum capital requirements and supervisory review aspects of Pillars 1 and 2 respectively. The object is to encourage market discipline by developing a set of disclosure requirements that will allow risk exposures, risk assessment processes, and so capital adequacy, to be compared on a like for like basis across firms. This is obviously important when, under the Basel 2 advanced approaches, firms have quite a bit of discretion, via the use of internal models, in determining their own capital requirements.

Generally speaking, under Basel 2, the amount of information to be disclosed and its frequency is set to increase, and potentially quite significantly.

### **14.3.2.4 Transposition of Basel 2 into EU and UK legislation**

The EU implemented Basel 1 through the Solvency Ratio Directive and the Own Funds Directive, which were adopted in December 1989. Market risk was introduced by the first Capital Adequacy Directive (CAD) in March 1993 and was amended in 1998 to form CAD2 to allow the use of VAR models.

The new Capital Adequacy Directive (CAD3), which implements Basel 2 in the EU, has a much wider scope than either Basel 1, or Basel 2. For example, CAD3 is designed to create a level playing field between all firms competing in the same markets. All credit firms and nearly all investments firms, as defined by the Investment Services Directive, also fall under CAD3, as they currently do under the existing CAD.

In other words the regulatory capital requirements of, for example, asset management firms in the EU will be determined by CAD3. Although most asset management firms do not collect credit or market risks, they may be required to have enough capital to cover the new operational risk regulatory capital requirement. For some firms, this may result in their regulatory capital requirements increasing substantially.

Whilst CAD3 and Basel 2 are almost identical in their technical proposals, there is an important difference in their application. Basel 2 is a voluntary agreement between the G-10 supervisors, whereas the EU's implementation will be legislative, with CAD3 being agreed using the co-decision process between the European Parliament and the Council.

To complicate matters further, there is an additional layer of bureaucracy for the EU countries as, once CAD3 forms a part of EU legislation, the local EU regulators, or supervisors, must then write their own local version of CAD3 into their own local rules. The UK's FSA, for example, will write CAD3 into its own regulations, so becoming law in the UK from that point on.

The US authorities' proposals for implementing Basel 2 are somewhat unclear and are at odds with those of the EU. At the time of writing, the stated intention is that only around ten of the largest banks will be required to adopt the Basel 2 advanced approaches, with perhaps another ten banks adopting these approaches voluntarily. The remainder of US banks will remain on Basel 1, plus some additional local US requirements. The US authorities believe that implementing Basel 2 for smaller banks would not be justified as they are already required to hold capital in excess of the Basel 1 minima and to meet supervisory review requirements similar to those required under Basel 2.

#### **14.3.2.5 Timescales**

The broad timetable for implementation in the UK is as follows:

- Adoption into EU legislation via CAD3 by mid to late 2006.
- Adoption into the FSA's regulations by late 2006.
- Apart from the most advanced approaches, the non retail credit risk AIRB and the operational risk AMA, it is planned that Basel 2 will be implemented in the UK from 1 January 2007.
- The non retail credit risk AIRB and the operational risk AMA will be available from 1 January 2008.
- Firms will be required to parallel run their Basel 1 and Basel 2 capital requirements during 2006, except for the most advanced approaches. For the most advanced approaches, parallel running will be required during both 2006 and 2007.

Note that during the first three years after implementation of Basel 2, during 2007, 2008 and 2009, transitional capital floors will be in place

limiting the full application of the new rules. In particular capital floors of 95%, 90% and 80%, respectively, of a firm's corresponding Basel 1 capital requirement will be in place during these first three years.

The Basel 2 capital requirement rules will be fully in place from 1 January 2010 at earliest, but the Basel Committee reserves the right to extend the transitional arrangements if the Accord is not behaving as planned.

#### **14.3.2.6 Business implications**

At this stage, as a result of the immense complexity and breadth of Basel 2, the business implications of the new Accord are unclear. However, during the course of the development of the Accord, a number of Quantitative Impact Studies (QIS) have been carried out to analyze the likely impacts that the new Accord may have. The main conclusions that can be inferred from these studies are broadly

- The aggregate amount of regulatory capital in the banking system will remain broadly unaltered, although its distribution across banking firms will alter significantly.
- The regulatory capital requirements for internationally active banks are expected to decline with the adoption of the more sophisticated approaches.
- Banks with higher retail exposures will generally have lower Pillar 1 minimum regulatory capital requirements, relative to current levels.
- Some specialized banks and many investment firms will see their regulatory capital requirements increase as a result of the new operational risk capital requirement.

Behavioral changes in lending might be expected to occur in those areas where the regulatory capital changes are largest, in particular

- Reducing regulatory capital requirements
  - Mortgage and investment grade corporate lending
  - Credit cards and overdrafts
- Increasing regulatory capital requirements
  - Unrated, or non investment grade, corporate lending.
  - Fee/service based businesses affected by the operational risk capital requirement.

## 14.4 INSURANCE

There is also a huge amount of change currently going on with the regulation of UK insurance firms. The background to this change, which was set out in Section 14.1, includes the problems facing the mutual life insurer Equitable Life. Nevertheless the regulatory changes affect all types of insurance firms including non profit life insurance firms, unit linked life insurance firms, non life insurance firms, but particularly with profits life insurance firms.

As mentioned previously, the UK regulator, the FSA, is keen to regulate all types of financial services firms, including insurers, like banks and, in particular, using a three Pillar risk based approach along the lines of the banking industry's Basel 2.

These changes were mostly implemented from 1 January 2005 when the FSA introduced its Integrated Prudential Source Book. Before going on to discuss the changes that affect the different types of insurance firms, we first discuss the changes that are common to all of them.

### 14.4.1 Capital changes

Traditionally, regulatory capital for insurance firms has been taken to equal regulatory assets less regulatory liabilities. The new approach that has been adopted in the UK, for all insurers, is to follow the components of capital approach that is used for banks, building societies and asset management firms. Note, however, that as the new and old approaches give the same results, the changes that have been introduced are mainly presentational.

In other words, capital is divided into tiers that reflect the differences in the extent to which capital satisfies the characteristics of permanency and loss absorbency that are features of the highest quality of capital, Core Tier 1 capital as discussed in Chapter 6. This does not change the substance of what is currently done, but it does introduce the terminology that is used in other sectors of the financial services markets.

The FSA have given two reasons for this change, as follows:

1. It introduces a degree of harmonization and consistency across different financial services sectors, and;
2. It introduces a consistent definition of capital, which is needed when considering financial services group capital requirements.

Capital tiering, sub-categories and limits have all been described in Chapter 6 in full detail.

### 14.4.2 With profits life insurance

The most significant regulatory changes affecting the insurance industry are those for the with profits life insurance sector. This sector of the industry has suffered from a number of issues in recent years including

- The Equitable Life situation, as described earlier.
- Pensions misselling.
- The general failure in the mid 2000s of mortgage endowment policies to pay off the associated mortgage loan.
- The general opacity of with profits policies, in combination with perceived poor returns, has resulted in considerable confusion amongst customers and very bad press.
- A perception that, neither the regulation of with profits business by supervisors, nor the financial risk management of with profits business by the firms themselves, have kept pace with modern financial risk management techniques.
- The failure of the old regulations to respond, in an appropriate manner, to falling stock markets.

We could debate the merits of these bullet points endlessly but, we believe that these are amongst the more important issues that have shaped the current bad sentiment towards with profits business.

#### *The old rules for with profits life insurance*

In this section, we give a high level summary of the old rules, including their salient features.

Assets were valued at market values, whereas liabilities were valued using the net premium method, a method generally recognized as somewhat dated and producing unrealistic liability valuations. In particular, the liability valuation was fairly insensitive to market movements, changes in the yields on equities and bonds, for example, so resulting in an asset/liability valuation method mismatch. Note that, for future reference, in life insurance terminology liability valuation reserves tend to be called mathematical reserves.

The liability valuation also did not value the options and guarantees embedded into the underlying policies, Equitable Life's GAOs for example, and did not reflect non guaranteed claim benefits that customers could very reasonably expect to receive. For example, so called terminal

bonuses that can represent a substantial part of a policy's claim value are not guaranteed and, therefore, were not reserved for.

The asset/liability valuation method mismatch and the limitations of the liability valuation method were particularly problematic for with profits business which has traditionally held very high proportions of volatile assets, such as equities and long duration fixed interest bonds, in combination with quite onerous investment guarantees.

Within the EU, the asset/liability valuation mismatch is mainly a UK phenomenon, as continental insurers tend to invest predominantly in bonds. To handle this mismatch, a resilience reserve requirement was introduced in the UK. The resilience reserve is an arbitrary deterministic stress test that quantifies the additional reserve that life insurers must hold to cover asset/liability mismatches.

Note also that this reserve applies to all life insurance business, not just with profits. Although the resilience reserve at least attempted to address the asset/liability method mismatch problem, the other problems mentioned above, such as not reserving for non guaranteed bonuses, remained.

The minimum regulatory capital requirement for life insurance business, including with profits business, and which derives from EU legislation, was defined broadly as the sum of

- A percentage, typically 4%, of mathematical reserves.
- A percentage, typically 0.3%, of policy sums at risk. A life insurance policy's sum at risk is, broadly, the death benefit provided under the policy less the policy's mathematical reserve.

where this requirement is aggregated across all policies and is also subject to a specified minimum base capital resources requirement.

In practice, the life insurance markets recognized that, whilst the minimum regulatory capital requirement was probably sufficient for non profit and unit linked life insurance, with profits life insurance business required a much larger capital requirement. For this reason, with profits life insurance firms tended to hold capital well in excess of the minimum regulatory capital requirement and, in fact, would not have been able to sell with profits business through financial intermediaries if this were not the case. Firms would otherwise have been perceived by intermediaries as being too weak to place business with.

This also allowed firms more investment freedom to invest more heavily in equities which, over the longer term, had historically generated real returns far in excess of fixed interest returns, and so earning higher returns for their customers. The financial intermediaries who, in

large part, distribute with profits products tended to promote only the products of the stronger life insurance firms, given the very long term nature of the business and the requirement for them to offer “best advice” to their clients.

However, as stock markets fell in the early years of the new millennium, these old rules performed very poorly. In particular the resilience reserve, which requires higher reserves for equity assets relative to fixed interest assets, interacted with falling stock markets to force life insurance firms to sell equities into a falling market, so causing equity markets to fall even further.

The life insurance firms argued that, although their solvency levels looked stretched under the old rules, under more realistic bases, such as those they used to manage their businesses internally, their solvency levels were more than adequate. The FSA responded by weakening the old rules and by advancing the application of the new rules, as described below, but on a piecemeal and reactive basis.

### *The new rules for with profits life insurance*

As described in Section 14.1 earlier, a goal of the FSA is to regulate insurance companies like banks. In particular, following the development and imminent implementation of Basel 2 for banks, the new rules for UK insurance companies are based on the three pillar approach of Basel 2.

The description of the new rules provided here is appropriate for most with profits life insurance firms, one exception being smaller with profits life insurers for whom the new rules have changed very little. See [www.fsa.gov.uk](http://www.fsa.gov.uk) for the detailed rules that apply to these smaller insurers.

As described in Section 14.4.5, new EU rules for insurance companies are also currently being developed and consulted on. This process and the new rules are commonly described as “Solvency 2.” The indications, at this stage, are that Solvency 2 will also follow a three pillar approach and it is generally expected that it will be based quite closely on the key elements of the FSA’s new rules as described below.

### *Pillar 1*

The changes that have been implemented by the FSA are quite radical and, at the time of writing, are still being bedded down within the UK life insurance industry. At this stage, it is not clear how workable the rules are in practice although certain elements, in particular the realistic peak as described below, is most definitely a step in the right direction of managing with profits business using modern financial risk management techniques.

The Pillar 1 minimum regulatory capital requirement for with profits life insurance business is based on the so called “twin peaks” approach. Appendix 11.1, which sets out the detailed assumptions underlying our with profits life insurance investment guarantee example, also provides technical information on the twin peaks approach.

The twin peaks are as follows:

The regulatory peak. This equals the sum of

1. *Mathematical reserves*. These are calculated using more modern actuarial techniques, such as the bonus reserve method, rather than the net premium method. These reserves have been weakened slightly as firms are no longer required to reserve for future anticipated annual reversionary bonuses.
2. *The long term insurance capital requirement (LTICR)*. This is based on a slightly amended version of the EU minimum regulatory capital requirement described in 14.4.3. These amendments apply to all UK insurers, not just with profits life insurers, and result from the UK’s implementation of the EU Solvency 1 directive which updated the previous EU minimum regulatory capital requirements. See Section 14.4.5 for more detail.
3. *The resilience reserve*. This is described in the ‘old rules’ part of this section on page 274.

The realistic peak. This equals the sum of

1. *With profits benefit reserve (WPBR)*. The WPBR of a policy is generally calculated using retrospective asset share techniques that accumulate the premiums, net of all policy charges and expenses, and using the actual investment return earned by the firm on the policy’s premiums and assets. The WPBR represents the market value of the policyholder fund assets that have been accumulated by the firm.
2. *Future policy related liabilities*. These liabilities generally relate to the guarantee, option, smoothing and other contractual, or non contractual, benefits provided under the policy. In valuing these liabilities, a firm must use either a market consistent stochastic model, the market cost of hedging the guarantee or option, or a series of deterministic projections with attributed probabilities. Management and policyholder behavior may and must, respectively, be reflected in quantifying these liabilities. A policy’s WPBR, plus its future policy related liabilities, is termed its realistic liability.

3. *The Risk Capital Margin (RCM)*. The RCM is a deterministic asset/liability mismatch test that is applied at the fund level to each with profits long term business fund's (WPLTBF) realistic assets and liabilities. The WPLTBF is the fund that contains the aggregate assets and liabilities associated with policies written in that fund. The simultaneous deterministic stresses that are applied to calculate the RCM involve market risk (equities, property, fixed interest bonds), credit risk (fixed interest bonds, reinsurance, derivatives) and persistency risk scenarios. Credit can be taken in computing the RCM for reasonable management actions that the firm may take in response to the RCM scenarios. For example, altering the future investment mix of the fund assumed in the fund projections.

Before specifying the Pillar 1 minimum regulatory capital requirement for with profits business under the new rules, we must first define a WPLTBF's with profits insurance capital component (WPICC). The WPICC is defined as the WPLTBF's regulatory surplus (regulatory assets less the regulatory peak) less realistic surplus (realistic assets less the realistic peak), subject to a minimum value of zero.

The Pillar 1 minimum regulatory capital requirement for UK with profits life insurers is then defined as the sum of

1. The LTICR, which is a slightly amended version of the old EU minimum regulatory requirement.
2. The resilience reserve, now a capital requirement, rather than a reserve and so renamed the resilience capital requirement.
3. The WPICC.

Apart from treating the resilience reserve as a capital requirement, the main "innovation" in the new rules is the WPICC capital requirement.

The WPICC ensures that UK with profits Pillar 1 regulatory capital is equal to at least the LTICR plus the resilience capital requirement. In particular, if the realistic peak bites, meaning that regulatory surplus exceeds realistic surplus, the WPICC ensures that the Pillar 1 regulatory capital requirement is increased by this excess surplus amount.

The rationale for this approach is that, when equity and fixed interest markets are performing well, the realistic peak will exceed the regulatory peak and with profits firms will be required to hold a Pillar 1 regulatory capital requirement that includes a positive WPICC. If, on the other hand, markets perform poorly then the regulations will respond as the regulatory peak will be expected to exceed the realistic peak, resulting in a zero WPICC and so a reduced Pillar 1 regulatory capital requirement.

In this sense, the regulations ought not to force with profits firms to sell equities into a falling market.

It is important to note that the FSA wanted to base regulatory capital requirements on realistic reserves, or the realistic peak only. However, the EU minimum regulatory requirement, which is based on the regulatory peak, and derives from EU rules, cannot be amended or replaced, until the EU rules themselves are altered. This is expected to occur when Solvency 2 is implemented, but this will not be for a number of years.

It is still too early to draw any conclusions as to how the new rules are performing in practice.

### *Pillar 2*

The FSA has introduced a Pillar 2 regulatory capital requirement, analogous to Basel 2's Pillar 2 requirement for banks. This applies to all UK insurers, not just with profits life insurance firms. The hard capital requirement, however, has been deferred beyond 1 January 2005 for non life insurers.

This is to allow the non life industry time to consult and prepare for the new requirements. It is generally recognized that UK non life insurance firms are, in all likelihood, under capitalized relative to the risks they are running and there is an expectation that non life insurers may be required to raise fresh capital once the hard capital requirement is implemented.

As for banks under Pillar 2 of Basel 2, insurance firms are required to identify the major risks that they collect and, where it is appropriate to use capital to mitigate these risks, to quantify how much capital and what type of capital is required to cover the risks. The types of risk that firms are required to consider include credit, market, liquidity, insurance, securitization, concentration, capital planning and business cycle risks. The process itself is called the Individual Capital Assessment (ICA) process.

Firms are required to conduct stress and scenario analyses in respect of each risk, based on their future business plans and projections. Aggregate stress and scenario analyses over all material risks should equate to a 99.5% capital requirement over a one year time period, or an equivalent lower confidence period over a longer time period. The particular models and approach to be used by firms is generally not specified. The specifics are left to be discussed and negotiated between the firm and the FSA, with the FSA appearing to be more interested in the process that firms follow, rather than in the technical details themselves.

Based on each firm's ICA, the FSA will issue ICG to each firm. Depending on the results of the ICA, the ICG may require firms to hold

additional capital over and above their Pillar 1 minimum regulatory capital requirement. Firm ICA and ICGs will not be disclosed publicly and will be a private matter between the firm and the FSA, much like the ICR process that currently operates in the UK for banks.

### *Pillar 3*

The FSA has introduced enhanced prudential disclosure requirements for UK with profits life insurance firms. See [www.fsa.gov.uk](http://www.fsa.gov.uk) for the detail of these new requirements.

### **14.4.3 Non profit and unit linked life insurance**

For non profit and unit linked life insurance firms, as the new rules are very similar to the old rules, we describe only the new rules. In particular, the twin peaks approach for with profits life insurance business, as described in Section 14.4.2, does not apply to non profit or unit linked life insurance business.

### *Pillar 1*

For non profit and unit linked life insurance firms, assets are essentially valued at market value and liabilities, or mathematical reserves, are valued using a realistic prospective valuation method, such as the gross premium method, in conjunction with assumptions that contain some element of conservatism, or prudence.

The mathematical reserves must include the value of any options, guaranteed annuity options for example, that are granted to policyholders under the terms of their policy. The option valuation must be on a market consistent basis and must anticipate long term behavioral and experience changes such as future improvements in mortality.

The Pillar 1 minimum regulatory capital requirement is then calculated as the sum of:

1. *The firm's LTICR.* As mentioned in Section 14.4.2, this is a requirement of EU legislation, in particular the Solvency 1 directive.
2. *The firm's resilience capital requirement.* As mentioned previously, this requirement is calculated by performing a prescribed deterministic stress test involving equity, fixed interest and real estate stresses and is a requirement only in the UK. For unit linked firms where assets and liabilities are likely to be well matched and where the product charges that recoup the firm's product expenses are not capped, the resilience capital requirement should be near to zero.

The LTICR is calculated as the sum of

1. *The insurance death risk capital component.* This equals a prescribed percentage of a policy's capital at risk, summed over all policies. The capital at risk is essentially the death benefit payable under the policy less its mathematical reserve.
2. *The insurance health risk capital component.* An amount similar to the MCR, as described in 14.4.4, and summed over all policies.
3. *The insurance expense risk capital component.* For unit linked business with no investment or charge guarantees, this equals 25% of the administration expenses occurred in the previous financial year. Otherwise a prescribed percentage, typically 1%, of mathematical reserves is used, with these amounts summed over all policies.
4. *The insurance market risk capital component.* This equals a prescribed percentage of mathematical reserves, typically 3% if the policy carries an element of investment guarantee, or 0% otherwise, again summed over all policies.

The LTICR is again subject to a specified minimum base capital resources requirement.

Although the LTICR seems sensible and appropriate to apply in practice, the choice of the prescribed percentages is, we believe, quite arbitrary.

### *Pillar 2*

The ICA process, as described in Section 14.4.2, applies at the firm wide level.

### *Pillar 3*

See [www.fsa.gov.uk](http://www.fsa.gov.uk) for the detailed prudential disclosure requirements.

## **14.4.4 General insurance**

The regulatory capital rules for general, or non life, insurers have also been subject to significant change in the UK although, as described below, this process is not yet complete and there remains uncertainty as to when the full set of proposed changes will be implemented.

## Pillar 1

At present, there is a so called “hard” minimum regulatory capital requirement (MCR), which is based on the EU Solvency 1 directive. This directive updated the previous EU requirements, which dated back to 1973. However these new requirements, although a slight improvement over the 1973 requirements, are still considered to be too low and risk insensitive and, at best, are a temporary measure until a fuller EU review of insurers’ and reinsurers’ capital requirements has been completed and implemented.

This review, Solvency 2 as described in Section 14.4.5, is not expected to be implemented for a number of years, however. At least in the UK, regulators are dealing with the inadequacy of the Solvency 1 MCR rules by requiring that non life insurers hold capital of a multiple, typically two times, of the MCR.

The FSA has also proposed an enhanced regulatory requirement (ECR) which, for the time being, is a “soft” requirement. In other words, insurers are not required to publish their ECR, nor hold capital to match it. They are, however, required to calculate and communicate their ECR privately to the FSA and the FSA will use this as an input into the firm’s ICA process and so to the Pillar 2 ICG issued to the firm by the FSA.

The ECR is designed to be more risk responsive than the MCR and to more adequately reflect the risks that non life insurers collect. According to the FSA, the ECR has been calibrated at the 99.5% level over a one year time period. In other words, the ECR represents the amount of capital that a non life insurance firm requires to survive for a one year time period with a probability 0.995.

The FSA intends to review, by 2006, whether or not the ECR should become a hard requirement and, if so, will consult again on the detail of the ECR at that time. In the interim, the ECR reflects the changes that the FSA anticipates will arise in due course from the implementation of the EU’s Solvency 2 directive.

The MCR is calculated as the largest of the following:

1. *The premiums amount.* This is broadly equal to a percentage of premiums either written, or earned, over the financial year in question.
2. *The claims amount.* This is broadly equal to a percentage of average claims incurred over the previous three financial years (or seven years for certain classes of business).
3. *The brought forward amount.* This is broadly equal to the previous financial year’s MCR multiplied by the ratio of the prior year year-end technical provisions to year-start technical provisions.

All components are subject to various adjustments, for example reinsurance adjustments, and the MCR is also subject to a specified minimum base capital resources requirement. As far as we are aware, there is no convincing rationale available to justify this somewhat arbitrary computation.

The ECR is calculated as the sum of

1. *The asset related capital requirement.* This is calculated by applying capital requirement factors to different categories of a firm's assets. The requirement is designed to measure the amount of capital that a firm should hold to cover the risk of loss if another party fails to perform its financial obligations to the firm or from adverse movements in the value of assets.
2. *The insurance related capital requirement.* This is calculated by applying capital requirement factors to the value of the net written premiums and the technical provisions in respect of different classes of business. The requirement is designed to measure the amount of capital that a firm should hold to cover inadequate premium rates, so recognizing potential under pricing of risks, and adverse movements in a firm's liabilities, so recognizing potential claims and provisioning volatilities.

Less:

*The firm's equalization provisions.* At least implicitly, equalization provisions are therefore treated as capital.

As with the MCR, there appears to be no convincing rationale available to justify the above somewhat arbitrary computation.

### *Pillar 2*

The ICA process, as described in Section 14.4.2 applies to non life insurers at the firm wide level. As mentioned above, the FSA plan to use a firm's ECR as a key input into the ICG that it will issue to each firm.

### *Pillar 3*

See [www.fsa.gov.uk](http://www.fsa.gov.uk) for the detailed prudential disclosure requirements.

## **14.4.5 Solvency 2**

As has been mentioned above, European legislation imposes a minimum regulatory capital requirement on all EU insurers. This minimum

regulatory capital requirement has been described in Sections 14.4.2, 14.4.3 and 14.4.4 for insurance firms. These requirements are based on the UK's implementation of the EU's Solvency 1 directive, adopted in Europe in February 2002, and implemented in the UK during 2004 in advance of the other regulatory capital changes planned by the FSA at that time.

Solvency 1 updated the previous EU rules, dating back to the 1970s, although the changes introduced were relatively minor and it is recognized that Solvency 1 is in need of a radical overhaul. In particular, Solvency 1 is regarded as being relatively risk insensitive and understates the amount of capital that non life insurance firms require to cover the risks they are collecting.

As a consequence, the EU is carrying out a fundamental review of the regulatory capital requirement regime of the entire insurance industry sector. This initiative is called the Solvency 2 project. Its main objective is to establish a solvency system that is better aligned, than Solvency 1 is, to the true risks that insurers collect. However, due to the complexity of the project and the numerous vested interests involved, a directive implementing Solvency 2 in Europe is not expected to be agreed for several years.

The risk based regulatory capital approach introduced by the UK's FSA, as described in Sections 14.4.2, 14.4.3 and 14.4.4, and which is modeled on Basel 2, is expected to provide a good lead indicator for Solvency 2 when it is finally implemented. Thus we can expect a three Pillar approach, with the economic capital, or ICA process, playing a key role.

#### **14.4.6 Business implications**

As discussed above, the UK insurance regulatory capital requirement changes mainly affect with profits life insurance and non life insurance firms. For the other classes of insurance firms discussed above, we do not expect to see much change in their business environment, or prospects.

For with profits life insurance, however, we can anticipate a very large amount of change some of which has already occurred, or is occurring, for example

1. As the new rules require firms to reserve for the options and guarantees embedded in their with profits business, firms have been de-risking their balance sheets to minimize the consequent increase in their reserves. This has been achieved and attempted, for example, by firms introducing explicit, rather than implicit, charges to cover the options and guarantees written in their with profits funds

and by investing more heavily in fixed interest bonds, rather than in equities.

2. Many with profits funds are closing to new business. The increased regulatory capital requirements and regulatory administrative burdens associated with such funds have persuaded certain firms that this type of business is no longer economically viable.
3. Certain existing firms, and new specially formed firms, such as Resolution Life, have emerged as consolidators of closed with profits fund businesses. We can expect that these firms will continue to grow their books of closed with profits funds over the next few years.

For general, or non life, insurance, as discussed earlier, it is expected that certain firms may have to raise fresh capital to cover the risks they are running. This may result in some firms withdrawing from certain business lines to focus on others that they feel are more economically viable.

## 14.5 FINANCIAL GROUPS DIRECTIVE

As has been discussed earlier in this book, the formation of financial groups with activities in the banking, investment and insurance sectors has been a trend in the financial services industry. This has prompted international regulators to consider the regulatory approach necessary for containing and supervising the risks arising in such groups, or financial conglomerates, as they are commonly termed. As a consequence, a directive covering the regulation of financial conglomerates, the Financial Groups Directive (FGD), was published by the EC in February 2003.

Before the FGD, EU directives required financial groups to be supervised *within* each of their major business sectors, by the setting of group capital adequacy requirements. The development of financial conglomerates prompted the need, however, for the internationally agreed principles described in the FGD, so helping to facilitate the effective prudent supervision of such groups *across* their major business sectors.

The aim of the FGD is to introduce a new prudential regime for financial conglomerates. That is, for groups with significant activities in the banking and investment sectors on the one hand, and insurance on the other. The main ways in which it achieves this, and which are of most interest to this book, are by

- Setting out four methods of measuring financial conglomerate capital adequacy. These methods eliminate double counting of capital and discount excessive leverage.

- Requiring financial conglomerates to have enough capital to meet an overall group capital adequacy test, with the test being binding rather than indicative.

The FGD introduces other requirements relating to supervision and to group systems and controls, for example. However, for the purposes of this book, we focus only on the regulatory capital requirement effects of the FGD.

The FGD also amends existing European group prudential supervision requirements for sectoral groups: the insurance sectoral group requirements, on the one hand, and the banking and investment sectoral group requirements, on the other. This is to close gaps in the coverage of these requirements. The main way in which it achieves this, and which is of interest to this book, is by closing loopholes in the existing group-wide capital adequacy/solvency measures to prevent double counting of capital where a sectoral group has subsidiaries or participations in financial firms in a different sector.

The UK's FSA implemented the directive as at 1 January 2005 and, additionally when implementing the FGD, the FSA also took the opportunity to introduce some complementary changes, in particular,

1. The move to a hard group capital adequacy test, that must be passed as a matter of regulatory obligation for UK insurance firms at the level of the most senior European parent in the group and;
2. To harmonize the existing consolidated supervision rules for investment firms into a single set of rules.

At the time of writing, the hard group capital adequacy test has not been adopted and is subject to further consultation. The equivalent soft test has been retained, being the requirement to calculate the group adequacy test, though not meet it. It is expected that the hard test will be implemented from the end of 2006, with public disclosure of the test result being required from the end of 2005.

### **14.5.1 Definition of a financial services conglomerate**

Broadly speaking, a group is defined as a financial services conglomerate if the following conditions are satisfied:

1. If the consolidated balance sheets of the financial sector firms in the group make up at least 40% of the total group balance sheet, the group is a financial services group.

2. The financial services group is then a financial services conglomerate if
  - The average of (i) and (ii), as described below, below exceeds 10%:
    - i. The ratio of the balance sheet of the smallest financial sector in the group to the consolidated balance sheet of the financial sectors in the group, and;
    - ii. The ratio of the regulatory capital requirement of the smallest financial sector in the group to the total regulatory capital requirements of all of the financial sectors in the group.
  - or, if the balance sheet of the smallest financial sector in the group exceeds six billion euros.

For the purposes of threshold test 2 above, the cross sector threshold test, the financial sectors to be considered are either the insurance sector, on the one hand, or the combined banking and investment sector, on the other.

Specific details on how to carry out these tests in practice is given in the FSA's handbook which can be found on the FSA's website [www.fsa.gov.uk](http://www.fsa.gov.uk).

### **14.5.2 Calculating regulatory capital for a financial services conglomerate**

The FGD allows one of four different calculation methods to be used to determine the regulatory capital requirement at the top firm level in a financial services conglomerate. The FSA's implementation of the FGD uses method 4, which requires a financial services conglomerate to calculate its regulatory capital requirement according to the sectoral rules for the type of conglomerate that it is.

For example, a building society conglomerate will use the building society sectoral rules and an insurance conglomerate will use the insurance sectoral rules, and so on. In practice, method 4 is a mixture of all of the other 3 methods involving the "Accounting Consolidation Method", the "Deduction and Aggregation Method" and the "Book Value/Requirement Method". See the relevant part of the FSA's handbook on its website [www.fsa.gov.uk](http://www.fsa.gov.uk).

The rules for deciding which type of conglomerate a financial services conglomerate is, are similar to threshold test 2 as described in Section 14.5.1. Again, the precise details can be found in the relevant part of the FSA's handbook on its website [www.fsa.gov.uk](http://www.fsa.gov.uk).

### 14.5.3 Main implications

The main implications of the FGD in the UK are felt by insurance firms as the changes affecting banks and investment firms are relatively minor.

First, insurance firms are no longer able to include the market value of investments in related banks, investment firms and financial institutions in calculating their own capital adequacy position. In practice, therefore, only surplus assets relative to regulatory capital requirements in cross-sectoral related firms now count towards a group's capital adequacy computation. For certain insurance firms, therefore, available capital at the group level will reduce. Second, and exacerbating this problem, once the hard group capital adequacy test is implemented, certain insurance firms may need to raise fresh capital to meet it.

In either case, the effect of the FGD, for certain insurance firms, is to reduce their capital adequacy at the group level.

## 14.6 ACCOUNTING CHANGES

At present, there is a huge amount of change occurring in the way that financial services firms, and conglomerates, prepare and present their financial statements. In particular, from 1 January 2005, a set of international financial reporting standards (IFRS), promulgated by the IASB, came into force for all listed firms in all member countries of the EU and in many other countries around the world. This is a key milestone for the IASB in their journey towards global harmonization of IFRS and which affects all firms, not just financial services firms.

IFRS will aim to value both assets and liabilities on the balance sheets of financial services firms at fair, or market, value. One consequence of this approach is that the volatility of a firm's profit and loss account is expected to increase.

Our approach to economic capital, as articulated in this book, is independent of the accounting approach adopted by the firm. In particular, economic capital is based on a firm's realistic balance sheet, where assets and liabilities are valued as realistically as possible using the actual cashflows generated by those assets and liabilities, with no artificial adjustments.

However, if a firm's regulatory capital requirement, or the value of its eligible Tier 1 or Tier capital depends on the accounts of the firm, then IFRS will clearly have an impact on a firm's published financial strength. At this stage, in the very early years of implementation of IFRS, it is not yet clear exactly what these effects might be and the

situation is complicated by potential interactions between IFRS and other new legislation such as the FGD and Basel 2 for banks.

An important advantage of our economic capital approach is that it is independent of accounting rules. This is obviously highly desirable as the amount of capital that a firm requires to hold to cover the risks it is running should not depend on the way that the firm accounts for its business.

## 14.7 SUMMARY

In this chapter we have given a description of some of the regulatory change that is currently ongoing for financial services firms and conglomerates. As described, we are seeing a move towards the use of more generic methods and principles that are applicable across the range of financial services firms and risk types and more modern financial risk management tools are also starting to be used and applied by regulators.

As our financial services firm applications in previous chapters have shown, it may always be too much to expect that simplistic formulaic approaches to financial services firm regulatory capital will always provide good approximations to economic capital. In particular, as financial services products and markets evolve and become increasingly complex, it is inevitable that such formulaic approaches will become dated and less accurate with the passage of time.

Economic capital, as described in this book, is therefore of crucial importance in assisting both firms and regulators in understanding how much capital is required to back the risks that firms are running. A key advantage of the approach to economic capital advocated here is that it is independent of financial services firm rules and regulations, particularly accounting rules.

# Summary and Conclusions

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In this book we have introduced and discussed economic capital and financial risk management for financial services firms and conglomerates. A feature of the book is that we have considered a very broad spectrum of financial services businesses, from retail banking and non life insurance at the short end of the risk duration spectrum, to with profits life insurance and pensions at the longer end. The tools and methods that we have developed are, we believe, applicable across this entire risk spectrum and are also appropriate for all types of risks that are collected by financial services firms.

Our view is that economic capital should be at the heart of how financial services conglomerates and firms are managed. Hopefully our practical examples support this. This is both from capital and finance perspectives, as well as from a risk management perspective.

Forthcoming regulatory change, specifically Basel 2 for banks, and Solvency 2 for insurers, both propose that economic capital should be central to how firms manage their businesses, and to how regulators set regulatory capital requirements. The regulatory capital use will, in particular, we believe help to reduce the amount of regulatory capital arbitrage that is present in financial services markets, so increasing the efficiency of these markets.

We conclude by stating our hope that

- Both firms, and financial services practitioners, will find this book to be of some interest and assistance in helping them to manage their businesses more effectively, and;
- Researchers may be motivated by the practical problems presented here to develop new and improved ideas and methodologies relating to economic capital and the financial risk management of financial services conglomerates.



# Appendix



## Appendix 7.1 Correlation Matrix of the $\varepsilon$ s

Response variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	1.0000	0.1000	0.3000	0.6000	0.3600	0.2160	0.2160	0.1296	0.3600	0.1000	0.3000	0.6000	0.3000	0.0300	0.0900	0.1800	0.1080	0.0648	0.0648	0.0389	0.1080
2	0.1000	1.0000	0.0300	0.0600	0.0360	0.0216	0.0216	0.0130	0.0360	0.0100	0.0300	0.0600	0.0300	0.0030	0.0090	0.0180	0.0108	0.0065	0.0065	0.0039	0.0108
3	0.3000	0.0300	1.0000	0.1800	0.1080	0.0648	0.0648	0.0389	0.1080	0.0300	0.0900	0.1800	0.0900	0.0090	0.0270	0.0540	0.0324	0.0194	0.0194	0.0117	0.0324
4	0.6000	0.0600	0.1800	1.0000	0.6000	0.3600	0.3600	0.2160	0.6000	0.0600	0.1800	0.3600	0.1800	0.0180	0.0540	0.1080	0.0648	0.0389	0.0389	0.0233	0.0648
5	0.3600	0.0360	0.1080	0.6000	1.0000	0.6000	0.6000	0.3600	0.3600	0.0360	0.1080	0.2160	0.1080	0.0108	0.0324	0.0648	0.0389	0.0233	0.0233	0.0140	0.0389
6	0.2160	0.0216	0.0648	0.3600	0.6000	1.0000	0.3600	0.2160	0.2160	0.0216	0.0648	0.1296	0.0648	0.0065	0.0194	0.0389	0.0233	0.0140	0.0140	0.0084	0.0233
7	0.2160	0.0216	0.0648	0.3600	0.6000	0.3600	1.0000	0.6000	0.2160	0.0216	0.0648	0.1296	0.0648	0.0065	0.0194	0.0389	0.0233	0.0140	0.0140	0.0084	0.0233
8	0.1296	0.0130	0.0389	0.2160	0.3600	0.2160	0.6000	1.0000	0.1296	0.0130	0.0389	0.0778	0.0389	0.0039	0.0117	0.0233	0.0140	0.0084	0.0084	0.0050	0.0140
9	0.3600	0.0360	0.1080	0.6000	0.3600	0.2160	0.2160	0.1296	1.0000	0.0360	0.1080	0.2160	0.1080	0.0108	0.0324	0.0648	0.0389	0.0233	0.0233	0.0140	0.0389
10	0.1000	0.0100	0.0300	0.0600	0.0360	0.0216	0.0216	0.0130	0.0360	1.0000	0.0300	0.0600	0.0300	0.0030	0.0090	0.0180	0.0108	0.0065	0.0065	0.0039	0.0108
11	0.3000	0.0300	0.0900	0.1800	0.1080	0.0648	0.0648	0.0389	0.1080	0.0300	1.0000	0.0030	0.0900	0.0090	0.0270	0.0540	0.0324	0.0194	0.0194	0.0117	0.0324
12	0.6000	0.0600	0.1800	0.3600	0.2160	0.1296	0.1296	0.0778	0.2160	0.0600	0.1800	1.0000	0.6000	0.0600	0.1800	0.3600	0.2160	0.1296	0.1296	0.0778	0.2160
13	0.3000	0.0300	0.0900	0.1800	0.1080	0.0648	0.0648	0.0389	0.1080	0.0300	0.0900	0.6000	1.0000	0.1000	0.3000	0.6000	0.3600	0.2160	0.2160	0.1296	0.3600
14	0.0300	0.0030	0.0090	0.0180	0.0108	0.0065	0.0065	0.0039	0.0108	0.0030	0.0090	0.0600	0.1000	1.0000	0.0300	0.0600	0.0360	0.0216	0.0216	0.0130	0.0360
15	0.0900	0.0090	0.0270	0.0540	0.0324	0.0194	0.0194	0.0117	0.0324	0.0090	0.0270	0.1800	0.3000	0.0300	1.0000	0.1800	0.1080	0.0648	0.0648	0.0389	0.1080
16	0.1800	0.0180	0.0540	0.1080	0.0648	0.0389	0.0389	0.0233	0.0648	0.0180	0.0540	0.3600	0.6000	0.0600	0.1800	1.0000	0.6000	0.3600	0.3600	0.2160	0.6000
17	0.1080	0.0108	0.0324	0.0648	0.0389	0.0233	0.0233	0.0140	0.0389	0.0108	0.0324	0.2160	0.3600	0.0360	0.1080	0.6000	1.0000	0.6000	0.6000	0.3600	0.3600
18	0.0648	0.0065	0.0194	0.0389	0.0233	0.0140	0.0140	0.0084	0.0233	0.0065	0.0194	0.1296	0.2160	0.0216	0.0648	0.3600	0.6000	1.0000	0.3600	0.2160	0.2160
19	0.0648	0.0065	0.0194	0.0389	0.0233	0.0140	0.0140	0.0084	0.0233	0.0065	0.0194	0.1296	0.2160	0.0216	0.0648	0.3600	0.6000	0.3600	1.0000	0.6000	0.2160
20	0.0389	0.0039	0.0117	0.0233	0.0140	0.0084	0.0084	0.0050	0.0140	0.0039	0.0117	0.0778	0.1296	0.0130	0.0389	0.2160	0.3600	0.2160	0.6000	1.0000	0.1296
21	0.1080	0.0108	0.0324	0.0648	0.0389	0.0233	0.0233	0.0140	0.0389	0.0108	0.0324	0.2160	0.3600	0.0360	0.1080	0.6000	0.3600	0.2160	0.2160	0.1296	1.0000



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**Appendix 8.1** Deterministic Retail Mortgage Bank Example
 

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*Economic assumptions*


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Risk discount rate	10%, representing a margin of 5.0% over medium term UK government bond yields. This margin is taken as we are of the view that the deterministic stresses considered in the example may not necessarily model all of the risks that the mortgage bank is running.
Corporate tax rate	30%

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*Mortgage product economic capital assumptions*


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Average loan size	£100,000
Average term	20 years
Interest only/capital repayment mix	50%/50%
Standard variable rate	Pricing 1: 5.0% Pricing 2: 5.25%
1 year discount	1.0% deduction from standard variable rate
Redemption penalty	4 months interest in year 1
Flexible features	Yes
Variable initial expense	0.5% of initial loan
Expected credit risk losses	0.20% p.a. (i.e. a probability of default of 1% and loss given default of 20%)
Fixed expenses	£300 (acquisition), £50 p.a. (maintenance), £100 (closure)
Fixed expense inflation	2%, as implied by index linked yields at the time of writing
Annual prepayment rates	10% of balance outstanding
Basel 1 Pillar 1 regulatory capital requirement	4% of loan outstanding
Basel 2 Pillar 1 regulatory capital requirement	Advanced internal ratings based approach for the retail credit risk capital requirement, where the probabilities of default and loss given defaults, as described above, are used. The operational risk capital requirement is calculated using the standardized approach and is based on the net interest income earned on the loan at each duration, gross of expenses.

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Continued

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**Appendix 8.1** Continued
 

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Capital structure	100% Tier 1 capital The Tier 1 capital is assumed to be invested in cash
Achieved pricing rate of return on Tier 1 capital (post-tax)	Pricing Basis 1: 12% on the Basel 1 Pillar 1 regulatory capital requirement Pricing Basis 2: 16% on the Basel 1 Pillar 1 regulatory capital requirement
Duration at which economic capital is calculated	1 month into the mortgage

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*Savings product economic capital assumptions*


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Average savings balance	£10,000
Cost of retail funding	Pricing 1: To achieve an interest rate margin of 1.25% Pricing 2: To achieve an interest rate margin of 1.50%
Fixed expenses	£100 (acquisition), £25 p.a. (maintenance), £15 (closure), all net of tax relief at 30%
Fixed expense inflation	2%, as implied by index linked yields at the time of writing
Annual withdrawal rates	10% of balance outstanding
Duration at which economic capital is calculated	1 month into the savings account

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**Appendix 8.2** Stochastic Retail Mortgage Bank Example
 

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*Economic assumptions*


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Risk discount rate	The short term UK cash yield as generated by the stochastic model, parameterized according to Table 7.11
Corporate tax rate	30%

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*Mortgage product economic capital assumptions*


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Average loan size	£100,000
Loan to value percentage	100%
Average term	20 years
Interest only/capital repayment mix	Each is modeled separately in the examples

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Continued

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**Appendix 8.2** Continued
 

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Standard variable rate	As generated by the stochastic model
1 year discount	1.0% deduction from standard variable rate
Redemption penalty	2.5% of the loan outstanding at that duration within the first 12 months. No penalty is levied beyond the first 12 months
Flexible features	No
Cost of funding	The short term UK cash yield as generated by the stochastic model plus 0.1%
Expected credit risk losses	<p>Loss given repossession (LGR) is calculated as:  <math>LGR = (\text{loan outstanding}) - (\text{property value}) \times 0.95</math>, if positive, and zero otherwise.</p> <p>Selling costs and late interest are assumed to amount to 5% of the value of the property on repossession.</p> <p>The property value is estimated as its starting value increased in line with UK HPI, as generated by the stochastic model.</p> <p>Expected and high probabilities of repossession (PR) are assumed as follows:          Expected PR = 0.0025 p.a.          High PR = 0.005 p.a.</p> <p>High PRs are used if the standard variable rate, as generated by the stochastic model, exceeds its unconditional expected value plus twice its unconditional standard deviation, as shown in Table 7.11, or if <math>LGR &gt; 1\%</math> of the property value at that duration.</p> <p>In other words, High PRs are used if either mortgage rates are high, or if a loss of at least 1% of the property value would be made on repossessing and selling the property.</p> <p>For defaults, it is assumed that 1 in 5 defaults lead to a repossession and loss given defaults are, on average, 1/5th of loss given repossessions. These default probabilities and losses are then used to compute the</p>

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**Appendix 8.2** Continued
 

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	Basel 2 Pillar 1 credit risk capital requirement.
Fixed expenses	£300 (acquisition), £50 p.a. (maintenance), £100 (closure)
Fixed expense inflation	UK RPI as generated by the stochastic model.
Variable initial expense	0.5% of initial loan
Annual prepayment rates	Two prepayment rate series are used: Expected: 1%, 25%, 15%, 12.5% and 10% p.a. of the loan outstanding at durations 1, 2, 3, 4, and $\geq 5$ years High: 1%, 50%, 20%, 15% and 10% p.a. of the loan outstanding at durations 1, 2, 3, 4, and $\geq 5$ years. Expected lapse rates are used unless the standard variable rate, as generated by the stochastic model, is larger than its unconditional expected value plus twice its unconditional standard deviation as shown in Table 7.11. In other words, high standard variable rates are a cause of high prepayment rates.
Pillar 1 regulatory capital requirement	Basel 1: 4% of loan outstanding Basel 2: Advanced internal ratings based approach for the retail credit risk capital requirement, where the probabilities of default and loss given defaults, as described above, are used. The operational risk capital requirement is calculated using the standardized approach and is based on the net interest income earned on the loan at each duration, gross of expenses.
Capital structure	100% Tier 1 capital The Tier 1 capital is assumed to be invested in cash, so earning the short term UK cash yield as generated by the stochastic model, parameterized according to Table 7.11.
Achieved pricing rate of return on Tier 1 capital (post-tax)	As calculated under each run of the stochastic model
Duration at which economic capital is calculated	All durations

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**Appendix 8.3** Stochastic Lifetime Mortgage Firm Example
 

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*Economic assumptions*


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Risk discount rate	The short term UK cash yield as generated by the stochastic model, parameterized according to Table 7.11.
Corporate tax rate	30%.

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*Lifetime mortgage product economic capital assumptions*


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Average property value at inception	£250,000
Loan to value percentage	30%
Customer profile	Male aged 75 Female aged 75
Fixed interest rate payable	7.0% p.a. or as specified in the text
Redemption penalty	5.0%, 4.0%, 3.0%, 2.0% and 1.0% of the initial loan in years 1, 2, 3, 4 and 5 respectively. No further penalties beyond the first 5 years.
Cost of funding	The short term UK cash yield, as generated by the stochastic model, plus 0.75%
Variable initial expense	1.0% of initial loan
Fixed expenses	£500 (acquisition), £25 p.a. (maintenance), £200 (closure)
Fixed expense inflation	UK RPI as generated by the stochastic model
Customer fees	£500 arrangement fee
No negative equity guarantee insurance	On termination of the mortgage, customers, or their estate, never owe more than the lower of <ol style="list-style-type: none"> <li>1. The loan plus accrued interest</li> <li>2. The value of the property, less selling expenses of 5% of the property value</li> </ol> Here, the value of the property at termination is estimated as its starting value, increased in line with UK HPI, as generated by the stochastic model. Costs incurred as a result of the no negative equity guarantee biting are met by the firm.
Annual aggregate LTC/prepayment rates	Two prepayment rate series are used: Expected: 1%, 2%, 3%, 4%, 5% and 10% p.a. of the loans outstanding at durations 1, 2, 3, 4, 5 and $\geq 6$ years.

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**Appendix 8.3** Continued
 

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Mortality base tables and stochastic improvement factors

High: 1%, 2%, 3%, 4%, 5% and 20% p.a. of the loans outstanding at durations 1, 2, 3, 4, 5 and  $\geq 6$  years.

Expected lapse rates are used unless the short term UK cash yield, as generated by the stochastic model, is smaller than its unconditional expected value less twice its unconditional standard deviation as shown in Table 7.11.

In other words, low short term UK cash yields are a cause of high prepayment rates. This is because, when short term UK cash yields are low, it is assumed that new products come onto the market

at a cheaper price than the current product.

Base mortality tables: PMA92Base, PFA92Base projected forward to 2005 using the published mortality improvement factors for these tables. See Continuous Mortality Investigation Bureau Report 17, Part 6 ([www.actuaries.org.uk](http://www.actuaries.org.uk)).

Improvement factors are assumed to be Normally distributed with the following expectations and standard deviations.

Male low expected improvement factors ( $\mu$ ): 3% p.a. in year 1 of the projection, increasing by 0.25% p.a. for each subsequent year in the projection, up to an upper limit of 5% p.a. This upper limit is assumed to apply thereafter once it is reached.

Male "cohort" expected improvement factors ( $\mu$ ): 5% p.a. in year 1 of the projection, increasing by 0.25% p.a. for each subsequent year in the projection, up to an upper limit of 7.5% p.a. This upper limit is assumed to apply thereafter once it is reached.

Male improvement factor standard deviation ( $\sigma$ ): 0.5%.

Female low expected improvement factors ( $\mu$ ): 2.25% p.a. in year 1 of the projection, increasing by 0.25% p.a. for each subsequent

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**Appendix 8.3** Continued
 

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	<p>year in the projection, up to an upper limit of 5% p.a. This upper limit is assumed to apply thereafter once it is reached.</p> <p>Female "cohort" expected improvement factors (<math>\mu</math>): 4.25% p.a. in year 1 of the projection, increasing by 0.25% p.a. for each subsequent year in the projection, up to an upper limit of 7.5% p.a. This upper limit is assumed to apply thereafter once it is reached.</p> <p>Female improvement factor standard deviation (<math>\sigma</math>): 0.5%.</p>
Pillar 1 regulatory capital requirement	1% of loan outstanding plus accrued interest
Capital structure	100% Tier 1 capital
	The Tier 1 capital is assumed to be invested in cash, so earning the short term UK cash yield, as generated by the stochastic model, parameterized according to Table 7.11.
Achieved pricing rate of return on Tier 1 capital (post-tax)	As calculated under each run of the stochastic model.
Duration at which economic capital is calculated	All durations

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**Appendix 9.1** Deterministic Annuity Life Insurance Firm Example
 

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*Economic assumptions*


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Risk discount rate	10%, representing a margin of 5.25% over medium term UK government bond yields. This margin is taken as we are of the view that the deterministic stresses considered in the example may not necessarily model all of the risks that the annuity life insurance firm is running.
Medium term UK government bond yield	4.75%
Medium term UK corporate bond yield	5.0%

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**Appendix 9.1** Continued
 

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Term of medium term UK corporate bond assets backing the annuity business	10 years
Corporate tax rate	30%
<i>Annuity product economic capital assumptions</i>	
Average single premium size	£250,000
Annuity income	Level
Mix of business	50% single life males aged 65, 50% single life females aged 60
Mortality tables	PMA92Base, PFA92Base These are the most recent pensioner annuitant tables that are available from the Continuous Mortality Investigation Bureau ( <a href="http://www.actuaries.org.uk">www.actuaries.org.uk</a> )
Mortality improvement factors	Continuous Mortality Investigation Report 17, Part 6 ( <a href="http://www.actuaries.org.uk">www.actuaries.org.uk</a> )
Variable initial expense	1% of the single premium
Fixed expenses	£500 (acquisition), £25 p.a. (maintenance)
Fixed expense inflation	2%, as implied by index linked yields at the time of writing
Mathematical reserving method and realistic reserving method	Realistic/gross premium
Mathematical reserving assumptions	Economic capital assumptions with a valuation rate of interest equal to the medium term UK government bond yield.
Realistic reserving assumptions	Economic capital assumptions with a valuation rate of interest equal to the medium term UK corporate bond yield.
Long term insurance capital requirement (LTICR)	4% of mathematical reserves
Resilience capital requirement	The additional asset/liability mismatch reserve required to cover a fall in medium term UK corporate bond yields from 5% to 3%.
Pillar 1 regulatory capital requirement	The long term insurance capital requirement plus the resilience capital requirement.
Capital structure	100% Tier 1 capital The Tier 1 capital is assumed to be invested in medium term UK government bonds.

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**Appendix 9.1** Continued
 

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Achieved pricing rate of return on Tier 1 capital	Pricing Basis 1: 5% on Pricing Capital 1 Pricing Basis 2: 10% on Pricing Capital 1 Pricing Basis 3: 10% on Pricing Capital 2
Duration at which economic capital is calculated	1 month into the annuity

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**Appendix 9.2** Stochastic Annuity Life Insurance Firm Example
 

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*Economic assumptions*


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Risk discount rate	The short term UK cash yield as generated by the stochastic model, parameterized according to Table 7.11.
Asset mix of non profit long term business fund (NPLTBF)	100% in long term UK corporate bonds Scenarios are also run with the NPLTBF invested 100% in long term UK government bonds, or 100% in UK equities.
Long term UK corporate bond gross yield	The long term UK corporate bond yield, as generated by the stochastic model, parameterized according to Table 7.11.
Long term UK government bond yield	The long term UK government bond yield, as generated by the stochastic model, parameterized according to Table 7.11.
UK equity earnings/dividend growth rate and dividend yield	The growth rate and dividend yield, as generated by the stochastic model, parameterized according to Table 7.11.
Term of long term UK corporate bond assets backing the annuity	15 years At the end of each month, assets are sold and reinvested in corporate bonds of duration 15 years, at the yield prevailing at the end of the month.
Corporate tax rate	30%

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*Annuity economic capital assumptions*


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Average single premium size	£250,000
Annuity income	Level
Mix of business	Joint life last survivor annuity for a male aged 65 and female aged 65

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**Appendix 9.2** Continued
 

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Mortality	Base mortality tables: PMA92Base, PFA92Base projected forward to 2005 using the published mortality improvement factors for these tables. See Continuous Mortality Investigation Bureau Report 17, Part 6 ( <a href="http://www.actuaries.org.uk">www.actuaries.org.uk</a> ).
Stochastic mortality improvement factors	<p>Improvement factors are assumed to be Normally distributed with the following expectations and standard deviations</p> <p>Male low expected improvement factors (<math>\mu</math>): 3% p.a. in year 1 of the projection, increasing by 0.25% p.a. for each subsequent year in the projection, up to an upper limit of 5% p.a. This upper limit is assumed to apply thereafter once it is reached.</p> <p>Male "cohort" expected improvement factors (<math>\mu</math>): 5% p.a. in year 1 of the projection, increasing by 0.25% p.a. for each subsequent year in the projection, up to an upper limit of 7.5% p.a. This upper limit is assumed to apply thereafter once it is reached.</p> <p>Male improvement factor standard deviation (<math>\sigma</math>): 0.5%.</p> <p>Female low expected improvement factors (<math>\mu</math>): 2.25% p.a. in year 1 of the projection, increasing by 0.25% p.a. for each subsequent year in the projection, up to an upper limit of 5% p.a. This upper limit is assumed to apply thereafter once it is reached.</p> <p>Female "cohort" expected improvement factors (<math>\mu</math>): 4.25% p.a. in year 1 of the projection, increasing by 0.25% p.a. for each subsequent year in the projection, up to an upper limit of 7.5% p.a. This upper limit is assumed to apply thereafter once it is reached.</p> <p>Female improvement factor standard deviation (<math>\sigma</math>): 0.5%.</p>
Long term UK corporate bond modeled credit risk	<p>The credit risk losses that we have assumed are as follows:</p> <p>Low corporate bond yield scenario: An annual probability of default equal to 0.5% p.a. and a</p>

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**Appendix 9.2** Continued
 

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	<p>loss given default of 25%, giving a conditional expected credit risk loss of 0.125% p.a.</p> <p>High corporate bond yield scenario: An annual probability of default equal to 2.5% p.a. and a loss given default of 75%, giving a conditional expected credit risk loss of 1.8750% p.a.</p> <p>High corporate bond scenarios are assumed to occur when the corporate bond yield exceeds its unconditional 90th percentile, according to the parameterization set out in Table 7.11. In other words, high corporate bond yield scenarios happen with probability 10%. This gives an overall unconditional expected credit risk loss of 0.30% p.a. As the unconditional expected yield differential between long term UK corporate bonds and long term UK government bonds, according to the parameterization set out in Table 7.11, is 0.50% p.a., we have assumed that 0.30% p.a. is due to corporate bond expected credit risk losses, and the remaining 0.20% p.a. is due to the inferior liquidity of the corporate bonds.</p>
Variable initial expense	1% of the single premium
Fixed expenses	£500 (acquisition), £25 p.a. (maintenance)
Fixed expense inflation	UK RPI as generated by the stochastic model
Realistic and mathematical reserving method	Realistic/gross premium
Realistic reserving assumptions	<p>The realistic reserve at each time point is calculated as follows:</p> <p>Annuity cash flows are projected using the values generated by the stochastic model. At each time point, the values generated by the stochastic model, and annuity cash flows, are projected forward deterministically using the expected values assumed in the stochastic model.</p> <p>The risk discount rate used for each time point going forward is the long term UK corporate bond yield as generated by the stochastic</p>

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**Appendix 9.2** Continued
 

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	<p>model at that time point, less 0.30% to cover unconditional credit risk losses.</p> <p>If the NPLTBF is backed by long term UK government bonds, the risk discount rate used from each time point forward is the long term UK government bond yield, as generated by the stochastic model at that time point.</p> <p>If the NPLTBF is backed by UK equities, the risk discount used from that time point forward is the annualized expected return on equities implied by the UK equity earnings/dividend growth rate and UK equity dividend yield, as generated by the stochastic model at that time point.</p>
Mathematical reserving assumptions	<p>The mathematical reserve at each time point is calculated as for realistic reserves except that: If the NPLTBF is backed by long term UK corporate bonds or long term UK government bonds, the risk discount rate used from that time point going forward is the long term UK government bond yield, as generated by the stochastic model at that time point.</p> <p>If the NPLTBF is backed by UK equities, the risk discount used from that time point forward is the UK equity dividend yield, as generated by the stochastic model at that time point.</p>
Long term insurance capital requirement (LTICR)	4% of mathematical reserves
Resilience capital requirement	<p>If the NPLTBF is backed by either long term UK corporate bonds, or long term UK government bonds, the additional asset/liability mismatch reserve needed to cover a 1.5% parallel shift in the yield curve, upwards or downwards, whichever requires the larger reserve.</p> <p>If the NPLTBF is backed by UK equities, the additional asset/liability mismatch reserve needed to cover a 25% fall in the market value of equities. Tapering, or dampening, adjustments are ignored.</p>

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**Appendix 9.2** Continued
 

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Pillar 1 regulatory capital requirement	<p>The Pillar 1 regulatory capital requirement is calculated as</p> <ol style="list-style-type: none"> <li>1. The long term insurance capital requirement</li> <li>2. The resilience capital requirement</li> <li>3. The mathematical reserve less the realistic reserve at each time point, provided this difference is positive, or zero otherwise. This difference represents the margin for prudence implicit in the mathematical reserves.</li> </ol>
Capital structure	<p>100% Tier 1 capital</p> <p>The Tier 1 capital is assumed to be invested in cash, so earning the short term UK cash yield as generated by the stochastic model, parameterized according to Table 7.11.</p>
Duration at which economic capital is calculated	All durations

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**Appendix 9.3** Stochastic United Linked Life Insurance Firm Example
 

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*Economic assumptions*


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Risk discount rate	The short term UK cash yield, as generated by the stochastic model, parameterized according to Table 7.11.
Asset mix in which life insurance premiums are invested	50% in UK equities and 50% in US equities, with all dividend income reinvested as it emerges, into the fund from which it was earned.
UK equity returns	UK equity earnings/dividend growth rates and UK equity dividend yields, as generated by the stochastic model, parameterized according to Table 7.11.
US equity returns	US equity earnings/dividend growth rates and US equity dividend yields, as generated by the stochastic model, parameterized according to Table 7.11.
\$/£ exchange rate	As generated by the stochastic model, parameterized according to Table 7.11.
Corporate tax rate	30%

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Continued

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**Appendix 9.3** Continued
 

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*Unit linked life insurance product economic capital assumptions*


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Age/sex	Male/35
Premium size	£250 per month
Term of product	25 years
Unit linked charging structure	<p>Bid offer spread of 5% on premiums invested and annual fund management charge of 0.5% p.a.</p> <p>Mortality charges are deducted from the customer's unit linked fund each month based on the customer's sum at risk (the sum assured less the unit linked fund, if positive, and zero otherwise) and expected mortality experience, as described below.</p> <p>These charges are guaranteed to apply throughout the term of the product.</p>
Fixed expenses	£500 initial, £50 per annum on maintenance
Fixed expense inflation	UK RPI as generated by the stochastic model
Variable expenses	5.0% of premiums in the first 5 years and 2.5% thereafter.
Investment management expenses	0.25% p.a. on assets under management
Underwriting	Fully underwritten with standard medical evidence.
Mortality	90% of AM92 (see Continuous Mortality Investigation Report 19, <a href="http://www.actuaries.org.uk">www.actuaries.org.uk</a> )
Death benefit	The greater of a sum assured of £50,000 and the customer's unit linked fund
Regular premium surrender rates	<p>Expected lapse rate scenario: 5% p.a.</p> <p>High lapse rate scenario: 10% p.a.</p> <p>Expected lapse rates are used unless if, in any month, UK or US stock markets, as generated by the stochastic model, fall by more than 5%. In that case, the high lapse rate scenario is used in the following month.</p>
Surrender value	The customer's unit linked fund
Maturity value	The customer's unit linked fund
Mathematical reserves	<p>The customer's unit linked fund</p> <p>No sterling reserve is required as the unit linked product expected charges are adequate to cover all expected expenses.</p>

Continued

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**Appendix 9.3** Continued
 

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Pillar 1 regulatory capital requirement	The long term insurance capital requirement, which equals 0.3% of each policy's sum at risk plus 1% of mathematical reserves.
Capital structure	The resilience capital requirement is assumed to be zero as assets and liabilities are matched. 100% Tier 1 capital The Tier 1 capital is assumed to be invested in cash, so earning the short term UK cash yield, as generated by the stochastic model, parameterized according to Table 7.11.
Duration at which economic capital is calculated	All durations

---



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**Appendix 9.4** Stochastic General Insurance Firm Example
 

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*Economic assumptions*


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Risk discount rate	The short term UK cash yield, as generated by the stochastic model, parameterized according to Table 7.11.
Asset mix in which general insurance premiums are invested	Short term UK cash, with yields as generated by the stochastic model, parameterized according to Table 7.11.
Corporate tax rate	30%

---

*Buildings insurance product economic capital assumptions*


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Initial size of portfolio	1 million policies
Premium size	£50 per policy month
Premium escalation	Increased in line with UK HPI as generated by the stochastic model
Amount insured	100% of the value of the property
Term of product	10 years
Increase in value of the property	Initial property value increased in line with UK HPI, as generated by the stochastic model
Claim incidence distribution	Let the random variable P denote the probability of a claim. Let q denote the probability of a catastrophe, where $q = 0.000025$ per month. The probability P of a claim, given that a catastrophe has not occurred, is assumed to equal $P = r = 0.0001$ per month.

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Continued

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**Appendix 9.4** Continued
 

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	<p>The probability <math>P</math> of a claim, given that a catastrophe has occurred, is assumed to equal <math>P = s = 1.0</math> per month.</p> <p>It then follows that:</p> $E(P) = (1 - q)^*r + q$ $E(P^2) = (1 - q)^*r^2 + q$ $\text{Var}(P) = E(P^2) - E(P)^2$ <p>For a portfolio of <math>m</math> policies at the start of a month, conditional on whether or not a catastrophe has occurred, the number of claims occurring in the month, <math>N</math>, is distributed as Binomial (<math>m, s</math>) or Binomial (<math>m, r</math>).</p>
Claim amount distribution	<p>Given that <math>N</math> claims have occurred in a particular month, the total claim amount for that month equals <math>S = C_1 + \dots + C_N</math>, where <math>C_i</math> represents the <math>i</math>th claim and is log normally distributed <math>\text{LN}(\mu, \sigma^2)</math> independently of the other claims, increased in line with UK HPI as generated by the stochastic model.</p> <p>The lognormal distribution is therefore used to model the distribution of house values in the portfolio of <math>m</math> policies.</p> <p>The mean and variance of a log normally distributed <math>\text{LN}(\mu, \sigma^2)</math> random variable are as follows:</p> $E(C_i) = \exp(\mu + \sigma^2/2)$ $\text{Var}(C_i) = \exp(2\mu + 2\sigma^2) - \exp(2\mu + \sigma^2)$ <p>With <math>\mu = 12</math> and <math>\sigma = 0.3</math>, the mean house value in the portfolio equals around £170,250 and the house value standard deviation equals £52,250.</p> <p>The expected total claim amount in each month, ignoring HPI, can then be expressed as: <math>mE(C_i)E(P)</math></p> <p>The variance of the total claim amount in each month, ignoring HPI, can then also be expressed in closed form as:</p> $E(C_i)^2 m^2 \text{Var}(P) + \text{Var}(C_i) m E(P)$
Fixed expenses per policy	£200 initial, £2 per month on maintenance
Fixed expense inflation	UK RPI as generated by the stochastic model
Variable expenses	10.0% of premiums

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Continued

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**Appendix 9.4** Continued
 

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Regular premium lapse rates	10% p.a.
Surrender value	None
Maturity value	None
General insurance technical provision	The annual expected claim at each duration.
Pillar 1 regulatory capital requirement	<p>At each duration, the larger of the Minimum Capital Requirement which, itself equals the larger of</p> <ol style="list-style-type: none"> <li>1. 18% of premiums received in the previous year, or;</li> <li>2. 26% of average annual claims incurred in the previous 3 years.</li> </ol> <p>Or the Enhanced Capital Requirement</p> <ol style="list-style-type: none"> <li>1. 10% of premiums received in the previous year, plus;</li> <li>2. 10% of the technical provision, plus;</li> <li>3. 0% of the value of the assets backing the technical provisions.</li> </ol> <p>For the purpose of this calculation, the technical provision is calculated as the expected annual claim at each duration.</p>
Capital structure	<p>100% Tier 1 capital.</p> <p>The Tier 1 capital is assumed to be invested in cash, so earning the short term UK cash yield as generated by the stochastic model, parameterized according to Table 7.11.</p>
Duration at which economic capital is calculated	All durations

---

**Appendix 11.1** Stochastic With Profits Life Insurance Firm Investment Guarantee Example
 

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*Asset mix assumptions*


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Non profit long term business fund (NPLTBF) asset mix	100% government bonds
With profits long term business fund (WPLTBF) asset mix	With profits benefit reserve (WPBR): 75% equity, 25% government bonds

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Continued

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**Appendix 11.1** Continued
 

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Capital structure	<p>Guarantee sub fund (GF): 100% government bonds.</p> <p>Additional guarantee sub fund (AGF): 100% government bonds.</p> <p>100% Tier 1 capital.</p> <p>The Tier 1 capital is assumed to be invested in UK government bonds.</p>
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*Stochastic model expected value assumptions*

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Retail price inflation (RPI)	2.75%
Equity dividend yield	3.25%
Equity earnings growth	4.25%
Government bond gross redemption yield	5.0%
Term of government bond	Constantly rebalanced at the end of each month to equal 15 years.

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*With profits life insurance product economic capital assumptions*

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Regular premium fixed expenses	£500 initial, £50 per annum on maintenance indexed in line with RPI.
Regular premium variable expenses	5.0% of premiums in the first 5 years and 2.5% thereafter.
Single premium fixed expenses	£500 initial, £25 per annum on maintenance indexed in line with RPI.
Single premium variable expenses	5.0% of the single premium.
Underwriting	Fully underwritten with standard medical evidence.
Mortality table	90% of AM92 (see Continuous Mortality Investigation Report 19, <a href="http://www.actuaries.org.uk">www.actuaries.org.uk</a> )
Regular premium surrender rates	5% p.a. for the first 3 years and 2.5% p.a. thereafter.
Single premium surrender rates	5% p.a. for the first 3 years and 2.5% p.a. thereafter.
NPLTBF mathematical reserves	No explicit reserve as, on the expected assumptions, charges will always cover expenses.
WPLTBF mathematical reserves	Aggregate guaranteed asset shares.
WPLTBF resilience capital requirement	The resilience capital requirement is calculated as the additional assets that the WPLTBF

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Continued

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**Appendix 11.1** Continued
 

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WPLTBF assets and realistic reserves	<p>requires to cover its mathematical reserves after the market stress: a 25% fall in equity market values in conjunction with a 100 basis point parallel shift in the yield curve, upwards or downwards, whichever is worse. Tapering, or dampening, adjustments are ignored.</p> <p>WPLTBF assets and realistic reserves equal sum of:</p> <ol style="list-style-type: none"> <li>1. The WPBR (aggregate actual asset shares);</li> <li>2. The GF, and;</li> <li>3. The AGF.</li> </ol>
WPLTBF “regulatory peak” and “realistic peak”	<p>The “regulatory peak” equals the sum of:</p> <ol style="list-style-type: none"> <li>1. Mathematical reserves (aggregate guaranteed asset shares);</li> <li>2. The “long term insurance capital requirement” (LTICR) which is the EC’s required minimum margin, a consequence of EC legislation, and which is broadly equal to 4% of WPLTBF mathematical reserves, and;</li> <li>3. The WPLTBF resilience capital requirement.</li> </ol> <p>The “realistic peak” equals the sum of:</p> <ol style="list-style-type: none"> <li>1. WPLTBF assets, and;</li> <li>2. The “risk capital margin” (RCM).</li> </ol> <p>The RCM was based on the same market risk stresses as the resilience capital requirement with no tapering or dampening adjustments. As this section deals with market risk economic capital only, the RCM credit and persistency stresses are ignored.</p> <p>Note that since this example was completed, the FSA has decided to slightly weaken the RCM stresses in its final regulations. In particular, for the purposes of this example, the equity market fall has been reduced to 20% and the parallel shift in the yield curve has been reduced to an 87.5 basis point shift. These changes simply strengthen the conclusions of the example.</p>

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 Continued

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**Appendix 11.1** Continued
 

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	<p>The RCM equals the amount by which the post RCM stressed realistic liabilities exceed the post RCM stressed realistic assets. The RCM is zero if realistic assets exceed realistic liabilities post the stress. The post RCM stressed realistic liabilities are computed assuming that all future projected stochastic asset values are subject to the RCM stress.</p> <p>If the RCM is positive, and the assets backing the RCM also reduce as a result of the RCM stress, the RCM must be increased to allow for this asset reduction to ensure that the post stressed RCM assets are sufficient to cover the RCM.</p>
WPLTBF Pillar 1 regulatory capital requirement	<p>Based on the “twin peaks” approach, the Pillar 1 regulatory capital requirement equals the sum of:</p> <ol style="list-style-type: none"> <li>1. The LTICR;</li> <li>2. The “with profits insurance capital component” (WPICC);</li> <li>3. The WPLTBF resilience capital requirement.</li> </ol>
	<p>The WPICC equals the amount by which the “realistic peak” exceeds the “regulatory peak”, subject to a minimum value of zero, and ensures that regulatory surplus does not exceed realistic surplus.</p> <p>The regulations allow WPLTBF surplus assets (i.e. WPLTBF assets less mathematical reserves) to count as capital towards the Pillar 1 regulatory capital requirement. The residual Pillar 1 regulatory capital requirement must be covered by Tier 1 and Tier 2 capital and we therefore compare economic capital with this residual capital requirement, where we assume that this is financed entirely by Tier 1 capital.</p>
Tax	<p>The WPLTBF and NPLTBF are assumed to be gross funds and so tax free. Tier 1 capital is assumed to be taxed on profits at 30%, with profits available to relieve all losses as they emerge.</p> <hr/>

**Appendix 11.2** Stochastic With Profits Life Insurance Firm Investment Guarantee Example – Correlation Matrix and Inverse Correlation of the  $\varepsilon$ s

*Correlation matrix of  $\varepsilon$ s*

	<i>RPI</i>	<i>Equity dividend yield</i>	<i>Equity earnings growth</i>	<i>Government bond yield</i>
RPI	1	0.3	0.1	0.6
Equity dividend yield	0.3	1	0.03	0.18
Equity earnings growth	0.1	0.03	1	0.06
Government bond yield	0.6	0.18	0.06	1

*Inverse correlation matrix of  $\varepsilon$ s*

	<i>RPI</i>	<i>Equity dividend yield</i>	<i>Equity earnings growth</i>	<i>Government bond yield</i>
RPI	1.67	(0.33)	(0.10)	(0.94)
Equity dividend yield	(0.33)	1.10	0.00	0.00
Equity earnings growth	(0.10)	0.00	1.01	0.00
Government bond yield	(0.94)	0.00	0.00	1.56

**Appendix 11.3** Stochastic With Profits Life Insurance Firm Investment Guarantee Example

*Product features – regular premium contract*

Age/sex	35/male
Premium	£250 per month
Fund management charge	To achieve an expected target net of tax rate of return on the financing provided by Tier 1 capital to the NPLTBF.
Investment guarantee charge	To achieve an expected target net of tax rate of return on the financing provided by Tier 1 capital to the WPLTBF to finance the AGF and the WPLTBF Pillar 1 regulatory capital requirement.

Continued

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**Appendix 11.3** Continued
 

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Guaranteed minimum investment return	0% p.a. after application of the death benefit charge
Bonus investment return	A bonus return of 2.0% p.a. is declared annually in advance each policy year and applies in addition to the guaranteed minimum investment return. Once added to a policy, this bonus cannot be taken away.
Applicability of guaranteed minimum and bonus investment returns	On death or maturity, but not surrender
Term	25 years
Death benefit	The greater of a sum assured of £50,000 and the customer's with profits fund
Surrender value	Actual asset share
Maturity value	With profits fund

---

*Product features – single premium contract*


---

Age/sex	35/male
Premium	£15,000
Fund management charge	To achieve an expected target net of tax rate of return on the financing provided by Tier 1 capital to the NPLTBF.
Investment guarantee charge	To achieve an expected target net of tax rate of return on the financing provided by Tier 1 capital to the WPLTBF to finance the AGF and the WPLTBF Pillar 1 regulatory capital requirement.
Guaranteed minimum investment return	0% p.a. after application of the death benefit charge.
Bonus investment return	A bonus return of 2.0% p.a. is declared annually in advance each policy year and applies in addition to the guaranteed minimum investment return. Once added to a policy, this bonus cannot be taken away.
Applicability of guaranteed minimum and bonus investment returns	On death or maturity, but not surrender

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 Continued

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**Appendix 11.3** Continued
 

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Term	25 years
Death benefit	The greater of a sum assured of £50,000 and the customer's with profits fund.
Surrender value	Actual asset share
Maturity value	With profits fund

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**Appendix 11.4** Stochastic With Profits Life Insurance Firm Smoothing Example\*
 

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*Corporate life insurance model assumptions*


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NPLTBF asset mix	100% government bonds
WPLTBF asset mix	WPBR: 75% equity, 25% government bonds SF: 75% equity, 25% government bonds GF: 100% government bonds AGF: 100% government bonds
Tier 1 capital asset mix	100% government bonds
WPLTBF assets and realistic reserves	WPLTBF assets and realistic reserves equal the sum of <ol style="list-style-type: none"> <li>1. The WPBR</li> <li>2. The SF</li> <li>3. The GF and</li> <li>4. The AGF</li> </ol>

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\* This Appendix sets out those assumptions that differ from those of Section 11.1.

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